Daniel Giannamore, NEPA Planner
Wayne National Forest
Attn: Plan Revision
13700 US HWY 33
Nelsonville, OH 45764

January 1, 2019

Delivered via email to: dgiannamore@fs.fed.us; wayneplanrevision@fs.fed.us

RE: Assessment Phase Comments for the Wayne National Forest Plan Revision

Dear Daniel and Planning Team,

The Ohio Environmental Council and The Wilderness Society are pleased to present the following comments for consideration and incorporation in the assessment phase of the Wayne National Forest Land and Resource Management Plan revision. The Assessment Report is required by the 2012 National Forest System Land Management Planning Rule and serves as a summary of the forest's condition to inform the development of the plan revision. Unlike its predecessor, the 2012 planning rule establishes a role for the public to provide information for incorporation into the assessment report and encourages the Forest Service to provide opportunities for public involvement.[1]

We are heartened that the Wayne is working with stakeholders on the development of the assessment and intends to release the draft for public review and comment.[2] We respectfully ask that you provide at least a month – but ideally more – for the review of the draft assessment report.

This submission addresses several of the topics the Forest Service is required to evaluate in a plan assessment[3]:

---

[1] 36 C.F.R. § 219.4(a) (generally requiring "opportunities to the public for participating in the assessment process"); *id.* § 219.6(a)(2) (agency must "[c]oordinate with or provide opportunities for . . . non-governmental parties[] and the public to provide existing information for the assessment"). The National FACA Committee for the implementation of the 2012 planning rule issued recommendations in late 2015 for improving the development of assessments and suggested that planning teams better address, incorporate, and respond to relevant information submitted by the public during the assessment phase. *See* Planning Rule National Advisory Committee, *Recommendations on the Development of Assessments*, Recommendation # 4 (Dec. 1, 2015), *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd489766.pdf.
[2] FSH 1909.12, section 42.11 requires that forests release a draft for public review and comment ("Make the draft assessment report available for public review and feedback during a specified time period.")
[3] 36 C.F.R. § 219.6(b) enumerates fifteen categories for which "the responsible official shall identify and evaluate existing information relevant to the plan area."

- Terrestrial ecosystems, aquatic ecosystems, and watersheds;
- System drivers, including dominant ecological processes, disturbance regimes, and stressors, such as natural succession, wildland fire, invasive species, and climate change; and the ability of terrestrial and aquatic ecosystems on the plan area to adapt to change;
- Threatened, endangered, proposed and candidate species, and potential species of conservation concern present in the plan area;
- Recreation settings, opportunities and access, and scenic character;
- Infrastructure, such as recreational facilities and transportation and utility corridors; and
- Existing designated areas located in the plan area including wilderness and wild and scenic rivers and potential need and opportunity for additional designated areas. (36 CFR 219.6(b)).

While certainly not exhaustive, we believe the information contained in this letter and its appendices represents the best available scientific information, which the 2012 planning rule requires the agency to utilize.[4] We anticipate that the Forest Service will have significant additional forest-specific information available and will also incorporate that information into the assessment.

The mission of the Ohio Environmental Council (OEC) is to secure healthy air, land, and water for all who call Ohio home. Founded in 1969, the OEC protects the environment by developing and ensuring the implementation of forward-thinking, science-based, and pragmatic solutions. Our experts work daily to restore, protect, and strengthen the quality of life for families and communities—from the air we breathe and the water we drink to the food we eat and the natural resources we enjoy. We work with diverse partners to forge inclusive and respectful relationships that support and strengthen Ohio's environmental movement, including and especially supporting partners in the communities they lead.

The mission of The Wilderness Society (TWS) is to protect wilderness and inspire Americans to care for our wild places. Since its founding in 1935, TWS has worked closely with diverse interests who care about the future of our national forests. We provide scientific, legal, and policy guidance to land managers, communities, local conservation groups, and state and federal decision-makers aimed at ensuring the best management of our public lands. Our one million members and supporters nationwide are deeply interested in forest planning as it pertains to the conservation, restoration, and protection of wildlands, wildlife, water, recreation, and the ability to enjoy public lands for inspiration and spiritual renewal.

We look forward to further discussing the information in this letter and working with you throughout the assessment and plan revision process. Please contact Nathan Johnson, Public Lands Director for the Ohio Environmental Council at njohnson@theoec.org, and Vera Smith, Forest Planning and Policy Director for TWS at vera_smith@tws.org with any questions.

[4] 36 C.F.R. § 219.3 (agency "shall use the best available scientific information to inform the planning process" and "shall document how [that] information was used to inform the assessment").

With regards,

Vera Smith
National Forest Policy and Planning Director
The Wilderness Society
303-650-5942
Vera_smith@tws.org

Nathan Johnson
Public Lands Director
Ohio Environmental Council
(614) 487-5841
NJohnson@theOEC.org

Table of Contents

I. Best Available Scientific Information

The planning rule requires the Forest Service to use best available scientific information.[5] Recognizing that the scientific literature is not monolithic, the responsible official must determine what information is the most "accurate, reliable, and relevant to the issues being considered" and document how the best available scientific information was used to inform the assessment….Such documentation must: Identify what information was determined to be the best available scientific information, explain the basis for that determination, and explain how the information was applied to the issues considered."[6]

While certainly not exhaustive, we believe the information contained in this letter and its appendices represents the best available scientific information.

II. Distinctive Role and Contribution

Under the 2012 planning rule, plans must "reflect[] the unit's expected distinctive roles and contributions to the local area, region, and Nation, and the roles for which the plan area is best suited, considering the Agency's mission, the unit's unique capabilities, and the resources and management of other lands in the vicinity."[7] The forest assessment is the logical place to identify the forest's current roles and contributions, based on existing information, to inform the plan revision process.[8] For example, the Flathead National Forest Assessment identified that forest's distinctive role as "the true heart of the Rocky Mountain ecosystem," providing large, interconnected blocks of wild habitat for carnivores and other wildlife species.[9] That assessment information then informed the draft plan, which identified the forest's nationally significant ecological role and contribution as "the heart of the Crown of the Continent Ecosystem, with a complex of wilderness and unroaded areas" that provide "one of the most intact assemblages of medium to large carnivores in the contiguous United States."[10]

---

[5] 36 C.F.R. § 219.3

[6] *Id.*

[7] 36 C.F.R. § 219.2(b)(1); *see also id.* § 219.7(f)(1)(ii) ("Every plan must . . . [d]escribe the plan area's distinctive roles and contributions within the broader landscape . . . .").

[8] Depending on the nature of those distinctive roles and contributions, this information would be consistent with any number of the required assessment topics, such as "[t]errestrial ecosystems, aquatic ecosystems, and watersheds," 36 C.F.R. § 219.6(b)(1), "[b]enefits people obtain from the NFS planning area," *id.* § 219.6(b)(7), "[m]ultiple uses and their contributions to local, regional, and national economies," *id.* § 219.6(b)(8), or "[e]xisting designated areas . . . and potential need and opportunity for additional designated areas," *id.* § 219.6(b)(15). For example, the final planning directives instruct that, in assessing the potential need and opportunity for additional designated areas, the forest should address "known important ecological roles such as providing habitat or connectivity for species at risk that could be supported by designation." Forest Service Handbook (FSH) 1909.12, ch. 10, § 14. And in assessing ecosystems' status and trends, the forest should consider "[h]ow the existing role or contributions of the plan area affects the key ecosystem characteristics or ecological functions (processes) relevant to the broader landscape." *Id.* § 12.14c.

[9] Flathead National Forest, Assessment, pt. 1, p. 3 (Apr. 2014), *available at* https://fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3796880.pdf.

[10] Flathead National Forest, Draft Revised Forest Plan, p. 10 (May 2016), *available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd502201.pdf. The distinctive roles and contributions section of the draft plan identifies numerous other ecological, social and economic, and cultural and historical resources that are unique attributes or benefits of local, regional, and/or national importance and contribute toward social, economic, and ecological sustainability. *Id.* pp. 9-13.

The Wayne National Forest is in the heart of Ohio's hill country. Comprised of acquired forested lands, the Wayne now is the single largest forest in Ohio by ownership and administration, and one of the largest tracts of public forests in the region. As such, it provides important wildlife habitat and outdoor recreation (hiking, boating, fishing, biking, birdwatching, backpacking) for Ohio's 11.6 million residents and the millions more who live within a 3-hour drive. The Wayne's relative size and public ownership make it one of the region's best opportunities for the recovery of old growth on a substantial scale. The Wayne also contains some of the best candidates in the region for future old growth with tracts as old as 140 years. The habitat and resiliency, carbon storage and sequestration, and aesthetic and recreational values provided by old growth forest are fundamentally important to people and wildlife alike. And, of course, with two hundred years of European settlement preceded by thousands of years of Native American habitation, the Wayne's landscape tells a deep human and ecological story, the signs of which remain throughout the landscape. Deforested, mined, and drilled over the past two centuries, the Wayne's story can now be one of restoration, healing, and adaptation. In the face of climate change and increasing human development, the Wayne provides a regionally large stronghold for wildlife within the Southern Unglaciated Allegheny Plateau.

III. Potential Need and Opportunity for Additional Designated Areas

The 2012 planning rule requires that an assessment evaluate "[e]xisting designated areas located in the plan area including wilderness and wild and scenic rivers ***and potential need and opportunity for additional designated areas***."[11] This evaluation is intended to inform the plan revision process, which in turn requires the Forest Service to determine whether to designate or recommend for designation any additional areas:

> The responsible official shall: . . . (v) Identify and evaluate lands that may be suitable for inclusion in the National Wilderness Preservation System and determine whether to recommend any such lands for wilderness designation. (vi) Identify the eligibility of rivers for inclusion in the National Wild and Scenic Rivers System . . . . (vii) Identify existing designated areas other than [Wilderness and Wild and Scenic Rivers] and determine whether to recommend any additional areas for designation. If the responsible official has the delegated authority to designate a new area or modify an existing area, then the responsible official may designate such area when approving the . . . plan revision.[12]

To comply with this mandatory duty, it is crucial that the assessment effectively evaluate the potential need and opportunity for additional designated areas. For reasonable examples of how forests have complied with this requirement see the final Assessment reports completed by the Rio Grande National Forest,[13] the Grand Mesa-Uncompahgre-Gunnison National Forest,[14] and

[11] 36 C.F.R. § 219.6(b)(15) (emphasis added).
[12] 36 C.F.R. § 219.7(c)(2)(v)-(vii). The 2012 rule defines "designated area" as "[a]n area or feature identified and managed to maintain its unique special character or purpose." *Id.* § 219.19. The definition further explains that "[s]ome categories of designated areas may be designated only by statute and some categories may be established administratively in the land management planning process or by other administrative processes of the Federal executive branch." *Id.* (listing examples of statutorily and administratively designated areas). See FSH 1909.12, Exhibit 14 01 for more detail on designation authority.
[13] See Rio Grande National Forest Assessment Report Chapter 15 available at https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd489288.pdf.

the Gila National Forest.[15] To effectively evaluate the potential need and opportunity for additional designated areas, we recommend that the assessment identify and strive to answer the following questions. For each, we have provided general background information and rationale. The list of recommended questions is non-exclusive and is intended to focus the assessment on the relevant substantive and procedural requirements of the 2012 rule, the corresponding directives contained in Forest Service Handbook (FSH) 1909.12, and other federal laws and policies.

A. Where are the Roadless Lands on the Wayne National Forest?

Roadless areas can be generally defined as undeveloped places of sufficient size that do not contain needed system roads that are open for public or administrative use.[16] Areas are of sufficient size if they are greater than 5,000 acres or a size that makes practicable their preservation and use in an unimpaired condition.[17] While the criteria for roadlessness are objective, applying the criteria must be undertaken within the context of the region. Hence, western forests with vast undeveloped lands do not often identify areas with less than 5,000 acres unless they are contiguous to existing wilderness, recommended wilderness, etc. In contrast, eastern forests, often comprised of acquired lands within more constrained and developed landscapes, contain tracts of unroaded and undeveloped lands that within the region possess wild qualities and associated benefits. While the tracts are usually not on the scale of those in western forests, they offer equally important wild lands values and experiences to the people, communities, and wildlife within the region.

Based on data provided to us by the Wayne National Forest, the Wayne contains 38 distinct roadless areas larger than 1,000 acres totaling 61,683 acres. See Figure 1. Of these, two (both located on the Ironton unit) are over 3,000 acres in size. In addition, many of the unroaded tracts are contiguous separated only by one road. Further, some are contiguous to lands managed by other entities for natural values (e.g., state wildlife areas).

B. What is the Ecological Benefit Relevant to Biodiversity, Connectivity, and Climate Change Adaption of Establishing Additional Designated Areas?

Undeveloped parcels present a significant opportunity to enhance the myriad ecological and social benefits associated with roadless lands, and to satisfy the Forest Service's substantive obligations under the 2012 planning rule to provide for ecological integrity, species diversity, and social, economic, and ecological sustainability.[18] Unroaded patches 1,000 acres and larger, which are growing increasingly rare in the east, are crucial to biodiversity and should be a priority for conservation (Fahrig 2003, pages 499-502).

Unroaded lands contribute to the conservation of biodiversity. Loucks et al. (2003) examined the potential contributions of roadless areas to the conservation of biodiversity and found that more

---

[14] See Grand Mesa-Uncompahgre-Gunnison National Forest Assessment Report Chapter 15 available at https://www.fs.usda.gov/detail/gmug/landmanagement/planning/?cid=fseprd563243.
[15] See Gila National Forest Assessment Report Chapter 13 available at https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd544951.pdf.
[16] FSH 1909.12, 71.
[17] FSH 1909.12, 71.21.
[18] *See* 36 C.F.R. §§ 219.8-219.9.

than 25% of Inventoried Roadless Areas (IRAs) are located in globally or regionally outstanding ecoregions and that 77% of IRAs have the potential to conserve threatened, endangered, or imperiled species. Several recent studies have emphasized the contribution that IRAs could make toward building a representative network of conservation reserves in the United States, finding that protecting IRAs would expand eco-regional representation, increase the area of reserves at lower elevations and the number of large, relatively undisturbed refugia for species, and increase landscape connectivity (Aycrigg et al 2016; Belote et al 2016; Aycrigg et al 2015; Loucks et al. 2003; USDA Forest Service 2001; Crist et al. 2005; Wilcove 1990; The Wilderness Society 2004; Strittholt and DellaSala 2001; DeVelice and Martin 2001).

Second, unroaded lands are responsible for higher quality water and watersheds. Anderson et al. (2012) assessed the relationship of watershed condition and land management status and found a strong spatial association between watershed health and protective designations. DellaSala et al. (2011) found that undeveloped and roadless watersheds are important for supplying downstream users with high-quality drinking water, and that developing those watersheds comes at significant costs associated with declining water quality and availability. The authors recommend a light-touch ecological footprint to sustain healthy watersheds and the many other values that derive from roadless areas. Without the disturbance caused by roads and associated activities, stream channel characteristics -- such as channel and floodplain configuration, substrate embeddedness, riparian condition, amount and distribution of woody debris, stream flow, and temperature regime are less likely to be altered compared to stream channel conditions in roaded areas (Furniss et al 1991).

Third, conserving uroaded lands is an important strategy for buffering climate change effects and enhancing climate change adaptation. Numerous government reports highlight the importance of this strategy. Conserving roadless lands reduces fragmentation and preserves blocks of natural landscape large enough to be resilient to large-scale disturbances and long-term changes (USDA Forest Service 2011; National Park Service 2010; National Park Service, undated; US Fish and Wildlife Service et al, 2013). It also enhances the resilience of larger landscapes by ensuring a percentage of lands are undeveloped and hence better able to absorb perturbations. Roadless areas also serve as ecological baselines to facilitate better understanding of our impacts to other landscapes and how to adapt to changing climates (Arcese and Sinclair 1997) and refuges for at-risk species (Butchart *et al*. 2012).[19] The 2012 planning rule's substantive ecological sustainability provision sanctions this reserve design and landscape connectivity approach, requiring the Forest Service to formulate "plan components, including standards and guidelines, to maintain or restore [the] structure, function, composition, and connectivity" of terrestrial and aquatic ecosystems and watersheds, taking into account stressors such as climate change.[20]

C. What ecosystem and habitats exist across the Wayne National Forest, and what are their levels of protection within the Wayne National Forest and throughout the region? What ecosystem types and habitats are least represented in designated areas?

[19] The Forest Service's Northern Research Station in its report on climate vulnerability in the Central Appalachians observes that places with more landscape complexity may provide opportunities for refugia. The report states: "With increasing topographic and landform complexity come a greater number of landscape characteristics and microhabitats that buffer against climate changes." See Patricia Butler et al., 2015 at 147.

[20] 36 C.F.R. § 219.8(a)(1).

Protection of diverse ecosystem and habitat types through wilderness and other designations is a cornerstone of regional, national, and international efforts to conserve biological diversity and ecological processes of natural ecosystems (Bertzky *et al.* 2012). For protected areas to conserve genetic, species, and community diversity – as well as the composition, structure, function, and evolutionary potential of natural systems – they must encompass the full variety of ecosystems (Olson and Dinerstein 1998; Margules and Pressey 2000). Indeed, protecting ecosystem diversity is a central purpose of forest planning under the 2012 planning rule:

> Plans will guide management of [National Forest System] land so that they are ecologically sustainable and contribute to social and economic sustainability; ***consist of ecosystems and watersheds with ecological integrity and diverse plant and animal communities***; and have the capacity to provide people and communities with ecosystem services and multiple uses that provide a range of social, economic, and ecological benefits for the present and into the future.[21]

To that end, a forest assessment's evaluation of the potential need and opportunity for additional designated areas should consider whether there are "specific land types or ecosystems present in the plan area that are not currently represented or minimally represented" in protected areas.[22] That analysis of ecosystem representation in turn will help inform the Forest Service's determination during the plan revision process whether to designate or recommend for designation additional areas.[23] The International Convention on Biological Diversity recommends that at least 17% of the world's terrestrial areas be conserved by 2020 (Woodley *et al*. 2012).

Wilderness is the strongest protective designation in the United States and the cornerstone of US conservation efforts (Bertzky *et al*. 2012). Wilderness and other protected areas, however, can help achieve biodiversity targets only if they are located in the right places – that is, if they are ecologically representative of terrestrial ecosystems. This "representation" approach assumes that for protected areas to conserve genetic, species, and community diversity – as well as the composition, structure, function, and evolutionary potential of natural systems – they must encompass the full variety of ecosystems (Olson & Dinerstein 1998; Margules & Pressey 2000). In other words, protection of distinct ecological communities in turn protects the species that rely on them and the natural ecological processes that are characteristic of those ecosystems (Rodrigues *et al*. 2004; Bunce *et al*. 2013).

Dietz et al. (2015) conducted an analysis of ecosystem representation in the National Wilderness Preservation System (NWPS) and showed that the NWPS suffers from a significant under-representation of many ecosystems. Over 20% (117) of the 553 types of unique ecosystems occurring on federal lands in the contiguous United States are not included in the NWPS. Even more concerning is that less than half of those 553 ecosystems are more than nominally represented: only 244 ecosystem types have at least 5% of their federal land area protected in the NWPS. And at a more reasonable 20% target for biodiversity conservation purposes, that

[21] 36 C.F.R. § 219.1(c) (emphasis added).
[22] FSH 1909.12, ch. 10, § 14(4)(c).
[23] *See, e.g.*, FSH 1909.12, ch. 70, § 72.1(4) (agency must "[e]valuate the degree to which [potential wilderness areas] may also contain ecological, geological, or other features of scientific, educational, scenic, or historical value," which "may include[r]are plant or animal communities or rare ecosystems").

number falls to only 113 ecosystems with at least 20% of their federal land area protected in the NWPS. 95% of that diversity was achieved by 1994, and wilderness designations over the past 15 years have added only 1 new ecosystem type above the 20% threshold. Moreover, there is not a clear correlation between how rare an ecosystem is on federal lands and how well it is represented in the NWPS. We found that there are many ecosystem types that are common on federal lands (covering over 100,000 hectares) but are poorly represented in the NWPS.

We evaluated the degree to which the ecosystems that occur on the Wayne National Forest are protected within the NWPS.[24] No ecosystems at the forest scale (that is, within the Wayne National Forest) enjoy Wilderness protection at the moment and thus can be considered at 0% representation at the forest scale. At the federal scale, the vast majority of the Wayne National Forest's acres are located within under-represented ecosystems. See Appendix 9 for a list of ecosystems and a description of our method. Specifically, 195,890 acres are in ecosystems with less than five percent in protection as Wilderness; 12,020 acres are within ecosystems that have between 5 and 9.9% in Wilderness status, and only 1,149 acres are within ecosystems between 10% and 20% represented in the NWPS. Aggregated, 209,059 acres (about 84% of the Wayne National Forest) are within under-represented ecosystems. This result is not unexpected given that relatively few lands in the eastern United States are in Wilderness.

From a biodiversity perspective it is also important to protect the habitats of as many species as possible, especially the at-risk species. The US Geological Survey recently published modeled data for terrestrial vertebrate species.[25] By our count, seventy-seven of these species are identified by the state of Ohio as at-risk (Ohio Department of Natural Resources 2018b).[26] While we did not have the resources, it would be helpful to map the modeled habitats of the 77 terrestrial species and evaluate the overlap with roadless tracts. This would help identify particular roadless tracts with high at-risk species richness where it would make sense to establish a conservation designation. Similarly, it would be helpful to evaluate the spatial relationship of modeled habitat of specific species of conservation concern (e.g., black bear) and roadless tracts to identify tracts that should be recommended for wilderness or considered for another protective designation.

In sum, a potential need and opportunity for additional designations exists in places - especially roadless tracts -- where ecosystem representation is below the accepted 20% threshold, where species (especially at risk species) richness is high, or where habitat of an at-risk species desiring low disturbance exists.

Finally, the Wayne should evaluate the spatial relationship of future old growth stands and roadless tracts. We did this overlay (using Wayne National Forest stand inventory data and 2006 Future Old Forest Management Area boundaries) and present it in Figure 1. While the forest contains very few if any true old growth stands, it does contain stands that are in the process of evolving towards old growth. The assessment should discuss the location, extent, condition,

[24] This is an accurate representation of the conservation status of lands within the Wayne National Forest since there are less than 100 acres within the Wayne in reasonably protective designations. Currently 117 acres are designated or proposed as Research Natural Areas which usually provide high levels of protections.
[25] See https://gapanalysis.usgs.gov/blog/national-species-data-for-conus-is-now-available/.
[26] See http://wildlife.ohiodnr.gov/portals/wildlife/pdfs/publications/information/pub356.pdf. Updated July 2018.

stressors, threats, and opportunities associated with these places, and that they present a potential need and opportunity for designations.

D. What unique or special features, values, or resources exist across the forest, and what is their current status of protection?

The 2012 planning rule defines designated area as "[a]n area or feature identified and managed to maintain its unique special character or purpose."[27] Accordingly, to properly assess the need and opportunity for additional designated areas, the forest assessment must identify those areas and features with unique, special character and evaluate their current status of protection.

In identifying and assessing unique and outstanding areas and features, the Forest Service should take a broad and inclusive approach. The Forest Service Manual addressing special recreation designations describes *some* of the potential types of special character that may warrant protective designation: areas with "scenic, geological, botanical, zoological, paleontological, archaeological, or other special characteristics or unique values" should be "protect[ed] and manage[d] for public use and enjoyment [as] special recreation areas."[28] The planning directives at FSH 1909.12, section 14 identify the following types of areas that can be designated by the Regional Forester: botanical, geological, scenic, zoological, paleontological, historical, and recreational. Those categories, however, are in no way an exhaustive list of the types of special features, values, or resources the Forest Service should identify in the assessment report, and special recreation designations are just one of a slate of potential designations that the agency should consider during the plan revision process.[29] Thus, in addition to scenic, geological, botanical, zoological, paleontological, and archaeological resources, the Forest Service should consider historical and cultural (including tribal) resources, aquatic resources, other recreational or educational resources, and any other unique or special features, values, or resources across the forest.

The current land management plan designates 22 special areas.[30] Most of these were designated to protect high quality examples of particular ecosystems or at-risk ecosystems and species. The assessment report should identify other places that merit designation as a special area. This is especially important in the context of climate change. As climate change alters and makes more vulnerable ecological systems, habitats, and species composition and distribution, there is an acute need to conserve migratory corridors, replication and representation within protected areas, larger protected tracts, and more connections between them (Mawdsley *et al.* 2009). Are there particular areas that are important for species movement or as refugia for species that will be increasingly stressed? Are there areas important to Tribes that have gone unrecognized to date? Are there important bird areas on the forest that deserve designation? For example, see Audubon's Important Bird Areas for Ohio map at https://www.audubon.org/important-bird-areas/state/ohio. While Audubon identifies the Wayne National Forest entirely as an Important Bird Area, are there places within the forest boundary that are particularly important to specific

[27] 36 C.F.R. § 219.19.
[28] Forest Service Manual 2372.02.
[29] *See* 36 C.F.R. § 219.7(c)(2)(vii) (broad, non-discretionary duty to "[i]dentify existing designated areas other than [Wilderness and Wild and Scenic Rivers]" and "determine whether to recommend any additional areas for designation"); *see also, e.g.*, FSH 1909.12, ch. 20, § 24, Exhibit 01 (providing a non-comprehensive list of "some types of designated areas that the Responsible Official may consider" during the forest plan revision).
[30] See Wayne National Forest Land and Resource Management Plan, 2006 at 3-47 to 3-50.

species? Are there places with older forests that deserve recognition and conservation so that they may evolve eventually into old growth? Are there geologic features that deserve recognition?

Consistent with the requirement under the 2012 planning rule that plans provide for sustainable recreation and opportunities to connect people with nature,[31] the assessment should also include information from the Forest Service's 2010 Framework for Sustainable Recreation when identifying special features, values, and resources. The framework highlights the importance of investing in special places and commits the agency to "evaluat[ing] other areas within the National Forest System that have outstanding recreational, scenic, historic, or other values of high attractiveness for designation and management as special areas" (USDA Forest Service 2010a). More generally, the assessment of recreation settings, opportunities and access, and scenic character should be integrated into the assessment of the need and opportunity for additional designations.[32]

E. Do existing Research Natural Areas satisfy the objectives listed in Forest Service Manual 4063.02?

A Research Natural Area (RNA) is "[a] physical or biological unit in which current natural conditions are maintained insofar as possible . . . by allowing natural physical and biological processes to prevail without human intervention."[33] RNAs should be "large enough to provide essentially unmodified conditions within their interiors . . . and to protect the ecological processes, features, and/or qualities for which the [RNAs] were established."[34] As Forest Service Manual 4063.1 explains, "[l]andscape-scale [RNAs] that incorporate several ecosystem elements are ideal, where feasible." Collectively, RNAs comprise "a national network of ecological areas designated in perpetuity for research and education and/or to maintain biological diversity."[35]

Forest Service Manual 4063.02 enumerates eight objectives for establishing RNAs:

- Maintain a wide spectrum of high quality representative areas that represent the major forms of variability . . . that, in combination, form a national network of ecological areas for research, education, and maintenance of biological diversity
- Preserve and maintain genetic diversity
- Protect against human-caused environmental disruptions
- Serve as reference areas for the study of natural ecological processes including disturbance
- Provide onsite and extension educational activities
- Serve as a baseline area for measuring long-term ecological changes
- Serve as control areas for comparing results from manipulative research
- Monitor effects of resource management techniques and practices

[31] 36 C.F.R. §§ 219.8(b)(2) & (6), 219.10(b)(i).
[32] *See* 36 C.F.R. § 219.6(b)(9).
[33] Forest Service Manual (FSM) 4063.05.
[34] FSM 4063.1.
[35] FSM 4063.

The role of RNAs is increasingly important in a climate change world for protecting as unblemished as possible specific types of ecosystems for study and preservation.

The Wayne has two designated RNAs[36]:

> **Reas Run Research Natural Area** was established in 1975. It is a 78-acre mature Virginia pine stand. Natural succession to climax hardwood forest is imminent and, therefore, of interest to forest researchers.
>
> **Buffalo Beats Research Natural Area** was established in 1999. It consists of 19 acres with the unique feature of a one-acre relict prairie within a mixed oak forest. Significant plants found at this site include prairie species such as big bluestem, rattlesnake master, stiff goldenrod, slender blazing star, and yellow gentian.

And one candidate RNA:

> **Kaiser Hollow** – Regionally significant undeveloped forest tract with mature upland forests containing small-flowered alumroot, Bicknell's panic-grass, and Ohio's largest population of Guyandotte beauty.[37]

To properly assess the need and opportunity for additional RNAs, the forest assessment should evaluate and document whether the size, distribution, and representation of its two designated RNAs satisfy each of the objectives enumerated in Forest Service Manual 4063.02. The assessment should identify where the system falls short of meeting the objectives articulated above and how the deficiencies demonstrate a potential need and opportunity for additional designated areas.

F. What are the socio-economic factors relevant to protecting national forest lands through conservation designations (e.g., recreation trends, public sentiment, etc.)?

In addition to their ecological values, areas protected through conservation-oriented designations, including wilderness, contribute to social and economic well-being. A proper assessment of the need and opportunity for additional designated areas must identify and evaluate these benefits. In particular, the assessment should consider recent trends in recreation, public opinion and values, and the economic contributions associated with wilderness and other conservation designations. A robust assessment of those benefits is a necessary prerequisite to satisfaction of the Forest Service's substantive planning mandate to provide for social and economic sustainability, including sustainable recreation, ecosystem services, and opportunities to connect people with nature.[38]

1. <u>Public opinion shows a need for additional wilderness-like lands.</u>

---

[36] 2006 Wayne National Forest Land and Resource Management Plan at 3-54.
[37] *Ibid.* at 3-57.
[38] 36 C.F.R. § 219.8(b).

Surveys consistently show that Americans value wilderness and generally favor the designation of additional wilderness. For instance,

- In Chapter 7 of Cordell's *Multiple Values of Wilderness* (2005), Schuster *et al.* addressed the social values of wilderness by looking at survey results at the national, regional, and state levels. They found that: (a) overall there is consensus across groups within the American population that there is not enough wilderness, regardless of how the data are stratified; (b) residents generally support designating more wilderness in their respective states; and (c) Americans are willing to make unspecified monetary tradeoffs to gain additional wilderness.

- As of 2006-2007, more than two-thirds of American citizens (67%) nationally supported the designation of additional wilderness in their home state (Cordell 2008b).[39]

- As of 2001, the majority of Americans felt that the current percentage of the National Forest System designated as wilderness was not enough (Scott 2003).[40]

- Over half of Americans (almost 51%) indicated there is not enough wilderness, while only 4% expressed the opinion that there is too much (Cordell 2008b).[41]

- Americans are willing to accept higher costs for electricity, gasoline, and other consumer products to have more wilderness lands designated and to have higher quality air over and near wilderness (Scott 2003).

The 2018 Ohio Statewide Comprehensive Outdoor Recreation Plan identifies a main outdoor recreation priority for Ohioans is to "protect and sustain the natural environment."[42] As the report states:

> Protection of wetlands, forests, rivers, lakes, and other habitats is a top funding priority for Ohioans and sustaining high quality natural areas will be key to sustaining the backdrop for Ohio's outdoor recreational activities. Ohio's federal, state, and local parks, forests, nature preserves, and wildlife areas protect many of the state's notable natural and cultural resources, including caves, cliffs, scenic ravines, lakes, historic sites, and wetlands. Many of Ohio's most popular outdoor recreation activities, such as walking, hiking, wildlife viewing, hunting, birdwatching, and night sky viewing are tied to high-quality natural resources.

---

[39] When asked how they felt about designating more of the federal lands as wilderness in their home state, 67% of National Survey on Recreation and the Environment (NSRE) respondents indicated they somewhat or strongly favor more.

[40] Question: "Currently, 18% of the land in the United States' national forests is permanently protected from logging and other development. Do you think the U.S. has too much permanently protected areas in the national forests, not enough protected areas in the national forest, or the right amount of permanently protected areas in the national forests, or aren't you sure about that?" N=1,000 likely voters.

[41] NSRE respondents were asked their opinions about whether they saw the amount of federal land now designated as wilderness as too little, about right, or too much. Over half in 2006-2007 (almost 51%) indicated there is not enough wilderness, and 35% indicated the amount is about right. Only 4% expressed the opinion that there is already too much.

[42] Ohio Statewide Comprehensive Outdoor Recreation Plan 2018. Pages 55-56. Available at http://parks.ohiodnr.gov/Portals/parks/PDFs/stay_informed/SCORP/2018_SCORP_Appendices.pdf.

> Based on the survey, Ohioans want more natural surface trails, undeveloped camping sites, and equestrian camping opportunities, activities that rely on scenic and high quality natural resources…
>
> It is also important to find ways to interpret Ohio's natural resources and biodiversity to increase appreciation and stewardship of Ohio's valuable natural resources.[43]

In addition, specific to Ohio, recent surveys demonstrate that Ohioans are very active in the outdoors and in particular want more natural surface trails.[44] Trail activities are particularly popular with 97.5% of households utilizing Ohio's trails with natural surface trails having the highest level of participation.[45]

2. Economic benefits of protected public lands.

Protected areas such as roadless areas are good for the economy. Based on a wealth of existing, scientifically validated research, the general rule is that there is a neutral-to-positive relationship between the presence and extent of wilderness, wild and scenic rivers, and other protected areas on one hand, and the economic performance of local economies and economic benefits available to nearby residents on the other (Rasker et al 2004; USDA Forest Service 2017). Protected public lands play an important role in stimulating local economic growth – especially when combined with access to markets and an educated workforce (Rasker 2006; Rasker *et al.* 2009; Phillips 2000). See Appendix 2 for a summary of recent research.

Headwaters Economics' Economic Profile System Human Dimensions Toolkit (EPS-HDT) provides an easy-to-digest and comprehensive look at the economic situation in and around the Wayne National Forest. As explained on Headwaters Economics' website:

> EPS-HDT is a free, easy-to-use software application that runs in Excel, from your desktop, and produces detailed socioeconomic reports of communities, counties, states, and regions, including custom aggregations and comparisons. EPS-HDT uses published statistics from federal data sources, including the Bureau of Economic Analysis and Bureau of the Census, U.S. Department of Commerce; Bureau of Labor Statistics, U.S. Department of Labor; and others.[46]

EPS-HDT can produce 14 separate reports for each county in and around the Wayne National Forest and for the region on a variety of relevant topics such as long-term economic trends, demographics, amenities, land use, non-labor income, development and wildfire, and payments in lieu of taxes. We have included some of these reports in Appendix 1 to illustrate the utility of this application. The reports show, for example, that[47]:

[43] *Id.*
[44] *Id.* at 50.
[45] *Id.* at 38.
[46] *See* https://headwaterseconomics.org/tools/economic-profile-system/about/.
[47] Appendix 1, EPS-HDT, Economic Information for the Wayne National Forest Region Generated from Headwater Economics EPS-HDT Application.

- For all three units, the travel and tourism sector is responsible for the most private employment. This is most pronounced in the Athens Unit where it makes up 23% of private employment. This compares to 2% for timber and mining/oil&gas industries, respectively, and 4% for agriculture.
- USDA Forest Service land makes up just under 10% of the land base in the Wayne National Forest region.
- Federal payments are not a significant factor in county government budgets (<0.2% of government revenue).
- Non-labor income is higher in the Wayne National Forest region than in Ohio and the US.
- Timber is a very small part of the Wayne National Forest regional economy and is in decline. It constitutes less than 2% of private employment in the Athens unit subregion, <0.1% of private employment in the Ironton unit subregion, and <1.5% of private employment in the Marietta unit subregion.

More information on the application as well as free downloads are available at http://headwaterseconomics.org/tools/eps-hdt.

IV. Transportation Infrastructure

The 2012 planning rule requires assessments to address forest infrastructure, including "recreational facilities and transportation and utility corridors."[48] As the Forest Service directives governing the assessment recognize, "[i]nfrastructure within the plan area can have a substantial impact on social, cultural, economic, and ecological conditions both within the plan area and in the broader landscape."[49] Given the extensive and decaying nature of the Forest Service road system and its significant aggregate impacts on landscape connectivity, ecological integrity, water quality, species viability and diversity, and other forest resources and ecosystem services, a robust assessment of transportation infrastructure is necessary to ensure the forest plan revision complies with the relevant substantive provisions of the 2012 planning rule[50] and other regulatory requirements.[51]

While the Wayne National Forest has a total of 322 miles of system roads, it has an extensive system of OHV and non-motorized trails. In addition, there are roads under other jurisdiction that

---

[48] 36 C.F.R. § 219.6(b)(11).

[49] FSH 1909.12, ch. 10, § 13.13.

[50] 36 C.F.R. § 219.8(a)(1)-(3) ("Forest plans must include standards and guidelines that maintain or restore healthy aquatic and terrestrial ecosystems, watersheds, and riparian areas, and air, water, and soil quality, taking into account climate change and other stressors. Plans also must implement national best management practices (BMPs) for water quality; ensure social and economic sustainability, including sustainable recreation and access and opportunities to connect people with nature; and provide for "[a]ppropriate placement and sustainable management of infrastructure." 36 C.F.R. §§ 219.8(a)(4), 219.8(b), 219.10(a)(3) ("Plans must implement national best management practices (BMPs) for water quality; ensure social and economic sustainability, including sustainable recreation and access and opportunities to connect people with nature; and provide for "[a]ppropriate placement and sustainable management of infrastructure.")

[51] 36 C.F.R. part 212 (requires each forest to conduct "a science-based roads analysis," generally referred to as a "travel analysis process" or "TAP." Based on that analysis, forests must "identify the minimum road system needed for safe and efficient travel and for administration, utilization, and protection of National Forest System lands." Forests must then "identify the roads . . . that are no longer needed to meet forest resource management objectives and that, therefore, should be decommissioned or considered for other uses, such as for trails."

cross US Forest Service lands as well as unauthorized routes. The spatial footprint, condition, and use of travelways has considerable effect on ecological integrity (e.g., erosion, compaction, sedimentation and impairment of water quality; fragmentation of wildlife habitat; and interference with feeding, breeding, and nesting, and spread of invasive species) and in delivering socio-economic benefits, and thus directly implicate these substantive requirements.

To provide the information necessary to satisfy the legal obligations described above, we recommend that the assessment identify and strive to answer the following questions. For each, we have provided general background information and rationale. The list of recommended questions is non-exclusive and is intended to focus the assessment on the relevant substantive and procedural requirements of the 2012 rule, the corresponding directives contained in Forest Service Handbook (FSH) 1909.12, and other federal laws and policies.

For each question, the agency should identify the best available scientific studies and reports that document the relevant condition, costs, benefits, and needs of the transportation system.[52] Principal sources of information may include the forest's Travel Analysis Process Report and appendices (finalized 9/30/2015) and Travel Management Plans, including the environmental impact statement, record of decision, and associated specialist reports addressing resources such as aquatics, recreation, wilderness, invasive species, roads, watershed, soils, wildlife, and socio-economics. Also, when possible, the assessment report should include maps that depict spatial relationships.

A. What transportation infrastructure exists on the forest?

Understanding the baseline system of transportation infrastructure is a necessary first step in a robust assessment of forest infrastructure – and eventual compliance with the Forest Service's legal obligation to provide for a well-maintained system of needed roads that is fiscally and environmentally sustainable and provides for safe and consistent access for the utilization and protection of the forest. Accordingly, the forest assessment should first describe existing infrastructure, including the number, condition, status (e.g., open or closed; permitee or administrative use only), maintenance level, purpose (e.g., leads to recreational destination, commercial use) and density of roads and trails.[53] The assessment should address *all* motorized routes. This includes Maintenance Level (ML) 1-5 system roads, motorized trails, non-system roads and temporary roads. Lastly, the assessment should describe how many roads are likely not needed and likely needed per the Wayne Travel Analysis Process Report (TAP).

According to the forest's 2015 TAP, the Wayne's road system consists of 322 miles, 57 of which are open to public use.[54] The forest also contains temporary roads, unauthorized roads, and roads under other jurisdictions (state, county, private). The TAP does not specify the mileages of the roads in any of these categories. The Forest also contains 148 miles of OHV trails, 107 miles of non-motorized trails, and 87 miles of equestrian trails. 67 miles of OHV trails are co-designated with system roads. OHV routes are not analyzed in the TAP. The forest contains "helicopter

---

[52] *See* 36 C.F.R. § 219.3.

[53] *See* FSH 1909.12, ch. 10, § 13.6(1) (Assessment "should identify and evaluate available information such as [t]he location and condition of infrastructure within the plan area . . . includ[ing] the forest road system [and] recreational infrastructure . . . . This information is for basic understanding of the role of infrastructure in the plan area . . . .").

[54] Wayne National Forest, *Final Travel Analysis Report*, at 11 (September 30, 2015 ("Wayne TAP").

roads" which are roads with no connectivity.[55] Finally, it appears as if the Forest Service staff (and others, conceivably) are using unclassified roads for administrative purposes.[56]

B. What is the physical condition of the existing transportation infrastructure?

After identifying existing transportation infrastructure, the forest assessment should evaluate the physical condition of that infrastructure.[57] The physical condition of forest roads has important implications for the fiscal and ecological sustainability of the system. Inadequately maintained roads are more likely to fail, causing corresponding damage to aquatic and other ecological systems, endangering public safety, and requiring additional funds to remediate damage and hazardous conditions. Particularly given the general state of disrepair of much of the National Forest road system and anticipated climate change stressors, understanding the baseline physical condition of the system is necessary to ensure the plan revision ultimately provides for an ecologically and fiscally sustainable transportation system.[58] Accordingly, the assessment should identify, for example, the percentage of the system that is: (1) maintained to standard annually; (2) in urgent need of work; (3) operating below objective maintenance level; and (4) with adequately performing BMPs in place. The assessment should also identify the physical condition of the motorized and non-motorized trail systems.

The TAP states that[59]:

- 94 roads (62 miles) have different operational and objective levels.
- 18 roads (16 miles) are on unstable soil types between 0.01% to less than 10% of their length; 32 roads, totaling 29 miles, cross unstable soils between 10% and 29% of their length; and 86 roads, totaling 53 miles, cross unstable soils for at least 30% of their length.
- Three roads, totaling 0.72 miles, cross these soils for greater than or equal to 50% of their length. 39 roads, totaling 38 miles, cross these soils for at least some portion but less than 50% of their length
- 405 roads, totaling 285 miles, have at least 50% of their length on soils with an erosion hazard potential of severe to very severe. 50 roads, totaling 29 miles, have at least 50% of their length on soils with an erosion hazard potential of moderate to very severe. 20 roads, totaling 4.8 miles, have greater than 50% of their length on soils with a slight erosion hazard potential.

The TAP also states that many of the roads that access the forest are county jurisdiction and are not actively maintained. These roads are often impassable and create area of resource and access concern.[60]

---

[55] *Id.* at 6.
[56] *Id.*
[57] *See* FSH 1909.12, ch. 10, § 13.6(1) (assessment "should identify and evaluate available information such as [t]he location *and condition* of infrastructure . . . includ[ing] the forest road system" (emphasis added)).
[58] *See* 36 C.F.R. § 219.1(g) (plan components generally must be "within . . . the fiscal capability of the unit"); *id.* § 219.8 (plans must provide for ecological, social, and economic sustainability); 36 C.F.R. § 212.5(b)(1) (minimum road system must "reflect long-term funding expectations" and "minimize[] adverse environmental impacts"); FSH 1909.12, ch. 20, § 23.23l (plan components for roads and trails infrastructure "must be within the fiscal capability of the planning unit").
[59] Wayne TAP, *supra,* at 19-20.

C. What is the annual maintenance revenue and cost, and what are the current and predicted maintenance needs and backlog over the life of the plan?

As described above, the Forest Service must provide for the fiscal sustainability of its transportation network. With the significant maintenance needs associated with the Forest Service's vast and deteriorating road system, understanding the maintenance and management budget for the system is a prerequisite to ensuring fiscal sustainability. Accordingly, Forest Service directives require that the assessment include "[i]nformation about the sustainability of the infrastructure, including planning unit's fiscal capability to maintain existing infrastructure and the current backlog of infrastructure maintenance."[61] More specifically, the assessment should identify annual maintenance revenue and cost, as well as the current and predicted maintenance backlog over the life of the plan.

Nationally, the 370,581-mile National Forest road system suffers an extraordinary maintenance backlog of over $3.2 billion.[62] From the small fiscal discussion in the TAP, it appears that the story on the Wayne is similar. The TAP states that between 2009 and 2015, the Wayne has experienced a 50% decrease in its road construction & maintenance budget. The decrease has been further exacerbated by the annual increase in fixed costs.[63] In 2015, the road maintenance & construction budget was $198,000 while direct costs are estimated at about $275,000 per year. This means that there is an annual budget gap of at least $79,000 or 60%. The TAP does not disclose the current road maintenance backlog or anticipated changes to the backlog in the future.

The Forest Service also suffers from a serious trail maintenance deficit and backlog. In 2012, the Government Accountability Office published a report in which it estimated the value of the Forest Service's national trail maintenance backlog to be $314 million, excluding an additional $210 million deficit for annual maintenance, capital improvements, and operations (Government Accountability Office 2013). The report estimated that nationally only about 25% of trails meet agency standards and cautioned that "[t]rails not maintained to the Forest Service's standards have a range of negative effects, including inhibiting trail use and posing potential safety hazards, harming natural resources, and adding to agency costs." We have been unable to locate information on the trail maintenance backlog for the Wayne National Forest, and the assessment should include that information.

D. How climate resilient is the transportation system?

Climate change generally intensifies the adverse impacts associated with roads. In particular, the warming climate is expected to lead to more extreme weather events, resulting in increased flood severity, more frequent landslides, altered hydrographs, and changes in erosion and sedimentation rates and delivery processes.[64] For instance, see the opinion piece in the Boulder Transcript by University of Colorado Professor Dr. Paul S. Chinowsky entitled *Resiliency Starts*

[60] *Id.* at 12-13.
[61] FSH 1909.12, ch. 10, § 13.6(4).
[62] USDA, Forest Service, National Forest System Statistics FY 2016.
[63] Wayne TAP, *supra*, at 13.
[64] Appx. 4, Lit. Review at 9-14.

with Infrastructure[65] where he predicts roads, in particular, will be damaged: "Although much of our infrastructure will be affected by these changes, two sectors are of particular concern and as such need to be a priority for resiliency actions — roads and public buildings."

Many national forest roads were not designed to current engineering standards (or, in some cases, any engineering standards), making them particularly vulnerable to climate-induced hydrologic shifts. That vulnerability is further exacerbated by the deteriorating physical condition of the system and significant maintenance backlog, as described above. Further, even those roads designed to current engineering standards and hydrologic conditions may fail under future weather scenarios, further intensifying adverse ecological impacts, public safety concerns, and maintenance needs (USDA Forest Service 2010b). Specific to Ohio forests, Butler et al. (2015) explains that infrastructure will be more vulnerable as a result of increased precipitation in the winter and spring and higher severity storms: "Specifications for water infrastructure are based on past climate patterns, and the current trend of intensifying precipitation has placed additional strain on outdated infrastructure."[66]

Given these stressors, the forest assessment should address the extent to which the existing transportation system is designed to accommodate projected hydrologic changes resulting from climate change. To the extent the system is not designed to accommodate projected climate changes, the assessment should describe implications of the status quo to sustainable access and ecological integrity of aquatic and terrestrial systems, and describe what changes are required to adapt the system.

Note that the 2015 TAP does not address the extent to which the existing transportation system is designed to accommodate climate stressors or take climate change into account.

E. What is the minimum road system pursuant to 36 C.F.R. part 212, subpart A, and what is the deviation between the minimum road system and the current road system?

Each national forest is required to identify "the minimum road system needed for safe and efficient travel and for administration, utilization, and protection of National Forest System lands" along with unneeded roads for decommissioning or conversion.[67] With forest plans determining the framework for integrated resource management, the plan revision is the appropriate place to ensure that the forest has an identified minimum road system to carry out the revised plan's goals and objectives, and to provide direction for achieving that system. Accordingly, the assessment should identify the minimum road system pursuant to subpart A, the deviation between that system and the current road system, and the unneeded roads for decommissioning or conversion. If this information is not available, the assessment report should acknowledge the gap and the need to fully comply with subpart A under the revised plan. It should also identify relevant recommendations from the TAR, including the number, types, and locations of roads likely needed and not needed for future use.

[65] Boulder Transcript, 5/2/2015. *Available at* http://www.dailycamera.com/editorial-roundtables/ci_28037562/paul-s-chinowsky-resiliency-starts-infrastructure-climate-change.

[66] Butler et al., 2015 at 3 and 176.

[67] 36 C.F.R. § 212.5(b)(1) and (2).

The Wayne National Forest, as far as we know, has yet to identify a minimum road system and fully comply with subpart A. While the Wayne TAP was an important first step in this process, it should be revisited in light of a few deficiencies. Most glaring of which is that the TAP identified 74 roads with high risk and 234 roads with medium risk yet did not identify any roads as likely unneeded in the future or candidates for decommissioning, and did not include decommissioning in its list of future actions (TAP at 23). In fact, the TAP identified 33 road with high or medium risk and low benefit and still did not categorize these as likely unneeded or candidates for decommissioning. The assessment report, therefore, should certainly reflect the risk/benefit analysis, issue identification (TAP at 6 and 15) and recommended actions (TAP at 23) but should also make clear that the Wayne still must identify the minimum road system and identify roads for decommissioning.

F. Does the current transportation system provide sustainable access and opportunities to connect people with nature?

Well-sited and maintained transportation infrastructure can provide important services to society, including access for the utilization, enjoyment, and protection of forest resources. To that end, the 2012 planning rule requires forest plans to provide for social and economic sustainability, including sustainable recreation and access, and integrated resource management for multiple use considering "[a]ppropriate placement and sustainable management of infrastructure, such as recreational facilities and transportation and utility corridors," and "[o]pportunities to connect people with nature."[68]

To comply with those mandates, the forest assessment should evaluate whether and how the current transportation system provides sustainable access.[69] Measures of sustainable access include the extent to which system routes: (1) are adequately managed and maintained; (2) are sited – and designated for specific uses and time of year – so that they do not interfere with important conservation resources or cause unnecessary conflict with other uses; (3) fulfill the access needs identified in the revised plan, and (4) connect people to nature.

The Wayne 2015 TAP states that 50 roads (totaling 36 miles) are in the primitive or semi-primitive non-motorized ROS areas.[70] It does not provide other information relevant to this question.

G. What effects does the transportation system have on the ecological integrity of aquatic and terrestrial systems?

The 2012 planning rule requires that plans provide for the ecological integrity of aquatic and terrestrial ecosystems and watersheds, including maintaining or restoring their structure, function, composition, and connectivity, while taking into account factors such as climate change and other stressors, the broader landscape beyond the plan area, and opportunities for landscape-

---

[68] 36 C.F.R. §§ 219.8(b), 219.10(a)(3) & (a)(10).
[69] *See* FSH 1909.12, ch. 10, §§ 13.4(1)(d)-(e), 13.6(7) (assessment "should identify and evaluate . . . [t]he infrastructure's contribution to social and economic sustainability," including "[t]he nature, extent, and condition of trails, roads, facilities, and other transportation . . . infrastructure to provide recreational access" and "[t]he opportunities within the plan area to foster greater connection between people and nature through education, experience, recreation, and stewardship").
[70] Wayne TAP, *supra*, at 20.

scale restoration.[71] To provide the information necessary to satisfy this substantive mandate, the forest assessment should evaluate impacts of the transportation system on the ecological integrity of the forest's aquatic and terrestrial systems.[72] The following questions are designed to assist the forest in that endeavor:

1. <u>What are the motorized route densities across the forest, and where do they exceed accepted scientific thresholds for aquatic and terrestrial integrity?</u>

The best available science shows that road density is one of the most important metrics of the ecological effects of roads on important watersheds, migratory corridors and other critical wildlife habitat, and other forest resources. Indeed, there is a direct correlation between road density and various markers for species abundance and viability, and adopting road density thresholds is one of the most effective strategies for achieving an ecologically sustainable road system.[73] Accordingly, Forest Service directives identify road density as one of the "[k]ey ecosystem characteristics [that] provide a mechanism for assessing status of ecosystem conditions regarding ecological integrity."[74] Because the ecological impacts associated with roads and motorized travel are not limited to open system roads, density thresholds should apply to all motorized forest routes, including closed, non-system, and temporary roads, and motorized trails.[75] Thus, the forest assessment should describe motorized route densities across the forest and identify where they exceed accepted scientific thresholds for aquatic and terrestrial integrity.[76]

2. <u>What are the impacts of transportation infrastructure on watershed conditions across the forest, as identified by the "Roads and Trails" indicator of the Forest Service's Watershed Condition Framework and other information sources?</u>

The Forest Service's Watershed Condition Framework characterizes the health and condition of national forest watersheds as Class 1: Properly Functioning, Class 2: Functioning at Risk, or Class 3: Impaired, based on a set of twelve condition indicators (USDA Forest Service 2011a). Indicator #6 is the condition of forest roads and trails and provides an important measure of the effects of the transportation system on the ecological integrity of aquatic systems. The indicator is based on four roads- and trails-related attributes: open road density; road maintenance; proximity to water; and mass wasting. Figure 2 shows that all the watersheds on the Wayne were ranked poor (the lowest rating) as a result of roads and trails.[77] The assessment should include this information and rationale for the ratings, as well as any other information relevant to watershed conditions associated with transportation infrastructure.

---

[71] 36 C.F.R. § 219.8(a)(1).

[72] *See* FSH 1909.12, ch. 10, § 13.6(6) (assessment "should identify and evaluate available information such as . . . [t]he impacts of infrastructure on ecological integrity and species diversity").

[73] Appx. 4, Lit. Review at 7-9 & Att. 2 (summarizing best available science on road density thresholds for fish and wildlife); *see also* USDA Forest Service (2011).

[74] FSH 1909.12, ch. 10, § 12.13, Exhibit 01.

[75] Appx. 4, Lit. Review Att. 2.

[76] Appx. 4, Lit. Review at 7-9 & Att. 2 (summarizing best available science on road density thresholds for fish and wildlife); *see also* USDA Forest Service (2011).

[77] The relevant data can be found at https://www.fs.fed.us/naturalresources/watershed/condition_framework.shtml.

3. How many miles of roads are connected by direct surface flow to streams, and how many road/stream crossings exist?

As described above, the planning rule establishes a Forest Service obligation to provide for the ecological integrity of aquatic systems. In addition to route density (discussed above), scientifically credible, landscape-scale measures of risk to aquatic integrity include miles of road connected by direct surface flow to streams and the number of road/stream crossings by sub-watershed.[78] Accordingly, the assessment should report on these two metrics. The data related to system roads should be retrieved relatively easily through a GIS query. If necessary, road miles within 300 feet of streams and riparian areas can serve as a proxy for miles of road connected by direct surface flow to streams.[79]

The Wayne TAP states that 119 roads are located within 100' of a waterbody.[80] It is silent on the number of road/stream crossings. The TAP however does list the miles of roads that cross poorly drained soils. potential landslide paths or unstable soil types, and soils with severe erosion potential.[81]

The forest plan assessment should provide all relevant existing data and scientifically-grounded related conclusions about aquatic health. To the degree that the Forest Service has information on non-system roads and OHV trails, the assessment report should attempt to describe the impacts to aquatic resources from these routes as well. Non-system roads include temporary roads (which the Forest Service should be tracking), unauthorized roads, and legal roads under other jurisdictions.

4. What percent of the current transportation infrastructure system is meeting required BMPs for water quality, and what is the effectiveness of the BMPs?

In addition to providing for the ecological integrity and protection of aquatic systems and water resources, the 2012 planning rule requires that plans implement national best management practices for water quality.[82] The Forest Service identified national "core" BMPs in a 2012 technical guide that also establishes expectations for monitoring and reporting into a national database (USDA Forest Service 2012). The national BMPs for road management activities are designed "to avoid, minimize, or mitigate adverse effects to soil, water quality, and instream riparian resources" and include general, non-prescriptive practices for eleven categories of road management activities (USDA Forest Service 2012). For example, unnecessary roads should be converted to trails or decommissioned entirely using hydrologically stable practices. Roads impacting water quality should be prioritized for maintenance. Stream crossings should be limited in number to the fewest necessary. And temporary roads should be decommissioned upon completion of their project use. Forests are to develop and implement site-specific prescriptions to achieve compliance with the national core BMPs, as well as any applicable regional, state, or local BMPs.

[78] *See* USDA Forest Service (2012a); Gucinski *et al.* (2000); Appx. 4, Lit. Review at 4.
[79] The Watershed Condition Framework uses this approach. *See* USDA Forest Service (2011).
[80] Wayne TAP, *supra*, at 19.
[81] *Id.*
[82] 36 C.F.R. § 219.8(a)(4).

The forest assessment should identify existing water-quality BMPs applicable to road management activities and the percent of the current transportation system that is meeting those BMPs, and report on the effectiveness of the existing BMPs.[83] This information will help identify the impacts of the forest transportation system on water quality and ecological health, and provide important baseline information for establishing plan components that customize and implement the national BMPs as they relate to the forest's transportation infrastructure.

5. <u>Are there Clean Water Act section 303(d) impaired streams or stream segments on the forest where the cause of impairment is sediment and/or temperature attributable at least in part to roads?</u>

Forest roads have significant impacts on water quality, particularly sediment loads and water temperatures. Roads, especially in close proximity to water, are the dominant vector for sediment delivery to stream channels and wetland/fen resources.[84] Under section 303(d) of the Clean Water Act, states are required to identify "impaired waters" that are failing to meet applicable water quality standards and designated uses, and develop maximum amounts of pollutants ("total maximum daily loads") that those impaired waters can receive and still meet water quality standards.[85] Sediment is one of the primary causes of impairment for 303(d) listed waters.[86] Given the importance of water quality as a measure of ecosystem health and integrity, forest assessments should identify any 303(d) impaired streams or stream segments whose cause of impairment is sedimentation and/or temperature attributable at least in part to forest roads. This information is necessary to ensure that the plan revision ultimately "maintain[s] or restore[s] . . . water quality" and complies with the Clean Water Act.[87]

The Wayne TAP states that 37 roads are within 100 feet of a designated impaired stream segment.[88] The assessment report should include all available information on the impaired segments including needed restorative activities and identify knowledge gaps and approaches to address them.

6. <u>How significantly is the transportation system contributing to the spread of invasive species?</u>

As part of its overarching ecosystem integrity goal, the 2012 planning rule specifically requires the responsible official to consider invasive species.[89] The introduction and spread of invasive species, however, poses a primary threat to the persistence of native species and the overall integrity of aquatic and terrestrial ecosystems. Indeed, in 2004, then Chief Dale Bosworth

[83] As part of a two-year monitoring phase-in period for the national BMP program, some forests have recently reported on BMP implementation and effectiveness. *See, e.g.*, Mount Hood National Forest, *Water Quality Best Management Practices (BMP) Monitoring Report Fiscal Year 2013* (Aug. 2014), *available at* http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3813091.pdf.
[84] Appx. 4, Lit. Review at 2-4 (citing Forest Service science concluding that roads contribute more sediment to streams than any other land management activity (Gucinski *et al.* 2000)).
[85] 33 U.S.C. § 1313(d).
[86] U.S. Environmental Protection Agency, *National Summary of Impaired Waters and TMDL Information*, http://iaspub.epa.gov/tmdl_waters10/attains_nation_cy.control?p_report_type=T#causes_303d (last visited Aug. 11, 2015).
[87] 36 C.F.R. § 219.8(a)(2)(iii).
[88] Wayne TAP, *supra*, at 19.
[89] 36 C.F.R. § 219.8(a)(1)(iv), 219.10(a)(8).

identified invasive species as one of the four primary threats facing our national forests.[90] By facilitating increased human intrusion into sensitive areas and species dispersal, motorized routes are the primary mechanism for spreading invasive species – which the Forest Service estimates infest an additional 4,600 acres in the western United States each day.[91] Accordingly, the forest assessment should describe how, where, and to what degree the transportation system (system and non-system) is contributing to the spread of invasive species. Notably, riparian zones are known to be more vulnerable to infestation by invasive plants than adjacent upland sites.[92]

In 2011, the Forest Service finalized Forest Service Manual (FSM) 2900 for invasive species management. The manual articulates a coordinated and proactive management approach that includes, among other things, determining vectors and pathways that favor the establishment and spread of invasive species and designing management practices to minimize that risk. The agency's 2013 National Strategic Framework for Invasive Species Management likewise describes various strategies for prevention, including identifying high-risk pathways of movement and introduction.[93]

The assessment should include any existing information documenting the impact of the forest transportation system on the spread of invasive species. This includes state and county surveys. The Wayne TAP provides the following relevant information[94]:

- 265 roads (211 miles) are within 100 feet of inventoried invasive plant population;
- 58 roads (632 miles) are within 100 feet of an inventoried invasive species infestation and within one mile of an ecologically significant area (e.g., wilderness, RNA, known TES and rare plant communities);
- One road (.34 miles) accesses a known infested waterbody; and
- Roads contribute to the spread of invasive species.

7. <u>How much is the current transportation system impairing species migration and ecological integrity at a landscape scale, and could modification of the system contribute to landscape-scale restoration?</u>

As a warming climate alters species distribution and forces shifts in wildlife migration, landscape connectivity is increasingly critical to species survival and the ability of ecosystems to adapt.[95] Yet one of the most significant impacts of the transportation system within the forest is to fragment wildlife habitat (terrestrial and aquatic), thereby altering species distribution,

---

[90] USDA Forest Service, *Four Threats*, http://www.fs.fed.us/projects/four-threats/ (last visited Aug. 11, 2015). In announcing the Four Threats, Chief Bosworth stated, "Public lands—especially federal lands—have become the last refuge for endangered species—the last place where they can find the habitat they need to survive. If invasives take over, these imperiled animals and plants will have nowhere else to go." *See also* USDA Forest Service (2004) (describing strategies for controlling and managing the spread of invasive species).
[91] Forest Service video "Dangerous Travelers," mins. 2:07 & 3:57, http://www.fs.fed.us/invasivespecies/prevention/dangeroustravelers.shtml (last visited Sept. 2, 2015); *see also* Appx. 4, Lit. Review at 7, 10, 12.
[92] Stohlgren, T. J. & Chong, G. W. (2002). *Assessing vulnerability to invasion by nonnative plant species at multiple spatial scales*. Environmental Management 29(4): 566-577.
[93] *Available at* https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd488910.pdf
[9494] Wayne TAP, *supra*, at 18 and 15.
[95] Appx. 4, Lit. Review at 9-14; *see also* Section III(A)(2) above (agency climate change strategies addressing connectivity).

interfering with life functions such as feeding, breeding, and nesting, and resulting in loss of biodiversity.[96]

Recognizing these threats, the 2012 planning rule requires that plan components "maintain or restore the structure, function, composition, and connectivity" of terrestrial, riparian, and aquatic ecosystems, taking into account climate change stressors and "opportunities for landscape scale restoration," and "provide for the diversity of plant and animal communities."[97] To provide the information necessary to address those substantive mandates during the plan revision process, the forest assessment should provide information on where and how the transportation system impedes fish or wildlife migration (e.g., where infrastructure such as culverts is impeding fish movement), and where and how it impairs terrestrial, riparian, or aquatic ecosystem integrity. Conversely, the assessment should also describe how modifications to the transportation system might provide opportunities for landscape-scale restoration. For instance, by removing unneeded routes in strategic locations (e.g., between contiguous roadless tracts, at-risk species habitat, priority watersheds); adequately storm-proofing needed routes (e.g., relocating roads away from water bodies, and resizing or removing culverts); and constructing wildlife friendly structures (crossings with appropriate management on either side of the crossing)[98] the Forest Service can reduce landscape-scale fragmentation, better enable landscape-scale processes such as floods, protect and restore aquatic and terrestrial habitats and habitat connections, and increase resilience.[99]

Specific to the Wayne, the TAP offers only a little information that is relevant, stating that two roads have 'indeterminate barriers' and ten roads have barriers to aquatic passage along rivers and streams and between lakes and reservoirs.[100] Available relevant information addressing landscape-scale ecological impacts and opportunities for restoration should be included in the assessment. Butler et al. (2015) explain that forests in the Central Appalachians have been fragmented from industrial and urban development resulting in "dispersal barriers that impede migration of species and exchange of genetic material, reduced forest patch size, and increased forest edge."[101] Additional information may be available from the Ohio Department of Transportation and the Ohio Department of Natural Resources.

V. Recreation

The 2012 planning rule requires the plan "to provide for . . . [s]ustainable recreation,"[102] considering appropriate placement of infrastructure, such as recreational facilities, and opportunities to coordinate with neighboring landowners to link open spaces and to connect

---

[96] Appx. 4, Lit. Review at 4-7.
[97] 36 C.F.R. §§ 219.8(a)(1), 219.9.
[98] *See, for example*, Lininger, Marci. 2015. Available at http://www.dot.state.oh.us/engineering/OTEC/2015_OTEC_Presentations/Wednesday_Oct.28/56/OTECWildlife%20Crossings.pdf.
[99] Appx. 4, Lit. Review at 10-12.
[100] Wayne TAP, *supra*, at 19.
[101] Butler et al., (2015) at 34.
[102] 36 C.F.R. § 219.10(b)(1)(i). The rule defines sustainable recreation as "the set of recreation settings and opportunities on the National Forest System that is ecologically, economically, and socially sustainable for present and future generations." 36 C.F.R. § 219.19.

people with nature.[103] In the assessment phase, the rule requires forest assessments to address "[r]ecreation settings, opportunities, and access, and scenic character," as well as forest infrastructure, including "recreational facilities and transportation . . . corridors."[104]As the planning directives recognize, this requires the Forest Service to identify and evaluate information about existing conditions (e.g., settings, opportunities, access, demands), trends, and sustainability in both the plan area and the broader landscape.[105] The directives provide a very useful list of issues to assess related to settings, opportunities, ecological impacts, connections to nature, etc.[106] This information will be essential to inform the need for change and the development of plan components to meet the rule's substantive requirements.

In addition to the issues listed in the handbook, we recommend that the Forest Service also make sure to explicitly discuss the Wayne's recreational niche within the National Forest System and the broader landscape[107], current recreational settings and their sustainability (e.g., have they changed since the current plan was finalized), current management of recreational special use permits for events and outfitting/guiding, and existing recreation-related plans, analyses, or studies for the Wayne National Forest and/or the broader landscape.

Because of the significant potential impact of motorized recreation on ecological integrity, biodiversity, and recreational conflicts and sustainability, it is important that the Forest Service conduct a robust assessment of where, how, when and to what extent motorized recreation occurs on the forest. In particular, the assessment report should describe the degree to which the Wayne National Forest's motorized trails are located to:

(1) minimize damage to soil, watershed, vegetation, or other resources of the public lands;
(2) minimize harassment of wildlife or significant disruption of wildlife habitats; and
(3) minimize conflicts between off-road vehicle use and other existing or proposed recreational uses of the same or neighboring public lands.[108]

It should also describe any information brought to light by previous monitoring.[109] We note that the Wayne TAP at 14 states that illegal motorized activity is a concern.

Lastly, in addressing the issue of connecting people with nature, the Forest Service should identify and evaluate how people (both those from the area and those traveling from further away) connect to nature and how and to what degree forest infrastructure and current recreation

---

[103] 36 C.F.R. § 219.10(a)(3), (4) & (10).
[104] 36 C.F.R. § 219.6(b)(9) & (11).
[105] FSH 1909.12, ch. 10, § 13.4.
[106] FSH 1909.12, ch. 10 § 13.4(1) & (2). Given the comprehensive nature of the directives on assessing recreation, we have not proposed questions related to this topic.
[107] *See* 36 C.F.R. § 219.2(b)(1) (plans must "reflect[] the unit's expected distinctive roles and contributions to the local area, region, and Nation"); *id.* § 219.7(f)(1)(ii) ("Every plan must . . . [d]escribe the plan area's distinctive roles and contributions within the broader landscape . . . .").
[108] Exec. Order No. 11644, § 3(a), 37 Fed. Reg. 2877 (Feb. 8, 1972), *as amended by* Exec. Order No. 11989, 42 Fed. Reg. 26,959 (May 24, 1977). *Also see:* Travel Management Rule, 36 C.F.R. part 212 subpart B.
[109] Exec. Order No. 11644, § 8(a) (requires periodic monitoring of motorized designations).

management facilitate or impede people connecting with nature.[110] This should include consideration of:

- Cross-jurisdictional provision and management of recreation settings, opportunities, and access;
- Use of gateway portals (e.g., visitor kiosks, centers, or services as gateways to the forest);
- Need and capacity analysis for outfitting and guiding;
- Areas with unique and outstanding characteristics that merit special designation to enable visitation, interpretation, and protection;
- Coordination with public schools and educational providers;
- Stewardship activities and opportunities;
- The gap between the demographics of Wayne National Forest visitors and the surrounding region[111];
- Barriers to minority participation in recreation[112]; and
- The use of multi-cultural outreach tools.

It should also incorporate the principles and priorities articulated in the agency's 2010 Framework for Sustainable Recreation, including investing in special places, restoring and adapting recreation settings, enhancing and collaborating with communities, and developing a sustainable financial foundation (USDA Forest Service 2010a).

VI. Old Growth, Carbon, and Mycorrhizal Networks

The 2006 Plan and EIS do not consider climate change or carbon storage and sequestration. The planning rule requires consideration of these topics. See 36 CFR 219.6(b)(1) through (4). We therefore ask that the Forest Service incorporate the following information, which we consider best available scientific information (BASI), in the Wayne's Assessment Report. If the agency does not regard portions of the following information as BASI or has conflicting scientific information, the agency must disclose and explain its reasoning. See 36 CFR 219.3 ("Such documentation must: Identify what information was determined to be the best available scientific information, explain the basis for that determination, and explain how the information was applied to the issues considered."). Please refer to Appendix 5 for an annotated bibliography of the citations provided below.

A. Above-Ground Carbon

Carbon sequestration and storage potential is highest when old growth forests are allowed to recover. This is because old growth forests in the eastern United States[113] are superior to all other

[110] FSH 1909.12, ch. 10, § 13.4(1)(e) (assessment should "identify and evaluate additional available information about . . . [t]he opportunities within the plan area to foster greater connection between people and nature through education, experience, recreation, and stewardship").
[111] For example, see "equitability index" concept put forth by Flores et al, 2018.
[112] *See* Appendix 3.
[113] Old growth forest habitat dominated the vast majority of the eastern United States prior to European settlement. Staeyert and Knox estimate that 70% of the original eastern old growth remained in 1850, only 7% in 1920, and an insufficient amount to include as a land-use category in 1992. Staeyert, L.T. and R.G. Knox, "Reconstructed

forest age classes for both carbon sequestration and carbon storage (see McGarvey et al. 2015; Liebman et al. 2017; Stephenson et al. 2014; Burrascano et al. 2013; Lichstein et al. 2009). Old growth forests of the eastern United States sequester and store significantly more carbon than both young and mature forests (McGarvey et al. 2015; Burrascano et al. 2013) because they generally host significantly more large living trees, above ground biomass, and dead wood (McGarvey et al. 2015; Burrascano et al. 2013), because they have been shown to have lower soil respiration rates than younger forests (Liebman et al. 2015), and because the rate of tree carbon accumulation increases continuously as trees grow in size (Stephenson et al. 2014). The transition of young and mature secondary forests in the eastern United States to old growth status is an especially promising opportunity to increase carbon sequestration and storage (Lichstein et al. 2009).

The assessment report should discuss anticipated carbon sequestration and storage in old growth forests (or those evolving toward old growth status) and compare it to anticipated carbon sequestration and storage in forests undergoing intensive timber harvesting as anticipated on the Wayne in the next several years.[114] Note that an analysis of U.S. public timberlands found that a "no timber harvest" scenario eliminating harvests on public lands would result in an annual increase of 17-29 million metric tonnes of carbon (MMTC) per year between 2010 and 2050—as much as a 43% increase over current sequestration levels on public timberlands and would offset up to 1.5% of total U.S. GHG emissions (Depro et al. 2008). In contrast, moving to a more intense harvesting policy similar to that which prevailed in the 1980s may result in annual carbon losses of 27-35 MMTC per year between 2010 and 2050. These losses would represent a significant decline (50-80%) in anticipated carbon sequestration associated with the existing timber harvest policies (Depro et al. 2008).

B. Soil Carbon; Old Forest Mycorrhizal Resiliency

It should be noted that the estimates of Depro et al. 2018 are likely overly conservative because the study did not take soil carbon fluxes into consideration. This is significant because soil carbon represents roughly 60% of forest carbon storage in temperate forests (James and Harrison 2016). And, harvesting substantially disrupts soil carbon storage, which results in significant carbon emissions. In particular, a recent meta-analysis of existing literature demonstrates that harvesting results in significant carbon losses in the organic horizons of forest Alfisols (-12%) and Ultisols (-66%), as well as in the mineral soils of Ultisols (-11.9%) (James and Harrison 2016).[115] And, these soil carbon findings are themselves likely overly conservative: they do not account for carbon losses in soils deeper than approximately 14 inches, which is a recognized

historical land cover and biophysical parameters for studies of land-atmosphere interactions within the eastern United States," *Journal of Geophysical Research* 113, at p. 6 (2008).

[114] The WNF's current (FY 2018) timber target level is more than 422% the size of historical target levels (1997-2017) (See PSTAR [Periodic Timber Sale Accomplishment Reports] data for WNF, FYs 1997 – 2018, available at: https://www.fs.fed.us/forestmanagement/products/ptsar/index.shtml). Also, the Executive Order issued by President Trump on December 21, 2018 entitled "Promoting Active Management of America's Forests, Rangelands, and other Federal Lands to Improve Conditions and Reduce Wildfire Risk" (E.O.) directs the Forest Service to sell 3.8 billion board feet (BBF) of timber in 2019, which is 19 percent more than the 3.2 BBF it sold in 2018 and 31 percent more than the 2.9 BBF sold in 2017.

[115] The major soil types in the Wayne's region appear to be Alfisols (Udalfs) and Ultisols (Udults). See USDA, NRCS "Distribution Maps of Dominant Soil Orders," available at: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/maps/?cid=nrcs142p2_053589

major gap in the scientific literature (James and Harrison 2016). The recovery period of soil C following harvest depends upon soil type and takes at least 60 years in many production forests (James and Harrison 2016).

The FS should consider the value of old forests in relation to their intact soils with highly developed and well-established mycorrhizal structure. These intact and structured soils are important for carbon storage and sequestration purposes, and for forest health and resiliency in the face of climate change. The 2006 Forest Plan did not account for mycorrhizal relationships, and the 2006 EIS contained only passing reference to the subject (2006 FEIS, Appendix D-8 to D-9). Subsequent emerging science has demonstrated the foundational role of mycorrhizal networks – dubbed the "Wood Wide Web" – in forest ecology.[116]

Mycorrhizal networks (MNs) influence the survival, growth, physiology, competitive ability, and behavior of the plants and fungi linked in the network (Gorzelak et al. 2015). MNs enable networked trees to share nutrients, carbon, water, electrical signals, and biochemical information. Plant behavioral responses that have been measured thus far include rapid changes in mycorrhizal colonization, root growth, shoot growth, photosynthetic rate, foliar nutrition, foliar defense chemistry and defense response to pest pressures (Gorzelak et al. 2015). And, large old trees tend to serve as especially important network "hubs" in MNs, as they have been found to have more numerous and robust mycorrhizal connections than younger, smaller trees (Beiler et al. 2015). The presence of large trees can influence the ambient temperature and moisture of local environments, modify local edaphic conditions (soil pH, nutrient status, etc.) and sustain rich assemblages of EMF species that provide a diverse inoculum source to regenerating seedlings (Beiler et al. 2015). The diverse capacities amongst mycorrhizal species for mobilizing nutrients from soil mineral and organic matter insure a host tree against environmental stresses (Spake et al. 2016). At the ecosystem level, mycorrhizal fungi are not only important for nutrient cycling, but high mycorrhizal fungal species diversity can facilitate resistance to disease and drought, and contribute to net primary productivity, mineral weathering and soil carbon storage (Spake et al. 2016). And, the presence of robust MNs is important for seedling establishment and growth. When seedlings become linked into a MN with veteran trees, they gain access to hydraulically lifted water and patchily distributed nutrients that might otherwise be limiting resources (Beiler et al. 2015; Gorzelak et al. 2015).

The FS should also note that MNs generally fall under two separate categories: Ectomycorrhizal (ECM) fungi and Arbuscular (AM) fungi. These two classes of MN have some fundamental differences and appear to compete with one another (Johnson et al. 2018).[117] Interestingly,

[116] Mycorrhizal fungi are obligate symbionts with all forest tree species, where they scavenge soil nutrients and water from the soil in exchange for photosynthate from the tree. Mycorrhizal fungi are considered the primary vectors for plant carbon to soils and, conversely, the primary vectors of soil nutrients to plants (Simard 2010). Plants invest photosynthate carbon in mycorrhizas (instead of building their own roots) because the small and profuse hyphae have 60 times more absorptive area than fine roots (Simard 2010).

[117] And, the distinction between ECM and AM networks has significant carbon sequestration and storage implications. AM systems have lower soil C:N ratios than those dominated by ECM, indicating fundamentally different nutrient cycling regimes, resulting in more carbon sequestered in EMF forests (Averill 2014). Global data sets have shown that soil in ecosystems dominated by ECM plants contains 70% more carbon per unit nitrogen than soil in ecosystems dominated by AM-associated plants (Averill 2014). The effect of mycorrhizal type on soil carbon is independent of, and of far larger consequence than, the effects of net primary production, temperature, precipitation and soil clay content (Averill 2014).

species such as oak, hickory, and beech are served by ECM networks, whereas maples and tulip poplars are served by AM networks. Red oak (*Quercus rubra*) seedlings have been found to benefit from the mycorrhizal networks of nearby chestnut oaks, but did not benefit when placed near the arbuscular MNs of maples (Dickie et al. 2002). An examination of an old growth oak-hickory forest in southern Indiana found that opposing mycorrhizal associations (AM saplings near ECM trees and ECM saplings near AM trees) had significant inhibition at distances up to 13 m, whereas sapling inhibition only extended to ~1 m for in-network species (i.e., ECM saplings near ECM trees) (Johnson et al. 2018). ECM trees typically produce slow-decaying leaf litters with lower nutrient content relative to co-occurring AM trees, resulting in distinct biogeochemical syndromes or nutrient economies. Because ECM fungi possess the ability to mine nutrients from detritus, whereas AM fungi do not, ECM trees may be most competitive in their own soils (Johnson et al. 2018). By implication, the removal of mature ECM trees and the corresponding disruption of ECM networks may facilitate AM invasion and succession from oak-hickory to maple-tulip ecosystems.

ECM networks are especially sensitive to intensive harvesting regimes. Research has shown that ECM fungi decline overall, regardless of ecozone, due to harvesting (Wilhelm et al. 2017). In contrast, arbuscular mycorrhiza populations increased in harvested plots likely due to their common symbioses with successional plant cover (Wilhelm et al. 2017). Soil compaction from harvesting profoundly affects ECM fungi abundance, structure, and function; it therefore raises concerns regarding forest productivity, juvenile tree regeneration and long-term ecosystem functioning (Hartmann et al. 2014). The disruption and diminishment of ECM networks due to harvest-induced soil compaction has been shown to be substantial and long-lasting, and recovery of a soil from severe compaction may take centuries rather than decades (Hartmann et al. 2014; Hartman et al. 2012). Data shows that clearcut harvesting is especially destructive of ECM fungal networks (Hartman et al. 2012). A meta-analysis of harvesting impacts on ectomycorrhizal fungi found that it generally takes 90 years for ectomycorrhizal species richness to approach that found in undisturbed old growth forests (Spake et al. 2015).[118] The slow recovery of species richness for some functional groups essential to ecosystem functioning makes old-growth forest an effectively irreplaceable biodiversity resource (Spake et al. 2015).

VII. White Oak

> "If oak is the king of trees, as tradition has it, then the white oak, throughout its range, is the king of kings."
>
> –Donald Peattie, A Natural History of Trees of Eastern and Central North America (1991).
>
> "White oak is the standard by which all other oaks are measured. The majesty of a mature tree warrants pause for reflection."
>
> –Michael Dirr, Dirr's Encyclopedia of Trees and Shrubs (2011).
>
> "White oak (*Quercus alba*) is an outstanding tree among all trees."
>
> –Burns & Honkala, Silvics of North America. Vol. 2: Hardwoods (1990).

[118] The same meta-analysis found that the best estimate for lichen species richness was 180 years to reach 90% of undisturbed forest values (between 140 years and never for full recovery), and that saproxylic beetles had a best estimate of about 60 years to reach 90% of old-growth values (between 10 years and never for full recovery).

Since 2006, Ohio's white oaks (*Quercus alba*) have experienced significant declines due to unsustainable rates of harvest. In addition, scientific understanding of oak ecosystem management has made important advances since the preparation and finalization of the 2006 Forest Plan. We therefore ask that the Forest Service incorporate the following oak ecosystem information, which we consider best available scientific information (BASI), in the Wayne's Assessment Report. If the FS does not regard portions of the following information as BASI or has conflicting scientific information, the FS must disclose and explain its reasoning. See 36 CFR 219.3 ("Such documentation must: Identify what information was determined to be the best available scientific information, explain the basis for that determination, and explain how the information was applied to the issues considered."). Please refer to Appendix 6 for an annotated bibliography of the citations provided below.

A. White oak (*Quercus alba*) is in serious decline in Ohio; unsustainable harvest is the most significant system driver of white oak's decline.

White oak (*Quercus alba*) is losing volume in Ohio, decreasing 7.3 percent from 2012 levels (Albright 2018). Notably, white oak joins the insect-devastated white ash (-21.1%) as the only major tree species experiencing volume declines in the state. By contrast, northern red oak has seen a 9.5% volume increase since 2012 (Albright 2018). The decline in Ohio's white oak is driven by unsustainable timber harvest (Albright 2018). White oak continues to be removed at rates exceeding net growth. In Ohio, white oak's growth to removal ratio (G:R) is 0.7:1 (Albright 2018). And, the present rate of unsustainable harvest is accelerating (see Albright 2017, reporting white oak G:R at 0.8:1).

B. White oak's significant downward trend should be considered in the context of its historical dominance in southeast Ohio.

Recent scholarship shows that oak, generally, was a stronger component of southeast Ohio's canopies prior to European settlement than it is today, with 59.4% (Gallia County) and 57.0% (Lawrence County) presettlement oak compositions and diminished 21.1% (Gallia County) and 36.5% (Lawrence County) modern era oak compositions (Deines et al. 2016). White oak, specifically, dominated the Wayne National Forest's region prior to European settlement, accounting for 40% of witness trees in southeast Ohio (Dyer 2001; Abrams 2016; Abrams 2003). White oak fell precipitously from its former dominance in Ohio and across the Midwest during the "Clearcut Era" of 1870 to 1920, in which when the vast majority of eastern forests were cleared (Abrams 2016).

C. Oaks, including *Quercus alba*, have species-specific management requirements.

An emerging trend in the best available oak management science is the acknowledgement that individual oak species have their own individual management needs and requirements – and that *Quercus alba*, in particular, is characterized by a conservative strategy of shade tolerance, persistence in the understory, slow growth, and exceptional longevity (Keyser et al. 2016; Rebbeck et al. 2012; Rebbeck et al. 2011; Hutchinson et al. 2012; Abrams 2003). The 2006 Forest Plan and FEIS do not account for this important development in scientific understanding, and instead treat "oak" and "oak-hickory" as a uniform management category. The slow growth rates, shade tolerance, and long lifespans of white oaks are not adequately accounted for in the 2006 Forest Plan and FEIS. These unique white oak characteristics are material to management considerations (Rebbeck 2012; Rebbeck 2011; McShea and Healy 2002; Burns and Honkala 1990), and should therefore be discussed in the assessment report. In addition, the SILVAH: OAK stand evaluation framework (Brose et al. 2008) largely fails to account for individual oak species requirements. In particular, SILVAH:OAK does not account for oak seedlings by species, which raises the distinct possibility that stands graded by SILVAH as ready for overstory removal may have little to no *Quercus alba* regeneration potential. The assessment report should therefore recognize this gap in the SILVAH:OAK methodology in order to inform the need for change.

D. White Oak responds poorly to aggressive harvest regimes; silvicultural (and commercial) clearcutting is a major driver of oak ecosystem decline.

The unique characteristics and survival strategies of white oak – slow rate of growth, shade tolerance, notably poor stump sprouting ability at maturity (Brose et al. 2008), and exceptionally long lifespan – make it an especially poor competitor in aggressive even-age harvest regimes (Abrams 2016; Swaim et al. 2018; Hutchinson et al. 2012; Rebbeck et al. 2011; Abrams 2003).

Clearcutting is a major driver of oak ecosystem loss. Robust emerging data shows that silvicultural (and commercial) clearcutting consistently and dramatically accelerates the decline of oak ecosystems in the Central Hardwood Region (Steiner et al. 2018; Dey 2014; Swaim et al. 2018; Swaim et al. 2016).

E. White Oak recruits best in small gaps.

Recent evaluations of current understories and historical old growth stands demonstrate that white oak establish well in small canopy gaps (Hutchinson et al. 2012), and that, historically, white oak attained landscape dominance by recruiting in small canopy gaps of approximately 1/20th an acre (McEwan et al. 2014; Buchanan et al. 2012; Rentch et al. 2003; Abrams 2003).

In southeast Ohio, light levels of between 6 – 18% (achieved via prescribed fire alone or in combination with thinning treatments) have been shown to successfully establish and grow oak seedlings; light levels above 18% may favor oak competitors and thereby disfavor oak regeneration (Iverson et al. 2017; Hutchinson et al. 2012).

F. The assessment report should include current scientific understanding of silvicultural prescriptions for oak management.

1. <u>Uneven-age prescriptions</u>

The 2006 Forest Plan (at Appendix E-12 and E-21) concludes that uneven-age harvest methods are inferior to even-age methods for regenerating oak, including white oak (*Quercus alba*).

> Regarding Single Tree Selection, the Forest Plan inaccurately states: “High levels of sun light are required for the survival and growth of advanced oak regeneration, and these

> light conditions cannot be achieved by the single tree selection method. (Fischer, 1979)" At p. E-12.
>
> Regarding Group Selection, the Forest Plan inaccurately states: "This method of cutting would likely result in the oak component of the future stand to be […] less than the component created with even-aged treatments. One reason for the less effective oak regeneration is the large amount of edge in each group. The more mesic and shade-tolerant species would have an advantage along these shaded edges, while the oaks may thrive in the centers and northern edges of each group. Eventually, the amount of oak in the entire stand will decrease so that only the dry south slopes and ridgetops would be stocked with significant numbers of oaks." At p. E-21.

The assessment report should reflect best available scientific information that has since found that seedlings of the relatively shade tolerant white oak best establish and recruit in small gaps (see, e.g., Part VII., Sections C, D, and E and supporting literature, above).

2. Shelterwood prescriptions

In addition, shelterwood treatments generally fail to increase oak stocking density and distribution and provide excessive light levels that favor competing species. Best available science holds that shelterwood treatments: (1) generally cannot correct for an initial lack of oak seedling numbers and spatial distribution (Steiner et al. 2008), and (2) are not the best method for enhancing the size of oak seedlings (see Iverson et al. 2017). This is noteworthy because the 2006 Forest Plan incorrectly assumes that shelterwood treatments are the likely best option when oak seedlings are small, scarce, or absent: "When oak advanced reproduction is small, scarce, or absent, the shelterwood regeneration method will most likely produce the best results." 2006 Forest Plan Appendix E, at E-7 and 8.

3. Clearcut prescriptions

The 2006 Forest Plan states that "clearcutting is the most effective method to regenerate [a] stand to species dominated by oak and hickory […] [when] there are adequate numbers of advanced oak seedlings over 4½ feet tall are vigorous and have well-developed root systems." (2006 Forest Plan Appendix E, at E-6-7). However, this statement contradicts best available science relating to white oak management (see Part VII, Sections C, D, E, and supporting literature, above). Further, the 2006 Plan does not recognize the severe scarcity of oak reproduction that characterizes the understories of oak-dominated stands in southeastern Ohio and the Central Hardwood Region, generally. Small oak seedlings are relatively rare, and competitive (large) oak seedlings and saplings are exceptionally rare. This severe scarcity of competitive oak reproduction means that clearcutting is inappropriate for oak regeneration purposes (let alone white oak regeneration purposes) on nearly all sites, including the vast majority of dry and intermediate sites (Iverson et al. 2017, finding only 2% of 237 understory plots in southeast Ohio oak-dominated stands were stocked with competitive oak seedlings, including only 3 of 130 plots on dry to intermediate sites; Iverson et al. 2018; Paulus et al. 2018, finding zero large sapling oaks on dry ridges in the Wayne; Dey 2014; Dey et al. 2010).

Sufficient numbers and distribution of competitive (large) oak seedlings and saplings must be in place prior to final overstory removal for oak regeneration treatments to be successful. While this principle has been known for decades (Sander et al. 1976), recent studies further support and highlight the principle (Dey 2014; Dey et al. 2010; Swaim et al. 2018; Swaim et al. 2016; Rebbeck et al. 2011). Moreover, this principle is especially important and relevant, given the demonstrated low numbers and sparse distribution of competitive oak seedlings in the Wayne and the region, and given the dramatic recent increase in the Wayne's assigned timber targets. The assessment report should acknowledge these important factors.

VIII. Cerulean Warbler

We ask that the Forest Service incorporate the following information regarding the Cerulean warbler (*Setophaga cerulea*), which we consider best available scientific information (BASI), in the Wayne's Assessment Report. If the FS does not regard portions of the following information as BASI or has conflicting scientific information, the FS must disclose and explain its reasoning. See 36 CFR 219.3 ("Such documentation must: Identify what information was determined to be the best available scientific information, explain the basis for that determination, and explain how the information was applied to the issues considered."). Please also refer to Appendix 8 (hereinafter the "Rodewald Report"), an expert literature review of cerulean warbler and habitat implications for the Wayne National Forest: Rodewald, Amanda D., "Conserving Cerulean Warbler in Temperate Forests: A Literature Review" (August 2018).

Cerulean warbler is listed in the 2006 forest plan as a Management Indicator Species. The cerulean warbler holds the number one ranking in the Ohio State Wildlife Action Plan's conservation status rankings for avian species of greatest conservation need (SGCN).
The species suffered range-wide decline of 3.04% per year from 1966-2000 (Link & Sauer 2002), and breeding bird survey (BBS) trends show that the species has continued to decline across its U.S. range, albeit at a slower rate of 1.31%, over the period of 2005-2015 (Sauer et al. 2017). Unfortunately, BBS data also indicate that declines across Ohio have been far steeper and are accelerating: the species declined by 4.22% per year over 1966-2015 and 4.91% per year from 2005-2015 (Sauer et al. 2017).

Cerulean warblers are dependent upon interior forests with complex old growth features, including heterogeneous canopies, small gaps, and large, tall trees with extensive grapevine cover. Large white oaks (*Quercus alba*) are the preferred and most important nesting sites for the species. During the breeding season, Cerulean Warblers are most closely associated with old, structurally complex forest stands (>80-100 years) that have features typical of old uneven-aged, steady-state forests (Bakermans and Rodewald 2009). Steady-state forests, which are typically >100 years old, are characterized by gap dynamics and natural disturbance processes that result in complex vertical strata and a heterogeneous canopy. One of the hallmarks of high-quality habitat for Cerulean Warblers is a relatively open and heterogeneous forest canopy that often includes canopy gaps of ~40-100 m^2 in size [1/100th to 1/40th an acre] and well-developed vertical strata (Roth and Islam 2007, Bakermans and Rodewald 2009, Hartman et al. 2009, Bakermans et al. 2012, Boves et al. 2013a, Kaminski and Kamal 2013). Canopy gaps of the size preferred by Ceruleans might be naturally expected to occur with natural disturbances including (but not limited to) treefalls in older forests with large trees and abundant grapevines, windstorms, icestorms, wildfire, or beaver activity.

The species requires specific old-forest features that are missing from many mature forests regenerated from stand-replacing disturbances, such as clearcutting (Rodewald Report). White oak (*Quercus alba*) stands out as the most consistently preferred tree species (Newell and Rodewald 2011, Boves et al. 2013a, Newell et al. 2014, Wagner and Islam 2014, Barnes et al. 2016, Nemes and Islam 2017). One especially striking pattern in southeast Ohio was that Ceruleans strongly avoided foraging or placing nests in Northern red oak (*Quercus rubra*) (Newell and Rodewald 2011, Boves et al. 2013a, Newell et al. 2014), which also was negatively associated with nest survival (Newell and Rodewald 2011).

For cerulean warbler management on the Wayne National Forest, the Rodewald Report recommends the following:

- "*Maintain or encourage heavily-forested landscapes*. […] Because most land in the WNF region is privately owned, public lands, including state and national forests, bear disproportionate responsibility for ensuring that landscapes remain heavily forested with significant cover in late-seral stages."
- "*Allow forests to mature and naturally develop old-forest features*. Given sufficient time to regenerate (usually >100 years, depending on site conditions), many forests will develop the structural attributes required by Cerulean Warblers. Among the features that are expected to develop after forests reach steady-state, gap-dynamic phases are heterogeneous canopies, well-developed vertical strata, large diameter trees (>38 cm dbh), and grapevines – all of which promote high densities and successful reproduction of Cerluean Warblers."
- "*Retain white oaks whenever possible and promote oak-hickory forests*. […] Unless [white oak] recruitment problems are addressed, continued harvesting of mature white oak trees is likely to exacerbate regional declines of the species." Due to poor oak regeneration on mesic sites – which are most preferred by Cerulean Warblers, "managers may consider foregoing harvest in these locations. Within harvested stands, managers should make every effort to retain white oak trees and, as possible, avoid removing overstory oaks after shelterwood harvesting."
- "*When appropriate, use silviculture to create suitable structural conditions*. […] specific harvest prescriptions (e.g., single tree and group selection) and timber stand improvement practices (e.g., thinning and crop tree release) also may be able to create features typical of old, uneven-aged forests." […] "Overall, the extent to which Ceruleans will respond positively to harvesting depends on the number, size, and species of overstory trees that are retained. In cases where overstory trees are removed, as is typically done 5-10 years after initial harvest of shelterwoods for example, the sites would no longer be suitable for Cerulean Warblers." […] "In cases where there is wide latitude in choice of harvest location, managers should avoid harvesting older forests with canopy gaps and/or those on northeast-facing slopes, because these tend to be most heavily used by Cerulean Warbler." […] "Until sufficient regeneration of white oak is achieved, continued harvest of mature trees will likely exacerbate declines in the state."

IX. American Black Bear

We ask that the Forest Service incorporate the following information regarding the American black bear (*Ursus americanus*), which we consider best available scientific information (BASI), in the Wayne's Assessment Report. If the agency does not regard portions of the following information as BASI or has conflicting scientific information, the agency must disclose and explain its reasoning. See 36 CFR 219.3 ("Such documentation must: Identify what information was determined to be the best available scientific information, explain the basis for that determination, and explain how the information was applied to the issues considered."). Please also refer to Appendix 7 (hereinafter the "Prange Report"), an expert literature review of American black bear and habitat implications for the Wayne National Forest: Prange, Suzanne, "Conserving Black Bears in Southeast Ohio: A Synthesis of the Literature" (August 2018).

The American black bear is currently one of three Ohio state endangered mammal species (ODNR 2018a), and is listed in Ohio's State Wildlife Action Plan as a Mammal Species of Greatest Conservation Need (SGCN). Once common in Ohio, black bear were extirpated from the state during the mid- to later-1800s due to extensive deforestation and unregulated hunting (ODOW 2015; ODOW Pub. 378 (R905)). Black bear are slowly making a comeback in southeast Ohio, with 135 sightings involving an estimated 88 individual black bears reported to the Ohio Division of Wildlife (ODOW) in 2014 (ODOW 2015). These sightings are often of immature males seeking new territory, although there is thought to be a small reproducing population in the state (ODOW Pub. 378 (R905)).

White oak (*Quercus alba*) acorn availability is the single most important driver of black bear population growth in the southern Appalachian region[119] (Azad 2017; Vaughan 2002; Prange Report: "Simply put, mature, mast-bearing oaks – especially white oaks – are the driving force behind black bear population dynamics and movements."). Most importantly in this region, successfully reproducing black bear populations will need large expanses of mature interior forest (Rogers and Allen 1987; Smith et al. 2016; Prange Report) that contain high levels of white oak mast (Azad 2017; Prange Report), mature oak forest-dependent squawroot (*Conopholis americana*) (Vaughan 2002; Seibert and Pelton 1994; Prange Report), large (>33 in dbh) hollow oak trees for den sites (Ryan and Vaughan 2004; Vaughan 2002; Oli et al. 1997; Prange Report), and significant amounts of downed coarse woody debris that hosts food insects (Beeman and Pelton 1980; Bull et al. 2001; Prange Report). Older stands, which support high levels of hard mast and moderate levels of soft mast, should be maintained to sustain population growth of black bears in the Appalachians (Reynolds-Hogland et al. 2007; Prange Report). Simultaneously, the acreage of intermediate stands (10-25 years) – which result from

[119] Southeastern Ohio and the southern Appalachians share many ecological similarities. The Wayne National Forest and much of the southern Appalachians fall within the same U.S. Forest Service Ecoregion Province, 221 "Eastern Broadleaf Forest." Southeastern Ohio and the southern Appalachians are also part of the same U.S. Environmental Protection Agency (EPA) Level II Ecoregion, 8.4 "Ozark, Ouachita-Appalachian Forests." For further context at a finer scale, the Wayne also falls within U.S. Forest Service Subregion, Section 221E "Southern Unglaciated Allegheny Plateau," and its acreage is divided among the still smaller Forest Service Subsections 221Eb "Teays Plateau," 221Ec "Ohio Valley Lowland," 221Ed "East Hocking Plateau," and 221Ef "Western Hocking Plateau." And, within the EPA Ecoregion framework, the Wayne National Forest further falls within EPA Level III Ecoregion 70 "Western Allegheny Plateau," and its acreage is divided among the still smaller EPA Level IV Ecoregions 70a "Permian Hills," 70b "Monongahela Transition Zone," and 70f "Ohio/Kentucky Carboniferous Plateau."

clearcutting – support very low levels of both hard mast and soft mast, should be minimized (Reynolds-Hogland et al. 2007; Prange Report).

X. Conclusion

Thank you for your consideration of the information in this letter. Although not comprehensive, we believe the information represents the best available scientific information that the agency must include in the upcoming forest assessment. We look forward to discussing this information further, and working with you throughout the planning process to ensure the revised forest plan conserves and protects the natural outdoor heritage of the Wayne National Forest.

List of Figures

List of Appendices

Cited References

Anderson, H.M., C. Gaolach, J. Thomson, and G. Aplet. 2012. Watershed Health in Wilderness, Roadless, and Roaded Areas of the National Forest System. Wilderness Society Report. Available at http://wilderness.org/resource/watershed-health-wilderness-roadless-and-roaded-areas-national-forest-system.

Arcese P. and A.R.E. Sinclair. 1997. The Role of Protected Areas as Ecological Baselines. The Journal of Wildlife Management, 61(3): 587-602. Available at http://www.jstor.org/stable/3802167?seq=8&uid=3739584&uid=2&uid=4&uid=3739256&sid=21106003242731#page_scan_tab_contents.

Aycrigg, J. L., J. Tricker, R. T. Belote, M. S. Dietz, L. Duarte, and G. H. Aplet. 2015. The next 50 years: opportunities for diversifying the ecological representation of the National Wilderness Preservation System within the contiguous United States. Journal of Forestry 114:1–9. https://academic.oup.com/jof/article/114/3/396/4599832.

Aycrigg, J. L., et al. 2016. Completing the system: opportunities and challenges for a national habitat conservation system. BioScience 66:774–784. https://academic.oup.com/bioscience/article/66/9/774/1753772.

Belote RT, Dietz MS, McRae BH, Theobald DM, McClure ML, Irwin GH, et al. (2016) Identifying Corridors among Large Protected Areas in the United States. PLoS ONE 11(4): e0154223. doi:10.1371/journal.pone.0154223. Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154223.

Bertzky, B., Corrigan, C., Kemsey, J., et al. 2012. Protected planet report 2012: tracking progress towards global targets for protected areas. IUCN, Gland, Switzerland and UNEP WCMC, Cambridge, UK.

Bunce, R.G.H., Bogers, M.M.B., Evans, D. *et al*. (2013). The significance of habitats as indicators of biodiversity and their links to species. *Ecol. Indic.*, **33**, 19-25.

Butchart, S.H.M., Scharlemann, J.P.W., Evans, M.I. *et al*. (2012). Protecting important sites for biodiversity contributes to meeting global conservation targets. *PLOS ONE*, **7** (3): e32529, 1-8.

Butler, Patricia et al. 2015. Central Appalachians forest ecosystem vulnerability assessment and synthesis: a report from the Central Appalachians Climate Change Response Framework project. Gen. Tech. Rep. NRS-146. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 310 p. Available at https://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs146.pdf.

Crist, M.R., B.O. Wilmer, and G.H. Aplet. 2005. Assessing the value of roadless areas in a conservation reserve strategy: biodiversity and landscape connectivity in the northern Rockies. Journal of Applied Ecology, 42: 181-191. https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/j.1365-2664.2005.00996.x.

DellaSala, D., J. Karr, and D. Olson. 2011. Roadless areas and clean water. Journal of Soil and Water Conservation, 66(3): 78A-84A. Available at http://www.jswconline.org/content/66/3/78A.full.pdf+html.

DeVelice, R. and J.R. Martin. 2001. Assessing the extent to which roadless areas complement the conservation of biological diversity. Ecological Applications 11(4): 1008-1018. Available at http://www.jstor.org/stable/3061008?seq=1&uid=3739584&uid=2&uid=4&uid=3739256&sid=21106003975961#page_scan_tab_contents.

Dietz, M.S., R.T. Belote, G.H. Aplet, & J.L. Aycrigg. 2015. The world's largest wilderness protection network after 50 years: An assessment of ecosystem representation in the U.S. National Wilderness Preservation System. Biological Conservation, 184: 431-438.

Fahrig, Lenore. 2003. Effects of Habitat Fragmentation on Biodiversity. *Annual Review of Ecology, Evolution, and Systematics* 34:1, 487-51.

Flores, David, Gennaro Falco, Nina S. Roberts, and Francisco P. Valenzuela. "Recreation Equity: Is the Forest Service Serving Its Diverse Publics?" *Journal of Forestry* 116, no. 3 (2018): 266–72. USDA Forest Service. 2010a. Connecting People with America's Great Outdoors: A Framework for Sustainable Recreation. Available at http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5346549.pdf.

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Road construction and maintenance. In: Meehan, W.R., ed. Influences of forest and rangeland management on salmonid fishes and their habitats. Spec. Publ. 19. Bethesda, MD: American Fisheries Society. p. 297-323.

Government Accountability Office. 2013. Forest Service Trails: Long- and Short-Term Improvements Could Reduce Maintenance Backlog and Enhance System Sustainability. GAO-13-618. Available at http://www.gao.gov/products/GAO-13-618.

Lininger, Marci. 2015. "Wildlife Crossings: Drawing Attention to New Connections." A powerpoint presentation offered at the Ohio Transportation Engineering Conference, October 27-28, 2015. Available at http://www.dot.state.oh.us/engineering/OTEC/2015_OTEC_Presentations/Wednesday_Oct.28/56/OTECWildlife%20Crossings.pdf.

Link, William A. and John R. Sauer, "A Hierarchical Analysis of Population Change with Application to Cerulean Warblers," *Ecology*, 83(10): 2832–2840 (2002), Available at https://www.mbr-pwrc.usgs.gov/bbs/LinkandSauer2002.pdf.

Loucks, C., N. Brown, A. Loucks, and K. Cesareo. 2003. USDA Forest Service Roadless areas: Potential Biodiversity Conservation Reserves. Conservation Ecology 7(2): 5. Available at http://www.ecologyandsociety.org/vol7/iss2/art5/.

Margules, C.R. and R.L. Pressey. 2000. Systematic conservation planning. Nature, 405: 243 253. Available at http://www.nature.com/nature/journal/v405/n6783/full/405243a0.html.

Mawdsley, J., R. O'Malley, and D.S. Ojima. 2009. A Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation. Conservation Biology, 23(5): 1080-1089. Available at http://onlinelibrary.wiley.com/doi/10.1111/j.1523-1739.2009.01264.x/abstract.

National Park Service, 2010. *Climate Change Response Strategy*. http://www.nature.nps.gov/climatechange/docs/NPS_CCRS.pdf.

National Park Service, undated. *Climate Change Response Program Brief.* Available at https://www.nps.gov/subjects/climatechange/adaptation.htm (web page last viewed November 7, 2018).

Ohio Department of Natural Resources. 2018a. Ohio's Listed Species: Wildlife that are Considered to be Endangered, Threatened, Species of Concern, Special Interest, Extirpated, or Extinct in Ohio. Ohio Department of Natural Resources, Division of Wildlife. Publication 5356 (RO717). Updated July 2018. Available at http://wildlife.ohiodnr.gov/portals/wildlife/pdfs/publications/information/pub356.pdf.

Ohio Department of Natural Resources, 2018b. Ohio Statewide Comprehensive Outdoor Recreation Plan 2018. Pages 55-56. Available at http://parks.ohiodnr.gov/Portals/parks/PDFs/stay_informed/SCORP/2018_SCORP_Appendices.pdf.

Ohio Division of Wildlife, "Summary of 2014 Black Bear Observations in Ohio" (22 February 2015). Available at http://wildlife.ohiodnr.gov/portals/wildlife/pdfs/research/Black%20bear%20report%202014.pdf.

Ohio Division of Wildlife, "Life History Notes: Black Bear" Pub. 378 (R905). Available at http://www2.ohiodnr.com/portals/wildlife/pdfs/publications/mammals%20life%20history/pub378.pdf.

Olson, D.M. and E. Dinerstein. 1998. The global 200: A representation approach to conserving the Earth's most biologically valuable ecoregions. Conservation Biology, 12: 502-515. Available at http://www.jstor.org.ezproxy.princeton.edu/stable/2387232?seq=1#page_scan_tab_contents.

Phillips, S. 2004. Windfalls for Wilderness: Land Protection and Land Value in the Green Mountains. Ph.D. Dissertation. Virginia Polytechnic Institute and State University, Blacksburg, VA. Available at http://www.wilderness.net/library/documents/Phillips_2-33.pdf.

Rasker, R., B. Alexander, J. van den Noort, and R. Carter. 2004. Prosperity in the 21st Century West – the Role of Protected Public Lands. Sonoran Institute. Available at: https://sonoraninstitute.org/resource/prosperity-in-the-21st-century-west-the-role-of-protected-public-lands-07-10-2004/.

Rasker, R. 2006. An exploration into the economic impact of industrial development versus conservation on western public lands. Society & Natural Resources, 19(3): 191–207. Available at http://www.tandfonline.com/doi/abs/10.1080/08941920500460583?journalCode=usnr20#.VUjLrPlVhBc.

Rasker, R., P.H. Gude, J.A. Gude, and J. van den Noort. 2009. The Economic Importance of Air Travel in High-Amenity Rural Areas. Journal of Rural Studies, 25: 343-353. Available at http://headwaterseconomics.org/3wests/Rasker_et_al_2009_Three_Wests.pdf.

Rodrigues, A.S.L., Andelman, S.J., Bakarr, M.I. *et al*. (2004). Effectiveness of the global protected areas network in representing species diversity. *Nature*, **428**, 640-643.

Sauer, J. R. et al., "The North American Breeding Bird Survey, Results and Analysis 1966 – 2015" Version 12.23.2015 USGS Patuxent Wildlife Research Center, Laurel, MD (2017), Available at https://www.mbr-pwrc.usgs.gov/bbs/bbs2015.html.

Strittholt, J. and D. DellaSala. 2001. Importance of Roadless Area Conservation in Forested Ecosystems: Case Study of the Klamath-Siskiyou Region of the United States. In Conservation Biology 15(6): 1742-1754. Available at http://www.researchgate.net/publication/255439281_Importance_of_Roadless_Areas_in_Biodiversity_Conservation_in_Forested_Ecosystems_Case_Study_of_the_Klamath-Siskiyou_Ecoregion_of_the_United_States.

The Wilderness Society, The. 2004. The Economic Benefits of Wilderness: Focus on Property Value Enhancement. http://www.roccnet.org/uploads/2/6/4/3/26435947/economic_benefits_of_wilderness_2004.pdf.

US Fish and Wildlife Service, National Oceanic and Atmospheric Administration, and the New York Division of Fish, Wildlife, and Marine Resources, 2013. "National Fish, Wildlife, and Plants Climate Adaptation Strategy." Chapter 3, Pages 55-59. Available at http://www.wildlifeadaptationstrategy.gov/pdf/NFWPCAS-Chapter-3.pdf.

USDA Forest Service 2001. Roadless Area Conservation Rule Final Environmental Impact Statement, Vol. 1. Available at http://www.fs.usda.gov/roaddocument/roadless/2001roadlessrule/finalruledocuments.

USDA Forest Service 2010a. Connecting People with America's Great Outdoors: A Framework for Sustainable Recreation. Recreation, Heritage and Volunteer Resources, June 25, 2010. Available at https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5346549.pdf.

USDA Forest Service. 2010b. Water, Climate Change, and Forests: Watershed Stewardship for a Changing Climate. PNW-GTR-812. Available at http://www.fs.fed.us/pnw/pubs/pnw_gtr812.pdf.

USDA Forest Service. 2011. National Roadmap for Responding to Climate Change. US Department of Agriculture. FS-957b. Available at: http://www.fs.fed.us/climatechange/pdf/Roadmap_pub.pdf.

USDA Forest Service. 2012. National Best Management Practices for Water Quality Management on National Forest System Lands, Volume 1: National Core BMP Technical Guide. Available at http://www.fs.fed.us/biology/resources/pubs/watershed/FS_National_Core_BMPs_April2012.pdf.

USDA Forest Service, 2017. Rio Grande National Forest, Assessment Report, Chapter 15: Designated Areas. Pages 21-22. Available at https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd489288.pdf.

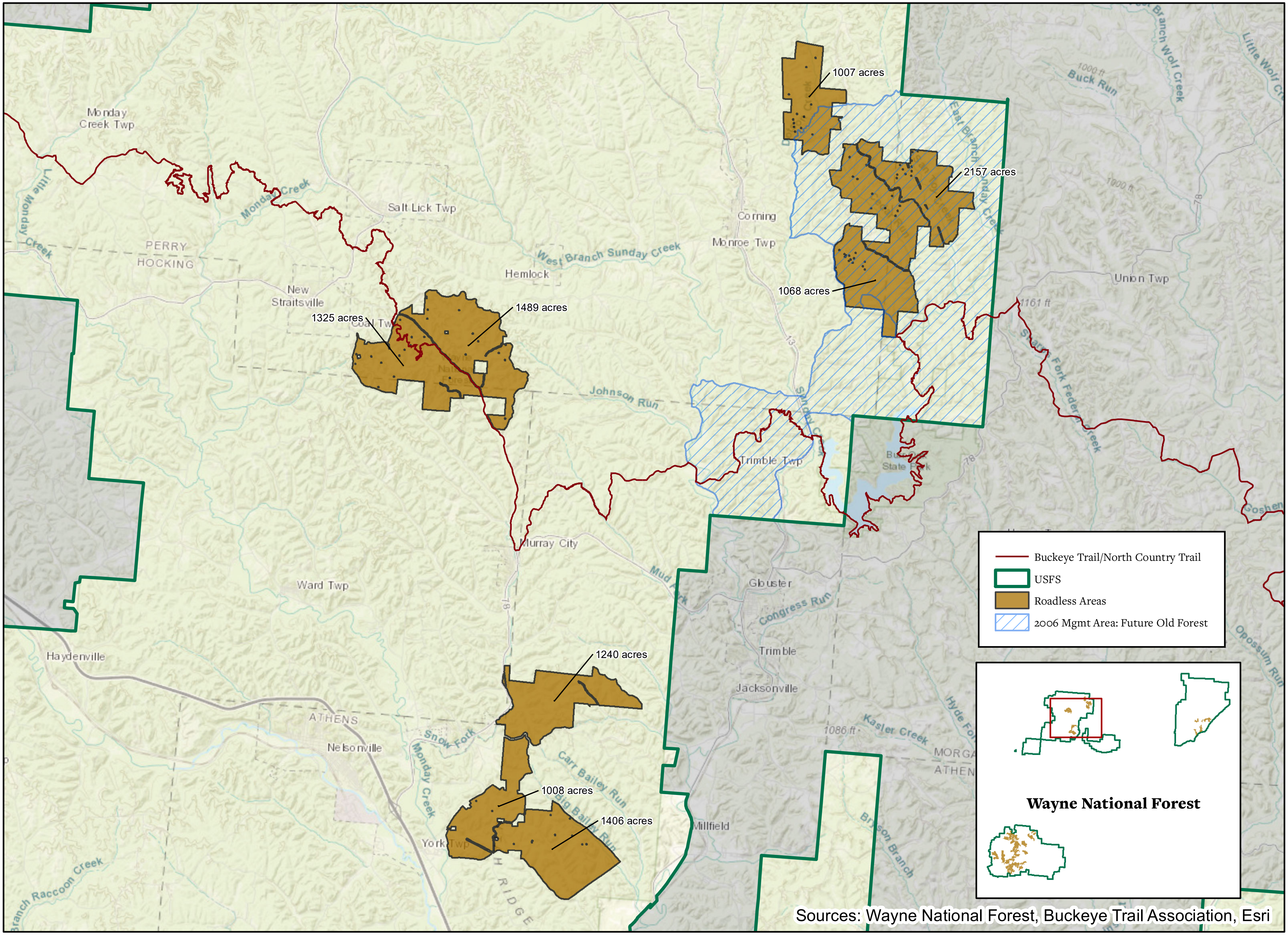
Wilcove, D.S. 1990. The role of wilderness in protecting biodiversity. Natural Resources and Environmental Issues: Vol. 0, Article 7. Available at http://digitalcommons.usu.edu/nrei/vol0/iss1/7/.

Woodley, S., Bertzky, B., Crawhall, N. *et al*. (2012). Meeting Aichi target 11: What does success look like for protected area systems? *Parks*, **18**, 23-36.

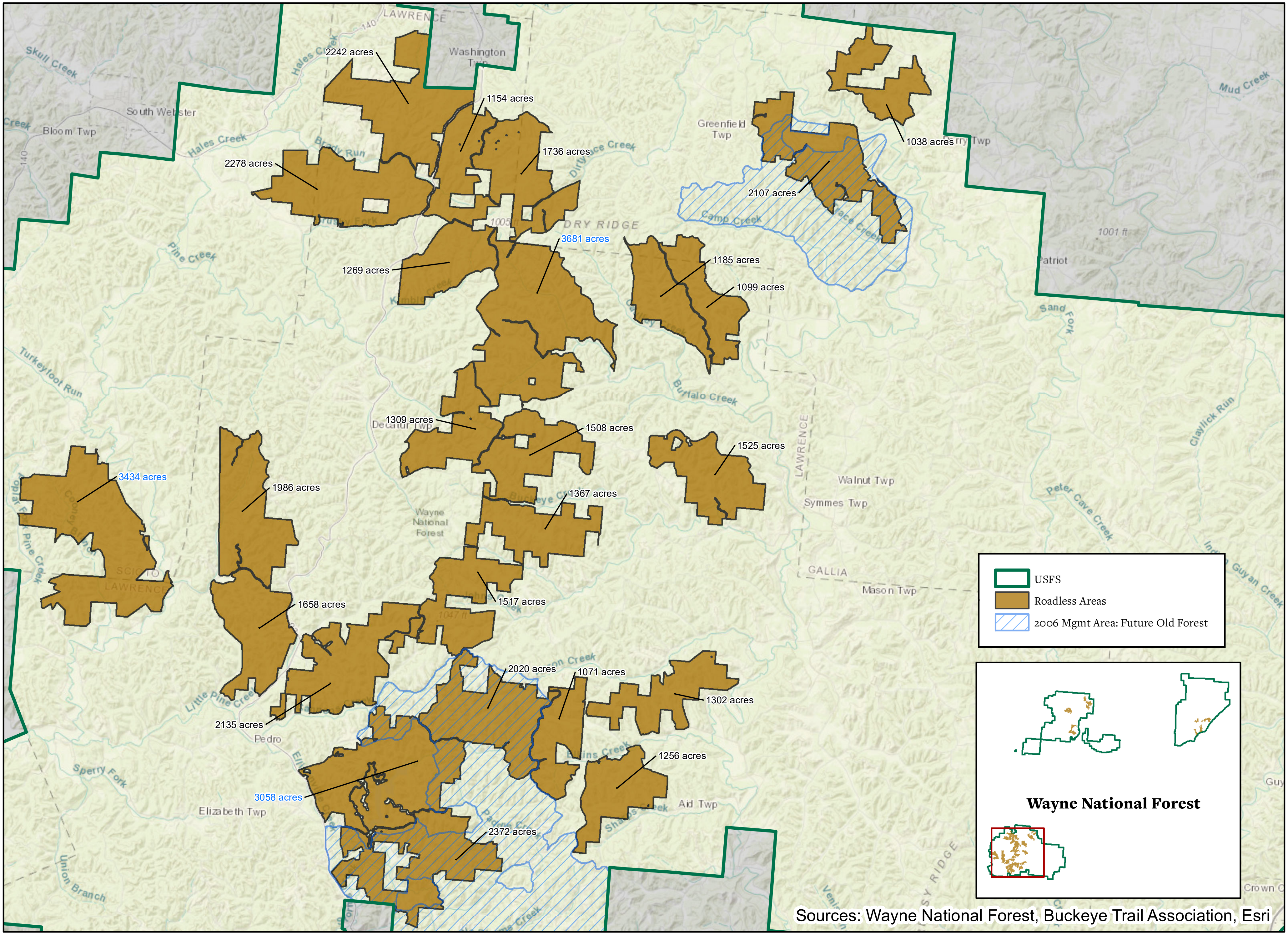
Figure 1. Maps of Roadless Parcels in the Wayne National Forest. Data Provided by Wayne National Forest.

The first three maps depict roadless tract boundaries and 2006 Land and Resource Management Plan Future Old Forest Management Area boundaries. The fourth, fifth, and sixth maps depict roadless tract boundaries, Special Area boundaries, Developed Recreation Area boundaries, and stands older than 100 years.

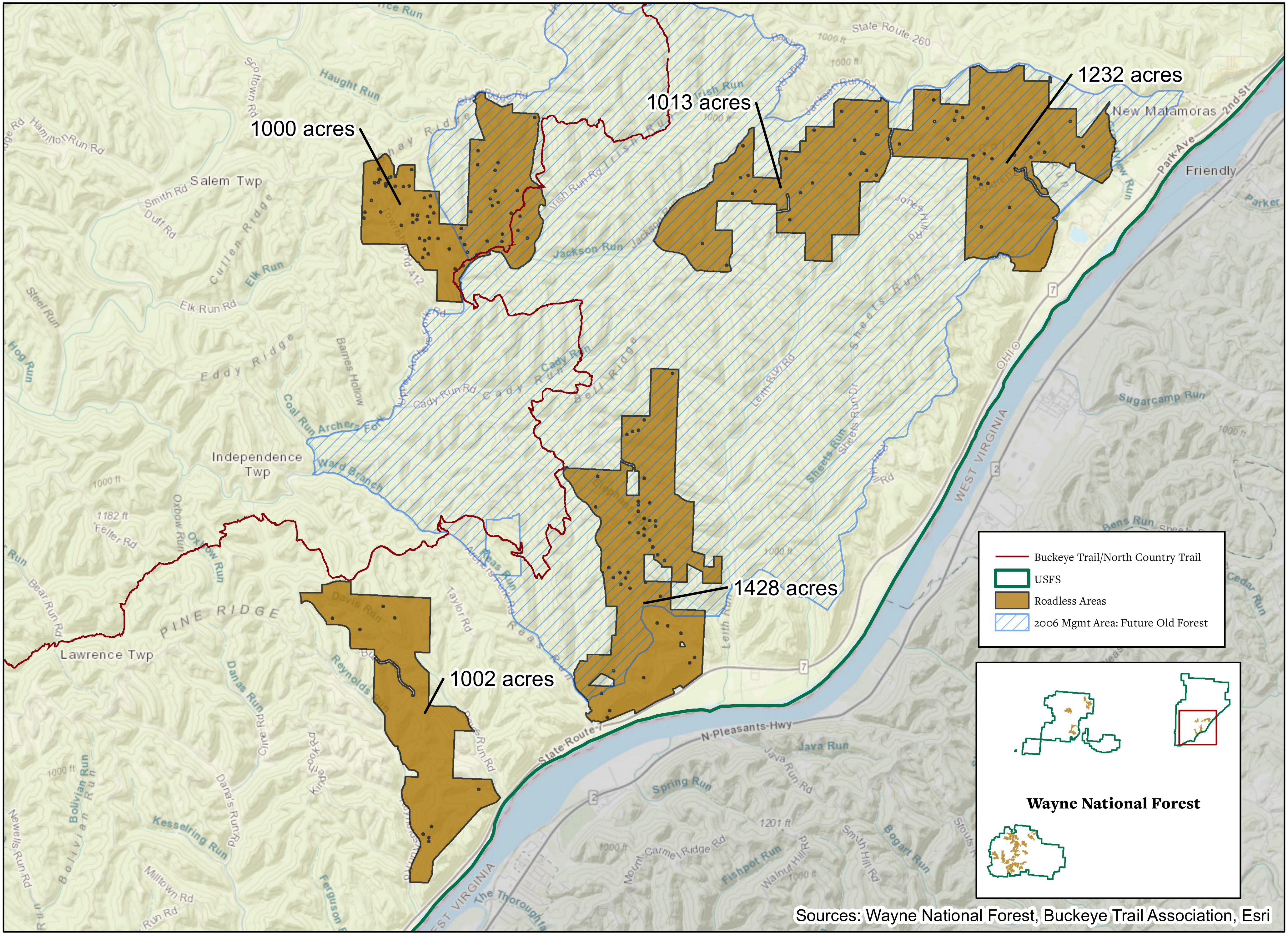
Wayne National Forest Roadless Areas and Future Old Forest - Athens



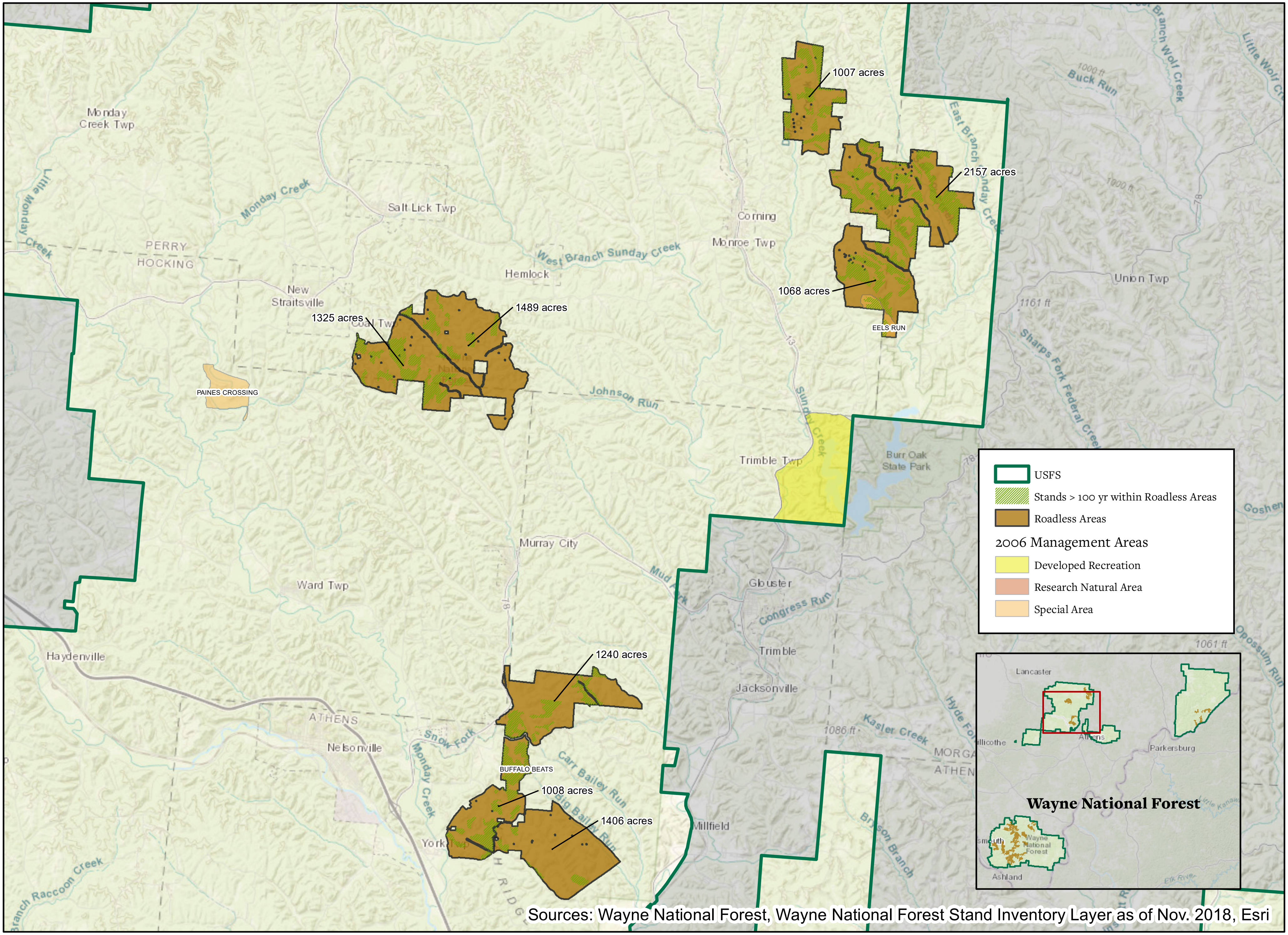
Wayne National Forest Roadless Areas and Future Old Forest - Ironton



Wayne National Forest Roadless Areas and Future Old Forest - Marietta

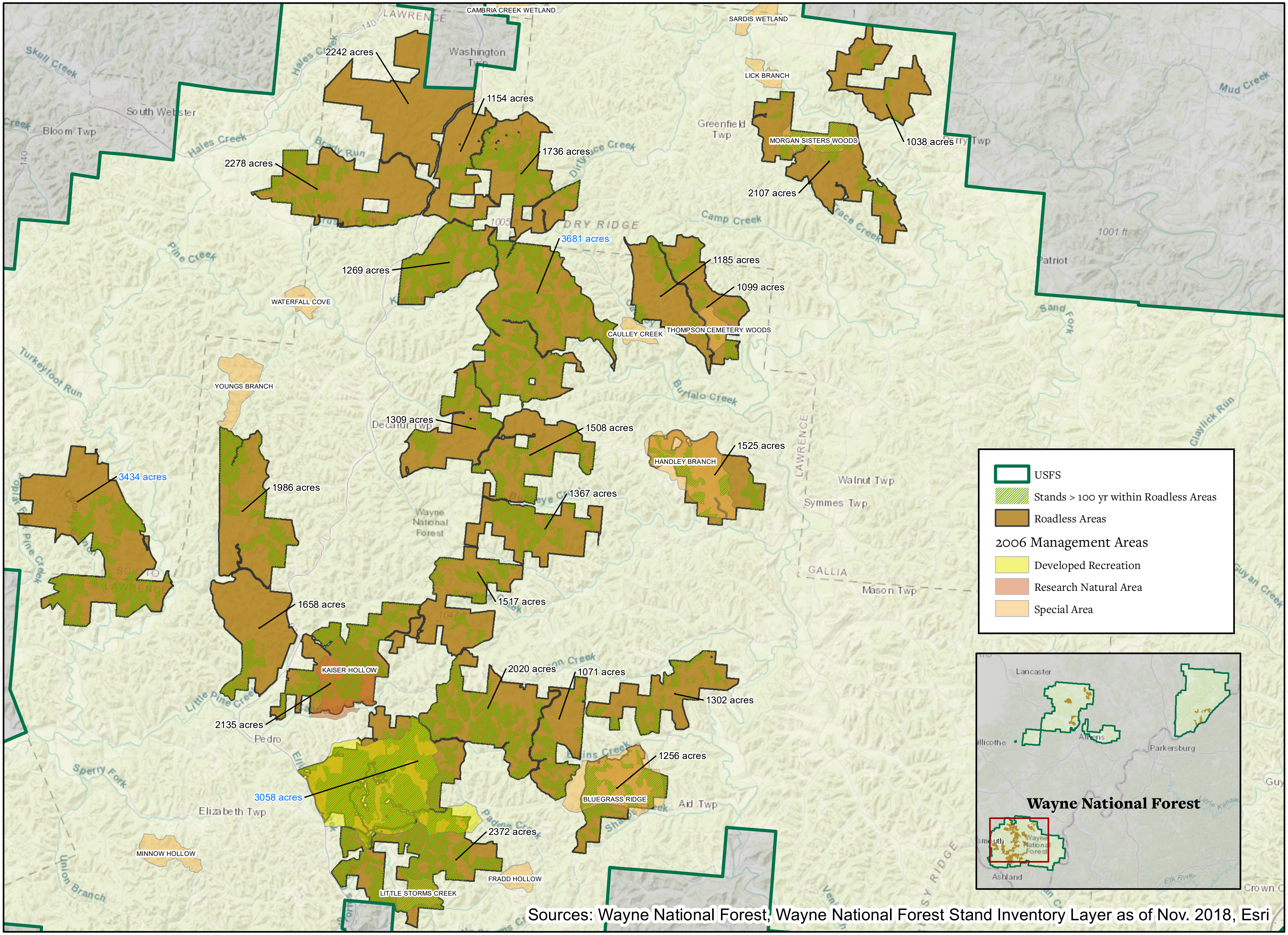


Wayne National Forest Roadless Areas and Stands Over 100 Years - Athens

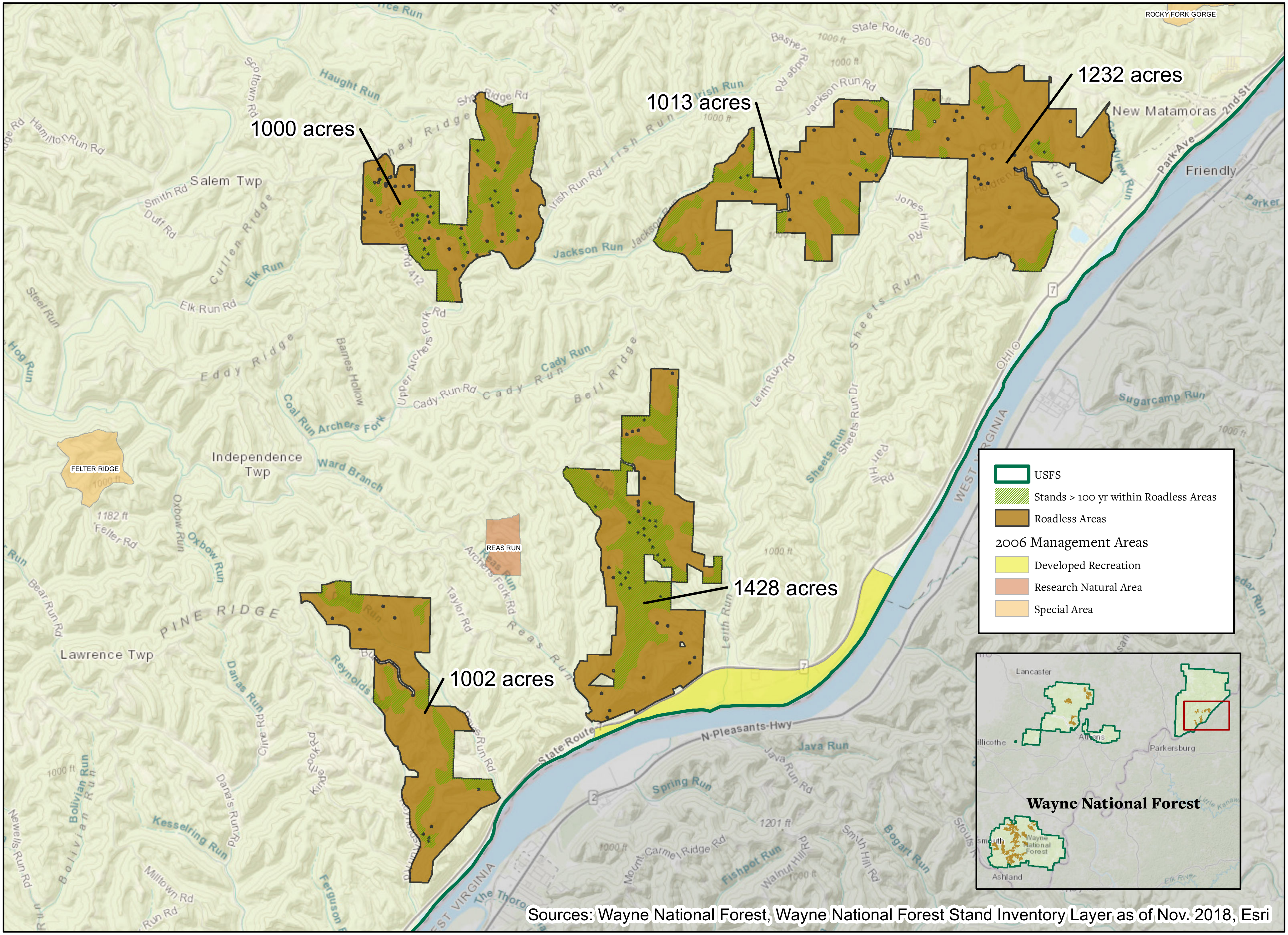


Sources: Wayne National Forest, Wayne National Forest Stand Inventory Layer as of Nov. 2018, Esri

Wayne National Forest Roadless Areas and Stands Over 100 Years - Ironton

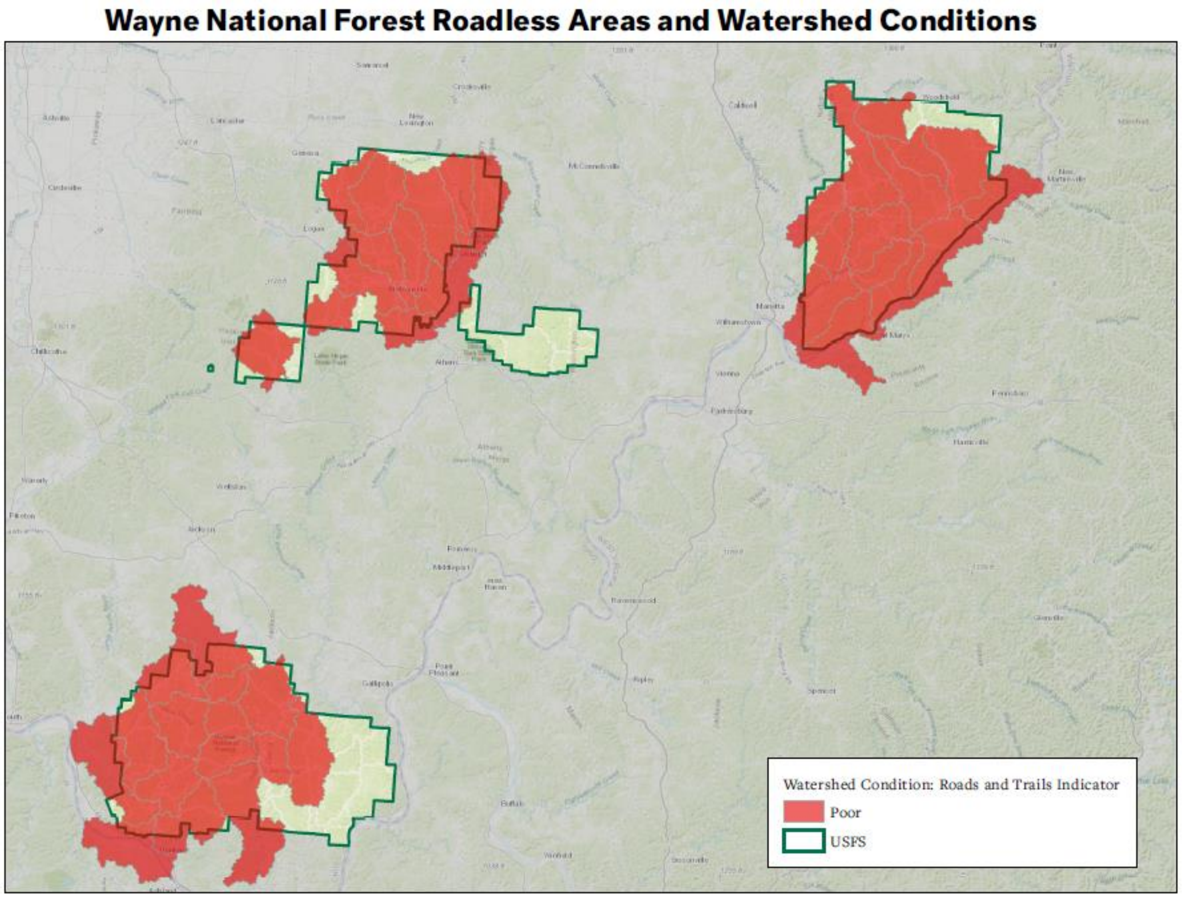


Wayne National Forest Roadless Areas and Stands Over 100 Years - Marietta



Sources: Wayne National Forest, Wayne National Forest Stand Inventory Layer as of Nov. 2018, Esri

Figure 2. Roads and Trails Indicator Ranking under the Watershed Condition Framework, Wayne National Forest, 2016. Data available at https://www.fs.fed.us/naturalresources/watershed/condition_framework.shtml.



WATERSHED NAME	WATERSHED CONDITION FS AREA	WATERSHED CLASS FS AREA	TOTAL WATERSHED AREA ACRES	FS AREA ACRES	NONFS AREA ACRES	AQUATIC BIOTA CONDITION	RIPARIAN WETLAND VEG CONDITION	WATER QUALITY CONDITION	AQUATIC HABITAT CONDITION	ROADS AND TRAILS CONDITION
Rich Fork	Functioning at Risk	2	14344.7	1568.6	12776.1	Fair	Fair	Poor	Fair	Poor
Wolfpen Run-Little Muskingum River	Functioning at Risk	2	13598.8	3284.8	10314	Fair	Fair	Poor	Fair	Poor
Witten Fork	Functioning at Risk	2	27114.2	4707.6	22406.6	Fair	Fair	Poor	Fair	Poor
Straight Fork-Little Muskingum River	Functioning at Risk	2	23491.4	4955.3	18536.1	Fair	Fair	Poor	Poor	Poor
Clear Fork Little Muskingum River	Functioning at Risk	2	31245.5	5104.8	26140.7	Fair	Fair	Fair	Fair	Poor
Archers Fork	Functioning at Risk	2	11874.9	6471.8	5403	Fair	Fair	Good	Poor	Poor
Wingett Run-Little Muskingum River	Functioning at Risk	2	23260.5	8847.5	14413	Fair	Fair	Fair	Poor	Poor
Fifteen Mile Creek	Functioning at Risk	2	13136.4	3178.8	9957.6	Fair	Fair	Poor	Fair	Poor
Eightmile Creek-Little Muskingum River	Functioning at Risk	2	26679.7	4726.5	21953.2	Fair	Fair	Poor	Poor	Poor

Paw Paw Creek	Functioning at Risk	2	14991.6	1179.3	13812.3	Fair	Fair	Good	Fair	Poor
Patton Run-Ohio River	Functioning at Risk	2	20573.5	2724.4	17849.1	Fair	Fair	Good	Fair	Poor
Mill Creek-Ohio River	Functioning at Risk	2	27702.4	6017.9	21684.5	Fair	Fair	Good	Fair	Poor
Leith Run-Ohio River	Functioning at Risk	2	17154.4	7612.8	9541.6	Fair	Fair	Good	Fair	Poor
Cow Creek-Ohio River	Functioning at Risk	2	30816.8	3275.7	27541.2	Fair	Fair	Good	Fair	Poor
Little Monday Creek	Impaired Function	3	16095.9	2315.8	13780.1	Poor	Fair	Fair	Poor	Poor
Lost Run-Monday Creek	Impaired Function	3	23386.9	12881.4	10505.5	Poor	Fair	Fair	Poor	Poor
Snow Fork	Impaired Function	3	17459.5	8182.8	9276.7	Poor	Fair	Fair	Fair	Poor
Kitchen Run-Monday Creek	Impaired Function	3	17292.6	9917.5	7375	Poor	Fair	Fair	Fair	Poor
Dorr Run-Hocking River	Impaired Function	3	20988	8031.3	12956.7	Fair	Fair	Poor	Fair	Poor
East Branch Sunday Creek	Impaired Function	3	21208	5917.1	15290.9	Poor	Fair	Fair	Poor	Poor
Dotson Creek-Sunday Creek	Functioning at Risk	2	15473.8	3598.9	11874.9	Poor	Fair	Fair	Fair	Poor
West Branch Sunday Creek	Impaired Function	3	27197.1	3185.4	24011.7	Poor	Fair	Fair	Poor	Poor

Greens Run-Sunday Creek	Impaired Function	3	24999.1	6872.3	18126.8	Poor	Fair	Fair	Poor	Poor
Hamley Run-Hocking River	Functioning at Risk	2	14218.5	3364.1	10854.5	Fair	Fair	Poor	Fair	Poor
East Branch Raccoon Creek	Impaired Function	3	12880.6	4393.8	8486.8	Poor	Fair	Poor	Fair	Poor
Brushy Fork	Impaired Function	3	21551.9	1336	20215.8	Poor	Fair	Poor	Fair	Poor
Dirtyface Creek	Functioning at Risk	2	8612.4	5395.1	3217.4	Fair	Fair	Good	Fair	Poor
Black Fork	Functioning at Risk	2	31604.7	3935.1	27669.7	Fair	Fair	Good	Fair	Poor
Sand Fork	Functioning at Risk	2	27150.6	2840.8	24309.8	Fair	Fair	Good	Fair	Poor
Buffalo Creek	Functioning at Risk	2	11238.8	9048	2190.8	Fair	Good	Good	Fair	Poor
Camp Creek-Symmes Creek	Functioning at Risk	2	25756.3	10673.8	15082.5	Fair	Good	Poor	Poor	Poor
Johns Creek	Functioning at Risk	2	14514.3	7903	6611.3	Fair	Fair	Good	Fair	Poor
Pigeon Creek-Symmes Creek	Functioning at Risk	2	11843.4	1587	10256.5	Fair	Fair	Good	Fair	Poor
Aaron Creek-Symmes Creek	Functioning at Risk	2	37333.5	7615.3	29718.2	Fair	Fair	Good	Fair	Poor
Storms Creek	Functioning at Risk	2	23803.7	8920	14883.8	Fair	Fair	Good	Fair	Poor

Pond Run-Ohio River	Functioning at Risk	2	28165	1759.4	26405.6	Fair	Fair	Good	Fair	Poor
Hales Creek	Functioning at Risk	2	20674.5	5832.5	14842.1	Fair	Fair	Poor	Fair	Poor
Headwaters Pine Creek	Functioning at Risk	2	21336.5	13268.2	8068.3	Fair	Fair	Poor	Fair	Poor
Little Pine Creek	Functioning at Risk	2	18892.2	9326.2	9566	Fair	Fair	Poor	Fair	Poor
Howard Run-Pine Creek	Functioning at Risk	2	24767.2	12634.8	12132.3	Fair	Fair	Poor	Fair	Poor
Lick Run-Pine Creek	Impaired Function	3	32177	4847.8	27329.2	Fair	Fair	Poor	Fair	Poor

Appendix 1

Economic Information for the Wayne National Forest Region Generated from Headwater Economics EPS-HDT Application, available at http://headwaterseconomics.org/tools/eps-hdt

Economic Profile System Selected Results
Athens, Ironton, and Marietta Units, Wayne National Forest

The data and information presented below was excerpted from reports generated through Headwaters Economics Economic Profile System (EPS), available at https://headwaterseconomics.org/tools/economic-profile-system/. The EPS system can generate 14 different reports. Attached to this data summary are the reports from which data was excerpted. Other reports can easily be generated by going to the EPS website. Counties containing more than a de minimum amount of USDA Forest Service acreage were included in this analysis.

Use Sectors, Summary Report, Page 1

Athens Unit

Use Sectors^	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	Athens unit	U.S.
Timber % of private employment, 2016	0.1%	0.5%	4.4%	13.8%	2.1%	0.6%
Mining % of private employment, 2016	0.1%	9.9%	0.2%	4.6%	2.1%	0.5%
Fossil fuels (oil, gas, & coal), 2016	0.0%	7.5%	0.1%	4.4%	1.7%	0.4%
Other mining, 2016	0.1%	1.7%	0.2%	0.8%	0.5%	0.3%
Agriculture % of employment, 2016	2.2%	7.1%	3.4%	6.6%	3.5%	1.4%
Travel & Tourism % of private emp., 2016	26.4%	13.7%	24.5%	14.6%	22.9%	15.8%

Ironton Unit

Use Sectors^	Ohio	Lawrence County, OH	Gallia County, OH	Ironton unit	U.S.
Timber % of private employment, 2016	0.6%	0.0%	0.2%	0.1%	0.6%
Mining % of private employment, 2016	0.2%	0.0%	0.0%	0.0%	0.5%
Fossil fuels (oil, gas, & coal), 2016	0.2%	0.0%	0.0%	0.0%	0.4%
Other mining, 2016	0.2%	0.7%	0.0%	0.4%	0.3%
Agriculture % of employment, 2016	1.3%	3.4%	5.9%	4.5%	1.4%
Travel & Tourism % of private emp., 2016	14.1%	14.3%	14.2%	14.3%	15.8%

Marietta Unit

Use Sectors^	Ohio	Monroe County, OH	Washington County, OH	Marietta unit	U.S.
Timber % of private employment, 2016	0.6%	0.2%	1.4%	1.3%	0.6%
Mining % of private employment, 2016	0.2%	30.1%	1.4%	4.0%	0.5%
Fossil fuels (oil, gas, & coal), 2016	0.2%	27.6%	1.3%	3.8%	0.4%
Other mining, 2016	0.2%	1.8%	0.2%	0.3%	0.3%
Agriculture % of employment, 2016	1.3%	13.9%	3.3%	4.8%	1.4%
Travel & Tourism % of private emp., 2016	14.1%	11.9%	13.1%	13.0%	15.8%

Observations: For all three units, the travel and tourism sector is responsible for the most private employment. This is most pronounced in the Athens Unit where it makes up 23% of private employments. This compares to 2% for timber and mining/oil&gas industries, respectively, and 4% for agriculture.

Federal Lands, Summary Report, Page 1

Athens Unit

Federal Land*	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	Athens unit	U.S.
Forest Service %	5.8%	8.5%	9.6%	0.7%	6.1%	8.4%
Federal land % Type A**	0.0%	0.0%	0.0%	0.0%	0.0%	41.8%
Federal payments % of gov. revenue, FY2012	0.1%	0.2%	0.1%	0.0%	0.1%	

Ironton Unit

Federal Land*	Ohio	Lawrence County, OH	Gallia County, OH	Ironton unit	U.S.
Forest Service %	0.9%	25.7%	6.1%	15.8%	8.4%
Federal land % Type A**	11.1%	0.0%	0.0%	0.0%	41.8%
Federal payments % of gov. revenue, FY2012	0.0%	0.3%	0.1%	0.2%	

Marietta Unit

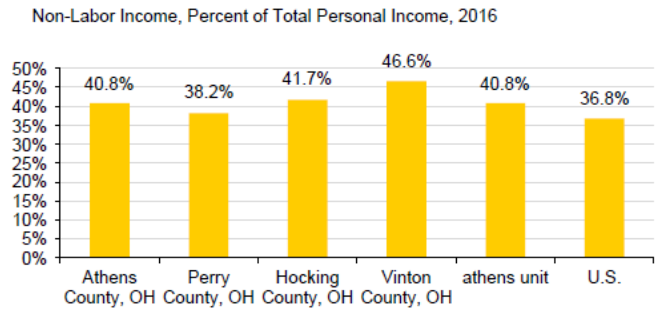
Federal Land*	Ohio	Monroe County, OH	Washington County, OH	Marietta unit	U.S.
Forest Service %	0.9%	8.4%	9.6%	9.1%	8.4%
Federal land % Type A**	11.1%	0.0%	0.0%	0.0%	41.8%
Federal payments % of gov. revenue, FY2012	0.0%	0.2%	0.1%	0.1%	

Observations: USDA Forest Service land makes up just under 10% of the land base in the three unit regions. There is no Type A Forest Service land (i.e., land in high levels of conservation protection). Federal payments are not a significant factor in county governments.

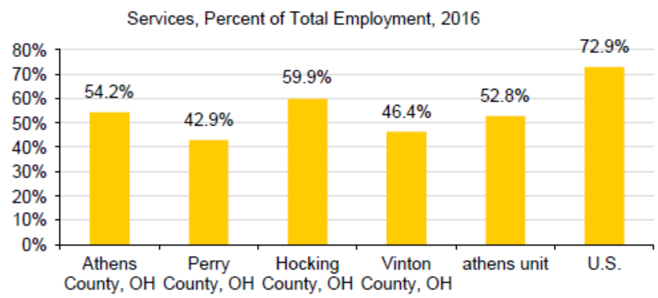
Non-Labor Income, Services, and Government, Summary Report, Page 4

Athens Unit

- In 2016, Vinton County, OH had the largest percent of total personal income from non-labor income sources (46.6%), and the U.S. had the smallest (36.8%).

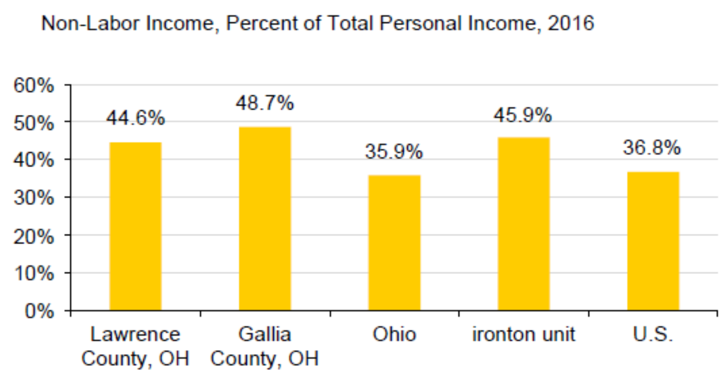


- In 2016, the U.S. had the largest percent of total jobs in services (72.9%), and Perry County, OH had the smallest (42.9%).

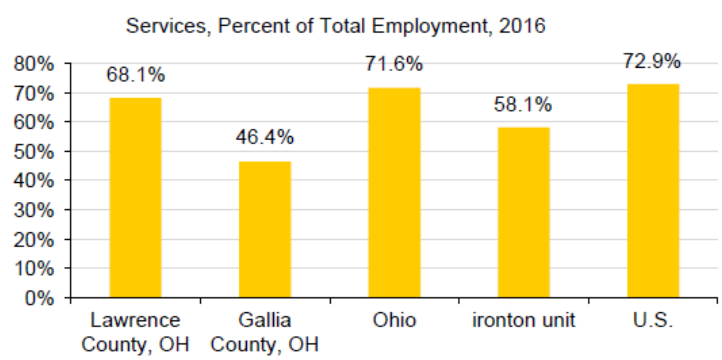


Ironton Unit

- In 2016, Gallia County, OH had the largest percent of total personal income from non-labor income sources (48.7%), and Ohio had the smallest (35.9%).

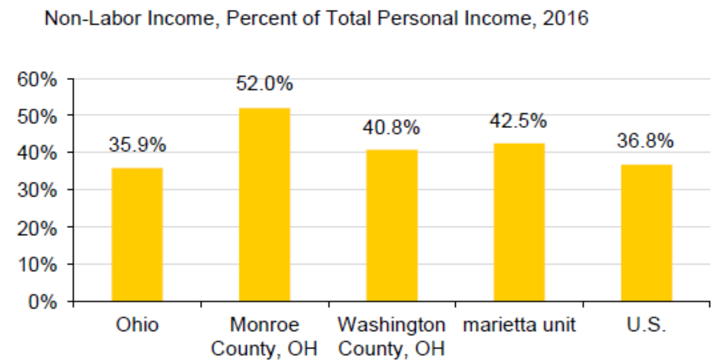


- In 2016, the U.S. had the largest percent of total jobs in services (72.9%), and Gallia County, OH had the smallest (46.4%).

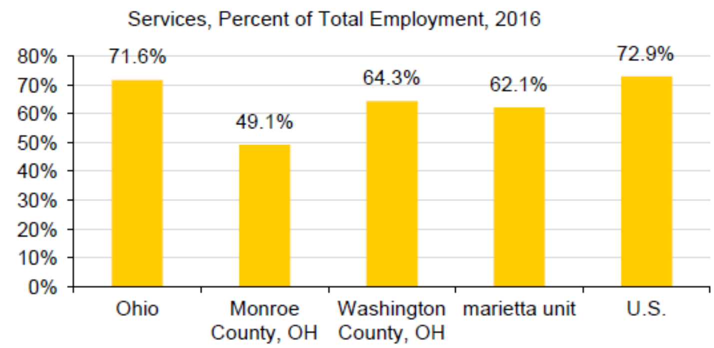


Marietta Unit

- In 2016, Monroe County, OH had the largest percent of total personal income from non-labor income sources (52%), and Ohio had the smallest (35.9%).



- In 2016, the U.S. had the largest percent of total jobs in services (72.9%), and Monroe County, OH had the smallest (49.1%).



Notes:

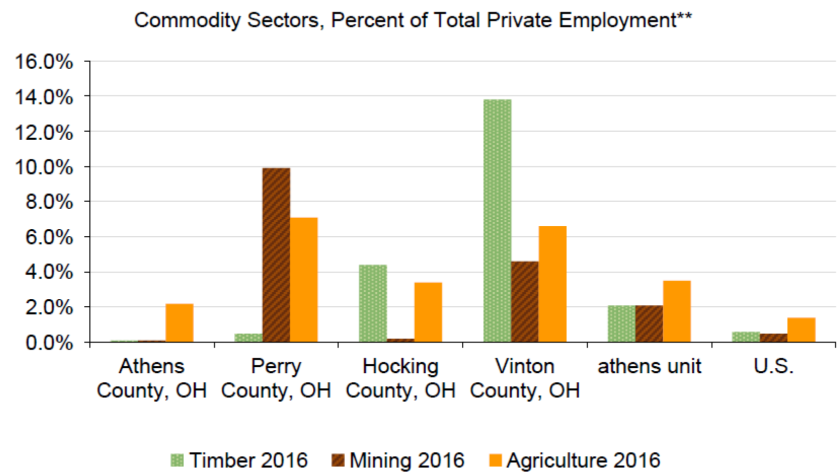
- *In many counties, non-labor income (for example, retirement and investment income, government transfer payments) can be more than a third of all personal income. As the Baby Boomer generation retires, this source of income will continue to grow. A high dependence on non-labor income can indicate a location with an aging population and/or attractiveness to people with investment income. In some cases, it can also signal hardship, such as when there is a high dependence on Medicaid and income maintenance payments. Summary Report Page 4.*
- *Nationally, services account for more than 95 percent of the growth in new jobs since 2000. Despite the strong growth of employment in services, the term "services" is often misunderstood. Services consist of a wide mix of jobs including high-wage, high-skilled occupations (e.g., doctors, engineers, software developers) and low-wage, low-skilled occupations (e.g., restaurant workers, tour bus operators). The service sector typically provides services, such as banking and education, rather than creating tangible objects. However, many service sectors such as utilities, engineering, and architecture are closely associated with goods-producing sectors. Summary Report Page 4.*

Observations: Non-labor income is higher in the Wayne National Forest region than in Ohio and the US. This could either indicate that people with assets live there possibly for the amenity, or it could indicate high dependence on support payments.

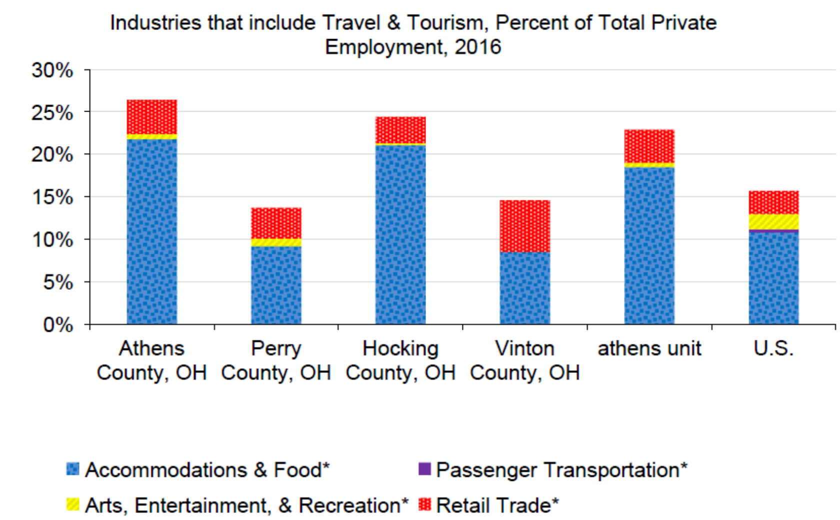
Employment in Commodities, Travel and Tourism, Page 6, Summary Report

Athens Unit

- Vinton County, OH had the largest percent of total jobs in commodity sectors (25%), and Athens County, OH had the smallest (2.4%).
- Agriculture was the largest component of commodity sector employment (3.5% of total jobs) in the athens unit, and timber was the smallest component (2.1% of total jobs).



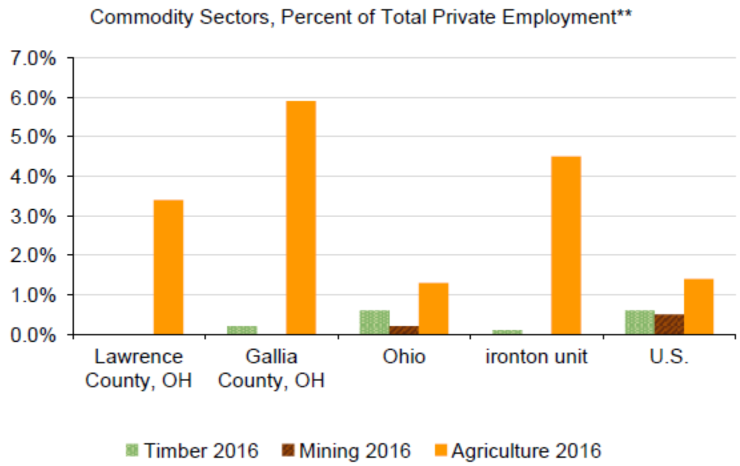
- In 2016, Athens County, OH had the largest percent of total jobs in industries that include travel and tourism (26.4%), and Perry County, OH had the smallest (13.7%).
- In 2016, accommodations & food* was the largest component of travel and tourism-related employment (18.5% of total jobs) in athens unit, and passenger transportation* was the smallest (0% of total jobs).



Ironton Unit

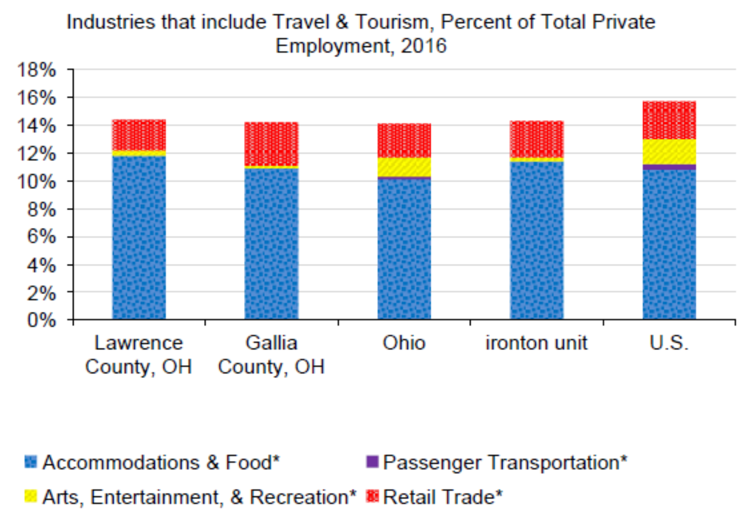
- Gallia County, OH had the largest percent of total jobs in commodity sectors (6.1%), and Ohio had the smallest (2.1%).

- Agriculture was the largest component of commodity sector employment (4.5% of total jobs) in the ironton unit, and mining was the smallest component (0% of total jobs).



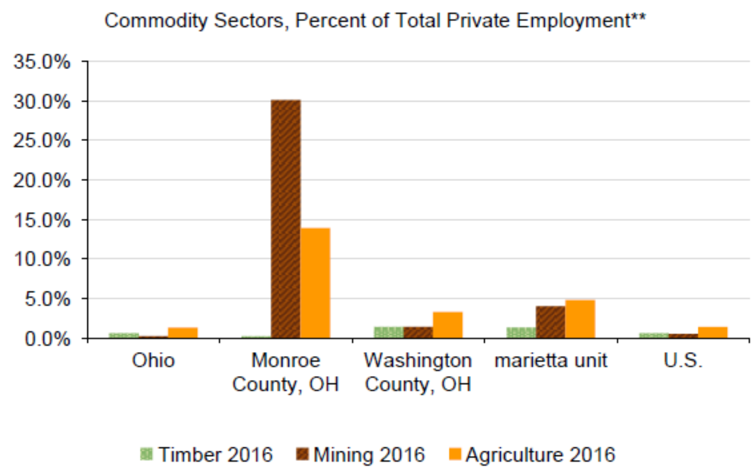
- In 2016, the U.S. had the largest percent of total jobs in industries that include travel and tourism (15.7%), and Ohio had the smallest (14.1%).

- In 2016, accommodations & food* was the largest component of travel and tourism-related employment (11.4% of total jobs) in ironton unit, and passenger transportation* was the smallest (0% of total jobs).

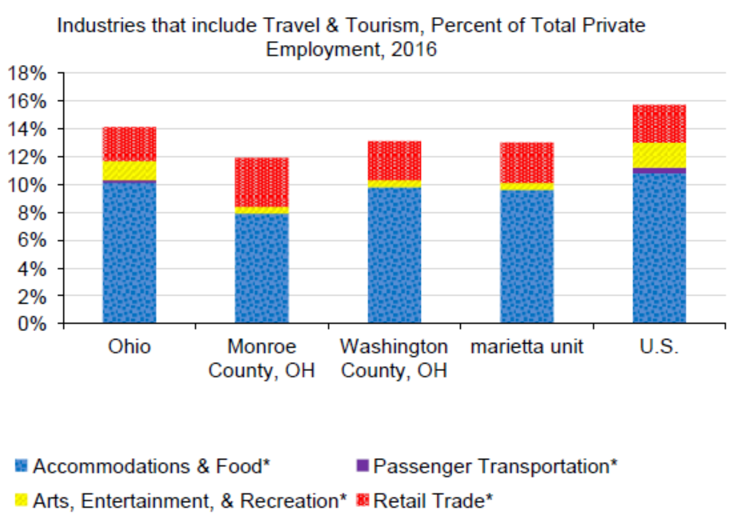


Marietta Unit

- Monroe County, OH had the largest percent of total jobs in commodity sectors (44.2%), and Ohio had the smallest (2.1%).
- Agriculture was the largest component of commodity sector employment (4.8% of total jobs) in the marietta unit, and timber was the smallest component (1.3% of total jobs).



- In 2016, the U.S. had the largest percent of total jobs in industries that include travel and tourism (15.7%), and Monroe County, OH had the smallest (11.9%).
- In 2016, accommodations & food* was the largest component of travel and tourism-related employment (9.6% of total jobs) in marietta unit, and passenger transportation* was the smallest (0% of total jobs).

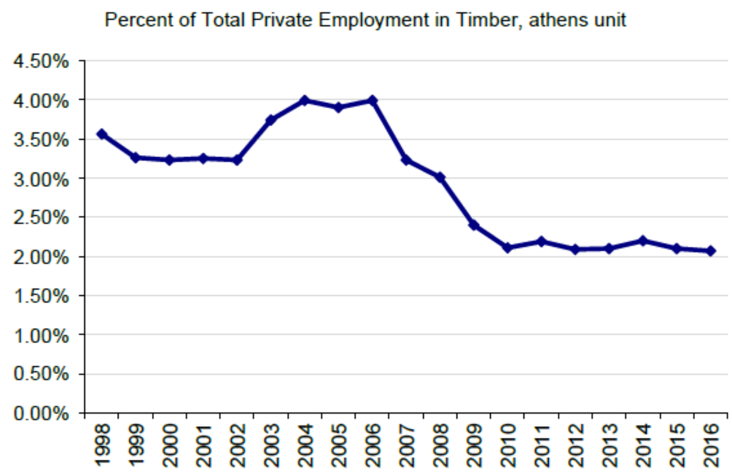


Observations: For all three units, the travel and tourism sector is responsible for the most private employment. This is most pronounced in the Athens Unit where it makes up 23% of private employments. This compares to 2% for timber and mining/oil&gas industries, respectively, and 4% for agriculture.

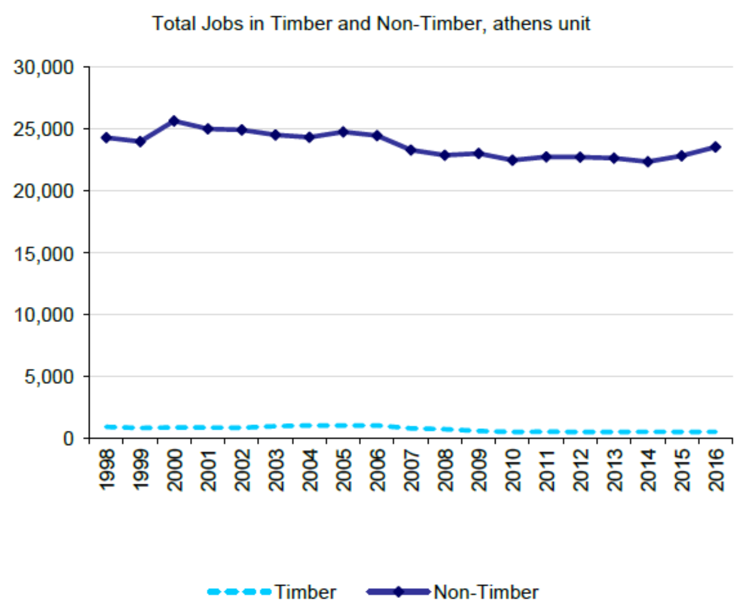
Timber Employment Trends, Timber Report, Page 2

Athens Unit

- In 1998, timber represented 3.56 percent of total employment. By 2016, timber represented 2.07 percent of total employment.

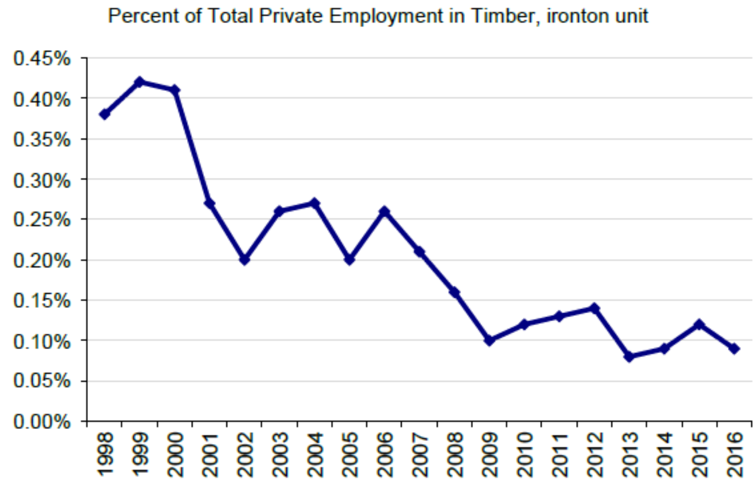


- From 1998 to 2016, timber employment shrank from 897 to 498 jobs, a 44.5 percent decrease.
- From 1998 to 2016, non-timber employment shrank from 24,306 to 23,546 jobs, a 3.1 percent decrease.



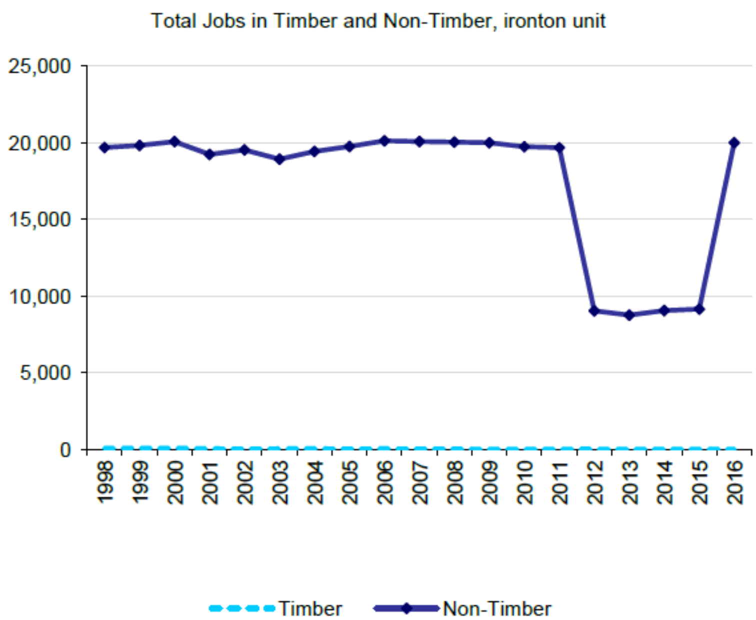
Ironton Unit

- In 1998, timber represented 0.38 percent of total employment. By 2016, timber represented 0.09 percent of total employment.



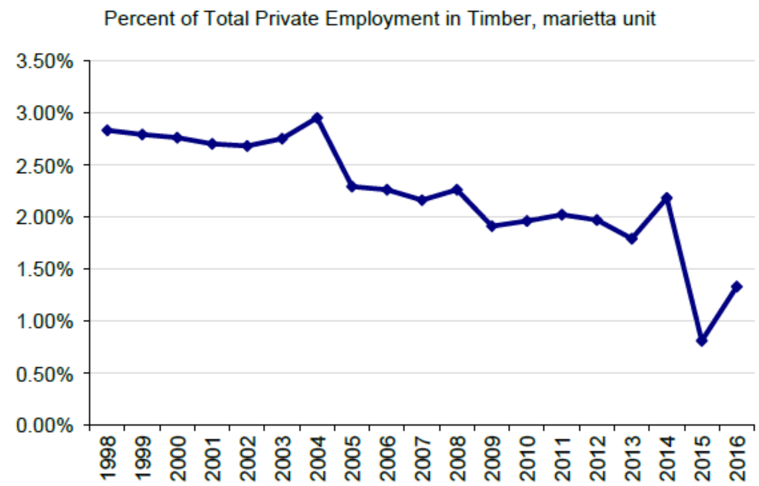
- From 1998 to 2016, timber employment shrank from 75 to 19 jobs, a 74.7 percent decrease.

- From 1998 to 2016, non-timber employment grew from 19,688 to 20,001 jobs, a 1.6 percent increase.



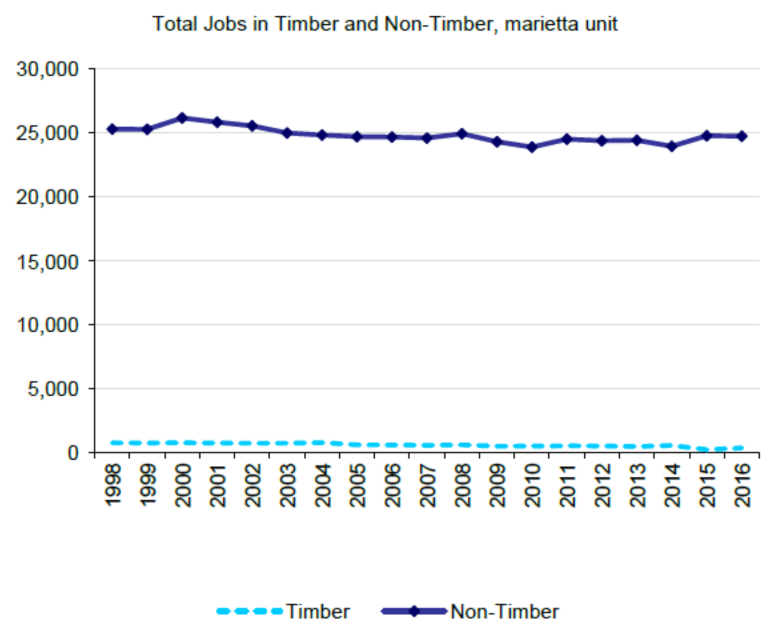
Marietta Unit

- In 1998, timber represented 2.83 percent of total employment. By 2016, timber represented 1.33 percent of total employment.



- From 1998 to 2016, timber employment shrank from 737 to 333 jobs, a 54.8 percent decrease.

- From 1998 to 2016, non-timber employment shrank from 25,299 to 24,743 jobs, a 2.2 percent decrease.

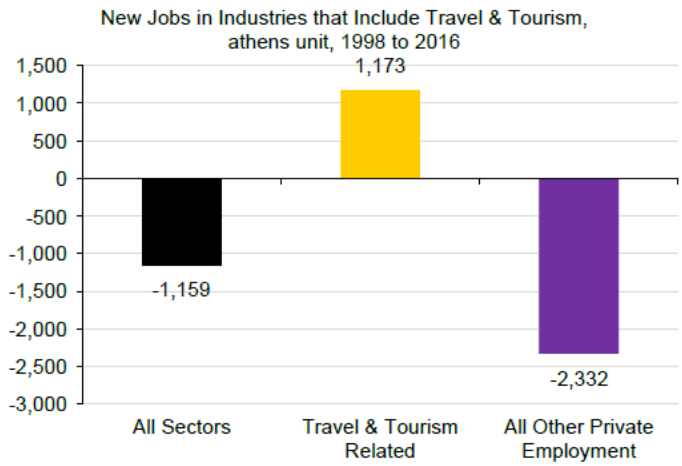


Observations: For all three sub-regions, timber is a very small part of the local economy and is in decline.

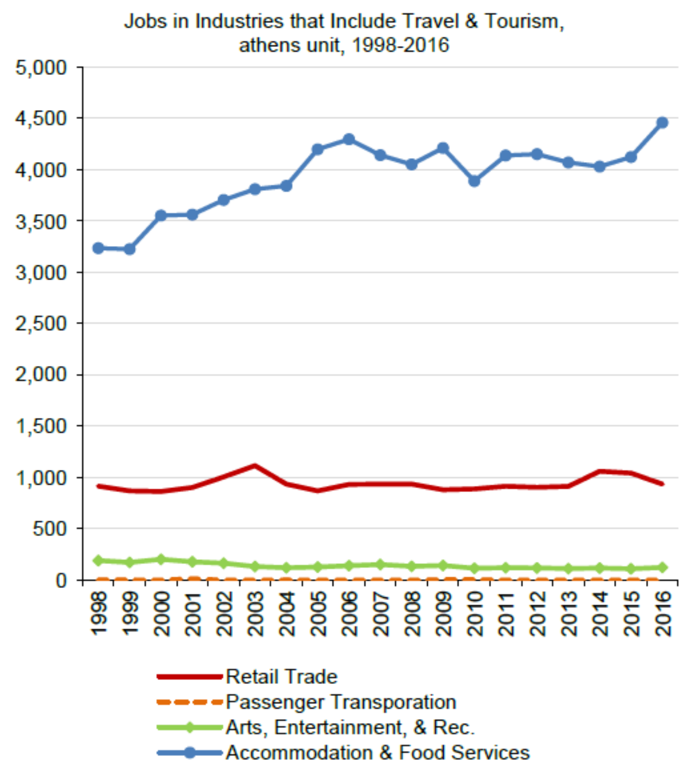
Travel and Tourism Employment Trends, Tourism Report, Page 3

Athens Unit

- From 1998 to 2016, travel & tourism employment grew by 1,173 jobs.
- From 1998 to 2016, non-travel & tourism employment shrank by 2,332 jobs.

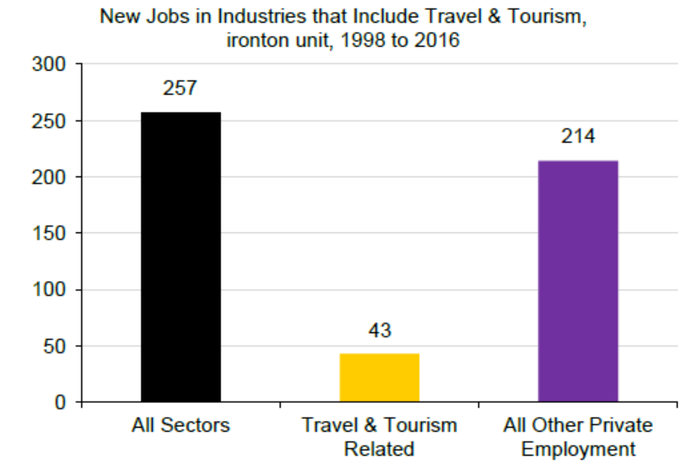


- From 1998 to 2016, retail trade grew from 915 to 935 jobs, a 2.2% increase.
- From 1998 to 2016, passenger transportation shrank from 3 to 1 jobs, a 66.7% decrease.
- From 1998 to 2016, arts, entertainment, and recreation shrank from 191 to 124 jobs, a 35.1% decrease.
- From 1998 to 2016, accommodation and food services grew from 3,232 to 4,454 jobs, a 37.8% increase.

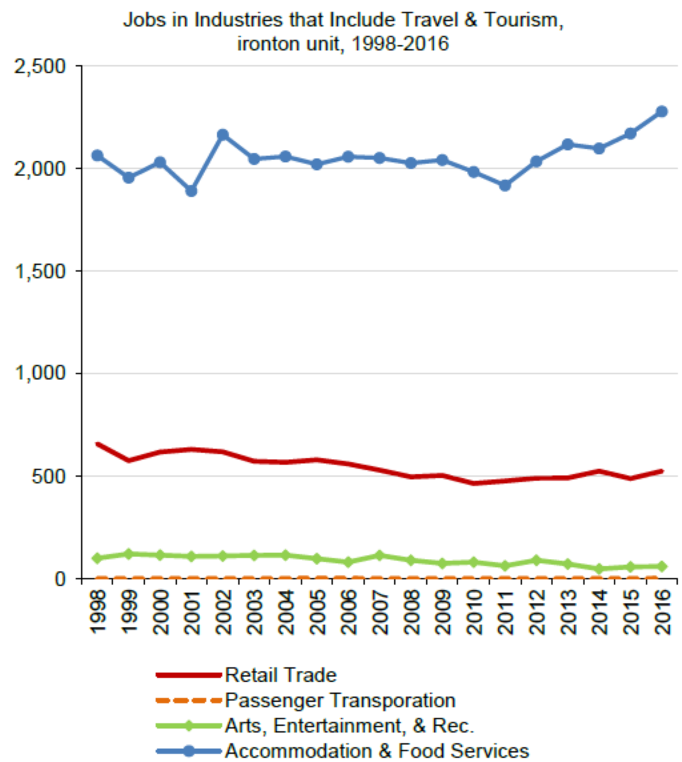


Ironton Unit

- From 1998 to 2016, travel & tourism employment grew by 43 jobs.
- From 1998 to 2016, non-travel & tourism employment grew by 214 jobs.

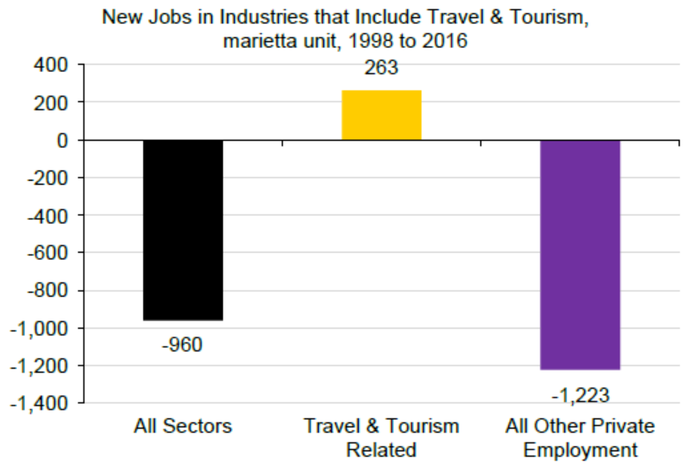


- From 1998 to 2016, retail trade shrank from 656 to 523 jobs, a 20.3% decrease.
- From 1998 to 2016, arts, entertainment, and recreation shrank from 99 to 59 jobs, a 40.4% decrease.
- From 1998 to 2016, accommodation and food services grew from 2,060 to 2,274 jobs, a 10.4% increase.

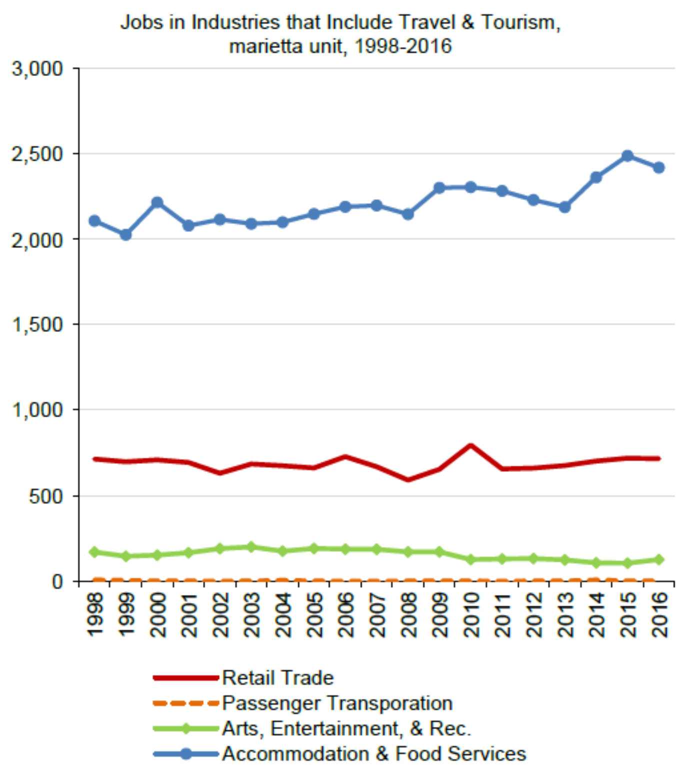


Marietta Unit

- From 1998 to 2016, travel & tourism employment grew by 263 jobs.
- From 1998 to 2016, non-travel & tourism employment shrank by 1,223 jobs.



- From 1998 to 2016, retail trade grew from 714 to 716 jobs, a 0.3% increase.
- From 1998 to 2016, passenger transportation shrank from 8 to 2 jobs, a 75% decrease.
- From 1998 to 2016, arts, entertainment, and recreation shrank from 171 to 127 jobs, a 25.7% decrease.
- From 1998 to 2016, accommodation and food services grew from 2,105 to 2,416 jobs, a 14.8% increase.



Observations: In the Athens and Marietta units, travel and tourism has added jobs over the past two decades while an aggregate of all other sectors showed loss in jobs. The Ironton unit, however, shows both travel and tourism and other sectors gaining jobs, and in fact other sectors grew faster than travel and tourism.

A Summary Profile

athens unit

Selected Geographies:

Athens County, OH; Perry County, OH; Hocking County, OH; Vinton County, OH

Benchmark Geographies:

U.S.

Produced by
Headwaters Economics'
Economic Profile System (EPS)
https://headwaterseconomics.org/eps
December 18, 2018

About the Economic Profile System (EPS)

EPS is a free web tool created by Headwaters Economics to build customized socioeconomic reports of U.S. counties, states, and regions. Reports can be easily created to compare or aggregate different areas. EPS uses published statistics from federal data sources, including the U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

The Bureau of Land Management and Forest Service have made significant financial and intellectual contributions to the operation and content of EPS.

See https://headwaterseconomics.org/eps for more information about the capabilities of EPS. For technical questions, contact Patty Gude at eps@headwaterseconomics.org or telephone 406-599-7425.

HEADWATERS ECONOMICS

headwaterseconomics.org

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions.

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

www.blm.gov

The Bureau of Land Management, an agency within the U.S. Department of Interior, administers 249.8 million acres of America's public lands, located primarily in western states. It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

www.fs.fed.us

The Forest Service, an agency of the U.S. Department of Agriculture, administers national forests and grasslands encompassing 193 million acres. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Summary

athens unit

Table of Contents

Note to Users:

This is one of 14 reports that can be created and downloaded from EPS. Topics include land use, demographics, specific industry sectors, the role of non-labor income, the wildland-urban interface, the role of amenities in economic development, and payments to county governments from federal lands. The EPS reports are downloadable as Excel or PDF documents. See https://headwaterseconomics.org/eps.

Summary

athens unit

Overview

	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
Population, 2016	66,186	35,927	28,340	12,921	143,374	323,127,513
Trends						
Population % change, 1970-2016	18.3%	30.6%	39.0%	37.3%	26.6%	58.6%
Employment % change, 1970-2016	70.4%	35.1%	47.8%	40.6%	56.7%	112.2%
Personal Income % change, 1970-2016	139.6%	149.3%	154.4%	195.1%	149.1%	201.1%
Prosperity						
Unemployment rate, 2017	6.0%	5.9%	5.3%	6.9%	5.9%	4.4%
Average earnings per job, 2016 (2017 $s)	$45,194	$38,470	$37,810	$39,287	$42,273	$59,598
Per capita income, 2016 (2017 $s)	$32,859	$35,019	$35,420	$31,832	$33,814	$50,280
Economy						
Non-Labor % of personal income, 2016	40.8%	38.2%	41.7%	46.6%	40.8%	36.8%
Services % of employment, 2016	54.2%	~42.9%	59.9%	~46.4%	~52.8%	72.9%
Government % of employment, 2016	36.6%	16.8%	17.9%	20.3%	28.6%	12.5%
Use Sectors^						
Timber % of private employment, 2016	~0.1%	~0.5%	~4.4%	~13.8%	~2.1%	0.6%
Mining % of private employment, 2016	0.1%	9.9%	0.2%	~4.6%	~2.1%	0.5%
Fossil fuels (oil, gas, & coal), 2016	~0.0%	~7.5%	~0.1%	~4.4%	~1.7%	0.4%
Other mining, 2016	~0.1%	~1.7%	~0.2%	~0.8%	~0.5%	0.3%
Agriculture % of employment, 2016	2.2%	7.1%	3.4%	6.6%	3.5%	1.4%
Travel & Tourism % of private emp., 2016	~26.4%	~13.7%	~24.5%	~14.6%	~22.9%	15.8%
Federal Land*						
Federal Land % total land ownership	5.8%	8.5%	9.6%	0.7%	6.1%	28.2%
Forest Service %	5.8%	8.5%	9.6%	0.7%	6.1%	8.4%
BLM %	0.0%	0.0%	0.0%	0.0%	0.0%	10.6%
Park Service %	0.0%	0.0%	0.0%	0.0%	0.0%	3.4%
Military %	0.0%	0.0%	0.0%	0.0%	0.0%	1.0%
Other %	0.0%	0.0%	0.0%	0.0%	0.0%	4.9%
Federal land % Type A**	0.0%	0.0%	0.0%	0.0%	0.0%	41.8%
Federal payments % of gov. revenue, FY201	0.1%	0.2%	0.1%	0.0%	0.1%	
Development						
Residential area % change, 2000-2010	10.0%	26.6%	14.8%	16.5%	16.0%	12.3%
Wildland-Urban Interface % developed, 2010	na	na	na	na	na	16.3%

Estimates for data that were not disclosed are indicated with tildes (~).

^Data for timber, mining, and travel and tourism-related are from County Business Patterns which excludes proprietors, and data for agriculture are from Bureau of Economic Analysis which includes proprietors.

* The land ownership data source and year vary depending on the selected geography. See following pages for specifics.

** Federal public lands that are managed primarily for natural, cultural, and recreational features. These lands include National Parks and Preserves (NPS), Wilderness (NPS, FWS, FS, BLM), National Conservation Areas (BLM), National Monuments (NPS, FS, BLM), National Recreation Areas (NPS, FS, BLM), National Wild and Scenic Rivers (NPS), Waterfowl Production Areas (FWS), Wildlife Management Areas (FWS), Research Natural Areas (FS, BLM), Areas of Critical Environmental Concern (BLM), and National Wildlife Refuges (FWS).

Data Sources: Various; see following pages for specifics.

Summary

athens unit

Overview

What do we measure on this page?

Using summary statistics from topical EPS reports, this page compares socioeconomic indicators[1] of the selected area to a benchmark.

Trends: General indicators of economic well-being (population, employment, and real personal income) measured over time.

Prosperity: Common indicators of individual well-being or hardship (unemployment, average earnings per job, and per capita income).

Economy: Three significant sectors of the economy: non-labor income (e.g., government transfer payments, and investment and retirement income), services, and government employment.

Use Sectors: Components of the economy (commodity sectors including timber, mining and agriculture, and industries that include travel and tourism) that could be associated with the use of public lands.

Federal Land: The amount and type of federal land ownership, and the dependence of county governments on payments related to federal lands such as National Park Service (NPS), Forest Service (FS), Bureau of Land Management (BLM), and Fish and Wildlife Service (FWS).

Development: Residential development of private lands, including the wildland-urban interface. The wildland-urban interface data are available and reported only for the 11 western states and do not include Alaska and Hawaii.

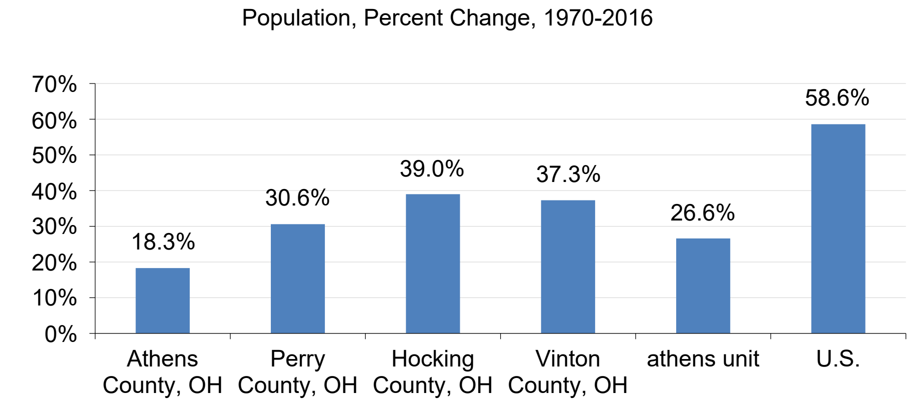
Why is it important?

This report allows the user to compare a broad range of socioeconomic measurements. A user can refer to EPS topic-specific reports for more details. For example, when a county shows unusually high unemployment rates, a user may want to create an EPS Socioeconomic Measures report for that county. Or an EPS Timber report could be created for a county that shows a relatively high number of people employed in the timber industry.

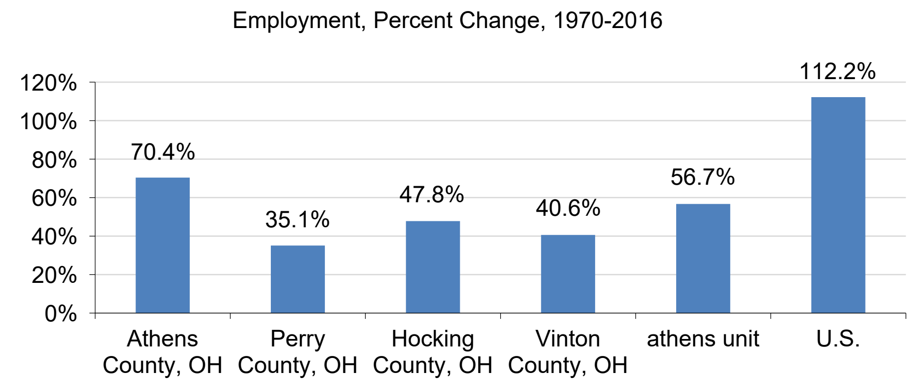
This report uses information from the following EPS reports: Socioeconomic Measures, Demographics, Agriculture, Mining, Services, Tourism, Government, Non-Labor Income, Timber, Land Use, Public Land Amenities, Wildland-Urban Interface, and Federal Land Payments. Consult these reports directly for additional information at https://headwaterseconomics.org/eps.

Population, Employment, and Personal Income

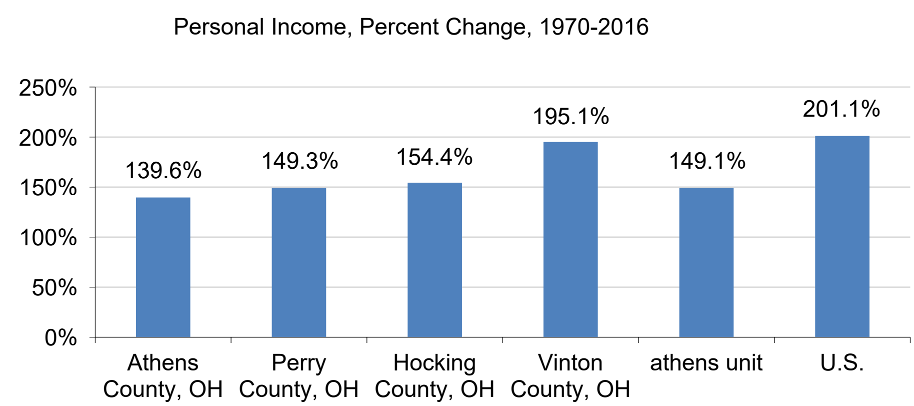
- Between 1970 and 2016, the U.S. had the largest percent change in population (58.6%), and Athens County, OH had the smallest (18.3%).



- Between 1970 and 2016, the U.S. had the largest percent change in employment (112.2%), and Perry County, OH had the smallest (35.1%).



- Between 1970 and 2016, the U.S. had the largest percent change in personal income (201.1%), and Athens County, OH had the smallest (139.6%).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.

Population, Employment, and Personal Income

What do we measure on this page?

This page describes percent change in population, employment, and real personal income.

The EPS Demographics report provides additional information on population dynamics, while the EPS Socioeconomic Measures report provides additional information on employment and personal income. See https://headwaterseconomics.org/eps.

The Bureau of Economic Analysis reports data either by place of residence or by place of work. Population and personal income data on this page are reported by place of residence, and employment data by place of work.[2]

Why is it important?

One measure of economic performance is whether a location is growing or declining. Standard measures of growth and decline are population, employment, and real personal income.

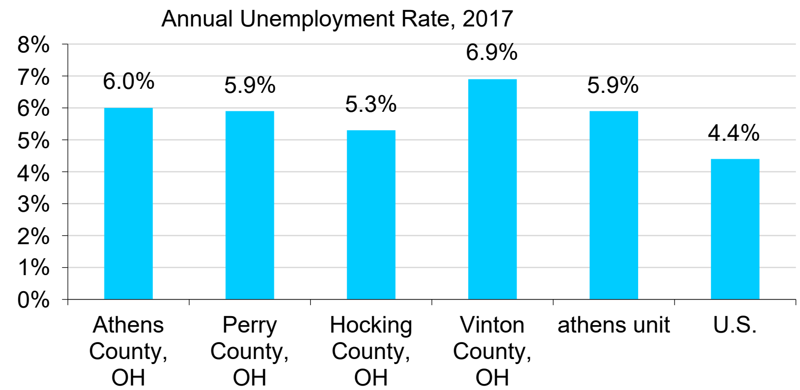
The information on this page helps users understand whether locations are growing or declining at different rates, and makes it easy to see discrepancies between changes in population, employment, and real personal income. If population and employment are growing faster than real personal income, for example, it may be worthwhile to research whether growth has been in low-wage industries and occupations. Alternatively, if personal income is growing faster than employment, it may be caused by growth in high-wage industries and occupations and/or non-labor income sources.

Summary

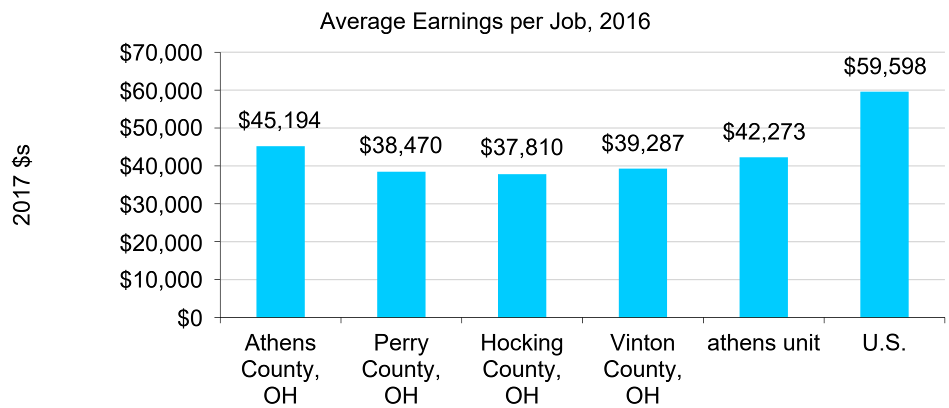
athens unit

Unemployment, Earnings, and Per Capita Income

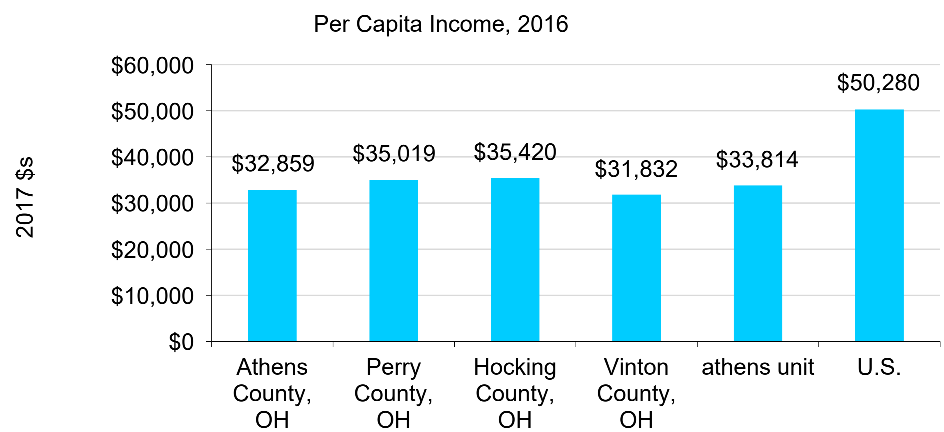
- In 2017, Vinton County, OH had the highest unemployment rate (6.9%), and the U.S. had the lowest (4.4%).



- In 2016, the U.S. had the highest average earnings per job ($59,598), and Hocking County, OH had the lowest ($37,810).



- In 2016, the U.S. had the highest per capita income ($50,280), and Vinton County, OH had the lowest ($31,832).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Labor. 2018. Bureau of Labor Statistics, Local Area Unemployment Statistics, Washington, D.C.

Unemployment, Earnings, and Per Capita Income

What do we measure on this page?

This page describes three measures of individual prosperity: unemployment, average earnings per job, and per capita income.[1]

Unemployment Rate: The number of people who are jobless, looking for jobs, and available for work divided by the labor force.[3]

Average Earnings per Job: Total earnings divided by total employment. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included.

Per Capita Income: Total personal income (from labor and non-labor sources) divided by total population.

Why is it important?

Statistics presented on this page are important indicators of economic well-being.

The annual unemployment rate is the number of people actively seeking but not finding work as a percent of the labor force. This figure can go up during national recessions and/or when more localized economies are affected by area downturns. Seasonal variations in unemployment can be viewed in the EPS Socioeconomic Measures report at https://headwaterseconomics.org/eps.

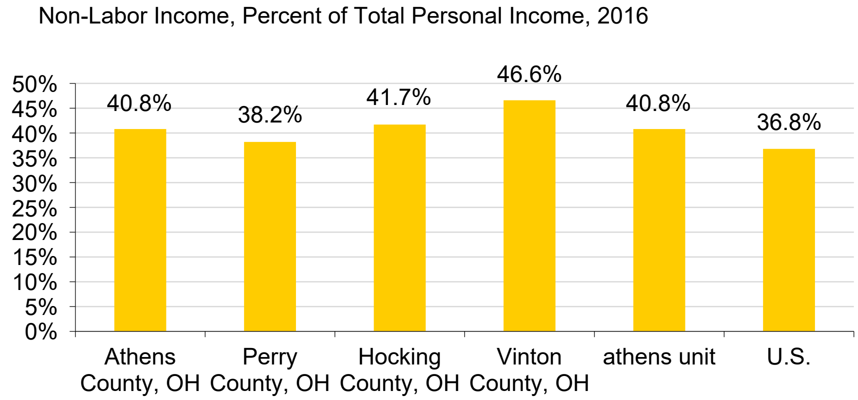
Average earnings per job is an indicator of the quality of local employment. A higher average earning per job indicates relatively more high-wage occupations.[4] It can be useful to consider earnings against local cost of living indicators.

Per capita income is one of the most important measures of economic well-being. However, it can be misleading. Per capita income is total personal income divided by population. Because per capita income is calculated using total population and not the labor force, per capita income can be relatively low when a disproportionate number of children and/or elderly people are in the population. And because total personal income includes non-labor income sources, per capita income can be relatively high due to the presence of retirees and people with investment income. To investigate the impact of non-labor income sources on total personal income, create the EPS Non-Labor report at https://headwaterseconomics.org/eps.

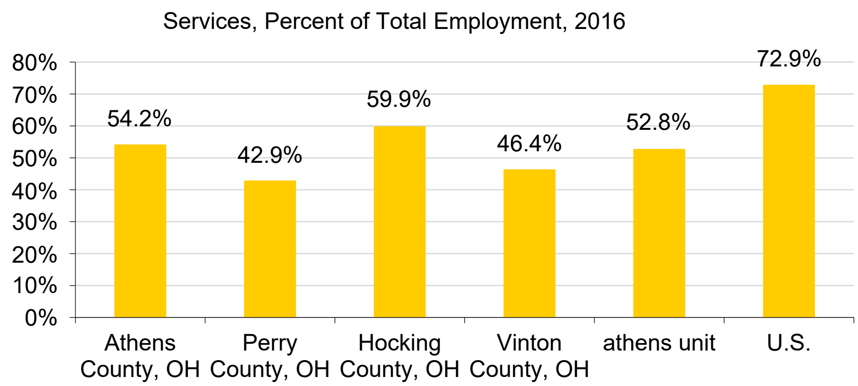
To see how these measurements have changed over time, create an EPS Socioeconomic Measures report at https://headwaterseconomics.org/eps.

Non-Labor Income, Services, and Government

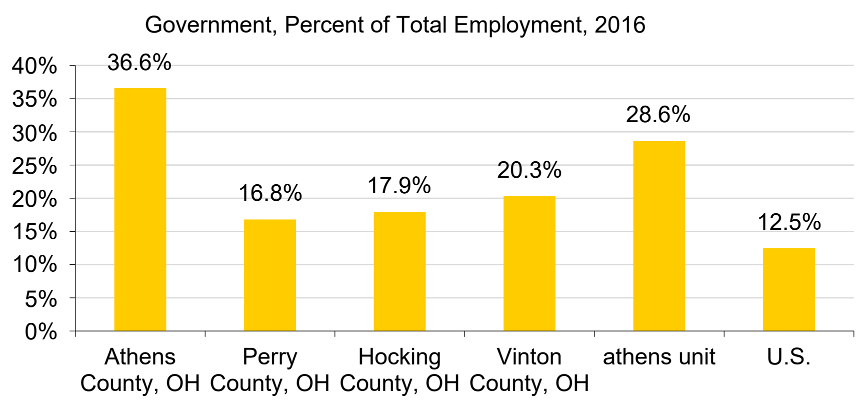
- In 2016, Vinton County, OH had the largest percent of total personal income from non-labor income sources (46.6%), and the U.S. had the smallest (36.8%).



- In 2016, the U.S. had the largest percent of total jobs in services (72.9%), and Perry County, OH had the smallest (42.9%).



- In 2016, Athens County, OH had the largest percent of total jobs in government (36.6%), and the U.S. had the smallest (12.5%).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.

Non-Labor Income, Services, and Government

What do we measure on this page?

This page describes non-labor income and employment in services and government.[1]

Non-Labor Income: Dividends, interest and rent (money earned from investments), and transfer payments (includes government retirement and disability insurance benefits, medical payments such as Medicare and Medicaid, income maintenance benefits, unemployment insurance benefits, etc.). Non-labor income is reported by place of residence.

Services: Employment in the following sectors: Utilities, Wholesale Trade, Retail Trade, Transportation & Warehousing, Information, Finance & Insurance, Real Estate & Rental & Leasing, Professional & Scientific & Tech., Management of Companies & Enterprises, Administrative & Support Services, Educational Services, Health Care & Social Assistance, Arts & Entertainment & Recreation, Accommodation & Food Services, and Other Services.

Government: Employment in federal, state, and local government agencies and government enterprises.

For more detailed information about the role of non-labor income, service industry employment, and government employment in the economy, create an EPS Non-Labor report, an EPS Services report, or an EPS Government report at https://headwaterseconomics.org/eps.

Why is it important?

In many counties, non-labor income (for example, retirement and investment income, government transfer payments) can be more than a third of all personal income. As the Baby Boomer generation retires, this source of income will continue to grow. A high dependence on non-labor income can indicate a location with an aging population and/or attractiveness to people with investment income. In some cases, it can also signal hardship, such as when there is a high dependence on Medicaid and income maintenance payments.

Nationally, services account for more than 95 percent of the growth in new jobs since 2000. Despite the strong growth of employment in services, the term "services" is often misunderstood. Services consist of a wide mix of jobs including high-wage, high-skilled occupations (e.g., doctors, engineers, software developers) and low-wage, low-skilled occupations (e.g., restaurant workers, tour bus operators). The service sector typically provides services, such as banking and education, rather than creating tangible objects. However, many service sectors such as utilities, engineering, and architecture are closely associated with goods-producing sectors.

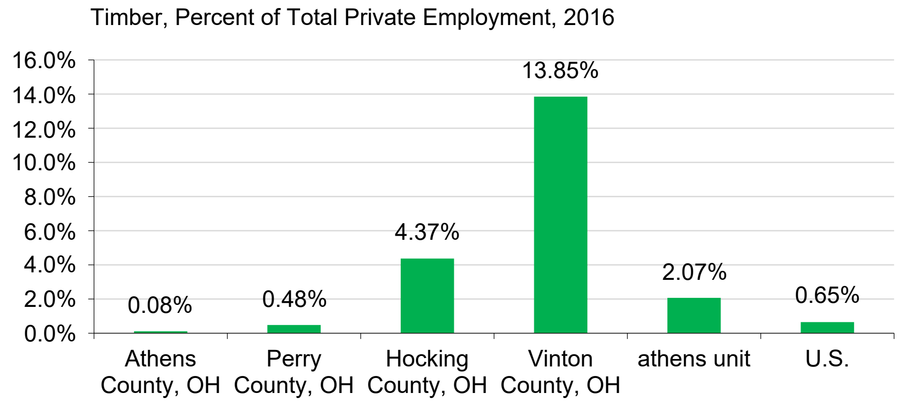
Government can be a major employer in some locations, particularly in rural areas and locations with significant government facilities such as federal land management offices, military bases, prisons, or research facilities. Changes in government employment tend to track population trends. Local government often accounts for much of job growth in the government sector as additional services are demanded by a growing population.

Summary

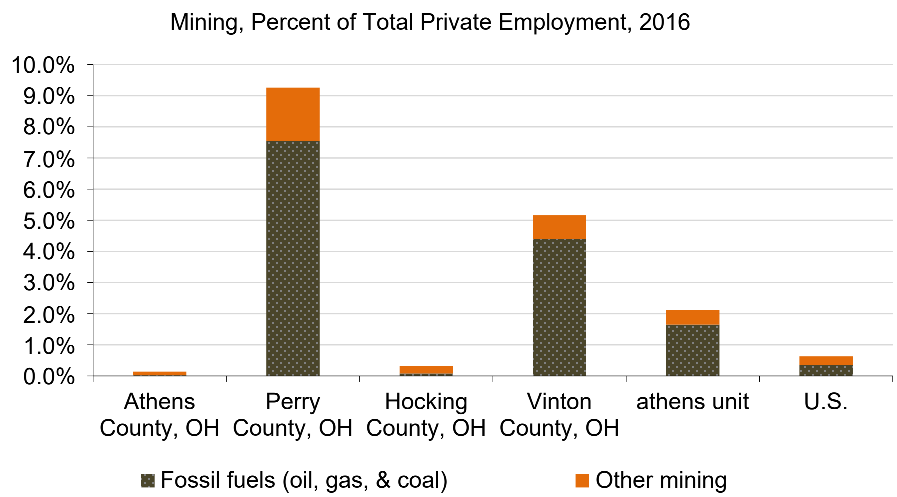
athens unit

Employment in Commodity Sectors

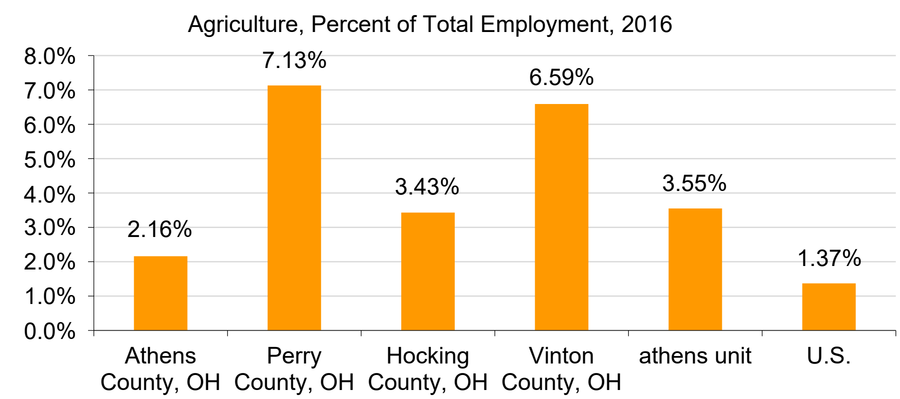
- In 2016, Vinton County, OH had the largest percent of total jobs in timber (13.85%), and Athens County, OH had the smallest (0.08%).



- In 2016, Perry County, OH had the largest percent of total jobs in mining of fossil fuels (7.54%), and Athens County, OH had the smallest (0.02%).
- In 2016, Perry County, OH had the largest percent of total jobs in mining unrelated to fossil fuels (1.72%), and Athens County, OH had the smallest (0.12%).



- In 2016, Perry County, OH had the largest percent of total jobs in agriculture (7.13%), and the U.S. had the smallest (1.37%).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Employment in Commodity Sectors

What do we measure on this page?

This page describes employment[1] in three commodity sectors: timber, mining (minerals, oil, gas, and coal), and agriculture. These are sectors of the economy that extract commodities from land (for example, timber harvesting, energy development, and grazing).

Timber: Employment associated with growing and harvesting trees, employment at sawmills and paper mills, and wood products manufacturing.

Mining: Employment associated with oil and gas extraction, coal mining, metals mining, and nonmetallic minerals mining.

Agriculture: Employment associated with all forms of agriculture, including farming and ranching.

County Business Patterns (CBP)[5] are used in EPS reports as a data source for timber and mining because this data set has fewer data gaps compared to other sources.

The Bureau of Economic Analysis (BEA) is used as the data source for agriculture because CBP data do not include agriculture. However, the BEA data include proprietors, which are not included in CBP data. As a result, the data for agriculture are not strictly comparable to data for timber and mining. The latest year for each data source may vary due to different data release schedules.

For more detailed information about commodity sectors and for industry definitions, create an EPS Timber, Mining, or Agriculture report at https://headwaterseconomics.org/eps.

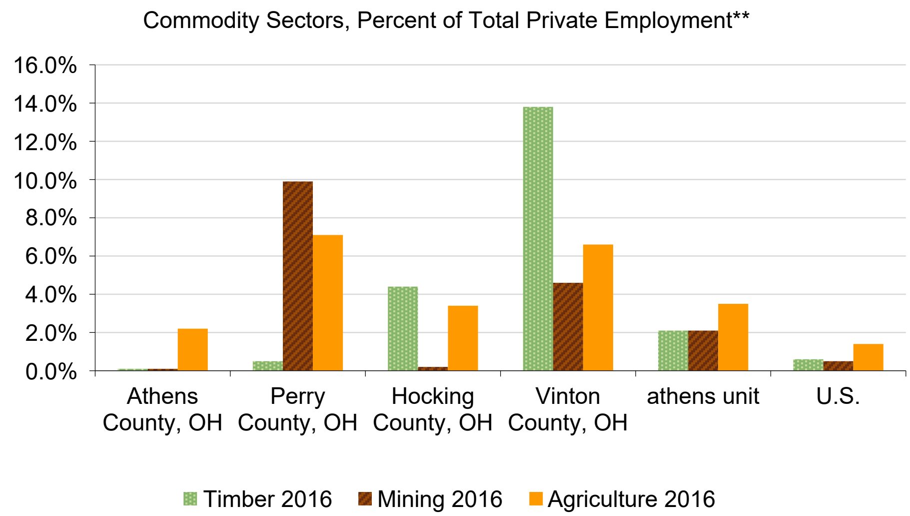
Why is it important?

Opportunities for commodity extraction can stimulate local employment.

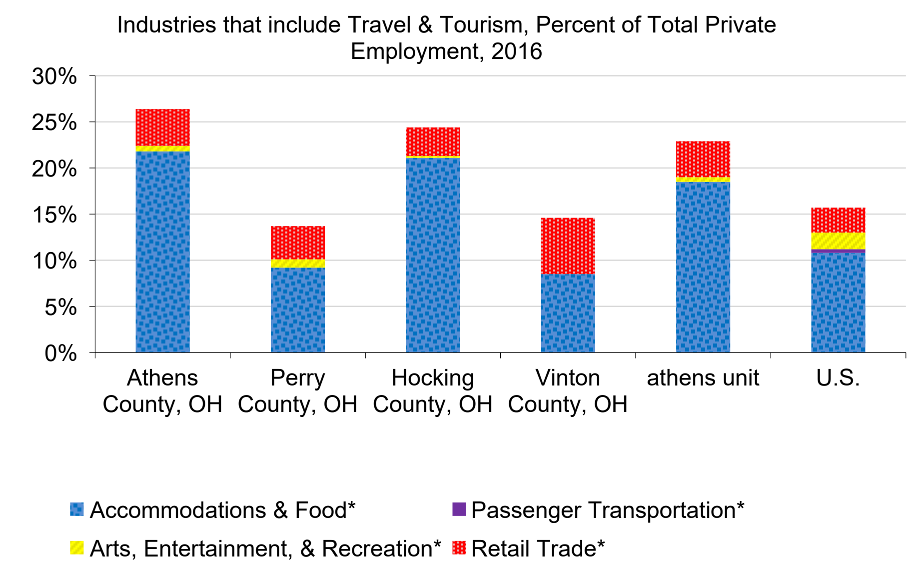
Timber industries, mining—including fossil fuel development (oil, natural gas, and coal)—and farming and ranching play important roles in some locations. Information on this page helps explain whether that is the case in the locations selected, and whether locations differ from one another.

Employment in Commodities, Travel & Tourism

- Vinton County, OH had the largest percent of total jobs in commodity sectors (25%), and Athens County, OH had the smallest (2.4%).
- Agriculture was the largest component of commodity sector employment (3.5% of total jobs) in the athens unit, and timber was the smallest component (2.1% of total jobs).



- In 2016, Athens County, OH had the largest percent of total jobs in industries that include travel and tourism (26.4%), and Perry County, OH had the smallest (13.7%).
- In 2016, accommodations & food* was the largest component of travel and tourism-related employment (18.5% of total jobs) in athens unit, and passenger transportation* was the smallest (0% of total jobs).



* Charted values do not represent the entirety of these sectors, rather their components typically related to travel & tourism.

** Data for timber and mining are from County Business Patterns which excludes proprietors, government, agriculture, and railroad. Data for agriculture are from Bureau of Economic Analysis. The latest year for each data source may vary due to different data release schedules.

Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Employment in Commodities, Travel & Tourism

What do we measure on this page?

This page describes employment for commodity sectors and for industries that are associated with travel and tourism.

Commodity Sectors: Employment in timber, mining (including oil, gas, and coal), and agriculture.

Travel and Tourism: Employment in sectors that provide goods and services to visitors as well as to the local population. These industries are: Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services. There is no single industrial classification for travel and tourism under the North American Industrial Classification System (NAICS). The exact proportion of jobs in these sectors attributable to expenditures by visitors, including business and pleasure travelers, is not known without additional research such as surveys.

County Business Patterns (CBP)[5] are used in EPS reports as a data source for timber and mining because this data set has fewer data gaps[1] compared to other sources.

The Bureau of Economic Analysis (BEA) is used as a data source for agriculture because CBP data do not include agriculture. However, the BEA data include proprietors, which are not included in CBP data. As a result, the data for agriculture are not strictly comparable to data for timber and mining. The latest year for each data source may vary due to different data release schedules.

For more detailed information about commodity sectors and for industry definitions, create an EPS Timber, Mining, or Agriculture report. For more information about the tourism-related components of the economy, create an EPS Tourism report at https://headwaterseconomics.org/eps.

Why is it important?

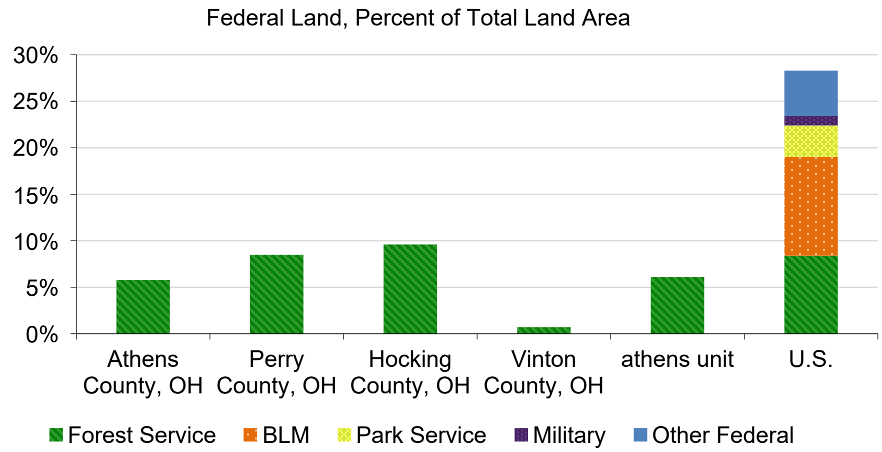
Commodity extraction can stimulate local employment. It is important to understand the relative size of sectors to put the commodity-related economy into perspective. For example, decisions that permit (or restrict) timber, mining, and grazing activities have a higher chance of impacting a county with a high percentage of its employment in the commodity sectors.

Tourism and recreation can stimulate local employment. Communities can benefit directly from visitors who spend money in hotels, restaurants, ski resorts, gift shops, and elsewhere. Tourism can also help communities retain and attract capital and spur transitions to move diverse economies. This report can be used to understand whether travel-and tourism-related economic activity is present and whether there are differences between locations.

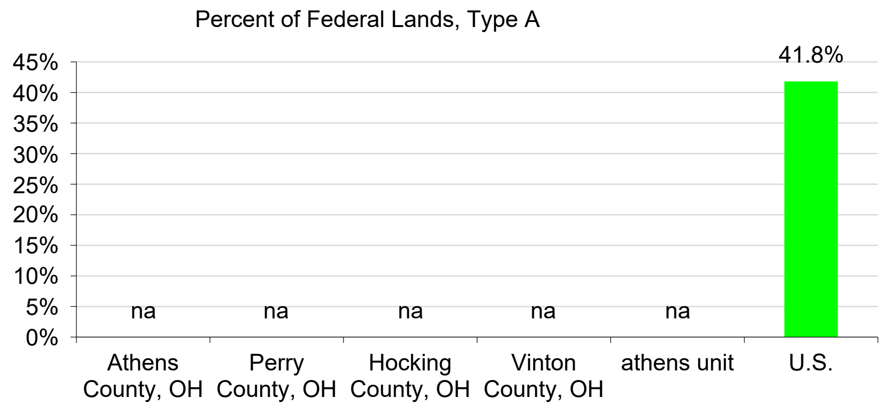
Federal Lands and Federal Land Payments

- The U.S. had the largest percent of total land area in federal ownership (28.2%), and Vinton County, OH had the smallest (0.7%).

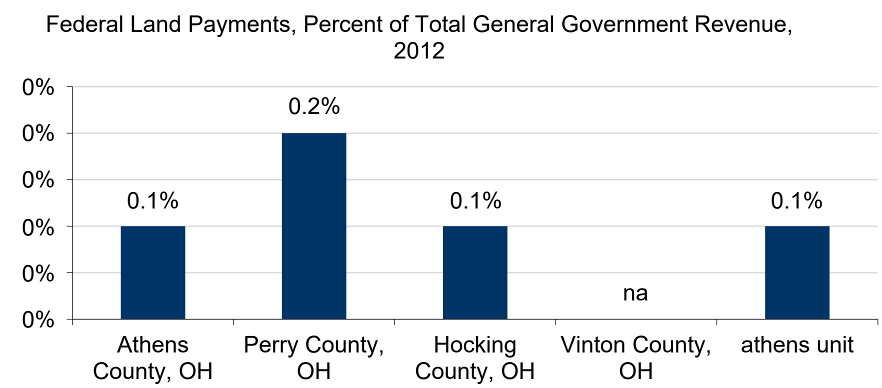
- Forest Service lands were the largest component of federal land ownership (6.1%) in athens unit, and BLM lands were the smallest (0%).



- The U.S. had the largest percent of federal lands in Type A (41.8%), and Athens County, OH had the smallest (0%).



- In FY 2012, Perry County, OH had the largest percent of total general government revenue from federal land payments (0.2%), and Vinton County, OH had the smallest (0%).



Data Sources: NASA MODIS Land Cover Type Yearly L3 Global 1km MOD12Q1, 2006; U.S. Geological Survey, Gap Analysis Program. 2016. Protected Areas Database of the United States (PADUS) version 1.4; U.S. Department of Commerce. 2014. Census Bureau, Governments Division, Washington, D.C.

Federal Lands and Federal Land Payments

What do we measure on this page?

This page describes differences in the percent of federal land ownership by agency; the share of federal lands managed primarily for natural, cultural, and recreational features; and the percent of county revenue derived from payments related to federal lands.

Type A Federal Lands: Federal public lands that are managed primarily for natural, cultural, and recreational features. There can be exceptions (for example, oil and gas development within a National Monument area), but generally Type A lands are less likely to be used for commodity production than other federal land types. Type A lands include National Parks and Preserves (NPS), Wilderness (NPS, FWS, FS, BLM), National Conservation Areas (BLM), National Monuments (NPS, FS, BLM), National Recreation Areas (NPS, FS, BLM), National Wild and Scenic Rivers (NPS), Waterfowl Production Areas (FWS), Wildlife Management Areas (FWS), Research Natural Areas (FS, BLM), Areas of Critical Environmental Concern (BLM), and National Wildlife Refuges (FWS). These definitions of land classifications are not legal or agency-adopted classifications—they are only provided for comparative purposes.

NPS = National Park Service; FS = Forest Service; BLM = Bureau of Land Management; FWS = Fish & Wildlife Service.

For additional information about land ownership and development patterns, create an EPS Land Use report. The EPS Public Land Amenities report provides additional information about the role of environmental amenities in economic development; see https://headwaterseconomics.org/eps.

Federal Land Payments: Federal payments that compensate state and local governments for non-taxable federal lands within their borders. Payments are funded by federal appropriations (e.g., PILT), from receipts received by federal agencies from activities on federal public lands (e.g., timber, grazing, and minerals), and from other programs such as the Secure Rural Schools & Community Self-Determination Act.

For additional information about the importance of federal payments to counties, create an EPS Federal Land Payments report at https://headwaterseconomics.org/eps.

Why is it important?

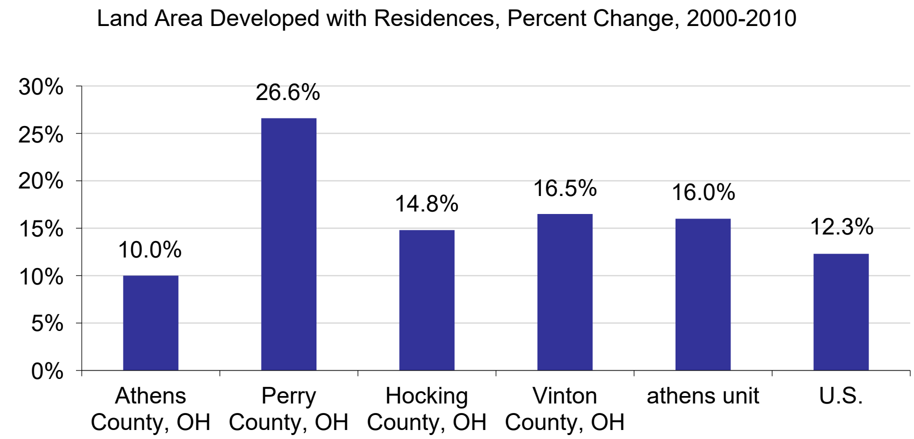
Understanding the composition of land ownership and management in an area is important because actions on federal lands may affect the local economy, particularly when federal lands are a large portion of the land base.

Some Type A federal public lands prohibit most forms of commercial use and development. These lands include national parks, wilderness areas, and national monuments. Because these lands are managed primarily for their non-commercial values (i.e., scenery, wildlife, recreation), they potentially play a different economic role than public lands more commonly associated with commodity sectors.[6, 7]

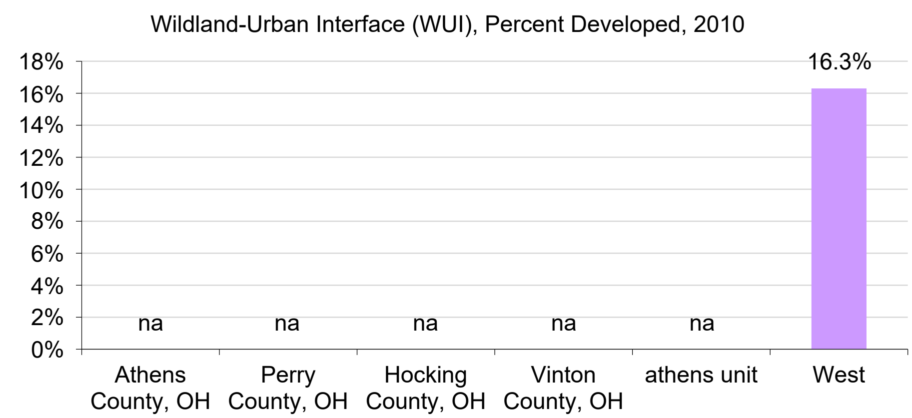
Locations with federal public lands receive government payments—for example, funding through Payments in Lieu of Taxes (PILT), the 25% Fund, or the Secure Rural Schools and Community Self-Determination Act. When these payments are a significant portion of the local county's budget, activities on public lands may affect the fiscal well-being of a county.[8]

Development and the Wildland-Urban Interface

- Between 2000 and 2010, Perry County, OH had the largest percent change in residential land area developed (26.6%), and Athens County, OH had the smallest (10%).



- In 2010, the west had the largest proportion of the wildland-urban interface that is developed (16.3%), and the west had the smallest (16.3%).



Data Sources: Theobald, DM. 2013. Land use classes for ICLUS/SERGoM v2013. Unpublished report, Colorado State University; Gude, P.H., Rasker, R., and van den Noort, J. 2008. Potential for Future Development on Fire-Prone Lands. Journal of Forestry 106(4):198-205; U.S. Department of Commerce. 2011. TIGER/Line 2010 Census Blocks and 2010 Summary File 1, Washington, D.C.

Development and the Wildland-Urban Interface

What do we measure on this page?

This page describes residential development on private lands, and the proportion of the wildland-urban interface (WUI) that is developed.[9] The EPS Land Use report provides additional information on land ownership, management, cover, and development: https://headwaterseconomics.org/eps.

This information is available only for the 11 western states and does not include Alaska and Hawaii.

Wildland-Urban Interface (WUI): Private forestlands that are within 500 meters of public forestlands. We use the threshold of 500 meters to identify the existing and potential WUI area because guidelines for the amount of defensible space necessary to protect homes from wildfire range from 40 to 500 meters around a home. We focus on adjacency to public forests because roughly 70 percent of western forests are publicly owned and because wildfire is a natural disturbance in many of these forests, creating a potential risk to adjacent private lands.[10]

Why is it important?

The conversion of open space and agricultural land to residential development has occurred at a rapid pace in many parts of the U.S. The popularity of exurban lot sizes in much of the country has exacerbated this trend. (Low-density development results in a larger area of land converted to residential development). The pattern of development can reflect a number of factors, including demographic trends, the increasingly "footloose" nature of economic activity, the availability and price of land, and preferences for homes on larger lots. Locations with a large percent change in the area of residential development often have experienced significant in-migration from more urbanized areas. Counties with a small percent change either experienced little growth or were already highly urbanized in 2000.

Development of homes adjacent to fire-prone federal public lands poses several challenges including the rising cost of protecting homes from wildfires; increased danger to wildland firefighters; and the consumption of funds that might otherwise be used for restoration, recreation, research, and other activities. When protecting homes is a priority, agencies are unable to allow otherwise beneficial fires to burn, even those that could reduce fuel loads.

Data Sources & Methods

This EPS Summary report uses national statistics from public government sources. All data used in EPS can be readily verified with the original sources:

- **County Business Patterns**
  Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/cbp.html
  Contacts
  https://www.census.gov/about/contact-us.html

- **Regional Economic Information Data**
  Bureau of Economic Analysis, U.S. Department of Commerce
  https://www.bea.gov/iTable/index_regional.cfm
  Contacts
  https://www.bea.gov/contacts/search.htm

- **Local Area Unemployment Statistics**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/lau/
  Contacts
  https://www.bls.gov/bls/contact.htm

The EPS Summary report also uses data derived from Geographic Information Systems (GIS) to show more accurate statistics for land ownership:

- **TIGER/Line County Boundaries**
  Bureau of the Census, U.S. Department of Commerce
  https://www.census.gov/geo/maps-data/data/tiger.html

- **Protected Areas Database**
  U.S. Geological Survey, Gap Analysis Program
  https://gapanalysis.usgs.gov/padus/

EPS core approaches
EPS is designed to focus on long-term trends across a range of important measures. Trend analysis provides a more comprehensive view of changes than spot data for select years. We encourage users to focus on major trends rather than absolute numbers. EPS displays detailed industry-level data to show changes in the composition of the economy over time and the mix of industries at points in time. EPS employs cross-sectional benchmarking – comparing smaller areas such as counties to larger regions, states, and the nation – to give a sense of relative performance. EPS allows users to aggregate data for multiple locations to allow for more sophisticated cross-sectional comparisons.

Adjusting dollar figures for inflation
Because a dollar in the past was worth more than a dollar today, data reported in current dollar terms should be adjusted for inflation. The U.S. Department of Commerce reports personal income figures in terms of current dollars. All income data in EPS are adjusted to real (or constant) dollars using the Consumer Price Index. Figures are adjusted to the latest date for which the annual Consumer Price Index is available.

Data gaps and estimation
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses supplemental data from the U.S. Department of Commerce to estimate these data gaps. These are indicated with tildes (~) in tables. Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

Endnotes

1 - Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics estimates these data gaps. Estimates are indicated with tildes (~). Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

2 - For details on Bureau of Economic Analysis terms, see: https://bea.gov/regional/definitions.

3 - For more information on unemployment, see the Bureau of Labor Statistics resources on this topic at https://www.bls.gov/bls/unemployment.htm.

4 - The Monthly Labor Review Online, published by the Bureau of Labor statistics, addresses earnings and wages by industry, sex, and educational achievement. Search at https://www.bls.gov/mlr/.

5- Data from County Business Patterns includes both full- and part-time employment. However, CBP data do not include employment in government, agriculture, railroads, or the self-employed and, as a result, under-count the size of industry sectors. Also, CBP data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing relationships between sectors over time.

6 - For examples of literature on the economic role of environmental amenities, see: Booth DE. 1999. Spatial Patterns in the Economic Development of the Mountain West. Growth and Change 30(3):384-405; Duffy-Deno KT. 1998. The Effect of Federal Wilderness on County Growth in the Intermountain Western United States. Journal of Regional Science 38(1):109-136; Lorah P and Southwick R. 2003. Environmental Protection, Population Change, and Economic Development in the Rural Western United States. Population and Environment 24(3):255-272; McGranahan DA. 1999. Natural Amenities Drive Rural Population Change. USDA Economic Research Service, Agricultural Economic Report No. 781. https://www.ers.usda.gov/webdocs/publications/41047/13201_aer781.pdf?v=42061; Rasker R. 2006. An Exploration Into the Economic Impact of Industrial Development Versus Conservation on Western Public Lands. Society & Natural Resources 19(3):191-207; Rudzitis G, Johansen HE. 1991. How Important is Wilderness? Results from a United States Survey. Environmental Management 15(2):227-233.

7- A bibliography of studies documenting the economic role of public lands can be found here: https://headwaterseconomics.org/wp-content/uploads/Annotated_Bib_Value_Public_Lands.pdf.

8- An online data visualization and map showing the history of federal land payments to counties can be seen here: https://headwaterseconomics.org/dataviz/county-payments/

9- For resources related to the wildland-urban interface (WUI), including planning tools and related solutions, see https://headwaterseconomics.org/wildfire/.

10- For a description of the methods used to define and measure the wildland-urban interface, see: Gude P, Rasker R, and van den Noort J. 2008. Potential for Future Development on Fire-Prone Lands. Journal of Forestry 106(4):198-205.

A Summary Profile

ironton unit

Selected Geographies:

Lawrence County, OH; Gallia County, OH

Benchmark Geographies:

U.S.

Produced by
Headwaters Economics'
Economic Profile System (EPS)
https://headwaterseconomics.org/eps
December 18, 2018

About the Economic Profile System (EPS)

EPS is a free web tool created by Headwaters Economics to build customized socioeconomic reports of U.S. counties, states, and regions. Reports can be easily created to compare or aggregate different areas. EPS uses published statistics from federal data sources, including the U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

The Bureau of Land Management and Forest Service have made significant financial and intellectual contributions to the operation and content of EPS.

See https://headwaterseconomics.org/eps for more information about the capabilities of EPS. For technical questions, contact Patty Gude at eps@headwaterseconomics.org or telephone 406-599-7425.

HEADWATERS ECONOMICS

headwaterseconomics.org

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions.

www.blm.gov

The Bureau of Land Management, an agency within the U.S. Department of Interior, administers 249.8 million acres of America's public lands, located primarily in western states. It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

www.fs.fed.us

The Forest Service, an agency of the U.S. Department of Agriculture, administers national forests and grasslands encompassing 193 million acres. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Summary
ironton unit

Table of Contents

Note to Users:

This is one of 14 reports that can be created and downloaded from EPS. Topics include land use, demographics, specific industry sectors, the role of non-labor income, the wildland-urban interface, the role of amenities in economic development, and payments to county governments from federal lands. The EPS reports are downloadable as Excel or PDF documents. See https://headwaterseconomics.org/eps.

Summary

ironton unit

Overview

	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
Population, 2016	60,872	30,015	11,614,373	90,887	323,127,513
Trends					
Population % change, 1970-2016	6.5%	18.1%	8.9%	10.1%	58.6%
Employment % change, 1970-2016	32.0%	73.7%	48.6%	48.4%	112.2%
Personal Income % change, 1970-2016	114.4%	148.5%	89.9%	124.7%	201.1%
Prosperity					
Unemployment rate, 2017	5.8%	6.5%	5.0%	6.1%	4.4%
Average earnings per job, 2016 (2017 $s)	$39,833	$41,935	$55,056	$40,801	$59,598
Per capita income, 2016 (2017 $s)	$35,731	$36,389	$45,529	$35,948	$50,280
Economy					
Non-Labor % of personal income, 2016	44.6%	48.7%	35.9%	45.9%	36.8%
Services % of employment, 2016	68.1%	~46.4%	71.6%	~58.1%	72.9%
Government % of employment, 2016	17.5%	12.3%	11.5%	15.1%	12.5%
Use Sectors^					
Timber % of private employment, 2016	~0.0%	~0.2%	0.6%	~0.1%	0.6%
Mining % of private employment, 2016	~0.0%	~0.0%	0.2%	~0.0%	0.5%
Fossil fuels (oil, gas, & coal), 2016	~0.0%	~0.0%	0.2%	~0.0%	0.4%
Other mining, 2016	~0.7%	0.0%	~0.2%	~0.4%	0.3%
Agriculture % of employment, 2016	3.4%	5.9%	1.3%	4.5%	1.4%
Travel & Tourism % of private emp., 2016	~14.3%	~14.2%	14.1%	~14.3%	15.8%
Federal Land*					
Federal Land % total land ownership	25.7%	6.1%	1.4%	15.8%	28.2%
Forest Service %	25.7%	6.1%	0.9%	15.8%	8.4%
BLM %	0.0%	0.0%	0.0%	0.0%	10.6%
Park Service %	0.0%	0.0%	0.1%	0.0%	3.4%
Military %	0.0%	0.0%	0.2%	0.0%	1.0%
Other %	0.0%	0.0%	0.2%	0.0%	4.9%
Federal land % Type A**	0.0%	0.0%	11.1%	0.0%	41.8%
Federal payments % of gov. revenue, FY201	0.3%	0.1%	0.0%	0.2%	
Development					
Residential area % change, 2000-2010	-1.1%	10.5%	11.6%	4.1%	12.3%
Wildland-Urban Interface % developed, 2010	na	na	na	na	16.3%

Estimates for data that were not disclosed are indicated with tildes (~).

^Data for timber, mining, and travel and tourism-related are from County Business Patterns which excludes proprietors, and data for agriculture are from Bureau of Economic Analysis which includes proprietors.

* The land ownership data source and year vary depending on the selected geography. See following pages for specifics.

** Federal public lands that are managed primarily for natural, cultural, and recreational features. These lands include National Parks and Preserves (NPS), Wilderness (NPS, FWS, FS, BLM), National Conservation Areas (BLM), National Monuments (NPS, FS, BLM), National Recreation Areas (NPS, FS, BLM), National Wild and Scenic Rivers (NPS), Waterfowl Production Areas (FWS), Wildlife Management Areas (FWS), Research Natural Areas (FS, BLM), Areas of Critical Environmental Concern (BLM), and National Wildlife Refuges (FWS).

Data Sources: Various; see following pages for specifics.

Summary

ironton unit

Overview

What do we measure on this page?

Using summary statistics from topical EPS reports, this page compares socioeconomic indicators[1] of the selected area to a benchmark.

Trends: General indicators of economic well-being (population, employment, and real personal income) measured over time.

Prosperity: Common indicators of individual well-being or hardship (unemployment, average earnings per job, and per capita income).

Economy: Three significant sectors of the economy: non-labor income (e.g., government transfer payments, and investment and retirement income), services, and government employment.

Use Sectors: Components of the economy (commodity sectors including timber, mining and agriculture, and industries that include travel and tourism) that could be associated with the use of public lands.

Federal Land: The amount and type of federal land ownership, and the dependence of county governments on payments related to federal lands such as National Park Service (NPS), Forest Service (FS), Bureau of Land Management (BLM), and Fish and Wildlife Service (FWS).

Development: Residential development of private lands, including the wildland-urban interface. The wildland-urban interface data are available and reported only for the 11 western states and do not include Alaska and Hawaii.

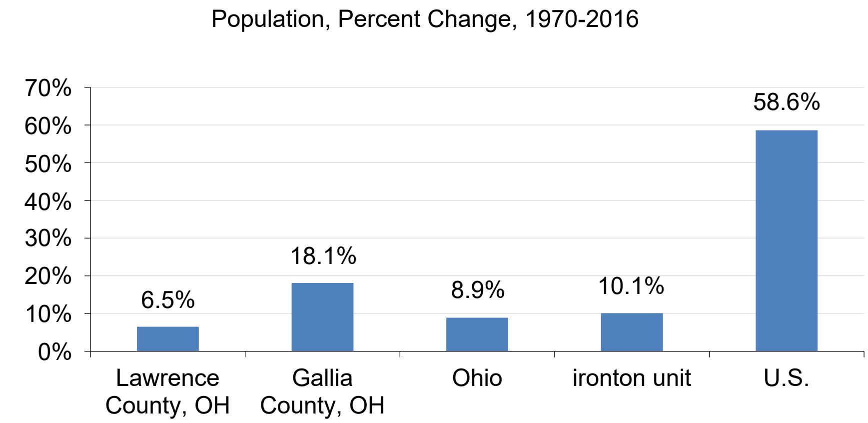
Why is it important?

This report allows the user to compare a broad range of socioeconomic measurements. A user can refer to EPS topic-specific reports for more details. For example, when a county shows unusually high unemployment rates, a user may want to create an EPS Socioeconomic Measures report for that county. Or an EPS Timber report could be created for a county that shows a relatively high number of people employed in the timber industry.

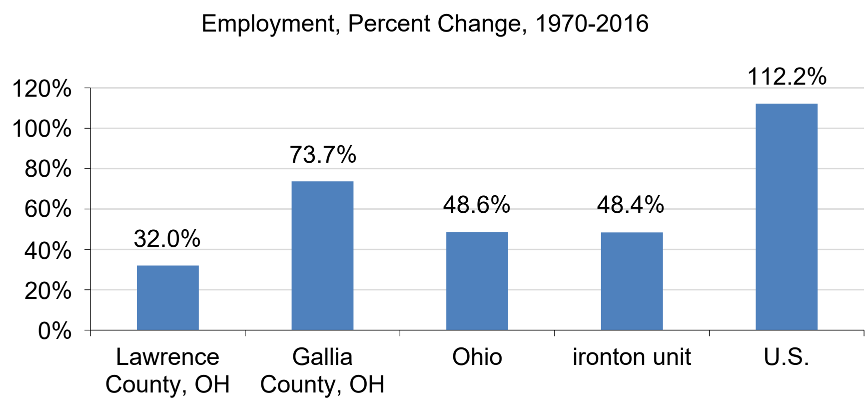
This report uses information from the following EPS reports: Socioeconomic Measures, Demographics, Agriculture, Mining, Services, Tourism, Government, Non-Labor Income, Timber, Land Use, Public Land Amenities, Wildland-Urban Interface, and Federal Land Payments. Consult these reports directly for additional information at https://headwaterseconomics.org/eps.

Population, Employment, and Personal Income

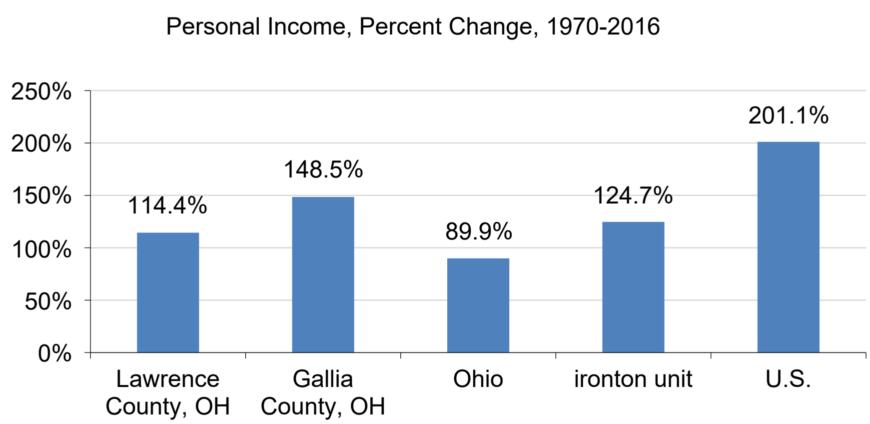
- Between 1970 and 2016, the U.S. had the largest percent change in population (58.6%), and Lawrence County, OH had the smallest (6.5%).



- Between 1970 and 2016, the U.S. had the largest percent change in employment (112.2%), and Lawrence County, OH had the smallest (32%).



- Between 1970 and 2016, the U.S. had the largest percent change in personal income (201.1%), and Ohio had the smallest (89.9%).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.

Population, Employment, and Personal Income

What do we measure on this page?

This page describes percent change in population, employment, and real personal income.

The EPS Demographics report provides additional information on population dynamics, while the EPS Socioeconomic Measures report provides additional information on employment and personal income. See https://headwaterseconomics.org/eps.

The Bureau of Economic Analysis reports data either by place of residence or by place of work. Population and personal income data on this page are reported by place of residence, and employment data by place of work.[2]

Why is it important?

One measure of economic performance is whether a location is growing or declining. Standard measures of growth and decline are population, employment, and real personal income.

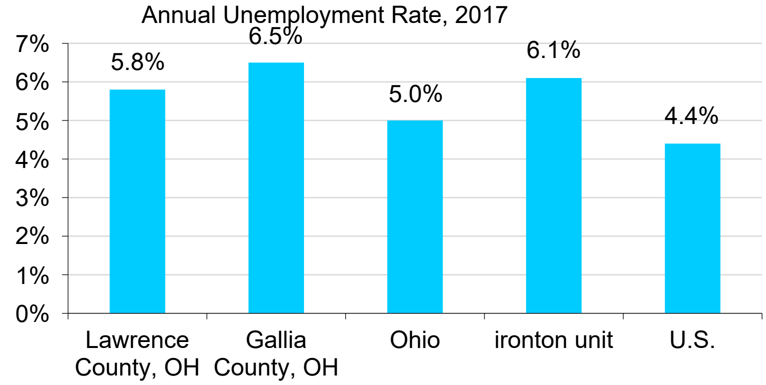
The information on this page helps users understand whether locations are growing or declining at different rates, and makes it easy to see discrepancies between changes in population, employment, and real personal income. If population and employment are growing faster than real personal income, for example, it may be worthwhile to research whether growth has been in low-wage industries and occupations. Alternatively, if personal income is growing faster than employment, it may be caused by growth in high-wage industries and occupations and/or non-labor income sources.

Summary

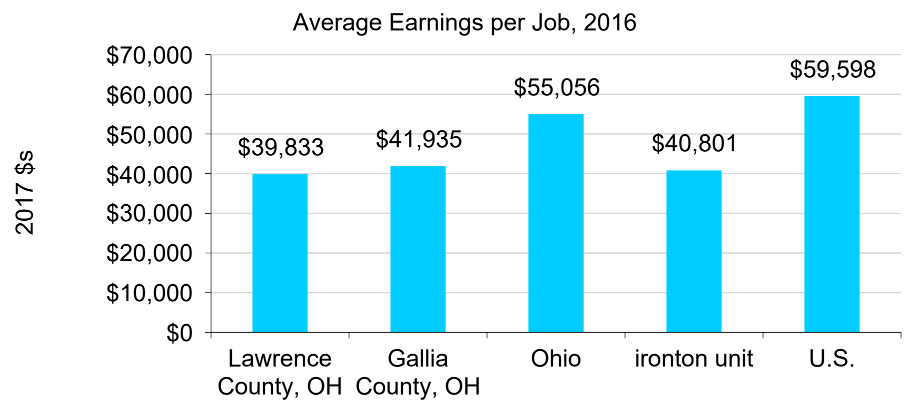
ironton unit

Unemployment, Earnings, and Per Capita Income

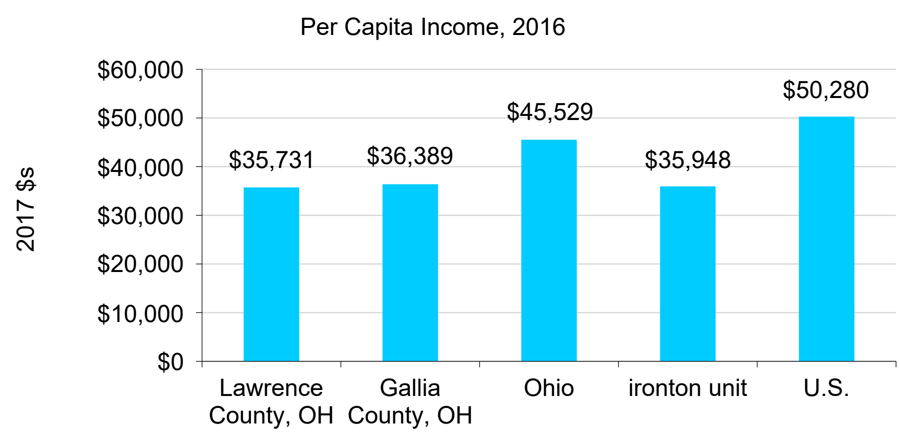
- In 2017, Gallia County, OH had the highest unemployment rate (6.5%), and the U.S. had the lowest (4.4%).



- In 2016, the U.S. had the highest average earnings per job ($59,598), and Lawrence County, OH had the lowest ($39,833).



- In 2016, the U.S. had the highest per capita income ($50,280), and Lawrence County, OH had the lowest ($35,731).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Labor. 2018. Bureau of Labor Statistics, Local Area Unemployment Statistics, Washington, D.C.

Unemployment, Earnings, and Per Capita Income

What do we measure on this page?

This page describes three measures of individual prosperity: unemployment, average earnings per job, and per capita income.[1]

Unemployment Rate: The number of people who are jobless, looking for jobs, and available for work divided by the labor force.[3]

Average Earnings per Job: Total earnings divided by total employment. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included.

Per Capita Income: Total personal income (from labor and non-labor sources) divided by total population.

Why is it important?

Statistics presented on this page are important indicators of economic well-being.

The annual unemployment rate is the number of people actively seeking but not finding work as a percent of the labor force. This figure can go up during national recessions and/or when more localized economies are affected by area downturns. Seasonal variations in unemployment can be viewed in the EPS Socioeconomic Measures report at https://headwaterseconomics.org/eps.

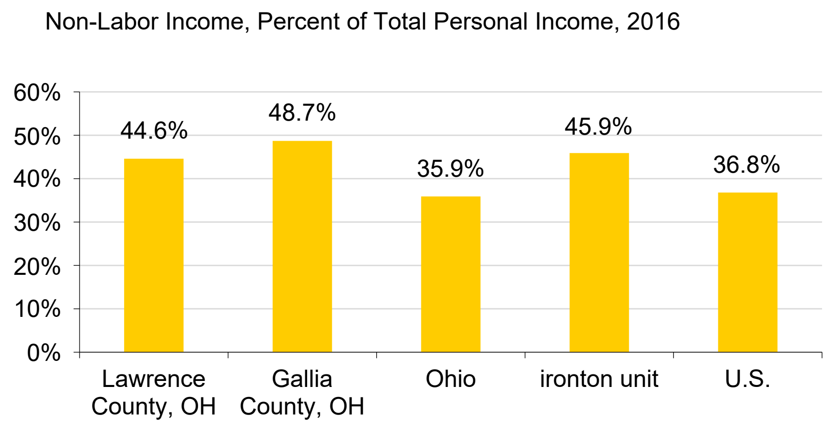
Average earnings per job is an indicator of the quality of local employment. A higher average earning per job indicates relatively more high-wage occupations.[4] It can be useful to consider earnings against local cost of living indicators.

Per capita income is one of the most important measures of economic well-being. However, it can be misleading. Per capita income is total personal income divided by population. Because per capita income is calculated using total population and not the labor force, per capita income can be relatively low when a disproportionate number of children and/or elderly people are in the population. And because total personal income includes non-labor income sources, per capita income can be relatively high due to the presence of retirees and people with investment income. To investigate the impact of non-labor income sources on total personal income, create the EPS Non-Labor report at https://headwaterseconomics.org/eps.

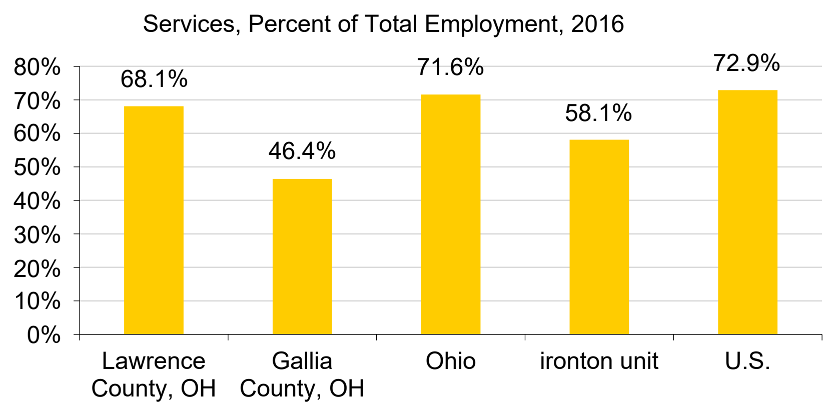
To see how these measurements have changed over time, create an EPS Socioeconomic Measures report at https://headwaterseconomics.org/eps.

Non-Labor Income, Services, and Government

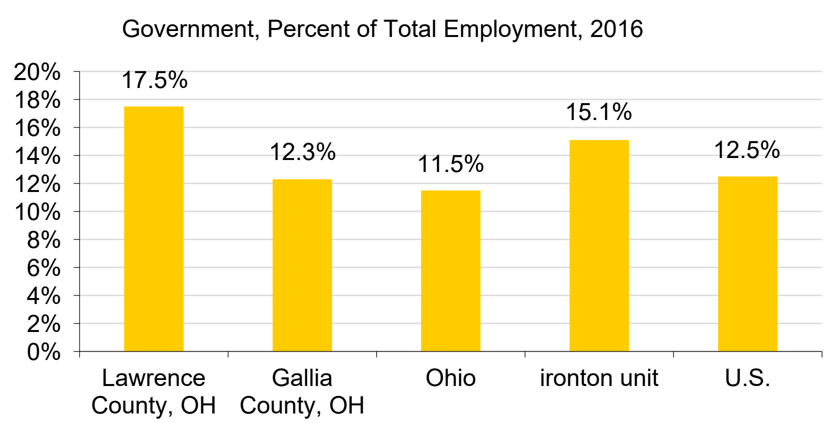
- In 2016, Gallia County, OH had the largest percent of total personal income from non-labor income sources (48.7%), and Ohio had the smallest (35.9%).



- In 2016, the U.S. had the largest percent of total jobs in services (72.9%), and Gallia County, OH had the smallest (46.4%).



- In 2016, Lawrence County, OH had the largest percent of total jobs in government (17.5%), and Ohio had the smallest (11.5%).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.

Non-Labor Income, Services, and Government

What do we measure on this page?

This page describes non-labor income and employment in services and government.[1]

Non-Labor Income: Dividends, interest and rent (money earned from investments), and transfer payments (includes government retirement and disability insurance benefits, medical payments such as Medicare and Medicaid, income maintenance benefits, unemployment insurance benefits, etc.). Non-labor income is reported by place of residence.

Services: Employment in the following sectors: Utilities, Wholesale Trade, Retail Trade, Transportation & Warehousing, Information, Finance & Insurance, Real Estate & Rental & Leasing, Professional & Scientific & Tech., Management of Companies & Enterprises, Administrative & Support Services, Educational Services, Health Care & Social Assistance, Arts & Entertainment & Recreation, Accommodation & Food Services, and Other Services.

Government: Employment in federal, state, and local government agencies and government enterprises.

For more detailed information about the role of non-labor income, service industry employment, and government employment in the economy, create an EPS Non-Labor report, an EPS Services report, or an EPS Government report at https://headwaterseconomics.org/eps.

Why is it important?

In many counties, non-labor income (for example, retirement and investment income, government transfer payments) can be more than a third of all personal income. As the Baby Boomer generation retires, this source of income will continue to grow. A high dependence on non-labor income can indicate a location with an aging population and/or attractiveness to people with investment income. In some cases, it can also signal hardship, such as when there is a high dependence on Medicaid and income maintenance payments.

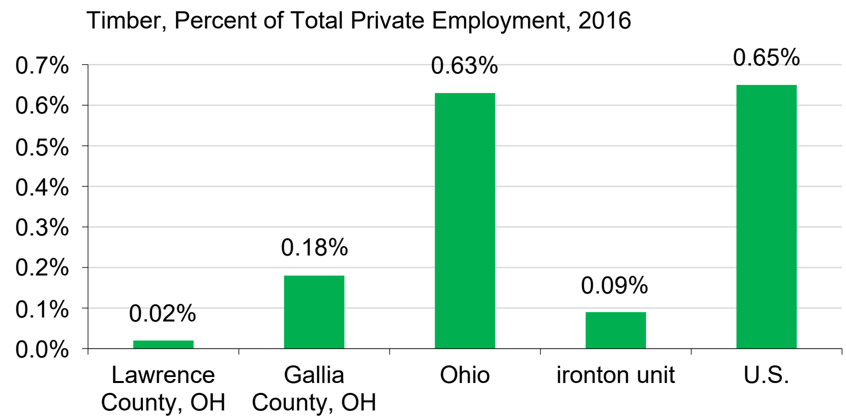
Nationally, services account for more than 95 percent of the growth in new jobs since 2000. Despite the strong growth of employment in services, the term "services" is often misunderstood. Services consist of a wide mix of jobs including high-wage, high-skilled occupations (e.g., doctors, engineers, software developers) and low-wage, low-skilled occupations (e.g., restaurant workers, tour bus operators). The service sector typically provides services, such as banking and education, rather than creating tangible objects. However, many service sectors such as utilities, engineering, and architecture are closely associated with goods-producing sectors.

Government can be a major employer in some locations, particularly in rural areas and locations with significant government facilities such as federal land management offices, military bases, prisons, or research facilities. Changes in government employment tend to track population trends. Local government often accounts for much of job growth in the government sector as additional services are demanded by a growing population.

Summary
ironton unit

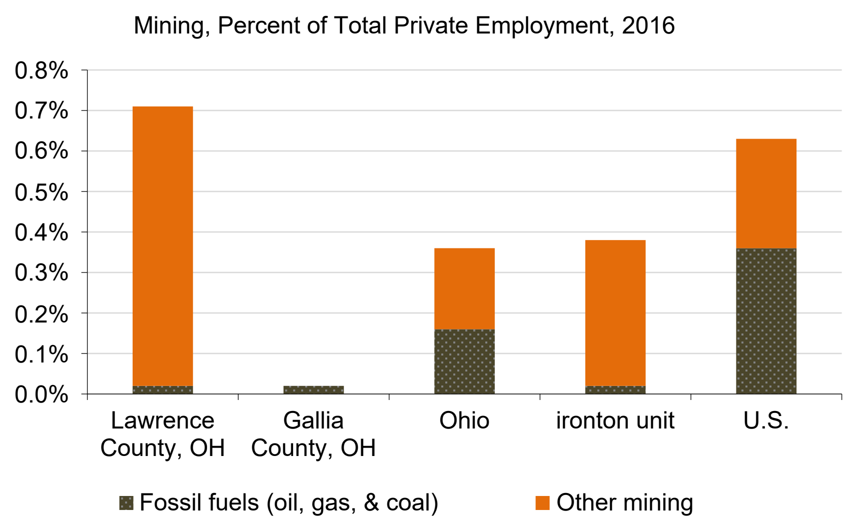
Employment in Commodity Sectors

- In 2016, the U.S. had the largest percent of total jobs in timber (0.65%), and Lawrence County, OH had the smallest (0.02%).

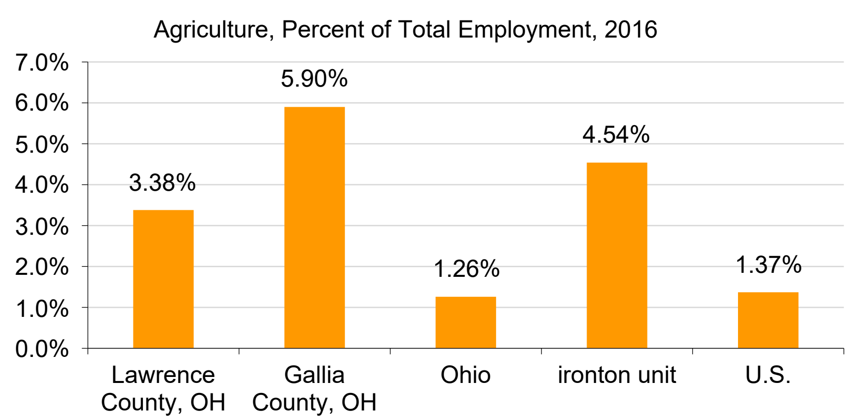


- In 2016, the U.S. had the largest percent of total jobs in mining of fossil fuels (0.36%), and Lawrence County, OH had the smallest (0.02%).

- In 2016, Lawrence County, OH had the largest percent of total jobs in mining unrelated to fossil fuels (0.69%), and Gallia County, OH had the smallest (0%).



- In 2016, Gallia County, OH had the largest percent of total jobs in agriculture (5.9%), and Ohio had the smallest (1.26%).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Employment in Commodity Sectors

What do we measure on this page?

This page describes employment[1] in three commodity sectors: timber, mining (minerals, oil, gas, and coal), and agriculture. These are sectors of the economy that extract commodities from land (for example, timber harvesting, energy development, and grazing).

Timber: Employment associated with growing and harvesting trees, employment at sawmills and paper mills, and wood products manufacturing.

Mining: Employment associated with oil and gas extraction, coal mining, metals mining, and nonmetallic minerals mining.

Agriculture: Employment associated with all forms of agriculture, including farming and ranching.

County Business Patterns (CBP)[5] are used in EPS reports as a data source for timber and mining because this data set has fewer data gaps compared to other sources.

The Bureau of Economic Analysis (BEA) is used as the data source for agriculture because CBP data do not include agriculture. However, the BEA data include proprietors, which are not included in CBP data. As a result, the data for agriculture are not strictly comparable to data for timber and mining. The latest year for each data source may vary due to different data release schedules.

For more detailed information about commodity sectors and for industry definitions, create an EPS Timber, Mining, or Agriculture report at https://headwaterseconomics.org/eps.

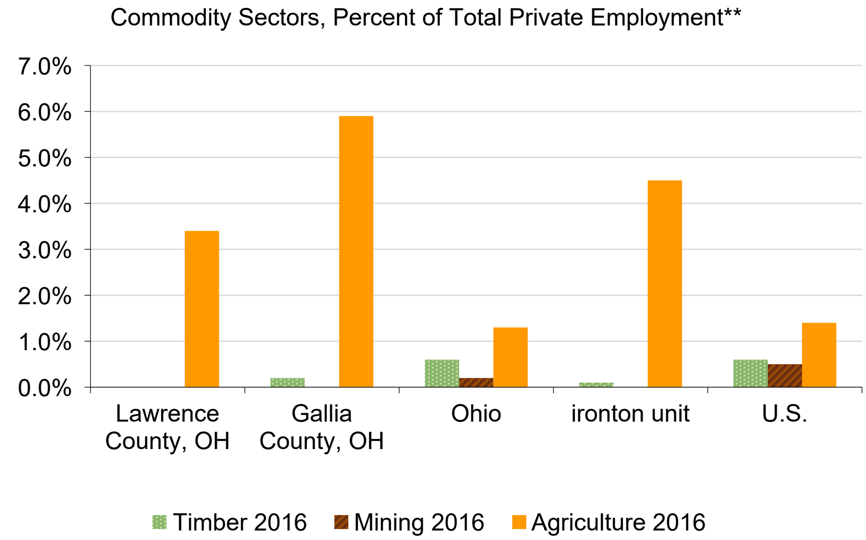
Why is it important?

Opportunities for commodity extraction can stimulate local employment.

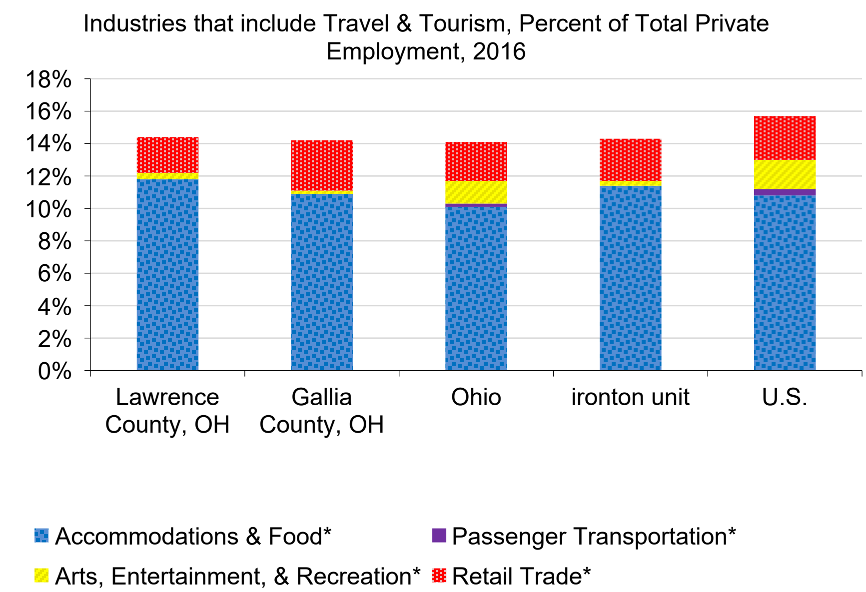
Timber industries, mining—including fossil fuel development (oil, natural gas, and coal)—and farming and ranching play important roles in some locations. Information on this page helps explain whether that is the case in the locations selected, and whether locations differ from one another.

Employment in Commodities, Travel & Tourism

- Gallia County, OH had the largest percent of total jobs in commodity sectors (6.1%), and Ohio had the smallest (2.1%).
- Agriculture was the largest component of commodity sector employment (4.5% of total jobs) in the ironton unit, and mining was the smallest component (0% of total jobs).



- In 2016, the U.S. had the largest percent of total jobs in industries that include travel and tourism (15.7%), and Ohio had the smallest (14.1%).
- In 2016, accommodations & food* was the largest component of travel and tourism-related employment (11.4% of total jobs) in ironton unit, and passenger transportation* was the smallest (0% of total jobs).



* Charted values do not represent the entirety of these sectors, rather their components typically related to travel & tourism.

** Data for timber and mining are from County Business Patterns which excludes proprietors, government, agriculture, and railroad. Data for agriculture are from Bureau of Economic Analysis. The latest year for each data source may vary due to different data release schedules.

Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Employment in Commodities, Travel & Tourism

What do we measure on this page?

This page describes employment for commodity sectors and for industries that are associated with travel and tourism.

Commodity Sectors: Employment in timber, mining (including oil, gas, and coal), and agriculture.

Travel and Tourism: Employment in sectors that provide goods and services to visitors as well as to the local population. These industries are: Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services. There is no single industrial classification for travel and tourism under the North American Industrial Classification System (NAICS). The exact proportion of jobs in these sectors attributable to expenditures by visitors, including business and pleasure travelers, is not known without additional research such as surveys.

County Business Patterns (CBP)[5] are used in EPS reports as a data source for timber and mining because this data set has fewer data gaps[1] compared to other sources.

The Bureau of Economic Analysis (BEA) is used as a data source for agriculture because CBP data do not include agriculture. However, the BEA data include proprietors, which are not included in CBP data. As a result, the data for agriculture are not strictly comparable to data for timber and mining. The latest year for each data source may vary due to different data release schedules.

For more detailed information about commodity sectors and for industry definitions, create an EPS Timber, Mining, or Agriculture report. For more information about the tourism-related components of the economy, create an EPS Tourism report at https://headwaterseconomics.org/eps.

Why is it important?

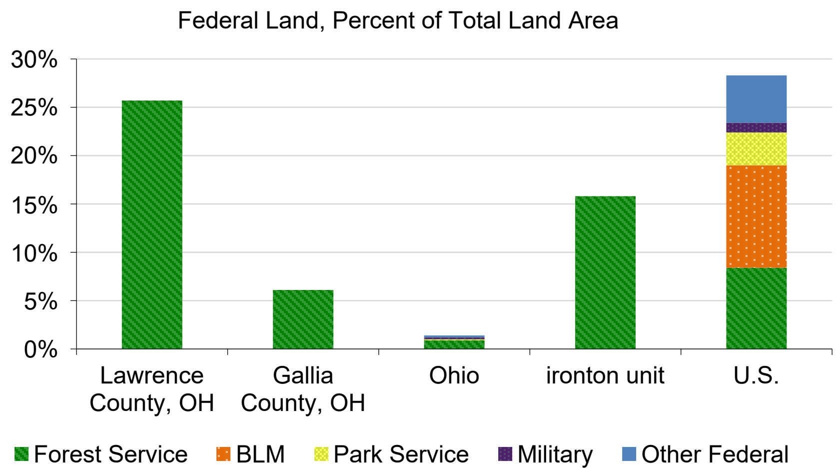
Commodity extraction can stimulate local employment. It is important to understand the relative size of sectors to put the commodity-related economy into perspective. For example, decisions that permit (or restrict) timber, mining, and grazing activities have a higher chance of impacting a county with a high percentage of its employment in the commodity sectors.

Tourism and recreation can stimulate local employment. Communities can benefit directly from visitors who spend money in hotels, restaurants, ski resorts, gift shops, and elsewhere. Tourism can also help communities retain and attract capital and spur transitions to move diverse economies. This report can be used to understand whether travel-and tourism-related economic activity is present and whether there are differences between locations.

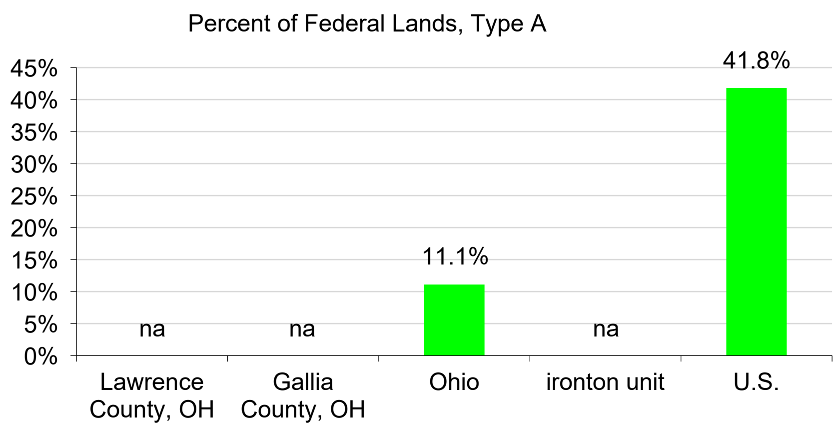
Federal Lands and Federal Land Payments

- The U.S. had the largest percent of total land area in federal ownership (28.2%), and Ohio had the smallest (1.4%).

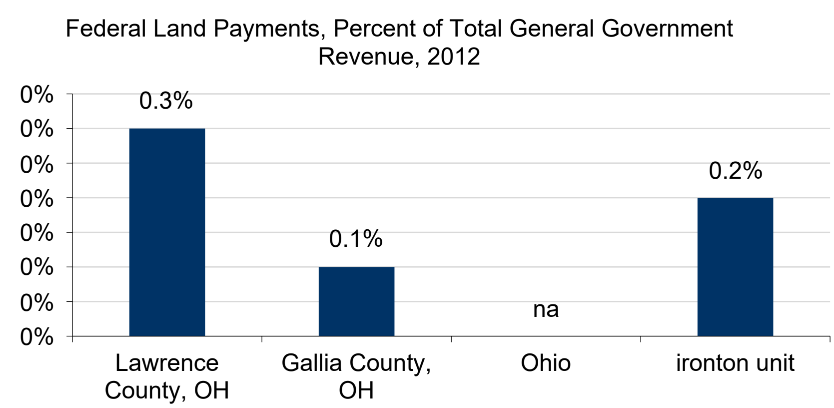
- Forest Service lands were the largest component of federal land ownership (15.8%) in ironton unit, and BLM lands were the smallest (0%).



- The U.S. had the largest percent of federal lands in Type A (41.8%), and Lawrence County, OH had the smallest (0%).



- In FY 2012, Lawrence County, OH had the largest percent of total general government revenue from federal land payments (0.3%), and Ohio had the smallest (0%).



Data Sources: NASA MODIS Land Cover Type Yearly L3 Global 1km MOD12Q1, 2006; U.S. Geological Survey, Gap Analysis Program. 2016. Protected Areas Database of the United States (PADUS) version 1.4; U.S. Department of Commerce. 2014. Census Bureau, Governments Division, Washington, D.C.

Federal Lands and Federal Land Payments

What do we measure on this page?

This page describes differences in the percent of federal land ownership by agency; the share of federal lands managed primarily for natural, cultural, and recreational features; and the percent of county revenue derived from payments related to federal lands.

Type A Federal Lands: Federal public lands that are managed primarily for natural, cultural, and recreational features. There can be exceptions (for example, oil and gas development within a National Monument area), but generally Type A lands are less likely to be used for commodity production than other federal land types. Type A lands include National Parks and Preserves (NPS), Wilderness (NPS, FWS, FS, BLM), National Conservation Areas (BLM), National Monuments (NPS, FS, BLM), National Recreation Areas (NPS, FS, BLM), National Wild and Scenic Rivers (NPS), Waterfowl Production Areas (FWS), Wildlife Management Areas (FWS), Research Natural Areas (FS, BLM), Areas of Critical Environmental Concern (BLM), and National Wildlife Refuges (FWS). These definitions of land classifications are not legal or agency-adopted classifications—they are only provided for comparative purposes.

NPS = National Park Service; FS = Forest Service; BLM = Bureau of Land Management; FWS = Fish & Wildlife Service.

For additional information about land ownership and development patterns, create an EPS Land Use report. The EPS Public Land Amenities report provides additional information about the role of environmental amenities in economic development; see https://headwaterseconomics.org/eps.

Federal Land Payments: Federal payments that compensate state and local governments for non-taxable federal lands within their borders. Payments are funded by federal appropriations (e.g., PILT), from receipts received by federal agencies from activities on federal public lands (e.g., timber, grazing, and minerals), and from other programs such as the Secure Rural Schools & Community Self-Determination Act.

For additional information about the importance of federal payments to counties, create an EPS Federal Land Payments report at https://headwaterseconomics.org/eps.

Why is it important?

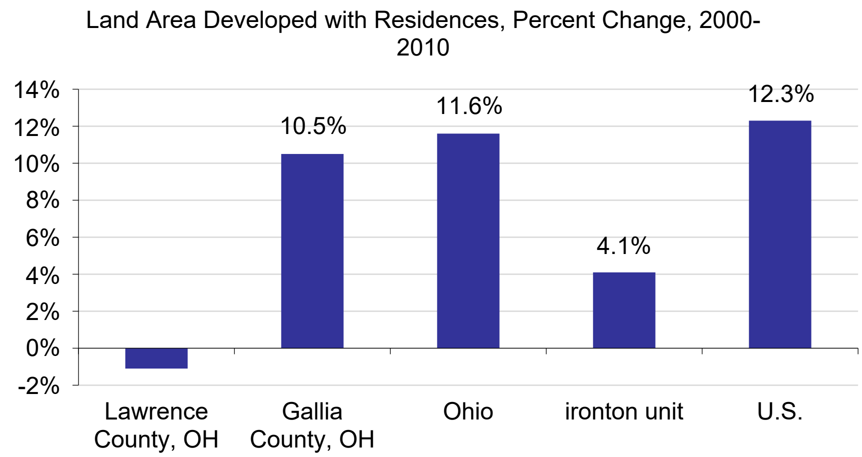
Understanding the composition of land ownership and management in an area is important because actions on federal lands may affect the local economy, particularly when federal lands are a large portion of the land base.

Some Type A federal public lands prohibit most forms of commercial use and development. These lands include national parks, wilderness areas, and national monuments. Because these lands are managed primarily for their non-commercial values (i.e., scenery, wildlife, recreation), they potentially play a different economic role than public lands more commonly associated with commodity sectors.[6, 7]

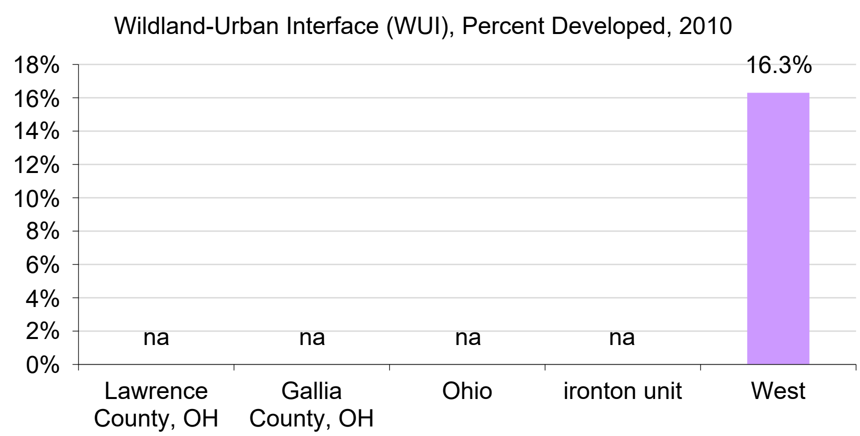
Locations with federal public lands receive government payments—for example, funding through Payments in Lieu of Taxes (PILT), the 25% Fund, or the Secure Rural Schools and Community Self-Determination Act. When these payments are a significant portion of the local county's budget, activities on public lands may affect the fiscal well-being of a county.[8]

Development and the Wildland-Urban Interface

- Between 2000 and 2010, the U.S. had the largest percent change in residential land area developed (12.3%), and Lawrence County, OH had the smallest (-1.1%).



- In 2010, the west had the largest proportion of the wildland-urban interface that is developed (16.3%), and the west had the smallest (16.3%).



Data Sources: Theobald, DM. 2013. Land use classes for ICLUS/SERGoM v2013. Unpublished report, Colorado State University; Gude, P.H., Rasker, R., and van den Noort, J. 2008. Potential for Future Development on Fire-Prone Lands. Journal of Forestry 106(4):198-205; U.S. Department of Commerce. 2011. TIGER/Line 2010 Census Blocks and 2010 Summary File 1, Washington, D.C.

Development and the Wildland-Urban Interface

What do we measure on this page?

This page describes residential development on private lands, and the proportion of the wildland-urban interface (WUI) that is developed.[9] The EPS Land Use report provides additional information on land ownership, management, cover, and development: https://headwaterseconomics.org/eps.

This information is available only for the 11 western states and does not include Alaska and Hawaii.

Wildland-Urban Interface (WUI): Private forestlands that are within 500 meters of public forestlands. We use the threshold of 500 meters to identify the existing and potential WUI area because guidelines for the amount of defensible space necessary to protect homes from wildfire range from 40 to 500 meters around a home. We focus on adjacency to public forests because roughly 70 percent of western forests are publicly owned and because wildfire is a natural disturbance in many of these forests, creating a potential risk to adjacent private lands.[10]

Why is it important?

The conversion of open space and agricultural land to residential development has occurred at a rapid pace in many parts of the U.S. The popularity of exurban lot sizes in much of the country has exacerbated this trend. (Low-density development results in a larger area of land converted to residential development). The pattern of development can reflect a number of factors, including demographic trends, the increasingly "footloose" nature of economic activity, the availability and price of land, and preferences for homes on larger lots. Locations with a large percent change in the area of residential development often have experienced significant in-migration from more urbanized areas. Counties with a small percent change either experienced little growth or were already highly urbanized in 2000.

Development of homes adjacent to fire-prone federal public lands poses several challenges including the rising cost of protecting homes from wildfires; increased danger to wildland firefighters; and the consumption of funds that might otherwise be used for restoration, recreation, research, and other activities. When protecting homes is a priority, agencies are unable to allow otherwise beneficial fires to burn, even those that could reduce fuel loads.

Data Sources & Methods

This EPS Summary report uses national statistics from public government sources. All data used in EPS can be readily verified with the original sources:

- **County Business Patterns**
  Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/cbp.html
  Contacts
  https://www.census.gov/about/contact-us.html

- **Regional Economic Information Data**
  Bureau of Economic Analysis, U.S. Department of Commerce
  https://www.bea.gov/iTable/index_regional.cfm
  Contacts
  https://www.bea.gov/contacts/search.htm

- **Local Area Unemployment Statistics**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/lau/
  Contacts
  https://www.bls.gov/bls/contact.htm

The EPS Summary report also uses data derived from Geographic Information Systems (GIS) to show more accurate statistics for land ownership:

- **TIGER/Line County Boundaries**
  Bureau of the Census, U.S. Department of Commerce
  https://www.census.gov/geo/maps-data/data/tiger.html

- **Protected Areas Database**
  U.S. Geological Survey, Gap Analysis Program
  https://gapanalysis.usgs.gov/padus/

EPS core approaches
EPS is designed to focus on long-term trends across a range of important measures. Trend analysis provides a more comprehensive view of changes than spot data for select years. We encourage users to focus on major trends rather than absolute numbers. EPS displays detailed industry-level data to show changes in the composition of the economy over time and the mix of industries at points in time. EPS employs cross-sectional benchmarking – comparing smaller areas such as counties to larger regions, states, and the nation – to give a sense of relative performance. EPS allows users to aggregate data for multiple locations to allow for more sophisticated cross-sectional comparisons.

Adjusting dollar figures for inflation
Because a dollar in the past was worth more than a dollar today, data reported in current dollar terms should be adjusted for inflation. The U.S. Department of Commerce reports personal income figures in terms of current dollars. All income data in EPS are adjusted to real (or constant) dollars using the Consumer Price Index. Figures are adjusted to the latest date for which the annual Consumer Price Index is available.

Data gaps and estimation
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses supplemental data from the U.S. Department of Commerce to estimate these data gaps. These are indicated with tildes (~) in tables. Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

Endnotes

1 - Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics estimates these data gaps. Estimates are indicated with tildes (~). Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

2 - For details on Bureau of Economic Analysis terms, see: https://bea.gov/regional/definitions.

3 - For more information on unemployment, see the Bureau of Labor Statistics resources on this topic at https://www.bls.gov/bls/unemployment.htm.

4 - The Monthly Labor Review Online, published by the Bureau of Labor statistics, addresses earnings and wages by industry, sex, and educational achievement. Search at https://www.bls.gov/mlr/.

5- Data from County Business Patterns includes both full- and part-time employment. However, CBP data do not include employment in government, agriculture, railroads, or the self-employed and, as a result, under-count the size of industry sectors. Also, CBP data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing relationships between sectors over time.

6 - For examples of literature on the economic role of environmental amenities, see: Booth DE. 1999. Spatial Patterns in the Economic Development of the Mountain West. Growth and Change 30(3):384-405; Duffy-Deno KT. 1998. The Effect of Federal Wilderness on County Growth in the Intermountain Western United States. Journal of Regional Science 38(1):109-136; Lorah P and Southwick R. 2003. Environmental Protection, Population Change, and Economic Development in the Rural Western United States. Population and Environment 24(3):255-272; McGranahan DA. 1999. Natural Amenities Drive Rural Population Change. USDA Economic Research Service, Agricultural Economic Report No. 781. https://www.ers.usda.gov/webdocs/publications/41047/13201_aer781.pdf?v=42061; Rasker R. 2006. An Exploration Into the Economic Impact of Industrial Development Versus Conservation on Western Public Lands. Society & Natural Resources 19(3):191-207; Rudzitis G, Johansen HE. 1991. How Important is Wilderness? Results from a United States Survey. Environmental Management 15(2):227-233.

7- A bibliography of studies documenting the economic role of public lands can be found here: https://headwaterseconomics.org/wp-content/uploads/Annotated_Bib_Value_Public_Lands.pdf.

8- An online data visualization and map showing the history of federal land payments to counties can be seen here: https://headwaterseconomics.org/dataviz/county-payments/

9- For resources related to the wildland-urban interface (WUI), including planning tools and related solutions, see https://headwaterseconomics.org/wildfire/.

10- For a description of the methods used to define and measure the wildland-urban interface, see: Gude P, Rasker R, and van den Noort J. 2008. Potential for Future Development on Fire-Prone Lands. Journal of Forestry 106(4):198-205.

A Summary Profile

marietta unit

Selected Geographies:

Monroe County, OH; Washington County, OH

Benchmark Geographies:

U.S.

Produced by
Headwaters Economics'
Economic Profile System (EPS)
https://headwaterseconomics.org/eps
December 18, 2018

About the Economic Profile System (EPS)

EPS is a free web tool created by Headwaters Economics to build customized socioeconomic reports of U.S. counties, states, and regions. Reports can be easily created to compare or aggregate different areas. EPS uses published statistics from federal data sources, including the U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

The Bureau of Land Management and Forest Service have made significant financial and intellectual contributions to the operation and content of EPS.

See https://headwaterseconomics.org/eps for more information about the capabilities of EPS. For technical questions, contact Patty Gude at eps@headwaterseconomics.org or telephone 406-599-7425.

HEADWATERS ECONOMICS

headwaterseconomics.org

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions.

www.blm.gov

The Bureau of Land Management, an agency within the U.S. Department of Interior, administers 249.8 million acres of America's public lands, located primarily in western states. It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

www.fs.fed.us

The Forest Service, an agency of the U.S. Department of Agriculture, administers national forests and grasslands encompassing 193 million acres. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Summary

marietta unit

Table of Contents

Note to Users:

This is one of 14 reports that can be created and downloaded from EPS. Topics include land use, demographics, specific industry sectors, the role of non-labor income, the wildland-urban interface, the role of amenities in economic development, and payments to county governments from federal lands. The EPS reports are downloadable as Excel or PDF documents. See https://headwaterseconomics.org/eps.

Summary

marietta unit

Overview

	Ohio	Monroe County, OH	Washington County, OH	marietta unit	U.S.
Population, 2016	11,614,373	14,210	60,610	74,820	323,127,513
Trends					
Population % change, 1970-2016	8.9%	-9.5%	5.8%	2.5%	58.6%
Employment % change, 1970-2016	48.6%	-24.4%	47.7%	29.9%	112.2%
Personal Income % change, 1970-2016	89.9%	37.1%	93.5%	82.1%	201.1%
Prosperity					
Unemployment rate, 2017	5.0%	8.6%	6.2%	6.5%	4.4%
Average earnings per job, 2016 (2017 $s)	$55,056	$26,237	$48,561	$45,348	$59,598
Per capita income, 2016 (2017 $s)	$45,529	$30,553	$39,962	$38,175	$50,280
Economy					
Non-Labor % of personal income, 2016	35.9%	52.0%	40.8%	42.5%	36.8%
Services % of employment, 2016	71.6%	~49.1%	~64.3%	~62.1%	72.9%
Government % of employment, 2016	11.5%	13.9%	9.0%	9.7%	12.5%
Use Sectors^					
Timber % of private employment, 2016	0.6%	~0.2%	~1.4%	~1.3%	0.6%
Mining % of private employment, 2016	0.2%	~30.1%	1.4%	~4.0%	0.5%
Fossil fuels (oil, gas, & coal), 2016	0.2%	~27.6%	~1.3%	~3.8%	0.4%
Other mining, 2016	~0.2%	~1.8%	~0.2%	~0.3%	0.3%
Agriculture % of employment, 2016	1.3%	13.9%	3.3%	4.8%	1.4%
Travel & Tourism % of private emp., 2016	14.1%	~11.9%	~13.1%	~13.0%	15.8%
Federal Land*					
Federal Land % total land ownership	1.4%	8.4%	9.6%	9.1%	28.2%
Forest Service %	0.9%	8.4%	9.6%	9.1%	8.4%
BLM %	0.0%	0.0%	0.0%	0.0%	10.6%
Park Service %	0.1%	0.0%	0.0%	0.0%	3.4%
Military %	0.2%	0.0%	0.0%	0.0%	1.0%
Other %	0.2%	0.0%	0.0%	0.0%	4.9%
Federal land % Type A**	11.1%	0.0%	0.0%	0.0%	41.8%
Federal payments % of gov. revenue, FY201	0.0%	0.2%	0.1%	0.1%	
Development					
Residential area % change, 2000-2010	11.6%	20.5%	5.2%	8.9%	12.3%
Wildland-Urban Interface % developed, 2010	na	na	na	na	16.3%

Estimates for data that were not disclosed are indicated with tildes (~).

^Data for timber, mining, and travel and tourism-related are from County Business Patterns which excludes proprietors, and data for agriculture are from Bureau of Economic Analysis which includes proprietors.

* The land ownership data source and year vary depending on the selected geography. See following pages for specifics.

** Federal public lands that are managed primarily for natural, cultural, and recreational features. These lands include National Parks and Preserves (NPS), Wilderness (NPS, FWS, FS, BLM), National Conservation Areas (BLM), National Monuments (NPS, FS, BLM), National Recreation Areas (NPS, FS, BLM), National Wild and Scenic Rivers (NPS), Waterfowl Production Areas (FWS), Wildlife Management Areas (FWS), Research Natural Areas (FS, BLM), Areas of Critical Environmental Concern (BLM), and National Wildlife Refuges (FWS).

Data Sources: Various; see following pages for specifics.

Summary

marietta unit

Overview

What do we measure on this page?

Using summary statistics from topical EPS reports, this page compares socioeconomic indicators[1] of the selected area to a benchmark.

Trends: General indicators of economic well-being (population, employment, and real personal income) measured over time.

Prosperity: Common indicators of individual well-being or hardship (unemployment, average earnings per job, and per capita income).

Economy: Three significant sectors of the economy: non-labor income (e.g., government transfer payments, and investment and retirement income), services, and government employment.

Use Sectors: Components of the economy (commodity sectors including timber, mining and agriculture, and industries that include travel and tourism) that could be associated with the use of public lands.

Federal Land: The amount and type of federal land ownership, and the dependence of county governments on payments related to federal lands such as National Park Service (NPS), Forest Service (FS), Bureau of Land Management (BLM), and Fish and Wildlife Service (FWS).

Development: Residential development of private lands, including the wildland-urban interface. The wildland-urban interface data are available and reported only for the 11 western states and do not include Alaska and Hawaii.

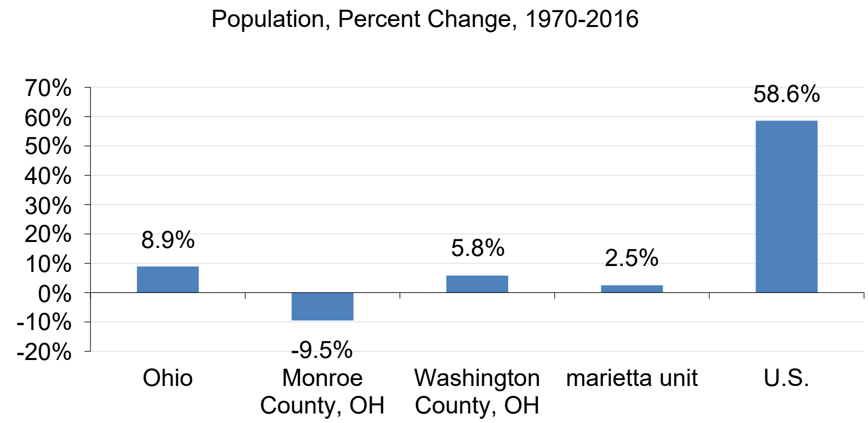
Why is it important?

This report allows the user to compare a broad range of socioeconomic measurements. A user can refer to EPS topic-specific reports for more details. For example, when a county shows unusually high unemployment rates, a user may want to create an EPS Socioeconomic Measures report for that county. Or an EPS Timber report could be created for a county that shows a relatively high number of people employed in the timber industry.

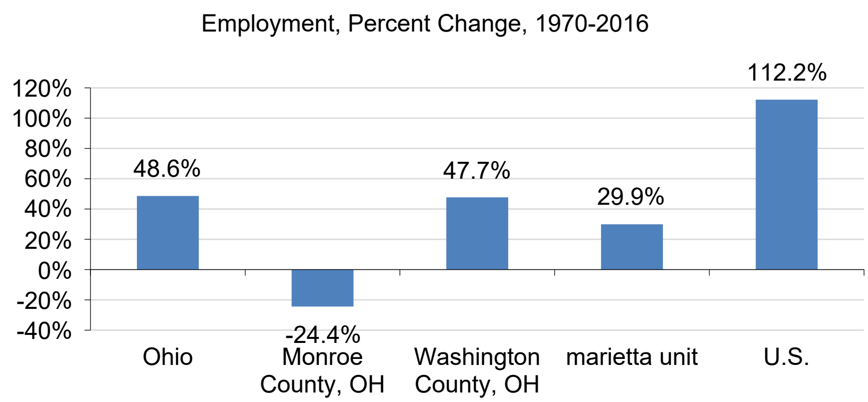
This report uses information from the following EPS reports: Socioeconomic Measures, Demographics, Agriculture, Mining, Services, Tourism, Government, Non-Labor Income, Timber, Land Use, Public Land Amenities, Wildland-Urban Interface, and Federal Land Payments. Consult these reports directly for additional information at https://headwaterseconomics.org/eps.

Population, Employment, and Personal Income

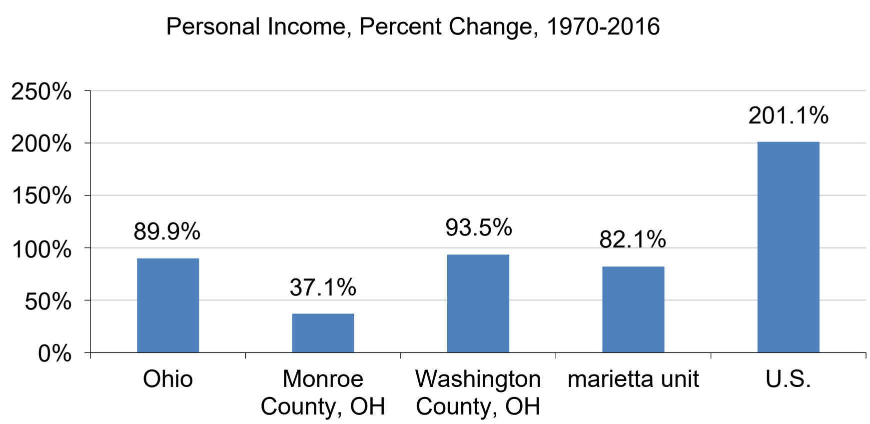
- Between 1970 and 2016, the U.S. had the largest percent change in population (58.6%), and Monroe County, OH had the smallest (-9.5%).



- Between 1970 and 2016, the U.S. had the largest percent change in employment (112.2%), and Monroe County, OH had the smallest (-24.4%).



- Between 1970 and 2016, the U.S. had the largest percent change in personal income (201.1%), and Monroe County, OH had the smallest (37.1%).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.

Population, Employment, and Personal Income

What do we measure on this page?

This page describes percent change in population, employment, and real personal income.

The EPS Demographics report provides additional information on population dynamics, while the EPS Socioeconomic Measures report provides additional information on employment and personal income. See https://headwaterseconomics.org/eps.

The Bureau of Economic Analysis reports data either by place of residence or by place of work. Population and personal income data on this page are reported by place of residence, and employment data by place of work.[2]

Why is it important?

One measure of economic performance is whether a location is growing or declining. Standard measures of growth and decline are population, employment, and real personal income.

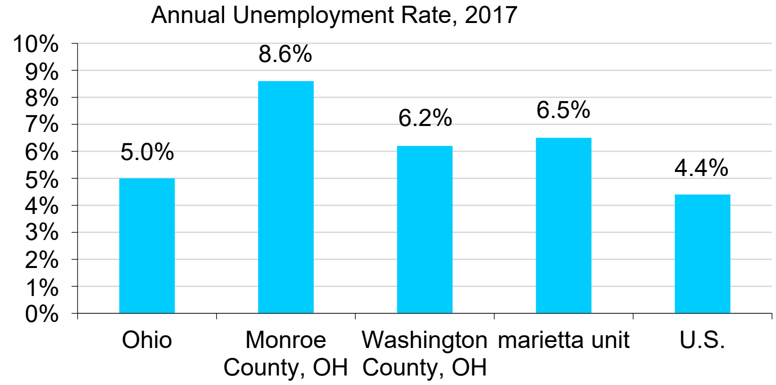
The information on this page helps users understand whether locations are growing or declining at different rates, and makes it easy to see discrepancies between changes in population, employment, and real personal income. If population and employment are growing faster than real personal income, for example, it may be worthwhile to research whether growth has been in low-wage industries and occupations. Alternatively, if personal income is growing faster than employment, it may be caused by growth in high-wage industries and occupations and/or non-labor income sources.

Summary

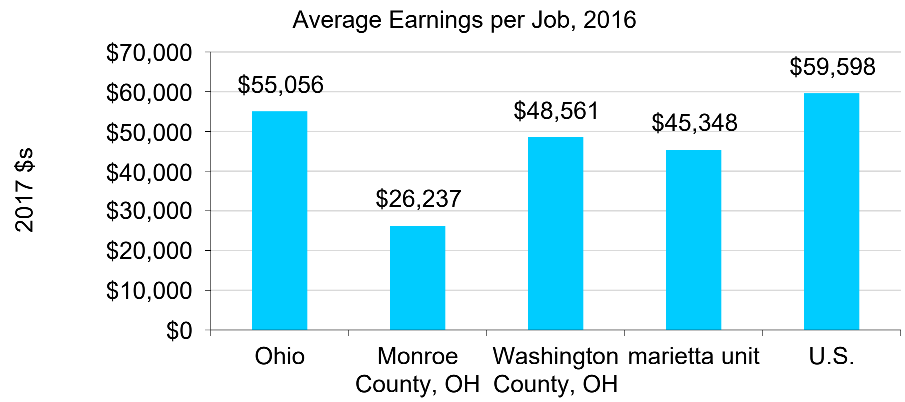
marietta unit

Unemployment, Earnings, and Per Capita Income

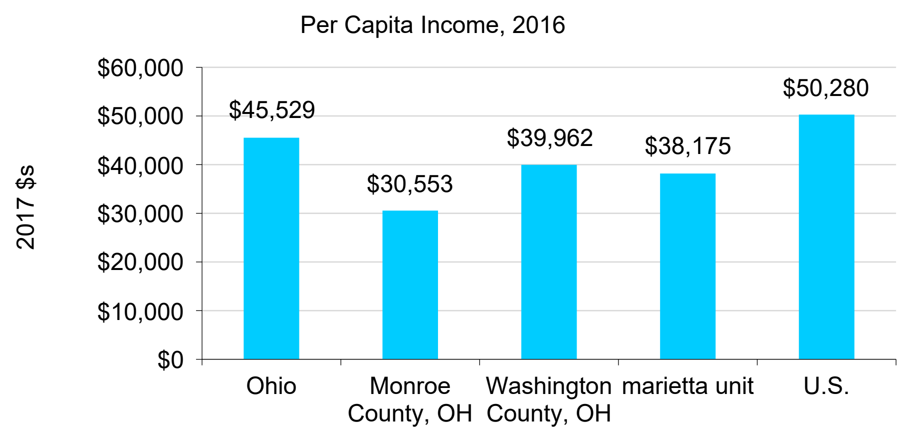
- In 2017, Monroe County, OH had the highest unemployment rate (8.6%), and the U.S. had the lowest (4.4%).



- In 2016, the U.S. had the highest average earnings per job ($59,598), and Monroe County, OH had the lowest ($26,237).



- In 2016, the U.S. had the highest per capita income ($50,280), and Monroe County, OH had the lowest ($30,553).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Labor. 2018. Bureau of Labor Statistics, Local Area Unemployment Statistics, Washington, D.C.

Unemployment, Earnings, and Per Capita Income

What do we measure on this page?

This page describes three measures of individual prosperity: unemployment, average earnings per job, and per capita income.[1]

Unemployment Rate: The number of people who are jobless, looking for jobs, and available for work divided by the labor force.[3]

Average Earnings per Job: Total earnings divided by total employment. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included.

Per Capita Income: Total personal income (from labor and non-labor sources) divided by total population.

Why is it important?

Statistics presented on this page are important indicators of economic well-being.

The annual unemployment rate is the number of people actively seeking but not finding work as a percent of the labor force. This figure can go up during national recessions and/or when more localized economies are affected by area downturns. Seasonal variations in unemployment can be viewed in the EPS Socioeconomic Measures report at https://headwaterseconomics.org/eps.

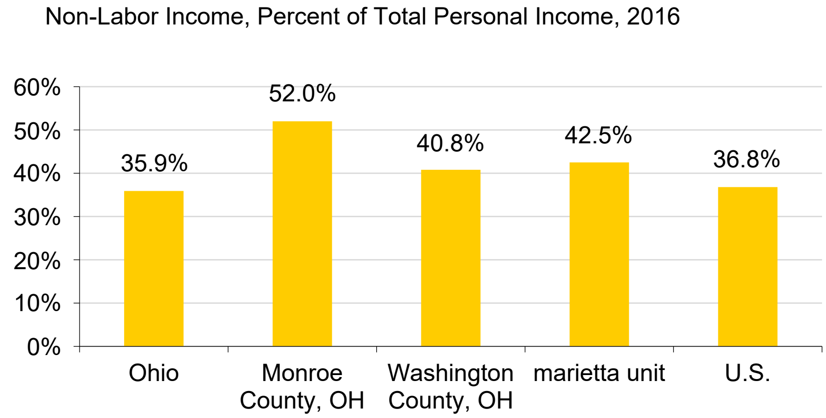
Average earnings per job is an indicator of the quality of local employment. A higher average earning per job indicates relatively more high-wage occupations.[4] It can be useful to consider earnings against local cost of living indicators.

Per capita income is one of the most important measures of economic well-being. However, it can be misleading. Per capita income is total personal income divided by population. Because per capita income is calculated using total population and not the labor force, per capita income can be relatively low when a disproportionate number of children and/or elderly people are in the population. And because total personal income includes non-labor income sources, per capita income can be relatively high due to the presence of retirees and people with investment income. To investigate the impact of non-labor income sources on total personal income, create the EPS Non-Labor report at https://headwaterseconomics.org/eps.

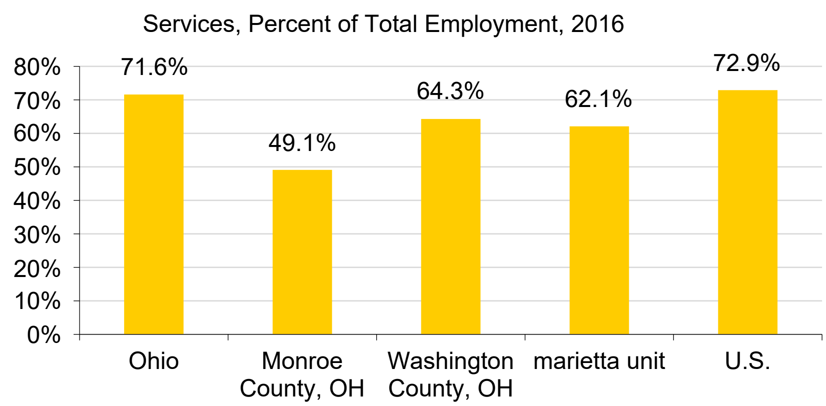
To see how these measurements have changed over time, create an EPS Socioeconomic Measures report at https://headwaterseconomics.org/eps.

Non-Labor Income, Services, and Government

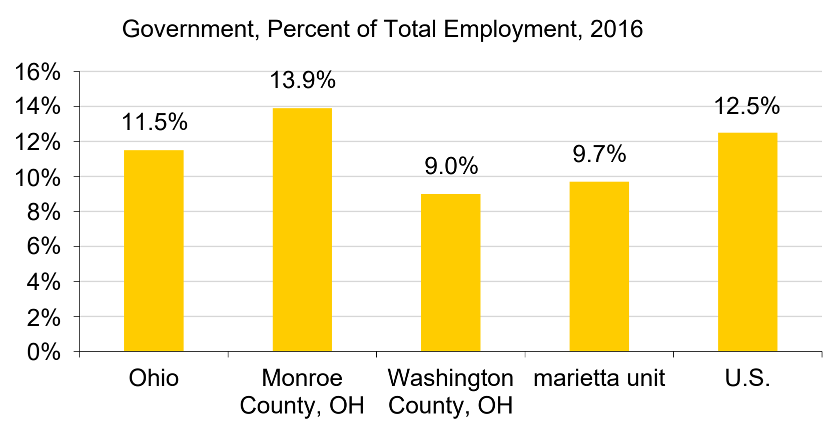
- In 2016, Monroe County, OH had the largest percent of total personal income from non-labor income sources (52%), and Ohio had the smallest (35.9%).



- In 2016, the U.S. had the largest percent of total jobs in services (72.9%), and Monroe County, OH had the smallest (49.1%).



- In 2016, Monroe County, OH had the largest percent of total jobs in government (13.9%), and Washington County, OH had the smallest (9%).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.

Non-Labor Income, Services, and Government

What do we measure on this page?

This page describes non-labor income and employment in services and government.[1]

Non-Labor Income: Dividends, interest and rent (money earned from investments), and transfer payments (includes government retirement and disability insurance benefits, medical payments such as Medicare and Medicaid, income maintenance benefits, unemployment insurance benefits, etc.). Non-labor income is reported by place of residence.

Services: Employment in the following sectors: Utilities, Wholesale Trade, Retail Trade, Transportation & Warehousing, Information, Finance & Insurance, Real Estate & Rental & Leasing, Professional & Scientific & Tech., Management of Companies & Enterprises, Administrative & Support Services, Educational Services, Health Care & Social Assistance, Arts & Entertainment & Recreation, Accommodation & Food Services, and Other Services.

Government: Employment in federal, state, and local government agencies and government enterprises.

For more detailed information about the role of non-labor income, service industry employment, and government employment in the economy, create an EPS Non-Labor report, an EPS Services report, or an EPS Government report at https://headwaterseconomics.org/eps.

Why is it important?

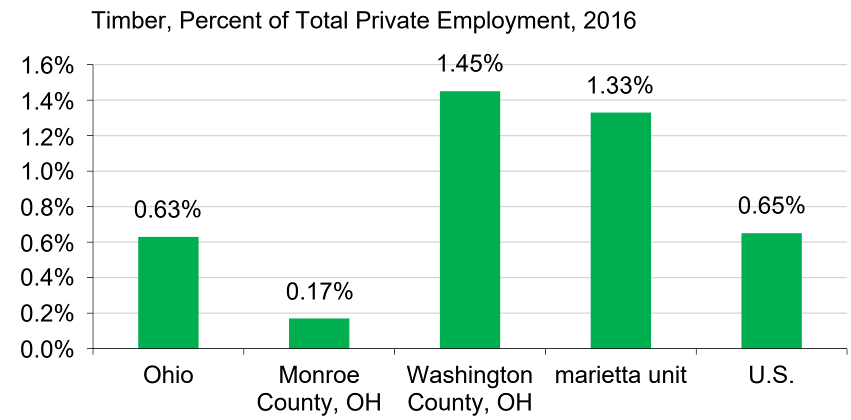
In many counties, non-labor income (for example, retirement and investment income, government transfer payments) can be more than a third of all personal income. As the Baby Boomer generation retires, this source of income will continue to grow. A high dependence on non-labor income can indicate a location with an aging population and/or attractiveness to people with investment income. In some cases, it can also signal hardship, such as when there is a high dependence on Medicaid and income maintenance payments.

Nationally, services account for more than 95 percent of the growth in new jobs since 2000. Despite the strong growth of employment in services, the term "services" is often misunderstood. Services consist of a wide mix of jobs including high-wage, high-skilled occupations (e.g., doctors, engineers, software developers) and low-wage, low-skilled occupations (e.g., restaurant workers, tour bus operators). The service sector typically provides services, such as banking and education, rather than creating tangible objects. However, many service sectors such as utilities, engineering, and architecture are closely associated with goods-producing sectors.

Government can be a major employer in some locations, particularly in rural areas and locations with significant government facilities such as federal land management offices, military bases, prisons, or research facilities. Changes in government employment tend to track population trends. Local government often accounts for much of job growth in the government sector as additional services are demanded by a growing population.

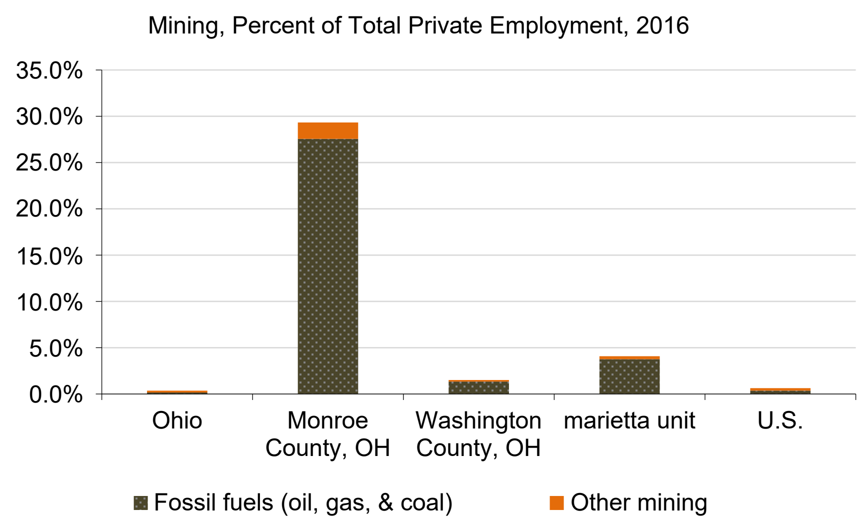
Employment in Commodity Sectors

- In 2016, Washington County, OH had the largest percent of total jobs in timber (1.45%), and Monroe County, OH had the smallest (0.17%).

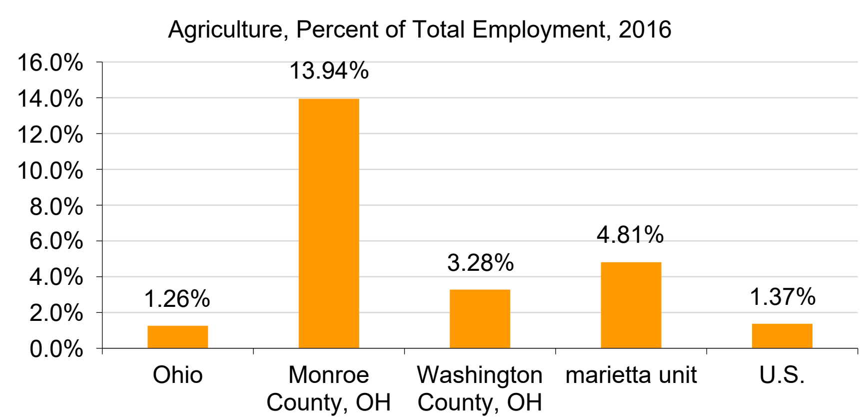


- In 2016, Monroe County, OH had the largest percent of total jobs in mining of fossil fuels (27.56%), and Ohio had the smallest (0.16%).

- In 2016, Monroe County, OH had the largest percent of total jobs in mining unrelated to fossil fuels (1.77%), and Washington County, OH had the smallest (0.17%).



- In 2016, Monroe County, OH had the largest percent of total jobs in agriculture (13.94%), and Ohio had the smallest (1.26%).



Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Employment in Commodity Sectors

What do we measure on this page?

This page describes employment[1] in three commodity sectors: timber, mining (minerals, oil, gas, and coal), and agriculture. These are sectors of the economy that extract commodities from land (for example, timber harvesting, energy development, and grazing).

Timber: Employment associated with growing and harvesting trees, employment at sawmills and paper mills, and wood products manufacturing.

Mining: Employment associated with oil and gas extraction, coal mining, metals mining, and nonmetallic minerals mining.

Agriculture: Employment associated with all forms of agriculture, including farming and ranching.

County Business Patterns (CBP)[5] are used in EPS reports as a data source for timber and mining because this data set has fewer data gaps compared to other sources.

The Bureau of Economic Analysis (BEA) is used as the data source for agriculture because CBP data do not include agriculture. However, the BEA data include proprietors, which are not included in CBP data. As a result, the data for agriculture are not strictly comparable to data for timber and mining. The latest year for each data source may vary due to different data release schedules.

For more detailed information about commodity sectors and for industry definitions, create an EPS Timber, Mining, or Agriculture report at https://headwaterseconomics.org/eps.

Why is it important?

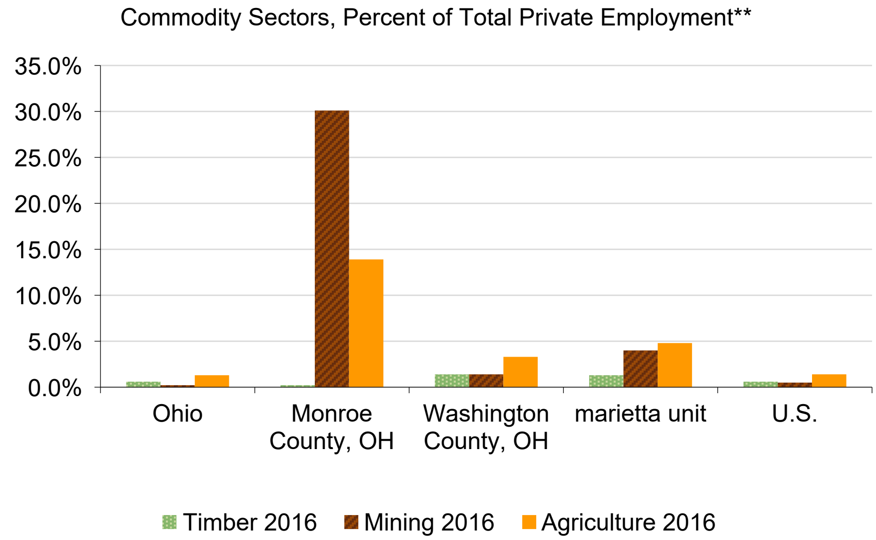
Opportunities for commodity extraction can stimulate local employment.

Timber industries, mining—including fossil fuel development (oil, natural gas, and coal)—and farming and ranching play important roles in some locations. Information on this page helps explain whether that is the case in the locations selected, and whether locations differ from one another.

Employment in Commodities, Travel & Tourism

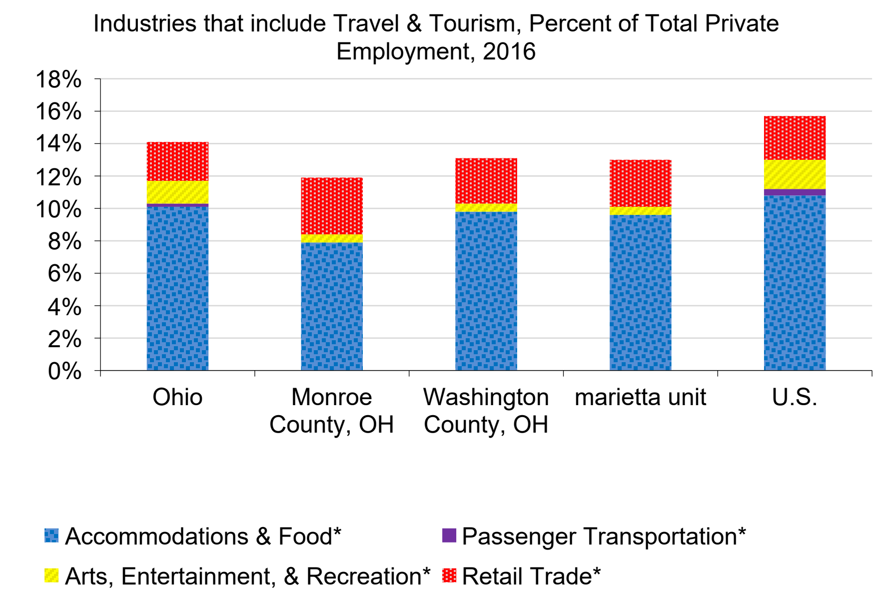
- Monroe County, OH had the largest percent of total jobs in commodity sectors (44.2%), and Ohio had the smallest (2.1%).

- Agriculture was the largest component of commodity sector employment (4.8% of total jobs) in the marietta unit, and timber was the smallest component (1.3% of total jobs).



- In 2016, the U.S. had the largest percent of total jobs in industries that include travel and tourism (15.7%), and Monroe County, OH had the smallest (11.9%).

- In 2016, accommodations & food* was the largest component of travel and tourism-related employment (9.6% of total jobs) in marietta unit, and passenger transportation* was the smallest (0% of total jobs).



* Charted values do not represent the entirety of these sectors, rather their components typically related to travel & tourism.

** Data for timber and mining are from County Business Patterns which excludes proprietors, government, agriculture, and railroad. Data for agriculture are from Bureau of Economic Analysis. The latest year for each data source may vary due to different data release schedules.

Data Sources: U.S. Department of Commerce. 2017. Bureau of Economic Analysis, Regional Economic Accounts, Washington, D.C.; U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Employment in Commodities, Travel & Tourism

What do we measure on this page?

This page describes employment for commodity sectors and for industries that are associated with travel and tourism.

Commodity Sectors: Employment in timber, mining (including oil, gas, and coal), and agriculture.

Travel and Tourism: Employment in sectors that provide goods and services to visitors as well as to the local population. These industries are: Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services. There is no single industrial classification for travel and tourism under the North American Industrial Classification System (NAICS). The exact proportion of jobs in these sectors attributable to expenditures by visitors, including business and pleasure travelers, is not known without additional research such as surveys.

County Business Patterns (CBP)[5] are used in EPS reports as a data source for timber and mining because this data set has fewer data gaps[1] compared to other sources.

The Bureau of Economic Analysis (BEA) is used as a data source for agriculture because CBP data do not include agriculture. However, the BEA data include proprietors, which are not included in CBP data. As a result, the data for agriculture are not strictly comparable to data for timber and mining. The latest year for each data source may vary due to different data release schedules.

For more detailed information about commodity sectors and for industry definitions, create an EPS Timber, Mining, or Agriculture report. For more information about the tourism-related components of the economy, create an EPS Tourism report at https://headwaterseconomics.org/eps.

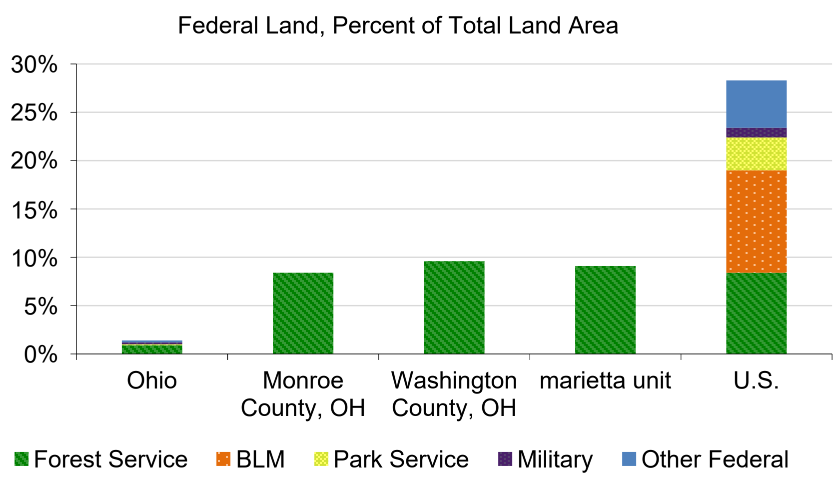
Why is it important?

Commodity extraction can stimulate local employment. It is important to understand the relative size of sectors to put the commodity-related economy into perspective. For example, decisions that permit (or restrict) timber, mining, and grazing activities have a higher chance of impacting a county with a high percentage of its employment in the commodity sectors.

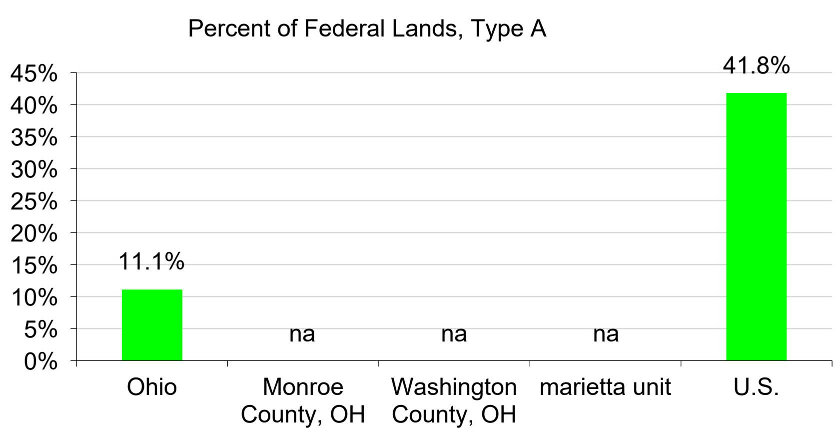
Tourism and recreation can stimulate local employment. Communities can benefit directly from visitors who spend money in hotels, restaurants, ski resorts, gift shops, and elsewhere. Tourism can also help communities retain and attract capital and spur transitions to move diverse economies. This report can be used to understand whether travel-and tourism-related economic activity is present and whether there are differences between locations.

Federal Lands and Federal Land Payments

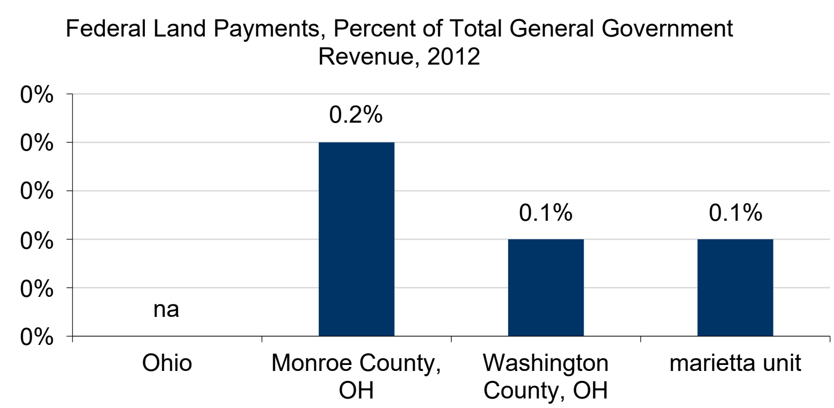
- The U.S. had the largest percent of total land area in federal ownership (28.2%), and Ohio had the smallest (1.4%).
- Forest Service lands were the largest component of federal land ownership (9.1%) in marietta unit, and BLM lands were the smallest (0%).



- The U.S. had the largest percent of federal lands in Type A (41.8%), and Monroe County, OH had the smallest (0%).



- In FY 2012, Monroe County, OH had the largest percent of total general government revenue from federal land payments (0.2%), and Ohio had the smallest (0%).



Data Sources: NASA MODIS Land Cover Type Yearly L3 Global 1km MOD12Q1, 2006; U.S. Geological Survey, Gap Analysis Program. 2016. Protected Areas Database of the United States (PADUS) version 1.4; U.S. Department of Commerce. 2014. Census Bureau, Governments Division, Washington, D.C.

Federal Lands and Federal Land Payments

What do we measure on this page?

This page describes differences in the percent of federal land ownership by agency; the share of federal lands managed primarily for natural, cultural, and recreational features; and the percent of county revenue derived from payments related to federal lands.

Type A Federal Lands: Federal public lands that are managed primarily for natural, cultural, and recreational features. There can be exceptions (for example, oil and gas development within a National Monument area), but generally Type A lands are less likely to be used for commodity production than other federal land types. Type A lands include National Parks and Preserves (NPS), Wilderness (NPS, FWS, FS, BLM), National Conservation Areas (BLM), National Monuments (NPS, FS, BLM), National Recreation Areas (NPS, FS, BLM), National Wild and Scenic Rivers (NPS), Waterfowl Production Areas (FWS), Wildlife Management Areas (FWS), Research Natural Areas (FS, BLM), Areas of Critical Environmental Concern (BLM), and National Wildlife Refuges (FWS). These definitions of land classifications are not legal or agency-adopted classifications—they are only provided for comparative purposes.

NPS = National Park Service; FS = Forest Service; BLM = Bureau of Land Management; FWS = Fish & Wildlife Service.

For additional information about land ownership and development patterns, create an EPS Land Use report. The EPS Public Land Amenities report provides additional information about the role of environmental amenities in economic development; see https://headwaterseconomics.org/eps.

Federal Land Payments: Federal payments that compensate state and local governments for non-taxable federal lands within their borders. Payments are funded by federal appropriations (e.g., PILT), from receipts received by federal agencies from activities on federal public lands (e.g., timber, grazing, and minerals), and from other programs such as the Secure Rural Schools & Community Self-Determination Act.

For additional information about the importance of federal payments to counties, create an EPS Federal Land Payments report at https://headwaterseconomics.org/eps.

Why is it important?

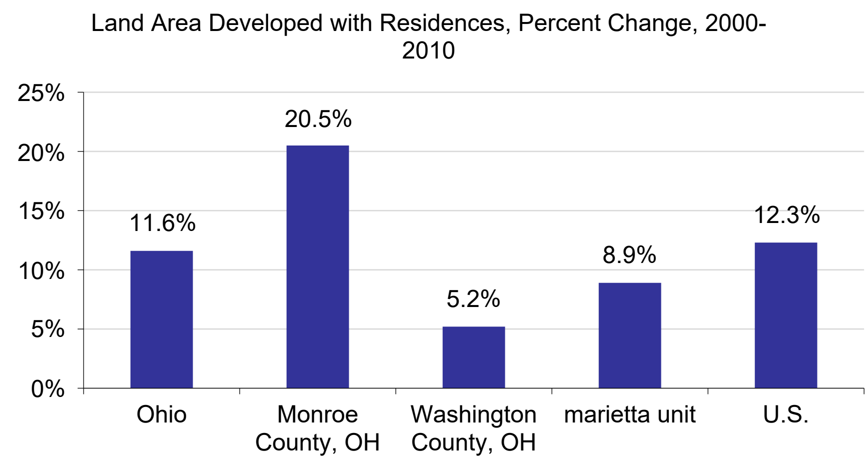
Understanding the composition of land ownership and management in an area is important because actions on federal lands may affect the local economy, particularly when federal lands are a large portion of the land base.

Some Type A federal public lands prohibit most forms of commercial use and development. These lands include national parks, wilderness areas, and national monuments. Because these lands are managed primarily for their non-commercial values (i.e., scenery, wildlife, recreation), they potentially play a different economic role than public lands more commonly associated with commodity sectors.[6, 7]

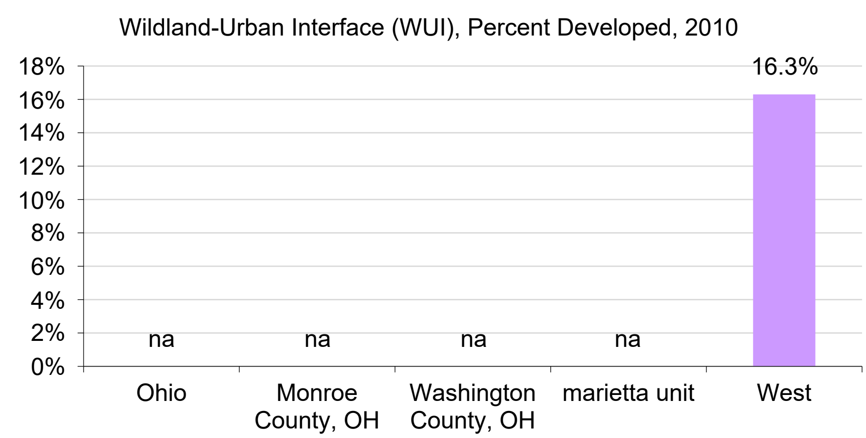
Locations with federal public lands receive government payments—for example, funding through Payments in Lieu of Taxes (PILT), the 25% Fund, or the Secure Rural Schools and Community Self-Determination Act. When these payments are a significant portion of the local county's budget, activities on public lands may affect the fiscal well-being of a county.[8]

Development and the Wildland-Urban Interface

- Between 2000 and 2010, Monroe County, OH had the largest percent change in residential land area developed (20.5%), and Washington County, OH had the smallest (5.2%).



- In 2010, the west had the largest proportion of the wildland-urban interface that is developed (16.3%), and the west had the smallest (16.3%).



Data Sources: Theobald, DM. 2013. Land use classes for ICLUS/SERGoM v2013. Unpublished report, Colorado State University; Gude, P.H., Rasker, R., and van den Noort, J. 2008. Potential for Future Development on Fire-Prone Lands. Journal of Forestry 106(4):198-205; U.S. Department of Commerce. 2011. TIGER/Line 2010 Census Blocks and 2010 Summary File 1, Washington, D.C.

Development and the Wildland-Urban Interface

What do we measure on this page?

This page describes residential development on private lands, and the proportion of the wildland-urban interface (WUI) that is developed.[9] The EPS Land Use report provides additional information on land ownership, management, cover, and development: https://headwaterseconomics.org/eps.

This information is available only for the 11 western states and does not include Alaska and Hawaii.

Wildland-Urban Interface (WUI): Private forestlands that are within 500 meters of public forestlands. We use the threshold of 500 meters to identify the existing and potential WUI area because guidelines for the amount of defensible space necessary to protect homes from wildfire range from 40 to 500 meters around a home. We focus on adjacency to public forests because roughly 70 percent of western forests are publicly owned and because wildfire is a natural disturbance in many of these forests, creating a potential risk to adjacent private lands.[10]

Why is it important?

The conversion of open space and agricultural land to residential development has occurred at a rapid pace in many parts of the U.S. The popularity of exurban lot sizes in much of the country has exacerbated this trend. (Low-density development results in a larger area of land converted to residential development). The pattern of development can reflect a number of factors, including demographic trends, the increasingly "footloose" nature of economic activity, the availability and price of land, and preferences for homes on larger lots. Locations with a large percent change in the area of residential development often have experienced significant in-migration from more urbanized areas. Counties with a small percent change either experienced little growth or were already highly urbanized in 2000.

Development of homes adjacent to fire-prone federal public lands poses several challenges including the rising cost of protecting homes from wildfires; increased danger to wildland firefighters; and the consumption of funds that might otherwise be used for restoration, recreation, research, and other activities. When protecting homes is a priority, agencies are unable to allow otherwise beneficial fires to burn, even those that could reduce fuel loads.

Data Sources & Methods

This EPS Summary report uses national statistics from public government sources. All data used in EPS can be readily verified with the original sources:

- **County Business Patterns**
  Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/cbp.html
  Contacts
  https://www.census.gov/about/contact-us.html

- **Regional Economic Information Data**
  Bureau of Economic Analysis, U.S. Department of Commerce
  https://www.bea.gov/iTable/index_regional.cfm
  Contacts
  https://www.bea.gov/contacts/search.htm

- **Local Area Unemployment Statistics**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/lau/
  Contacts
  https://www.bls.gov/bls/contact.htm

The EPS Summary report also uses data derived from Geographic Information Systems (GIS) to show more accurate statistics for land ownership:

- **TIGER/Line County Boundaries**
  Bureau of the Census, U.S. Department of Commerce
  https://www.census.gov/geo/maps-data/data/tiger.html

- **Protected Areas Database**
  U.S. Geological Survey, Gap Analysis Program
  https://gapanalysis.usgs.gov/padus/

EPS core approaches
EPS is designed to focus on long-term trends across a range of important measures. Trend analysis provides a more comprehensive view of changes than spot data for select years. We encourage users to focus on major trends rather than absolute numbers. EPS displays detailed industry-level data to show changes in the composition of the economy over time and the mix of industries at points in time. EPS employs cross-sectional benchmarking – comparing smaller areas such as counties to larger regions, states, and the nation – to give a sense of relative performance. EPS allows users to aggregate data for multiple locations to allow for more sophisticated cross-sectional comparisons.

Adjusting dollar figures for inflation
Because a dollar in the past was worth more than a dollar today, data reported in current dollar terms should be adjusted for inflation. The U.S. Department of Commerce reports personal income figures in terms of current dollars. All income data in EPS are adjusted to real (or constant) dollars using the Consumer Price Index. Figures are adjusted to the latest date for which the annual Consumer Price Index is available.

Data gaps and estimation
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses supplemental data from the U.S. Department of Commerce to estimate these data gaps. These are indicated with tildes (~) in tables. Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

Endnotes

1 - Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics estimates these data gaps. Estimates are indicated with tildes (~). Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

2 - For details on Bureau of Economic Analysis terms, see: https://bea.gov/regional/definitions.

3 - For more information on unemployment, see the Bureau of Labor Statistics resources on this topic at https://www.bls.gov/bls/unemployment.htm.

4 - The Monthly Labor Review Online, published by the Bureau of Labor statistics, addresses earnings and wages by industry, sex, and educational achievement. Search at https://www.bls.gov/mlr/.

5- Data from County Business Patterns includes both full- and part-time employment. However, CBP data do not include employment in government, agriculture, railroads, or the self-employed and, as a result, undercount the size of industry sectors. Also, CBP data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing relationships between sectors over time.

6 - For examples of literature on the economic role of environmental amenities, see: Booth DE. 1999. Spatial Patterns in the Economic Development of the Mountain West. Growth and Change 30(3):384-405; Duffy-Deno KT. 1998. The Effect of Federal Wilderness on County Growth in the Intermountain Western United States. Journal of Regional Science 38(1):109-136; Lorah P and Southwick R. 2003. Environmental Protection, Population Change, and Economic Development in the Rural Western United States. Population and Environment 24(3):255-272; McGranahan DA. 1999. Natural Amenities Drive Rural Population Change. USDA Economic Research Service, Agricultural Economic Report No. 781. https://www.ers.usda.gov/webdocs/publications/41047/13201_aer781.pdf?v=42061; Rasker R. 2006. An Exploration Into the Economic Impact of Industrial Development Versus Conservation on Western Public Lands. Society & Natural Resources 19(3):191-207; Rudzitis G, Johansen HE. 1991. How Important is Wilderness? Results from a United States Survey. Environmental Management 15(2):227-233.

7- A bibliography of studies documenting the economic role of public lands can be found here: https://headwaterseconomics.org/wp-content/uploads/Annotated_Bib_Value_Public_Lands.pdf.

8- An online data visualization and map showing the history of federal land payments to counties can be seen here: https://headwaterseconomics.org/dataviz/county-payments/

9- For resources related to the wildland-urban interface (WUI), including planning tools and related solutions, see https://headwaterseconomics.org/wildfire/.

10- For a description of the methods used to define and measure the wildland-urban interface, see: Gude P, Rasker R, and van den Noort J. 2008. Potential for Future Development on Fire-Prone Lands. Journal of Forestry 106(4):198-205.

A Profile of Timber and Wood Products

athens unit

Selected Geographies:

Athens County, OH; Perry County, OH; Hocking County, OH; Vinton County, OH

Benchmark Geographies:

U.S.

Produced by
Headwaters Economics'
Economic Profile System (EPS)
https://headwaterseconomics.org/eps
December 18, 2018

About the Economic Profile System (EPS)

EPS is a free web tool created by Headwaters Economics to build customized socioeconomic reports of U.S. counties, states, and regions. Reports can be easily created to compare or aggregate different areas. EPS uses published statistics from federal data sources, including the U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

The Bureau of Land Management and Forest Service have made significant financial and intellectual contributions to the operation and content of EPS.

See https://headwaterseconomics.org/eps for more information about the capabilities of EPS. For technical questions, contact Patty Gude at eps@headwaterseconomics.org or telephone 406-599-7425.

headwaterseconomics.org

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions.

www.blm.gov

The Bureau of Land Management, an agency within the U.S. Department of Interior, administers 249.8 million acres of America's public lands, located primarily in western states. It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

www.fs.fed.us

The Forest Service, an agency of the U.S. Department of Agriculture, administers national forests and grasslands encompassing 193 million acres. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Timber

athens unit

Table of Contents

Note to Users:

This is one of 14 reports that can be created and downloaded from EPS. Topics include land use, demographics, specific industry sectors, the role of non-labor income, the wildland-urban interface, the role of amenities in economic development, and payments to county governments from federal lands. The EPS reports are downloadable as Excel or PDF documents. See https://headwaterseconomics.org/eps.

Timber

athens unit

Timber Sectors

	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
Total Private Employment, 2016	12,856	4,175	5,309	1,704	24,044	126,752,238
Timber	~10	~20	~232	~236	~498	821,502
Growing & Harvesting	~7	~6	20	35	~68	67,408
Forestry & Logging	~6	~6	20	35	~67	55,726
Support Activities for Forestry	~1	0	0	0	~1	11,682
Sawmills & Paper Mills	~1	0	0	168	~169	262,878
Sawmills & Wood Preservation	0	0	0	168	168	84,792
Pulp, Paper, & Paperboard Mills	0	0	0	0	0	103,048
Veneer, Plywood, Engineered Wood	~1	0	0	0	~1	75,038
Wood Products Manufacturing	~2	~14	~212	~33	~261	491,216
Other Wood Product Mfg.	~2	~14	~69	~33	~118	231,547
Converted Paper Product Mfg.	0	0	~143	0	~143	245,415
Non-Timber	~12,846	~4,155	~5,077	~1,468	~23,546	125,930,736

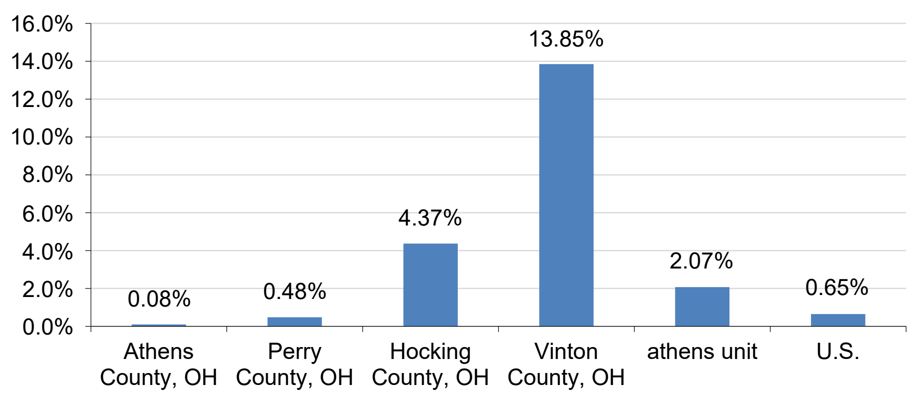
Percent of Total

	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
Timber	~0.1%	~0.5%	~4.4%	~13.8%	~2.1%	0.6%
Growing & Harvesting	~0.1%	~0.1%	0.4%	2.1%	~0.3%	0.1%
Forestry & Logging	~0.0%	~0.1%	0.4%	2.1%	~0.3%	0.0%
Support Activities for Forestry	~0.0%	0.0%	0.0%	0.0%	~0.0%	0.0%
Sawmills & Paper Mills	~0.0%	0.0%	0.0%	9.9%	~0.7%	0.2%
Sawmills & Wood Preservation	0.0%	0.0%	0.0%	9.9%	0.7%	0.1%
Pulp, Paper, & Paperboard Mills	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
Veneer, Plywood, Engineered Wood	~0.0%	0.0%	0.0%	0.0%	~0.0%	0.1%
Wood Products Manufacturing	~0.0%	~0.3%	~4.0%	~1.9%	~1.1%	0.4%
Other Wood Product Mfg.	~0.0%	~0.3%	~1.3%	~1.9%	~0.5%	0.2%
Converted Paper Product Mfg.	0.0%	0.0%	~2.7%	0.0%	~0.6%	0.2%
Non-Timber	~99.9%	~99.5%	~95.6%	~86.2%	~97.9%	99.4%

This table does not include employment data for government, agriculture, railroads, or the self-employed because these are not reported by County Business Patterns. Estimates for data that were not disclosed are indicated with tildes (~).

- In 2016, Vinton County, OH had the largest percent of total timber employment (13.85%), and Athens County, OH had the smallest (0.08%).

Percent of Total Private Employment in Timber, 2016



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Timber Sectors

What do we measure on this page?

This page describes the number of jobs (full- and part-time) and the share of total jobs in the timber industry, broken out by three major categories: growing and harvesting, sawmills and paper mills, and wood products manufacturing.

Growing and Harvesting: Jobs associated with growing and harvesting trees on a long production cycle. This category includes people employed in forest nurseries, as well as those involved in the cutting of trees and transportation of timber.

Sawmills and Paper Mills: Jobs associated with converting logs into lumber, boards, poles, shingles, and other milled products. This category includes those involved in the conversion of logs and wood chips into pulp and paper as well as the creation of veneer and plywood.

Wood Products Manufacturing: Jobs associated with manufacturing. This category includes the production of corrugated boxes, gum and wood chemical products, cabinets, furniture, and other wood manufactured products.

The categories "growing and harvesting," "sawmills and paper mills," and "woods products manufacturing" are aggregations of multiple North American Industry Classification System (NAICS) codes.[1, 2, 3] They are used in this report to differentiate major components of the timber and wood products industry and to distinguish between different levels of value-added production. The first level of production is the growing and harvesting of trees. This is followed by milling. In some cases the milling results in a final product such as paper, while in others it is an intermediary product such as pulp. Some milled products go on to further value-added production (for example, cabinets). This last level includes products that are typically manufactured after leaving a mill.

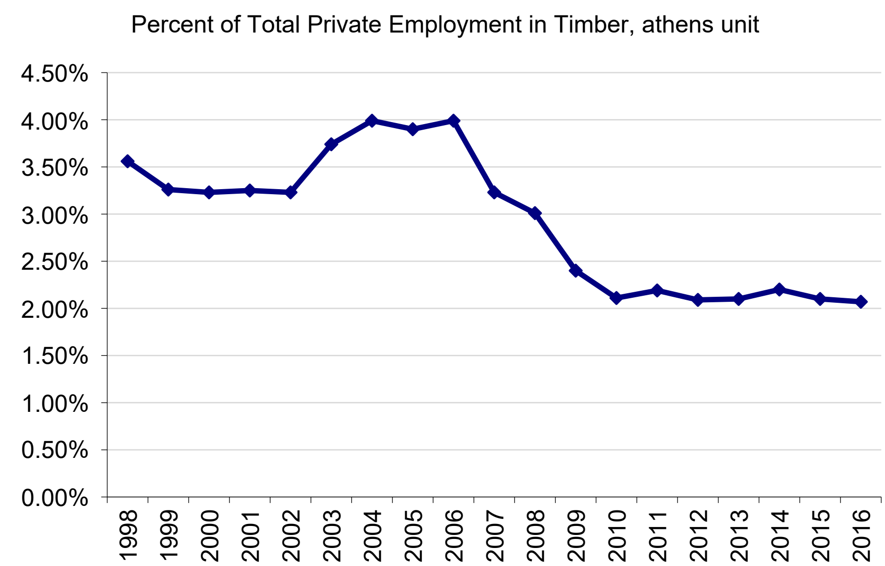
Data on this page were obtained from the U.S. Census Bureau's County Business Patterns (CBP) series. We use this source because, compared to other sources, it has fewer data gaps (instances when the federal government will not release information to protect the confidentiality of individual businesses). It also includes both full- and part-time employment. The disadvantage of CBP data is that they do not include employment in government, agriculture, railroads, or the self-employed and as a result under-count the size of industry sectors. Also, CBP data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing the relationship between sectors over time.

Why is it important?

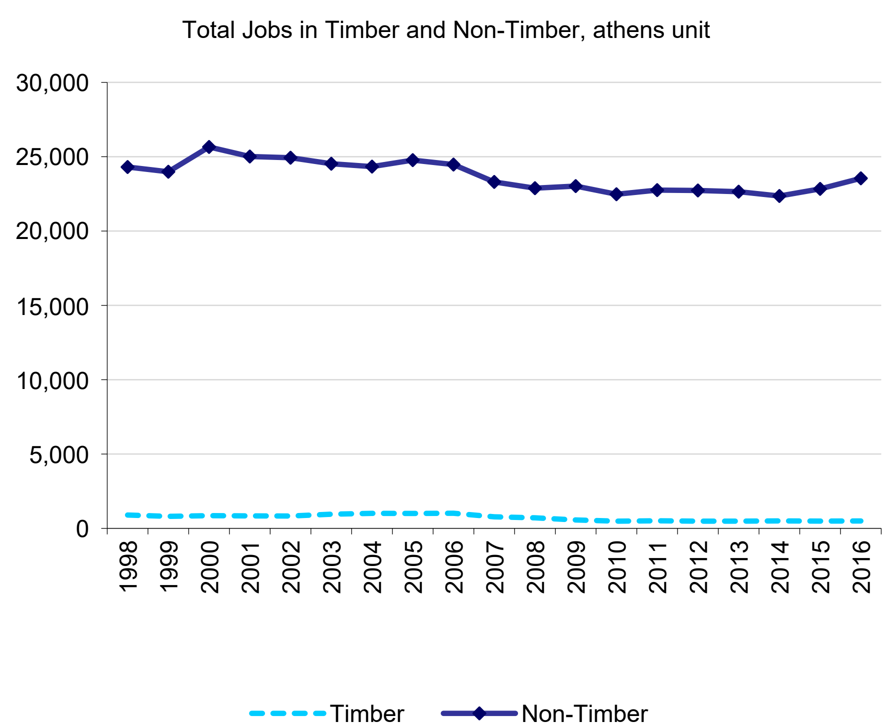
Forest and timberland comprise one-quarter of the contiguous United States.[4, 5] To understand the potential impact of timber-related policies and land management practices, it is important to grasp the relative size of the timber industry and its components, how these have changed over time, and how local trends compare to trends in other locations. Important issues to consider are whether policies or management actions stimulate growth or decline in the industry, how proposed actions relate to ongoing trends shown in the data, whether some locations would be affected more than others, and given the relative size of the industry whether changes to it will affect the broader economy.

Timber Employment Trends

- In 1998, timber represented 3.56 percent of total employment. By 2016, timber represented 2.07 percent of total employment.



- From 1998 to 2016, timber employment shrank from 897 to 498 jobs, a 44.5 percent decrease.
- From 1998 to 2016, non-timber employment shrank from 24,306 to 23,546 jobs, a 3.1 percent decrease.



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Timber Employment Trends

What do we measure on this page?

This page describes long-term trends in timber employment as a percent of all jobs and compares timber to non-timber employment over time.

The figures on this page start in 1998 because that is the year the U.S. Census Bureau (and County Business Patterns) shifted to using the new North American Industrial Classification System (NAICS).

Data on this page were obtained from the U.S. Census Bureau's County Business Patterns (CBP) series. We use this source because, compared to other sources, it has fewer data gaps (instances when the federal government will not release information to protect the confidentiality of individual businesses). It also includes both full- and part-time employment. The disadvantage of CBP data is that they do not include employment in government, agriculture, railroads, or the self-employed and as a result under-count the size of industry sectors. Also, CBP data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing the relationship between sectors over time.

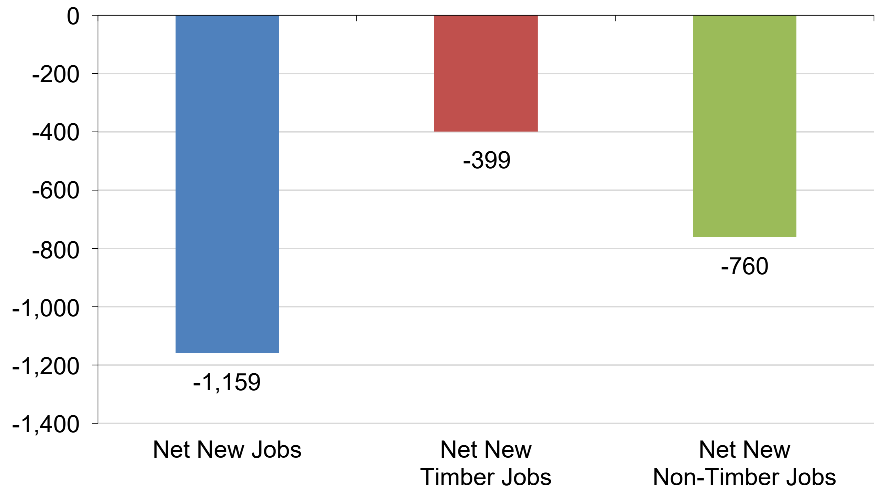
Why is it important?

When the timber industry is a significant driver of the economy, other sectors of the economy, total employment, and total personal income will likely follow trends in the timber industry.[6, 7] In timber-dependent communities, policies and management actions that impact the timber industry can impact the overall economy. If, on the other hand, jobs in the rest of the economy are growing independently of trends in the timber industry, then policies and management actions that potentially affect the timber industry may have impacts that are limited to that industry.

Timber Employment Trends (cont.)

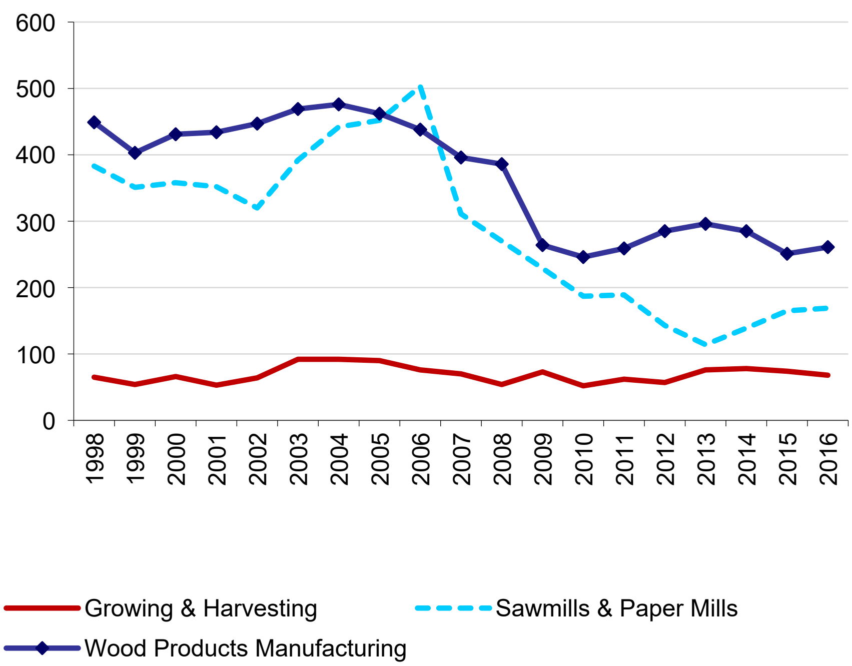
- From 1998 to 2016, timber employment shrank by 399 jobs.
- From 1998 to 2016, non-timber employment shrank by 760 jobs.

New Jobs in Timber and Non-Timber, athens unit, 1998-2016



- From 1998 to 2016, Harvest grew from 65 to 68 jobs, a 4.6% increase.
- From 1998 to 2016, Mills shrank from 383 to 169 jobs, a 55.9% decrease.
- From 1998 to 2016, Mfg shrank from 449 to 261 jobs, a 41.9% decrease.

Jobs in Timber Sectors, athens unit



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Timber Employment Trends (cont.)

What do we measure on this page?

This page describes the change in timber jobs compared to the change in non-timber jobs and compares how employment in various timber sectors has changed over time.[8]

The bottom chart on this page starts in 1998 because that is the year the U.S. Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS).

Data on this page were obtained from County Business Patterns. We use this source because, compared to other sources, it has fewer data gaps (instances when the federal government will not release information to protect confidentiality of individual businesses). It also includes both full- and part-time employment.

The disadvantage of the County Business Patterns data is that they do not include employment in government, agriculture, railroads, or the self-employed and, as a result, undercount the size of industry sectors. Also, County Business Patterns data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing the relationship among sectors over time.

Why is it important?

To understand the importance of timber and wood products in the local economy, it is useful to grasp the source of new jobs and the relative contribution of the timber industry to net new jobs.[7]

Components of the timber industry may create or lose jobs at different rates. A growth in wood products manufacturing employment, for example, can indicate increased value-added activity. Alternatively, a loss of employment at sawmills and paper mills can indicate the closure of a mill with important impacts on the community.

Some places are more dependent on timber-related employment than others. This is important to understand because policies and management activities that impact the timber industry may affect other sectors of the economy.

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth.

In the case of timber and wood products, mechanization, rising transportation costs, volatile prices, competition from abroad, shifting public values related to the management of public lands, the restructuring of timber companies as Real Estate Investment Trusts, and other factors have led to business and employment declines in many communities.[9]

Timber

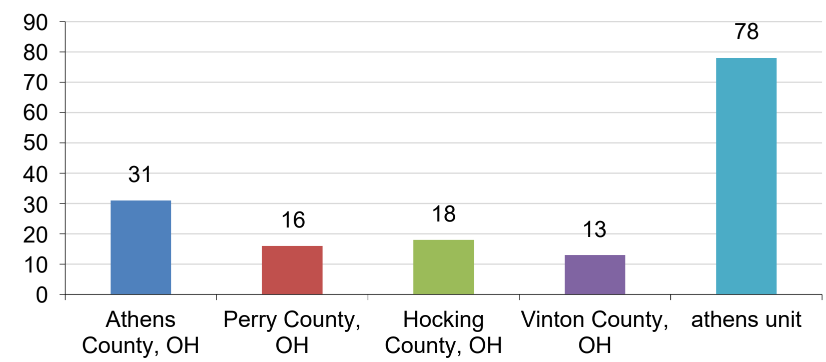
athens unit

Self-Employment

	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
Total Proprietors, 2016	3,172	2,019	1,897	656	7,744	24,813,048
Timber	31	16	18	13	78	71,891
Forestry & Logging	21	16	9	7	53	44,862
Wood Products Manufacturing	10	na	9	6	25	25,699
Paper Manufacturing	0	0	0	0	0	1,330
Non-Timber	3,141	2,003	1,879	643	7,666	24,741,157
Percent of Total						
Timber	1.0%	0.8%	0.9%	2.0%	1.0%	0.3%
Forestry & Logging	0.7%	0.8%	0.5%	1.1%	0.7%	0.2%
Wood Products Manufacturing	0.3%	na	0.5%	0.9%	0.3%	0.1%
Paper Manufacturing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Non-Timber	99.0%	99.2%	99.1%	98.0%	99.0%	99.7%

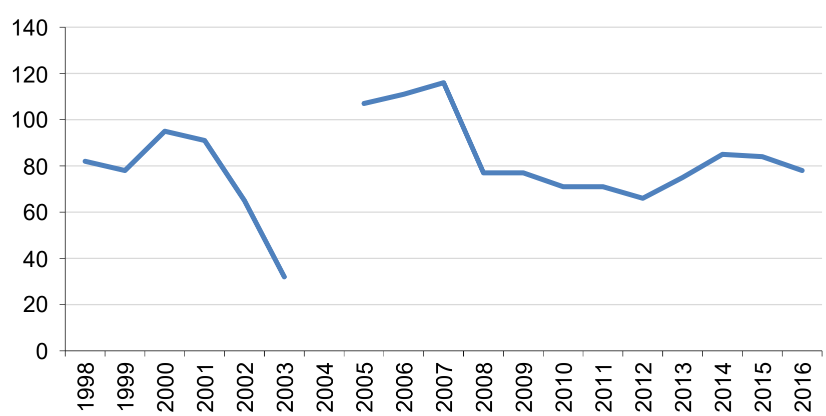
- In 2016, athens unit had the largest number of timber proprietors (78), and Vinton County, OH had the smallest (13).

Timber Proprietors, athens unit, 2016



- From 1998 to 2016, timber proprietors in the athens unit shrank from 82 to 78, a 4.9% decrease.

Timber Proprietors, athens unit



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, Nonemployer Statistics, Washington, D.C.

Self-Employment

What do we measure on this page?

This page describes the number of nonemployer businesses (in most cases self-employed individuals) in timber by sector and location. It offers data to supplement previous pages of this report that do not include the self-employed.

Nonemployer Business: A business with no paid employees, with annual business receipts of $1,000 or more, and subject to federal income taxes. Nonemployer businesses can be individual proprietorships, partnerships, or corporations. Most nonemployers are self-employed individuals operating very small unincorporated businesses that may or may not be the owner's principal source of income.[10]

The U.S. Census Bureau’s Nonemployer Statistics database provides the only source of detailed and comprehensive data on the scope, nature, and activities of U.S. businesses with no paid employment and payroll.[11]

The three timber sub-categories in the upper table Proprietors in Timber are 3-digit NAICS categories from Nonemployer Statistics.[12] They are different from the three summary categories (from County Business Patterns) shown on previous pages.

Depending on the geographies selected, some data may not be available due to disclosure restrictions.

Why is it important?

Significant portions of the timber industry—especially those related to forestry and logging activities that include activities such as cutting, harvesting, and transporting timber—may be conducted by nonemployer businesses. These nonemployer businesses are not reported by County Business Patterns but are reported by Nonemployer Statistics. It is important to use these two data sources in tandem when evaluating the size and trends in timber employment.

Wages and Employment

Wages*, 2017	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
All Sectors, 2017 (2017 $s)	$41,108	$38,292	$32,395	$35,295	$38,678	$55,390
Private	$32,551	$39,171	$28,964	$33,997	$33,109	$55,338
Timber	$0	~$27,593	$30,848	$43,029	~$38,403	$54,394
Forestry & Logging	$0	na	$21,661	$44,712	$35,846	$44,407
Wood Products Manufacturing	$0	$27,593	$33,811	$42,702	$38,926	$44,273
Paper Manufacturing	$0	$0	na	$0	$0	$66,798
Non-Timber	~$31,395	~$39,588	$27,372	~$25,252	$31,675	$55,344
Government	$59,376	$35,854	$42,337	$38,467	$40,197	$55,686

Percent of Employment*, 2017	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
Private	61.1%	73.5%	74.3%	71.0%	66.2%	85.1%
Timber	0.0%	~0.4%	1.2%	8.9%	~0.8%	0.6%
Forestry & Logging	0.0%	na	0.3%	1.5%	0.1%	0.0%
Wood Products Manufacturing	0.0%	0.4%	0.9%	7.5%	0.7%	0.3%
Paper Manufacturing	0.0%	0.0%	na	0.0%	0.0%	0.3%
Non-Timber	~52.7%	~55.3%	64.0%	~31.8%	53.9%	84.5%
Government	1.0%	26.5%	25.7%	29.0%	11.5%	14.9%

* These tables show data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on previous pages of this report.

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment

What do we measure on this page?

This page describes wages (in real terms) from employment in the timber industry, including sub-sectors, compared to wages from employment in all non-timber sectors combined.[13] It also describes the percent of jobs in each category. These are shown together to illustrate the relative wage levels in timber, including sub-sectors, and how many people are employed in each sub-sector.

The wage and employment data on this page are from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[14, 15, 16]

The three timber sub-sectors in the tables are 3-digit NAICS categories from Quarterly Census of Employment and Wages[17] and are different than the three summary categories (from County Business Patterns) shown on the initial pages of this report.

Depending on the locations selected, some data may not be available due to disclosure restrictions.[18]

Why is it important?

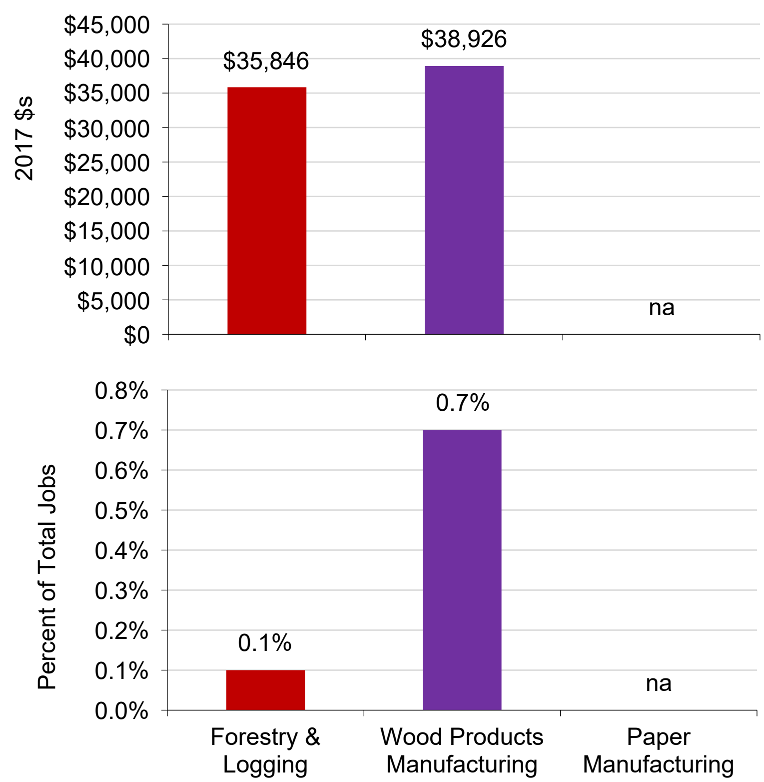
The timber industry has the potential to provide high-wage jobs, but this may differ by timber sub-sector and by location. Important issues to consider are how timber industry wages compare to wages in other sectors, whether some components of the timber industry pay higher wages than others, and whether there are significant wage differences between locations.

Wages and Employment (cont.)

- In 2017, timber sector average wages, from highest to lowest, were: wood products manufacturing ($38,926), forestry & logging ($35,846), and paper manufacturing ($0).

- In 2017, timber sector percent of total employment, from highest to lowest, were: wood products manufacturing (0.7%), forestry & logging (0.1%), and paper manufacturing (0%).

Avg. Annual Wages & Percent of Total Employment in Timber Sectors, athens unit, 2017



- From 1998 to 2017, average wages in wood products manufacturing grew (in real terms) from $34,677 to $38,926, a 12% increase.

Avg. Annual Wages in Timber Sectors, athens unit

Wages and Employment (cont.)

What do we measure on this page?

This page describes wages (in real terms) and employment levels in different timber sectors. It also shows average wage trends (in real terms) for timber sectors.

The wage and employment data on this page are from the Bureau of Labor Statistics, which does not report data for proprietors nor the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[14, 15]

The three timber sub-sectors in the tables are 3-digit NAICS categories (from Quarterly Census of Employment and Wages)[17] and are different than the three summary categories (from County Business Patterns) shown on the initial pages of this report.

The chart *Avg. Annual Wages in Timber Sectors* starts in 1998 to be consistent with the start date of figures on earlier pages of this report.

Depending on the locations selected, some data may not be available due to disclosure restrictions.[18]

Why is it important?

While the timber industry has the potential to offer high wages, not all components of the timber industry pay the same wages or employ the same number of people. A significant increase in timber jobs that pay above the average for all industries will increase overall average earnings per job. On the other hand, a significant increase in timber jobs that pay below the average for all industries will decrease overall average earnings per job. A modest change in timber employment, especially when this industry is a small share of total employment, will not likely affect average earnings in a local area.

Timber

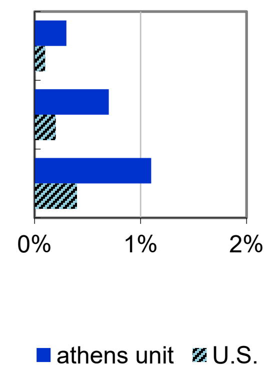
athens unit

Comparisons

Timber Sector	Employment Share, 2016 athens unit	Employment Share, 2016 U.S.	Location Quotient
Growing & Harvesting	~0.3%	0.1%	3.0
Sawmills & Paper Mills	~0.7%	0.2%	3.5
Wood Products Mfg.	~1.1%	0.4%	2.8

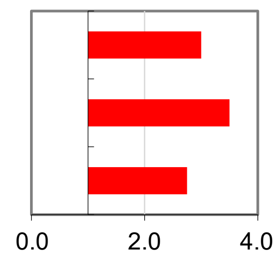
Employment Share

athens unit vs. U.S.



Location Quotient

athens unit vs. U.S.



- In 2016, sawmills & paper mills had the highest location quotient score (3.5), and wood products mfg. had the lowest (2.8).

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Comparisons

What do we measure on this page?

This page describes whether the region is specialized (or under-specialized) in timber employment. The chart illustrates the difference between the selected region and the selected benchmark area.[19] (If no custom benchmark area was selected, EPS defaults to benchmarking against the U.S.)

Location Quotient[20]: A ratio that compares an industry's share of total employment in a region to the benchmark. More precisely, it is the percent of local employment in a sector divided by the percent employment in the same sector in the benchmark area. In other words, it is a ratio that measures specialization using the benchmark area for comparison. A location quotient of more than 1.0 means the local area is more specialized in that sector relative to the benchmark area. A location quotient of less than 1.0 means it is less specialized.[21]

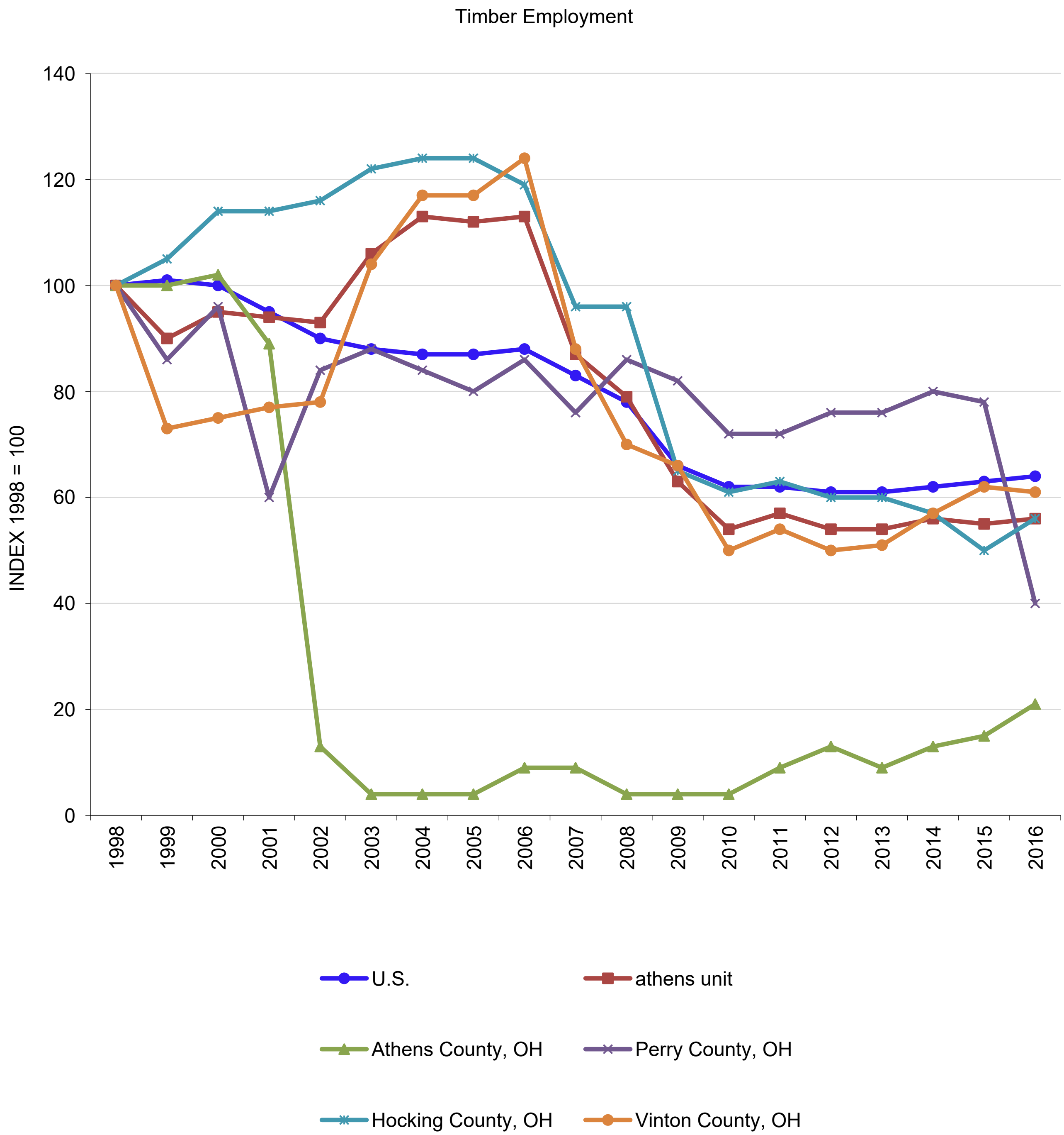
Another way to think about location quotients is as a measure of whether a place produces enough goods or services from an industry to satisfy local demand for those goods or services. Results above or below the 1.0 standard indicate the degree to which a place may import or export a good or service. Although there is no precise cutoff, location quotients above 2.0 indicate a strong industry concentration (and that an area is likely exporting goods or services) and those less than 0.5 indicate a weak industry concentration (and that an area is likely importing goods or services).

Why is it important?

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth. In the case of timber and wood products, mechanization, rising transportation costs, volatile prices, competition from abroad, shifting public values related to the management of public lands, the restructuring of timber companies as Real Estate Investment Trusts, and other factors have led to business and employment declines in many communities. In some cases, rural economies that have historically been tied to commodity production are becoming more diverse.[9, 22]

A few caveats: (1) A large location quotient for a particular sector does not necessarily mean that sector is a significant contributor to the economy. (2) LQs greater than 1.0 only suggest potential export capacity when compared to the benchmark area and do not take into account local demand. Local demand may be greater than average, and therefore all goods and services may be consumed locally (i.e., not exported). (3) LQs can change from year to year. (4) LQs can vary when one uses income or wage data rather than employment.

Comparisons Over Time



- From 1998 to 2016, athens unit had the fastest rate of change in timber employment, and Athens County, OH had the slowest.

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Comparisons Over Time

What do we measure on this page?

This page describes the change in mining employment for all selected locations and the benchmark area.[19] The information is indexed (1998=100) so that data from locations with different-sized economies can be compared. Indexing makes it easier to understand the relative rate of growth or decline of mining employment over time.

Index: Indexed numbers are compared with a base value. In the line chart, employment in 1998 is the base value and is set to 100. The employment values for subsequent years are expressed as 100 times the ratio to the base value. The indexing used in the line chart enables easier comparisons between locations over time. (If many locations are selected, it may be difficult to read the figure on this page.)

The chart begins in 1998 because that is the year the Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS).

Why is it important?

Not all locations have attracted or lost timber industries and employment at the same rate.[8] An index makes it clear where the rate of timber growth or decline has been the fastest. Lines above 100 indicate positive absolute growth while those below 100 show absolute decline. The steeper the curve, the faster the rate of change.

It may be helpful to look for large year-to-year rises or dips in the lines on the chart to identify rapid employment changes. If the reasons behind these fluctuations are not evident, it may be helpful to talk with regional experts or locals to learn more about what caused abrupt changes.[23]

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth.

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth. In the case of timber and wood products, mechanization, rising transportation costs, volatile prices, competition from abroad, shifting public values related to the management of public lands, the restructuring of timber companies as Real Estate Investment Trusts, and other factors have led to business and employment declines in many communities. In some cases, rural economies that have historically been tied to commodity production are becoming more diverse.[6, 9]

Data Sources & Methods

This EPS Timber report uses national statistics from public government sources. All data used in EPS can be readily verified with the original sources:

- **County Business Patterns**
  Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/cbp.html
  Contacts:
  https://www.census.gov/about/contact-us.html

- **Quarterly Census of Employment and Wages**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/cew/
  Contact
  https://www.bls.gov/bls/contact.htm

- **Nonemployer Statistics**
  Bureau of the Census, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/nonemployer-statistics.html
  Contacts:
  https://www.census.gov/programs-surveys/nonemployer-statistics/about/contact-us.html

EPS core approaches
EPS is designed to focus on long-term trends across a range of important measures. Trend analysis provides a more comprehensive view of changes than spot data for select years. We encourage users to focus on major trends rather than absolute numbers. EPS displays detailed industry-level data to show changes in the composition of the economy over time and the mix of industries at points in time. EPS employs cross-sectional benchmarking—comparing smaller areas such as counties to larger regions, states, and the nation—to give a sense of relative performance. EPS allows users to aggregate data for multiple locations to allow for more sophisticated cross-sectional comparisons.

Data Limitations
Much of the data in this report were obtained from the U.S. Census Bureau’s County Business Patterns (CBP) series. Compared to other sources, CBP has fewer data gaps (instances when the federal government will not release data to protect confidentiality of individual businesses). It also includes both full- and part-time employment.

However, CBP data do not include employment in government, agriculture, railroads, or the self-employed. Also, CBP data are based on mid-March employment and do not account for seasonal fluctuations. Since March is a "shoulder" season for several tourism activities, CBP may underrepresent employment in industries associated with tourism. Despite these limitations, the data are most useful for showing long-term trends, displaying differences between places, and showing relationships between sectors over time.

Adjusting dollar figures for inflation
Because a dollar in the past was worth more than a dollar today, data reported in current dollar terms should be adjusted for inflation. The U.S. Department of Commerce reports personal income figures in terms of current dollars. All income data in EPS are adjusted to real (or constant) dollars using the Consumer Price Index. Figures are adjusted to the latest date for which the annual Consumer Price Index is available.

Data gaps and estimation
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses supplemental data from the U.S. Department of Commerce to estimate these data gaps. These are indicated in italics in tables. Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

Endnotes

1 - The three timber and wood products categories are made up of the following NAICS codes:
Growing and Harvesting: forestry and logging (113), support activities for forestry (1153).
Sawmills and Paper Mills: sawmills and wood preservation (3211), pulp, paper, and paperboard mills (3221), veneer, plywood, and engineered wood product manufacturing (3212).
Wood Products Manufacturing: other wood product manufacturing (3219) and converted paper product manufacturing (3222).

2 - For an online listing of all NAICS codes, see: naics.com/search.htm.

3 - For additional online manuals and definitions of industry codes, see: bls.gov/bls/naics.htm and census.gov/eos/www/naics.

4 - For an illustration of how Americans use their land to create wealth (including forestry), see Merrill D and L Leatherby. 2018. Here's How America Uses Its Land. Bloomberg. https://www.bloomberg.com/graphics/2018-us-land-use/.

5 - See the U.S. Forest Service's Forest Inventory and Analysis Program at https://www.fia.fs.fed.us/.

6 - The Forest Service produces a number of publications about the timber industry, including Resources Planning Act (RPA) Assessment reports on the status and trends of the Nation's renewable resources on all forests. See https://www.fs.fed.us/research/rpa/.

7 - The Bureau of Business and Economic Research's (BBER) Forest Industry Research Program monitors forest products operations in the West and researches the industry's size, diversity, and economic impacts. BBER is located at the University of Montana in Missoula, MT. http://www.bber.umt.edu/FIR/Default.asp.

8 - The Bureau of Labor Statistics provides an overview and outlook of the timber industry (as part of agriculture, forestry, and fishing). See https://www.bls.gov/ooh/farming-fishing-and-forestry/.

9 - In 2017 Headwaters Economics analyzed the economic performance of formerly timber-dependent counties. See Lessons from the Timber Transition at https://headwaterseconomics.org/economic-development/trends-performance/timber-transition/.

10 - Nonemployer definitions can be found at https://www.census.gov/epcd/nonemployer/view/define.html.

11 - Nonemployer Statistics data can be found at https://www.census.gov/programs-surveys/nonemployer-statistics.html.

12 - Timber in the table and charts on this page is the sum of the following NAICS codes: Forestry and Logging (113), Wood Products Manufacturing (321), and Paper Manufacturing (322).

13 - The EPS Socioeconomic Measures report provides more information on wages in non-timber industries: https://headwaterseconomics.org/eps.

Endnotes (cont.)

14 - For an overview of how the Bureau of Labor Statistics treats pay and benefits, see https://www.bls.gov/bls/blswage.htm.

15 - For an overview of how the Bureau of Labor Statistics treats employment, see https://www.bls.gov/bls/employment.htm.

16 - Employment and wage estimates are also available from the Bureau of Labor Statistics for more than 800 occupations. Looking at timber by occupation rather than by sector or industry is helpful because wages can vary dramatically across occupations. For more information, see https://www.bls.gov/oes/.

17 - Timber in the tables on this page is the sum of the following NAICS codes: Forestry and Logging (113), Woods Product Manufacturing (321), and Paper Manufacturing (322).

18 - If there are significant undisclosed data on this page, other sources for timber wage data include: The Bureau of Labor Statistics' Quarterly Census of Employment and Wages, which has data for industries at the state level (https://www.bls.gov/cew/);

the Bureau of Labor Statistics' Occupational Outlook Handbook, which has detailed industry earnings and wages data at the national level (https://www.bls.gov/ooh/); and the County Business Patterns database, which reports industry-level employment and payroll and can be used to estimate earnings (https://www.census.gov/programs-surveys/cbp.html).

19 - The term "benchmark" in this report should not be construed as having the same meaning as in the National Forest Management Act (NFMA).

20 - LQ = (ei/e) divided by (Ei/E)
Where: ei = Local employment in industry i; e = Total local employment; Ei = U.S. employment in industry i; E = Total U.S. employment.

21 - A succinct definition of a location quotient is offered by Indiana Business Research Center at IU's Kelley School of Business. See http://www.incontext.indiana.edu/2006/march/1.asp.

22 - For a review of literature on economic diversity, see Sterling A. 1998. On the Economics and Analysis of Diversity. Electronic Working Papers Series, Paper No, 28. Brighton, UK: University of Sussex http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.144.8865&rep=rep1&type=pdf; and Malizia EE and Shanzai K. 2006. The Influence of Economic Diversity on Unemployment and Stability. Journal of Regional Science 33(2):221-235.

23 - Useful resources for investigating trends related to timber harvest on public lands are the National Forest Timber Sales and Timber Cuts and Gross Receipts from Commercial Activities data visualizations available online at https://headwaterseconomics.org/dataviz/national-forests-timber-cut-sold/ and

https://headwaterseconomics.org/dataviz/national-forests-gross-receipts/.

A Profile of Timber and Wood Products

ironton unit

Selected Geographies:

Lawrence County, OH; Gallia County, OH

Benchmark Geographies:

U.S.

Produced by
Headwaters Economics'
Economic Profile System (EPS)
https://headwaterseconomics.org/eps
December 18, 2018

About the Economic Profile System (EPS)

EPS is a free web tool created by Headwaters Economics to build customized socioeconomic reports of U.S. counties, states, and regions. Reports can be easily created to compare or aggregate different areas. EPS uses published statistics from federal data sources, including the U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

The Bureau of Land Management and Forest Service have made significant financial and intellectual contributions to the operation and content of EPS.

See https://headwaterseconomics.org/eps for more information about the capabilities of EPS. For technical questions, contact Patty Gude at eps@headwaterseconomics.org or telephone 406-599-7425.

HEADWATERS ECONOMICS

headwaterseconomics.org

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions.

NATIONAL SYSTEM OF PUBLIC LANDS
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

www.blm.gov

The Bureau of Land Management, an agency within the U.S. Department of Interior, administers 249.8 million acres of America's public lands, located primarily in western states. It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

www.fs.fed.us

The Forest Service, an agency of the U.S. Department of Agriculture, administers national forests and grasslands encompassing 193 million acres. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Timber

ironton unit

Table of Contents

Note to Users:

This is one of 14 reports that can be created and downloaded from EPS. Topics include land use, demographics, specific industry sectors, the role of non-labor income, the wildland-urban interface, the role of amenities in economic development, and payments to county governments from federal lands. The EPS reports are downloadable as Excel or PDF documents. See https://headwaterseconomics.org/eps.

Timber Sectors

	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
Total Private Employment, 2016	10,533	9,487	4,790,178	20,020	126,752,238
Timber	~2	~17	30,101	~19	821,502
Growing & Harvesting	~2	~3	367	~5	67,408
Forestry & Logging	~2	~3	325	~5	55,726
Support Activities for Forestry	0	0	42	0	11,682
Sawmills & Paper Mills	0	~7	5,454	~7	262,878
Sawmills & Wood Preservation	0	~7	1,556	~7	84,792
Pulp, Paper, & Paperboard Mills	0	0	2,373	0	103,048
Veneer, Plywood, Engineered Wood	0	0	1,525	0	75,038
Wood Products Manufacturing	0	~7	24,280	~7	491,216
Other Wood Product Mfg.	0	~7	7,845	~7	231,547
Converted Paper Product Mfg.	0	0	16,218	0	245,415
Non-Timber	~10,531	~9,470	4,760,077	~20,001	125,930,736

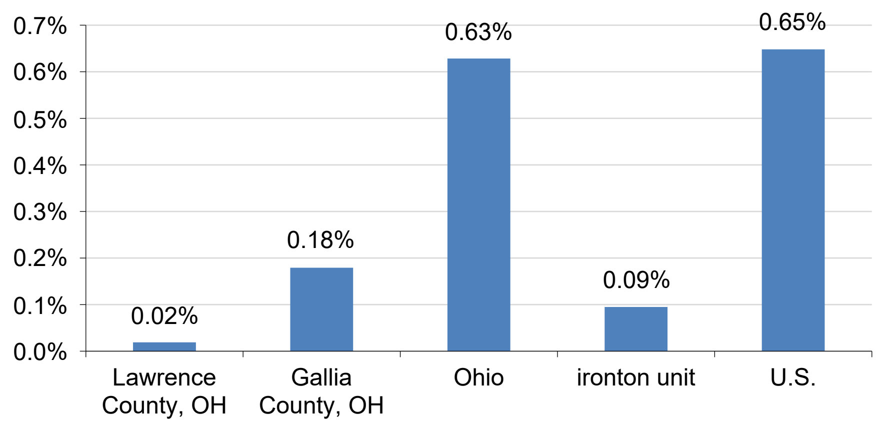
Percent of Total

	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
Timber	~0.0%	~0.2%	0.6%	~0.1%	0.6%
Growing & Harvesting	~0.0%	~0.0%	0.0%	~0.0%	0.1%
Forestry & Logging	~0.0%	~0.0%	0.0%	~0.0%	0.0%
Support Activities for Forestry	0.0%	0.0%	0.0%	0.0%	0.0%
Sawmills & Paper Mills	0.0%	~0.1%	0.1%	~0.0%	0.2%
Sawmills & Wood Preservation	0.0%	~0.1%	0.0%	~0.0%	0.1%
Pulp, Paper, & Paperboard Mills	0.0%	0.0%	0.0%	0.0%	0.1%
Veneer, Plywood, Engineered Wood	0.0%	0.0%	0.0%	0.0%	0.1%
Wood Products Manufacturing	0.0%	~0.1%	0.5%	~0.0%	0.4%
Other Wood Product Mfg.	0.0%	~0.1%	0.2%	~0.0%	0.2%
Converted Paper Product Mfg.	0.0%	0.0%	0.3%	0.0%	0.2%
Non-Timber	~100.0%	~99.8%	99.4%	~99.9%	99.4%

This table does not include employment data for government, agriculture, railroads, or the self-employed because these are not reported by County Business Patterns. Estimates for data that were not disclosed are indicated with tildes (~).

- In 2016, U.S. had the largest percent of total timber employment (0.65%), and Lawrence County, OH had the smallest (0.02%).

Percent of Total Private Employment in Timber, 2016



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Timber

ironton unit

Timber Sectors

What do we measure on this page?

This page describes the number of jobs (full- and part-time) and the share of total jobs in the timber industry, broken out by three major categories: growing and harvesting, sawmills and paper mills, and wood products manufacturing.

Growing and Harvesting: Jobs associated with growing and harvesting trees on a long production cycle. This category includes people employed in forest nurseries, as well as those involved in the cutting of trees and transportation of timber.

Sawmills and Paper Mills: Jobs associated with converting logs into lumber, boards, poles, shingles, and other milled products. This category includes those involved in the conversion of logs and wood chips into pulp and paper as well as the creation of veneer and plywood.

Wood Products Manufacturing: Jobs associated with manufacturing. This category includes the production of corrugated boxes, gum and wood chemical products, cabinets, furniture, and other wood manufactured products.

The categories "growing and harvesting," "sawmills and paper mills," and "woods products manufacturing" are aggregations of multiple North American Industry Classification System (NAICS) codes.[1, 2, 3] They are used in this report to differentiate major components of the timber and wood products industry and to distinguish between different levels of value-added production. The first level of production is the growing and harvesting of trees. This is followed by milling. In some cases the milling results in a final product such as paper, while in others it is an intermediary product such as pulp. Some milled products go on to further value-added production (for example, cabinets). This last level includes products that are typically manufactured after leaving a mill.

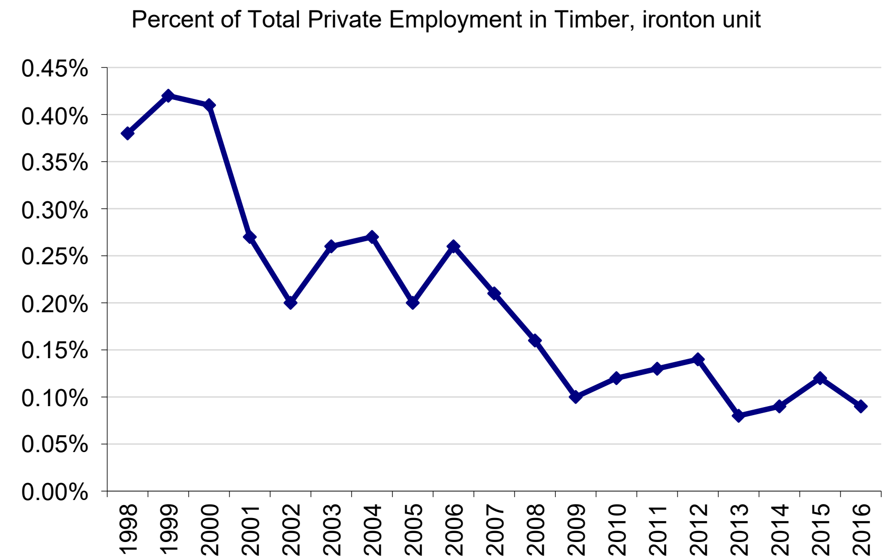
Data on this page were obtained from the U.S. Census Bureau's County Business Patterns (CBP) series. We use this source because, compared to other sources, it has fewer data gaps (instances when the federal government will not release information to protect the confidentiality of individual businesses). It also includes both full- and part-time employment. The disadvantage of CBP data is that they do not include employment in government, agriculture, railroads, or the self-employed and as a result under-count the size of industry sectors. Also, CBP data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing the relationship between sectors over time.

Why is it important?

Forest and timberland comprise one-quarter of the contiguous United States.[4, 5] To understand the potential impact of timber-related policies and land management practices, it is important to grasp the relative size of the timber industry and its components, how these have changed over time, and how local trends compare to trends in other locations. Important issues to consider are whether policies or management actions stimulate growth or decline in the industry, how proposed actions relate to ongoing trends shown in the data, whether some locations would be affected more than others, and given the relative size of the industry whether changes to it will affect the broader economy.

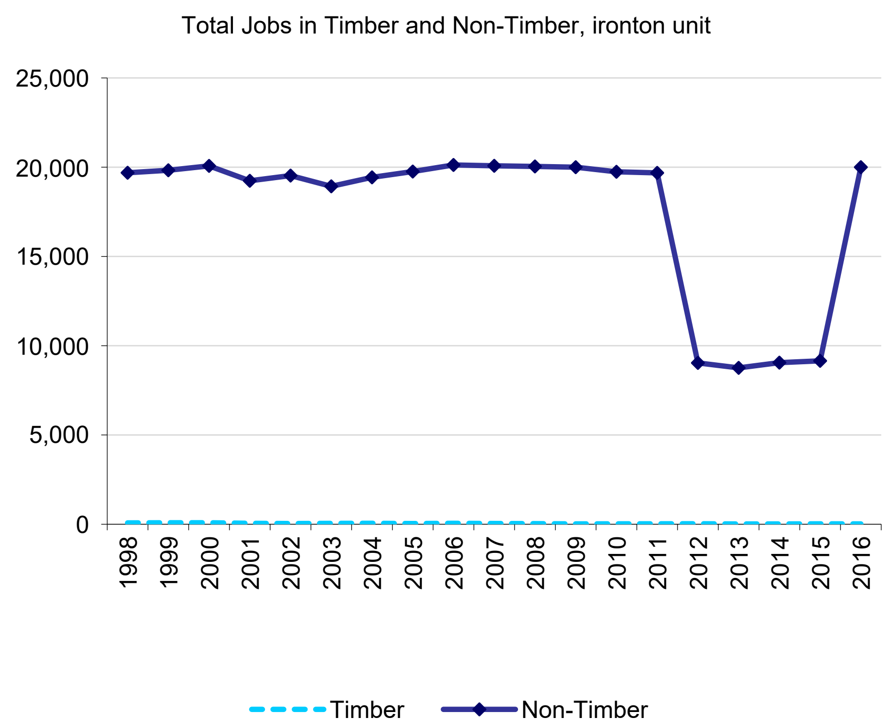
Timber Employment Trends

- In 1998, timber represented 0.38 percent of total employment. By 2016, timber represented 0.09 percent of total employment.



- From 1998 to 2016, timber employment shrank from 75 to 19 jobs, a 74.7 percent decrease.

- From 1998 to 2016, non-timber employment grew from 19,688 to 20,001 jobs, a 1.6 percent increase.



Timber Employment Trends

What do we measure on this page?

This page describes long-term trends in timber employment as a percent of all jobs and compares timber to non-timber employment over time.

The figures on this page start in 1998 because that is the year the U.S. Census Bureau (and County Business Patterns) shifted to using the new North American Industrial Classification System (NAICS).

Data on this page were obtained from the U.S. Census Bureau's County Business Patterns (CBP) series. We use this source because, compared to other sources, it has fewer data gaps (instances when the federal government will not release information to protect the confidentiality of individual businesses). It also includes both full- and part-time employment. The disadvantage of CBP data is that they do not include employment in government, agriculture, railroads, or the self-employed and as a result under-count the size of industry sectors. Also, CBP data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing the relationship between sectors over time.

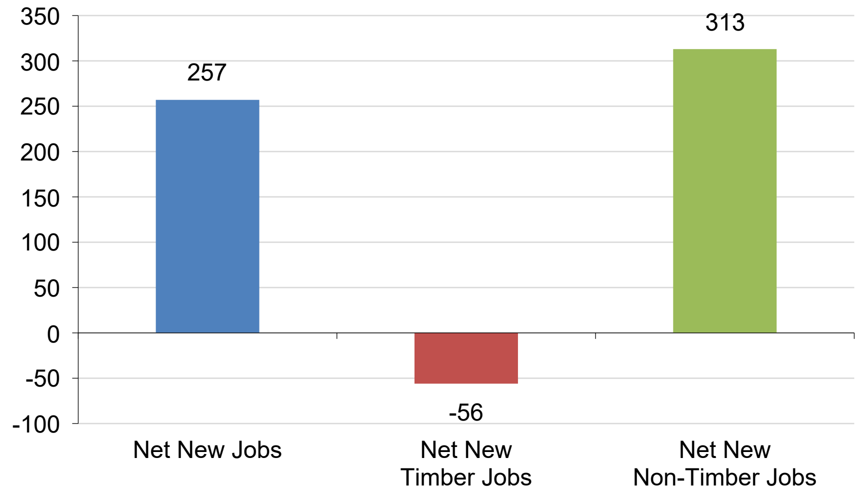
Why is it important?

When the timber industry is a significant driver of the economy, other sectors of the economy, total employment, and total personal income will likely follow trends in the timber industry.[6, 7] In timber-dependent communities, policies and management actions that impact the timber industry can impact the overall economy. If, on the other hand, jobs in the rest of the economy are growing independently of trends in the timber industry, then policies and management actions that potentially affect the timber industry may have impacts that are limited to that industry.

Timber Employment Trends (cont.)

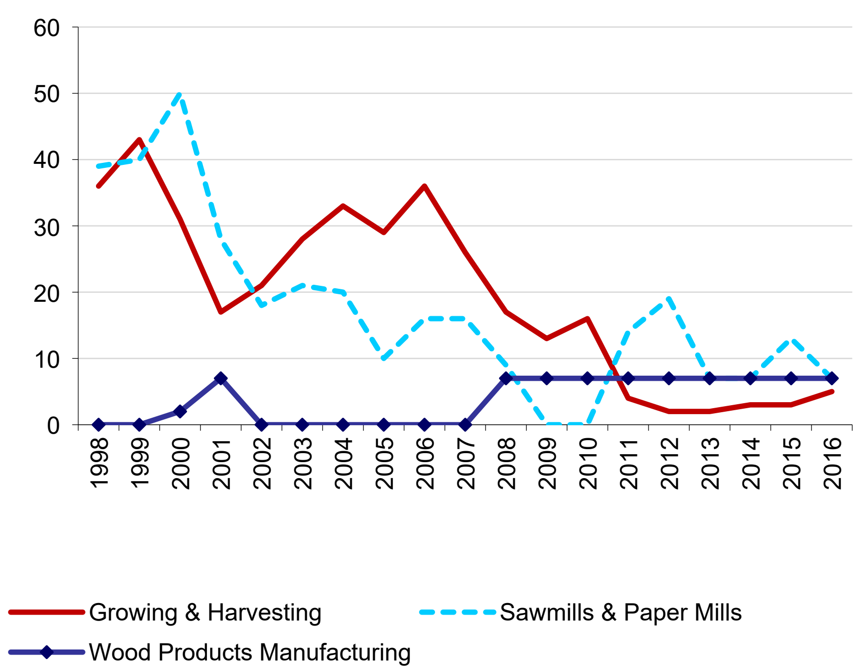
- From 1998 to 2016, timber employment shrank by 56 jobs.
- From 1998 to 2016, non-timber employment grew by 313 jobs.

New Jobs in Timber and Non-Timber, ironton unit, 1998-2016



- From 1998 to 2016, Harvest shrank from 36 to 5 jobs, a 86.1% decrease.
- From 1998 to 2016, Mills shrank from 39 to 7 jobs, a 82.1% decrease.

Jobs in Timber Sectors, ironton unit



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Timber Employment Trends (cont.)

What do we measure on this page?

This page describes the change in timber jobs compared to the change in non-timber jobs and compares how employment in various timber sectors has changed over time.[8]

The bottom chart on this page starts in 1998 because that is the year the U.S. Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS).

Data on this page were obtained from County Business Patterns. We use this source because, compared to other sources, it has fewer data gaps (instances when the federal government will not release information to protect confidentiality of individual businesses). It also includes both full- and part-time employment.

The disadvantage of the County Business Patterns data is that they do not include employment in government, agriculture, railroads, or the self-employed and, as a result, undercount the size of industry sectors. Also, County Business Patterns data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing the relationship among sectors over time.

Why is it important?

To understand the importance of timber and wood products in the local economy, it is useful to grasp the source of new jobs and the relative contribution of the timber industry to net new jobs.[7]

Components of the timber industry may create or lose jobs at different rates. A growth in wood products manufacturing employment, for example, can indicate increased value-added activity. Alternatively, a loss of employment at sawmills and paper mills can indicate the closure of a mill with important impacts on the community.

Some places are more dependent on timber-related employment than others. This is important to understand because policies and management activities that impact the timber industry may affect other sectors of the economy.

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth.

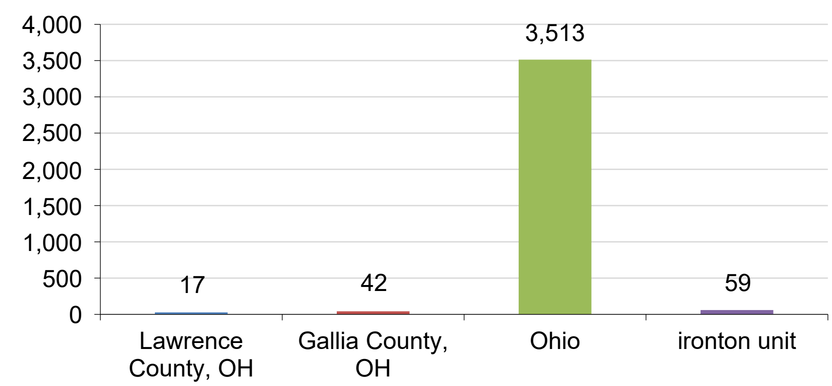
In the case of timber and wood products, mechanization, rising transportation costs, volatile prices, competition from abroad, shifting public values related to the management of public lands, the restructuring of timber companies as Real Estate Investment Trusts, and other factors have led to business and employment declines in many communities.[9]

Self-Employment

	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
Total Proprietors, 2016	2,762	1,653	768,858	4,415	24,813,048
Timber	17	42	3,513	59	71,891
Forestry & Logging	17	32	1,857	49	44,862
Wood Products Manufacturing	na	10	1,602	10	25,699
Paper Manufacturing	0	0	54	0	1,330
Non-Timber	2,745	1,611	765,345	4,356	24,741,157
Percent of Total					
Timber	0.6%	2.5%	0.5%	1.3%	0.3%
Forestry & Logging	0.6%	1.9%	0.2%	1.1%	0.2%
Wood Products Manufacturing	na	0.6%	0.2%	0.2%	0.1%
Paper Manufacturing	0.0%	0.0%	0.0%	0.0%	0.0%
Non-Timber	99.4%	97.5%	99.5%	98.7%	99.7%

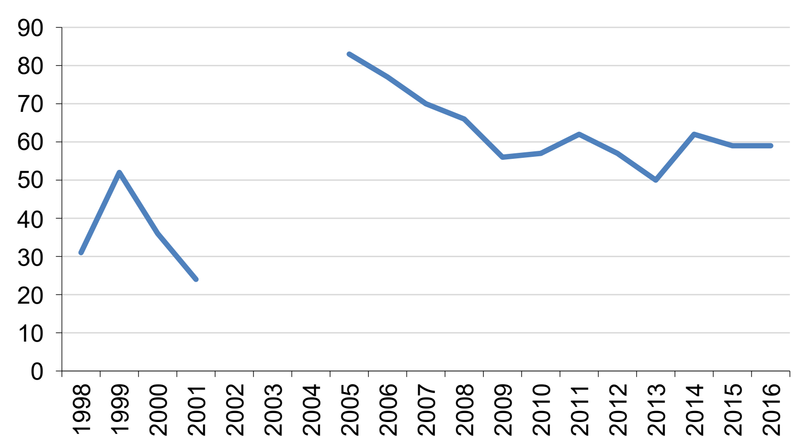
- In 2016, Ohio had the largest number of timber proprietors (3513), and Lawrence County, OH had the smallest (17).

Timber Proprietors, ironton unit, 2016



- From 1998 to 2016, timber proprietors in the ironton unit grew from 31 to 59, a 90.3% increase.

Timber Proprietors, ironton unit



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, Nonemployer Statistics, Washington, D.C.

Self-Employment

What do we measure on this page?

This page describes the number of nonemployer businesses (in most cases self-employed individuals) in timber by sector and location. It offers data to supplement previous pages of this report that do not include the self-employed.

Nonemployer Business: A business with no paid employees, with annual business receipts of $1,000 or more, and subject to federal income taxes. Nonemployer businesses can be individual proprietorships, partnerships, or corporations. Most nonemployers are self-employed individuals operating very small unincorporated businesses that may or may not be the owner's principal source of income.[10]

The U.S. Census Bureau's Nonemployer Statistics database provides the only source of detailed and comprehensive data on the scope, nature, and activities of U.S. businesses with no paid employment and payroll.[11]

The three timber sub-categories in the upper table Proprietors in Timber are 3-digit NAICS categories from Nonemployer Statistics.[12] They are different from the three summary categories (from County Business Patterns) shown on previous pages.

Depending on the geographies selected, some data may not be available due to disclosure restrictions.

Why is it important?

Significant portions of the timber industry—especially those related to forestry and logging activities that include activities such as cutting, harvesting, and transporting timber—may be conducted by nonemployer businesses. These nonemployer businesses are not reported by County Business Patterns but are reported by Nonemployer Statistics. It is important to use these two data sources in tandem when evaluating the size and trends in timber employment.

Wages and Employment

Wages*, 2017	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
All Sectors, 2017 (2017 $s)	$34,102	$35,754	$49,153	$34,875	$55,390
Private	$32,500	$35,824	$48,577	$34,106	$55,338
Timber	˜$0	˜$0	$52,382	$0	$54,394
Forestry & Logging	$0	na	$34,231	$0	$44,407
Wood Products Manufacturing	na	na	$40,926	na	$44,273
Paper Manufacturing	$0	$0	$60,078	$0	$66,798
Non-Timber	˜$32,392	˜$35,190	$48,535	$33,494	$55,344
Government	$39,697	$35,400	$52,885	$37,951	$55,686

Percent of Employment*, 2017	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
Private	77.7%	82.7%	86.6%	80.0%	85.1%
Timber	˜0.0%	˜0.0%	0.6%	0.0%	0.6%
Forestry & Logging	0.0%	na	0.0%	0.0%	0.0%
Wood Products Manufacturing	na	na	0.2%	na	0.3%
Paper Manufacturing	0.0%	0.0%	0.4%	0.0%	0.3%
Non-Timber	˜72.2%	˜53.4%	86.0%	63.4%	84.5%
Government	22.3%	17.3%	13.4%	20.0%	14.9%

* These tables show data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on previous pages of this report.

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment

What do we measure on this page?

This page describes wages (in real terms) from employment in the timber industry, including sub-sectors, compared to wages from employment in all non-timber sectors combined.[13] It also describes the percent of jobs in each category. These are shown together to illustrate the relative wage levels in timber, including sub-sectors, and how many people are employed in each sub-sector.

The wage and employment data on this page are from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[14, 15, 16]

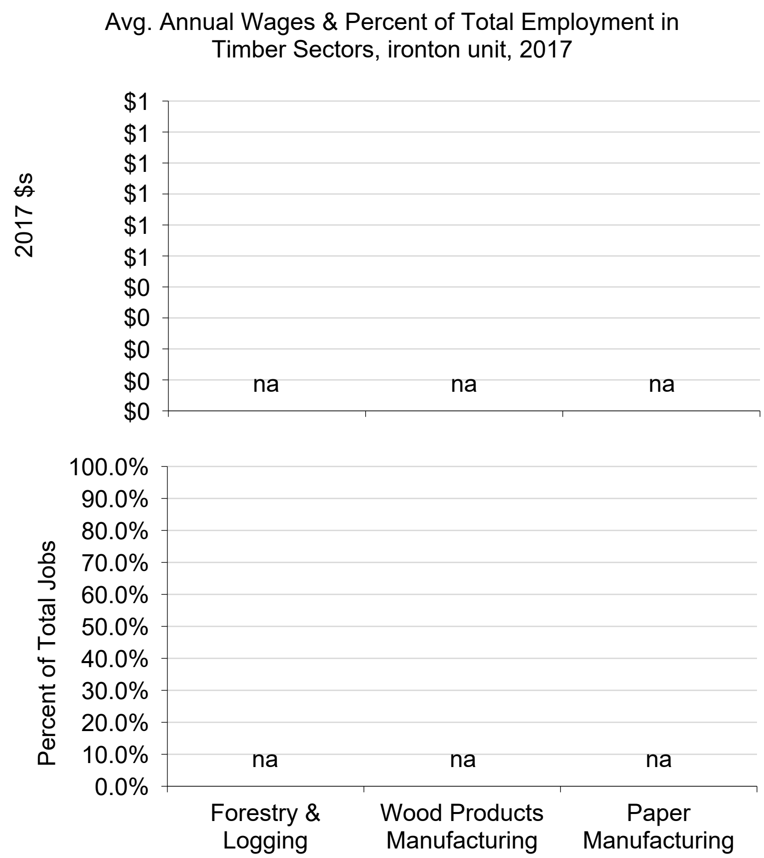
The three timber sub-sectors in the tables are 3-digit NAICS categories from Quarterly Census of Employment and Wages[17] and are different than the three summary categories (from County Business Patterns) shown on the initial pages of this report.

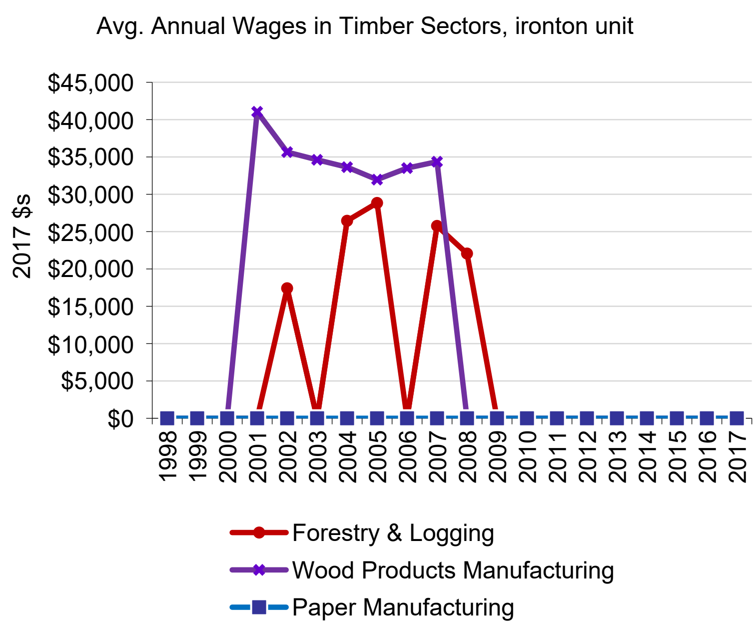
Depending on the locations selected, some data may not be available due to disclosure restrictions.[18]

Why is it important?

The timber industry has the potential to provide high-wage jobs, but this may differ by timber sub-sector and by location. Important issues to consider are how timber industry wages compare to wages in other sectors, whether some components of the timber industry pay higher wages than others, and whether there are significant wage differences between locations.

Wages and Employment (cont.)





Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment (cont.)

What do we measure on this page?

This page describes wages (in real terms) and employment levels in different timber sectors. It also shows average wage trends (in real terms) for timber sectors.

The wage and employment data on this page are from the Bureau of Labor Statistics, which does not report data for proprietors nor the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[14, 15]

The three timber sub-sectors in the tables are 3-digit NAICS categories (from Quarterly Census of Employment and Wages)[17] and are different than the three summary categories (from County Business Patterns) shown on the initial pages of this report.

The chart *Avg. Annual Wages in Timber Sectors* starts in 1998 to be consistent with the start date of figures on earlier pages of this report.

Depending on the locations selected, some data may not be available due to disclosure restrictions.[18]

Why is it important?

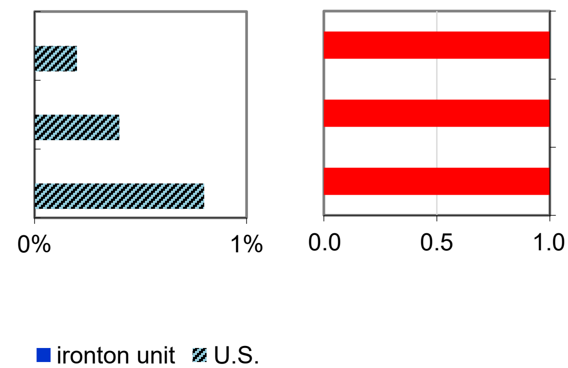
While the timber industry has the potential to offer high wages, not all components of the timber industry pay the same wages or employ the same number of people. A significant increase in timber jobs that pay above the average for all industries will increase overall average earnings per job. On the other hand, a significant increase in timber jobs that pay below the average for all industries will decrease overall average earnings per job. A modest change in timber employment, especially when this industry is a small share of total employment, will not likely affect average earnings in a local area.

Timber

ironton unit

Comparisons

	Employment Share, 2016		Location Quotient	Employment Share	Location Quotient
Timber Sector	ironton unit	U.S.		ironton unit vs. U.S.	ironton unit vs. U.S.
Growing & Harvesting	~0.0%	0.1%	0.0		
Sawmills & Paper Mills	~0.0%	0.2%	0.0		
Wood Products Mfg.	~0.0%	0.4%	0.0		



- In 2016, growing & harvesting had the highest location quotient score (0), and growing & harvesting had the lowest (0).

Comparisons

What do we measure on this page?

This page describes whether the region is specialized (or under-specialized) in timber employment. The chart illustrates the difference between the selected region and the selected benchmark area.[19] (If no custom benchmark area was selected, EPS defaults to benchmarking against the U.S.)

Location Quotient[20]: A ratio that compares an industry's share of total employment in a region to the benchmark. More precisely, it is the percent of local employment in a sector divided by the percent employment in the same sector in the benchmark area. In other words, it is a ratio that measures specialization using the benchmark area for comparison. A location quotient of more than 1.0 means the local area is more specialized in that sector relative to the benchmark area. A location quotient of less than 1.0 means it is less specialized.[21]

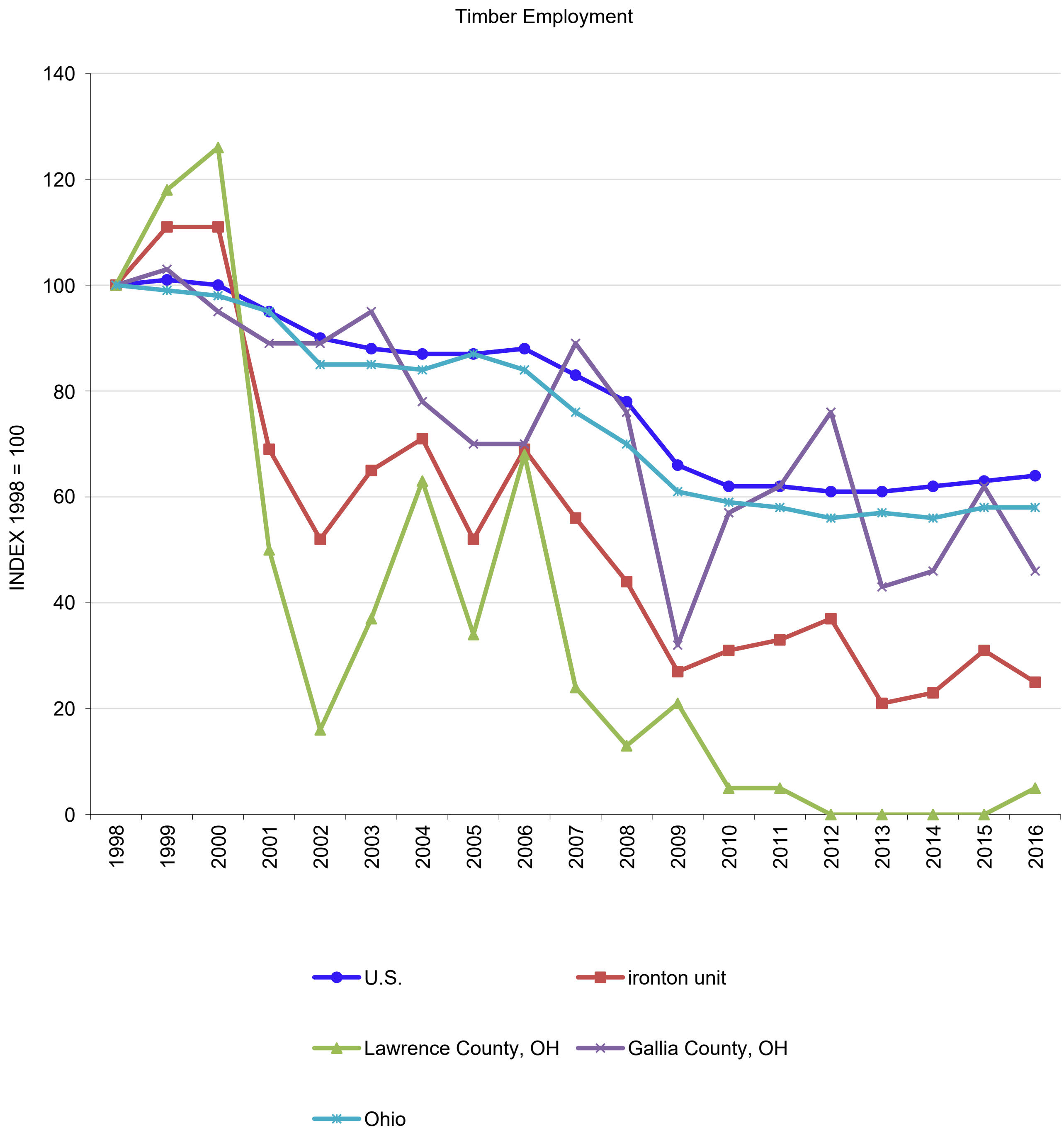
Another way to think about location quotients is as a measure of whether a place produces enough goods or services from an industry to satisfy local demand for those goods or services. Results above or below the 1.0 standard indicate the degree to which a place may import or export a good or service. Although there is no precise cutoff, location quotients above 2.0 indicate a strong industry concentration (and that an area is likely exporting goods or services) and those less than 0.5 indicate a weak industry concentration (and that an area is likely importing goods or services).

Why is it important?

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth. In the case of timber and wood products, mechanization, rising transportation costs, volatile prices, competition from abroad, shifting public values related to the management of public lands, the restructuring of timber companies as Real Estate Investment Trusts, and other factors have led to business and employment declines in many communities. In some cases, rural economies that have historically been tied to commodity production are becoming more diverse.[9, 22]

A few caveats: (1) A large location quotient for a particular sector does not necessarily mean that sector is a significant contributor to the economy. (2) LQs greater than 1.0 only suggest potential export capacity when compared to the benchmark area and do not take into account local demand. Local demand may be greater than average, and therefore all goods and services may be consumed locally (i.e., not exported). (3) LQs can change from year to year. (4) LQs can vary when one uses income or wage data rather than employment.

Comparisons Over Time



- From 1998 to 2016, ironton unit had the fastest rate of change in timber employment, and Lawrence County, OH had the slowest.

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Comparisons Over Time

What do we measure on this page?

This page describes the change in mining employment for all selected locations and the benchmark area.[19] The information is indexed (1998=100) so that data from locations with different-sized economies can be compared. Indexing makes it easier to understand the relative rate of growth or decline of mining employment over time.

Index: Indexed numbers are compared with a base value. In the line chart, employment in 1998 is the base value and is set to 100. The employment values for subsequent years are expressed as 100 times the ratio to the base value. The indexing used in the line chart enables easier comparisons between locations over time. (If many locations are selected, it may be difficult to read the figure on this page.)

The chart begins in 1998 because that is the year the Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS).

Why is it important?

Not all locations have attracted or lost timber industries and employment at the same rate.[8] An index makes it clear where the rate of timber growth or decline has been the fastest. Lines above 100 indicate positive absolute growth while those below 100 show absolute decline. The steeper the curve, the faster the rate of change.

It may be helpful to look for large year-to-year rises or dips in the lines on the chart to identify rapid employment changes. If the reasons behind these fluctuations are not evident, it may be helpful to talk with regional experts or locals to learn more about what caused abrupt changes.[23]

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth.

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth. In the case of timber and wood products, mechanization, rising transportation costs, volatile prices, competition from abroad, shifting public values related to the management of public lands, the restructuring of timber companies as Real Estate Investment Trusts, and other factors have led to business and employment declines in many communities. In some cases, rural economies that have historically been tied to commodity production are becoming more diverse.[6, 9]

Data Sources & Methods

This EPS Timber report uses national statistics from public government sources. All data used in EPS can be readily verified with the original sources:

- **County Business Patterns**
  Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/cbp.html
  Contacts:
  https://www.census.gov/about/contact-us.html

- **Quarterly Census of Employment and Wages**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/cew/
  Contact
  https://www.bls.gov/bls/contact.htm

- **Nonemployer Statistics**
  Bureau of the Census, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/nonemployer-statistics.html
  Contacts:
  https://www.census.gov/programs-surveys/nonemployer-statistics/about/contact-us.html

EPS core approaches
EPS is designed to focus on long-term trends across a range of important measures. Trend analysis provides a more comprehensive view of changes than spot data for select years. We encourage users to focus on major trends rather than absolute numbers. EPS displays detailed industry-level data to show changes in the composition of the economy over time and the mix of industries at points in time. EPS employs cross-sectional benchmarking—comparing smaller areas such as counties to larger regions, states, and the nation—to give a sense of relative performance. EPS allows users to aggregate data for multiple locations to allow for more sophisticated cross-sectional comparisons.

Data Limitations
Much of the data in this report were obtained from the U.S. Census Bureau's County Business Patterns (CBP) series. Compared to other sources, CBP has fewer data gaps (instances when the federal government will not release data to protect confidentiality of individual businesses). It also includes both full- and part-time employment.

However, CBP data do not include employment in government, agriculture, railroads, or the self-employed. Also, CBP data are based on mid-March employment and do not account for seasonal fluctuations. Since March is a "shoulder" season for several tourism activities, CBP may underrepresent employment in industries associated with tourism. Despite these limitations, the data are most useful for showing long-term trends, displaying differences between places, and showing relationships between sectors over time.

Adjusting dollar figures for inflation
Because a dollar in the past was worth more than a dollar today, data reported in current dollar terms should be adjusted for inflation. The U.S. Department of Commerce reports personal income figures in terms of current dollars. All income data in EPS are adjusted to real (or constant) dollars using the Consumer Price Index. Figures are adjusted to the latest date for which the annual Consumer Price Index is available.

Data gaps and estimation
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses supplemental data from the U.S. Department of Commerce to estimate these data gaps. These are indicated in italics in tables. Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

Endnotes

1 - The three timber and wood products categories are made up of the following NAICS codes:
Growing and Harvesting: forestry and logging (113), support activities for forestry (1153).
Sawmills and Paper Mills: sawmills and wood preservation (3211), pulp, paper, and paperboard mills (3221), veneer, plywood, and engineered wood product manufacturing (3212).
Wood Products Manufacturing: other wood product manufacturing (3219) and converted paper product manufacturing (3222).

2 - For an online listing of all NAICS codes, see: naics.com/search.htm.

3 - For additional online manuals and definitions of industry codes, see: bls.gov/bls/naics.htm and census.gov/eos/www/naics.

4 - For an illustration of how Americans use their land to create wealth (including forestry), see Merrill D and L Leatherby. 2018. Here's How America Uses Its Land. Bloomberg. https://www.bloomberg.com/graphics/2018-us-land-use/.

5 - See the U.S. Forest Service's Forest Inventory and Analysis Program at https://www.fia.fs.fed.us/.

6 - The Forest Service produces a number of publications about the timber industry, including Resources Planning Act (RPA) Assessment reports on the status and trends of the Nation's renewable resources on all forests. See https://www.fs.fed.us/research/rpa/.

7 - The Bureau of Business and Economic Research's (BBER) Forest Industry Research Program monitors forest products operations in the West and researches the industry's size, diversity, and economic impacts. BBER is located at the University of Montana in Missoula, MT. http://www.bber.umt.edu/FIR/Default.asp.

8 - The Bureau of Labor Statistics provides an overview and outlook of the timber industry (as part of agriculture, forestry, and fishing). See https://www.bls.gov/ooh/farming-fishing-and-forestry/.

9 - In 2017 Headwaters Economics analyzed the economic performance of formerly timber-dependent counties. See Lessons from the Timber Transition at https://headwaterseconomics.org/economic-development/trends-performance/timber-transition/.

10 - Nonemployer definitions can be found at https://www.census.gov/epcd/nonemployer/view/define.html.

11 - Nonemployer Statistics data can be found at https://www.census.gov/programs-surveys/nonemployer-statistics.html.

12 - Timber in the table and charts on this page is the sum of the following NAICS codes: Forestry and Logging (113), Wood Products Manufacturing (321), and Paper Manufacturing (322).

13 - The EPS Socioeconomic Measures report provides more information on wages in non-timber industries: https://headwaterseconomics.org/eps.

Endnotes (cont.)

14 - For an overview of how the Bureau of Labor Statistics treats pay and benefits, see https://www.bls.gov/bls/blswage.htm.

15 - For an overview of how the Bureau of Labor Statistics treats employment, see https://www.bls.gov/bls/employment.htm.

16 - Employment and wage estimates are also available from the Bureau of Labor Statistics for more than 800 occupations. Looking at timber by occupation rather than by sector or industry is helpful because wages can vary dramatically across occupations. For more information, see https://www.bls.gov/oes/.

17 - Timber in the tables on this page is the sum of the following NAICS codes: Forestry and Logging (113), Woods Product Manufacturing (321), and Paper Manufacturing (322).

18 - If there are significant undisclosed data on this page, other sources for timber wage data include: The Bureau of Labor Statistics' Quarterly Census of Employment and Wages, which has data for industries at the state level (https://www.bls.gov/cew/);

the Bureau of Labor Statistics' Occupational Outlook Handbook, which has detailed industry earnings and wages data at the national level (https://www.bls.gov/ooh/); and the County Business Patterns database, which reports industry-level employment and payroll and can be used to estimate earnings (https://www.census.gov/programs-surveys/cbp.html).

19 - The term "benchmark" in this report should not be construed as having the same meaning as in the National Forest Management Act (NFMA).

20 - LQ = (ei/e) divided by (Ei/E)
Where: ei = Local employment in industry i; e = Total local employment; Ei = U.S. employment in industry i; E = Total U.S. employment.

21 - A succinct definition of a location quotient is offered by Indiana Business Research Center at IU's Kelley School of Business. See http://www.incontext.indiana.edu/2006/march/1.asp.

22 - For a review of literature on economic diversity, see Sterling A. 1998. On the Economics and Analysis of Diversity. Electronic Working Papers Series, Paper No, 28. Brighton, UK: University of Sussex http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.144.8865&rep=rep1&type=pdf; and Malizia EE and Shanzai K. 2006. The Influence of Economic Diversity on Unemployment and Stability. Journal of Regional Science 33(2):221-235.

23 - Useful resources for investigating trends related to timber harvest on public lands are the National Forest Timber Sales and Timber Cuts and Gross Receipts from Commercial Activities data visualizations available online at https://headwaterseconomics.org/dataviz/national-forests-timber-cut-sold/ and

https://headwaterseconomics.org/dataviz/national-forests-gross-receipts/.

A Profile of Timber and Wood Products

marietta unit

Selected Geographies:

Monroe County, OH; Washington County, OH

Benchmark Geographies:

U.S.

Produced by
Headwaters Economics'
Economic Profile System (EPS)
https://headwaterseconomics.org/eps
December 18, 2018

About the Economic Profile System (EPS)

EPS is a free web tool created by Headwaters Economics to build customized socioeconomic reports of U.S. counties, states, and regions. Reports can be easily created to compare or aggregate different areas. EPS uses published statistics from federal data sources, including the U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

The Bureau of Land Management and Forest Service have made significant financial and intellectual contributions to the operation and content of EPS.

See https://headwaterseconomics.org/eps for more information about the capabilities of EPS. For technical questions, contact Patty Gude at eps@headwaterseconomics.org or telephone 406-599-7425.

HEADWATERS ECONOMICS

headwaterseconomics.org

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions.

www.blm.gov

The Bureau of Land Management, an agency within the U.S. Department of Interior, administers 249.8 million acres of America's public lands, located primarily in western states. It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

www.fs.fed.us

The Forest Service, an agency of the U.S. Department of Agriculture, administers national forests and grasslands encompassing 193 million acres. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Timber

marietta unit

Table of Contents

Note to Users:

This is one of 14 reports that can be created and downloaded from EPS. Topics include land use, demographics, specific industry sectors, the role of non-labor income, the wildland-urban interface, the role of amenities in economic development, and payments to county governments from federal lands. The EPS reports are downloadable as Excel or PDF documents. See https://headwaterseconomics.org/eps.

Timber

marietta unit

Timber Sectors

	Ohio	Monroe County, OH	Washington County, OH	marietta unit	U.S.
Total Private Employment, 2016	4,790,178	2,315	22,761	25,076	126,752,238
Timber	30,101	~4	~329	~333	821,502
Growing & Harvesting	367	~2	~2	~4	67,408
Forestry & Logging	325	~2	~2	~4	55,726
Support Activities for Forestry	42	0	0	0	11,682
Sawmills & Paper Mills	5,454	~2	~126	~128	262,878
Sawmills & Wood Preservation	1,556	~2	119	~121	84,792
Pulp, Paper, & Paperboard Mills	2,373	0	0	0	103,048
Veneer, Plywood, Engineered Wood	1,525	0	~7	~7	75,038
Wood Products Manufacturing	24,280	0	~201	~201	491,216
Other Wood Product Mfg.	7,845	0	58	58	231,547
Converted Paper Product Mfg.	16,218	0	~143	~143	245,415
Non-Timber	4,760,077	~2,311	~22,432	~24,743	125,930,736

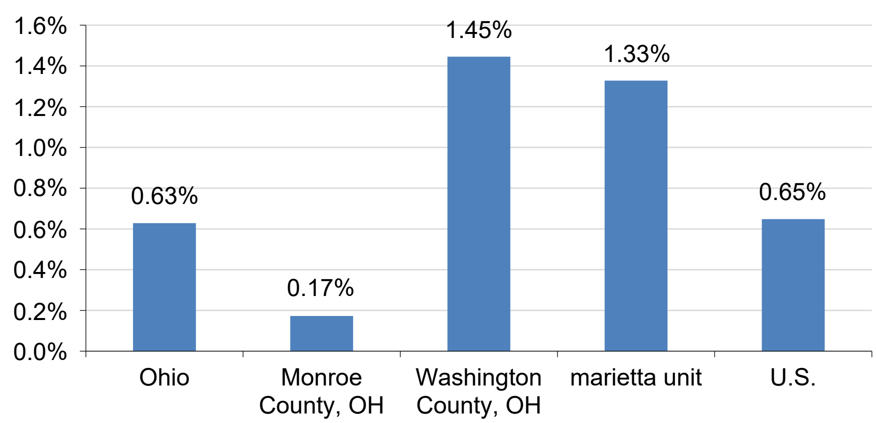
Percent of Total

Timber	0.6%	~0.2%	~1.4%	~1.3%	0.6%
Growing & Harvesting	0.0%	~0.1%	~0.0%	~0.0%	0.1%
Forestry & Logging	0.0%	~0.1%	~0.0%	~0.0%	0.0%
Support Activities for Forestry	0.0%	0.0%	0.0%	0.0%	0.0%
Sawmills & Paper Mills	0.1%	~0.1%	~0.6%	~0.5%	0.2%
Sawmills & Wood Preservation	0.0%	~0.1%	0.5%	~0.5%	0.1%
Pulp, Paper, & Paperboard Mills	0.0%	0.0%	0.0%	0.0%	0.1%
Veneer, Plywood, Engineered Wood	0.0%	0.0%	~0.0%	~0.0%	0.1%
Wood Products Manufacturing	0.5%	0.0%	~0.9%	~0.8%	0.4%
Other Wood Product Mfg.	0.2%	0.0%	0.3%	0.2%	0.2%
Converted Paper Product Mfg.	0.3%	0.0%	~0.6%	~0.6%	0.2%
Non-Timber	99.4%	~99.8%	~98.6%	~98.7%	99.4%

This table does not include employment data for government, agriculture, railroads, or the self-employed because these are not reported by County Business Patterns. Estimates for data that were not disclosed are indicated with tildes (~).

Percent of Total Private Employment in Timber, 2016

- In 2016, Washington County, OH had the largest percent of total timber employment (1.45%), and Monroe County, OH had the smallest (0.17%).



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Timber Sectors

What do we measure on this page?

This page describes the number of jobs (full- and part-time) and the share of total jobs in the timber industry, broken out by three major categories: growing and harvesting, sawmills and paper mills, and wood products manufacturing.

Growing and Harvesting: Jobs associated with growing and harvesting trees on a long production cycle. This category includes people employed in forest nurseries, as well as those involved in the cutting of trees and transportation of timber.

Sawmills and Paper Mills: Jobs associated with converting logs into lumber, boards, poles, shingles, and other milled products. This category includes those involved in the conversion of logs and wood chips into pulp and paper as well as the creation of veneer and plywood.

Wood Products Manufacturing: Jobs associated with manufacturing. This category includes the production of corrugated boxes, gum and wood chemical products, cabinets, furniture, and other wood manufactured products.

The categories "growing and harvesting," "sawmills and paper mills," and "woods products manufacturing" are aggregations of multiple North American Industry Classification System (NAICS) codes.[1, 2, 3] They are used in this report to differentiate major components of the timber and wood products industry and to distinguish between different levels of value-added production. The first level of production is the growing and harvesting of trees. This is followed by milling. In some cases the milling results in a final product such as paper, while in others it is an intermediary product such as pulp. Some milled products go on to further value-added production (for example, cabinets). This last level includes products that are typically manufactured after leaving a mill.

Data on this page were obtained from the U.S. Census Bureau's County Business Patterns (CBP) series. We use this source because, compared to other sources, it has fewer data gaps (instances when the federal government will not release information to protect the confidentiality of individual businesses). It also includes both full- and part-time employment. The disadvantage of CBP data is that they do not include employment in government, agriculture, railroads, or the self-employed and as a result under-count the size of industry sectors. Also, CBP data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing the relationship between sectors over time.

Why is it important?

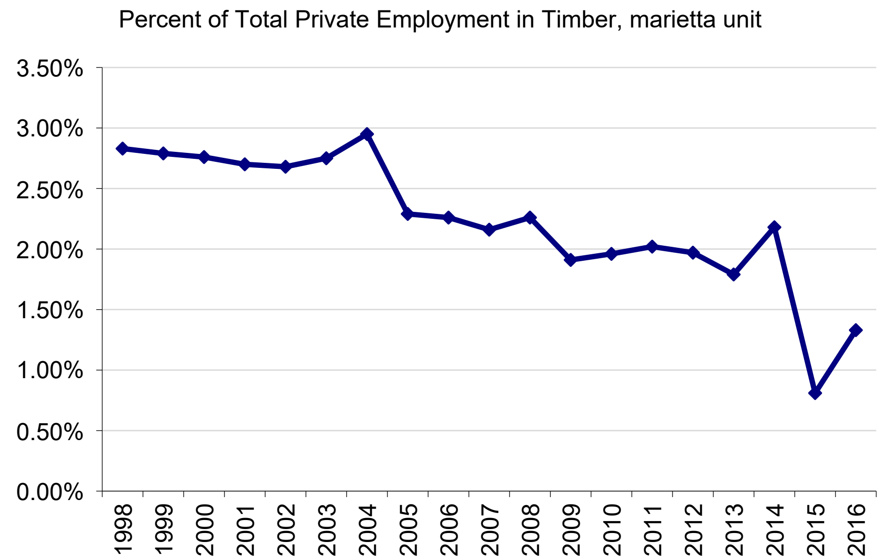
Forest and timberland comprise one-quarter of the contiguous United States.[4, 5] To understand the potential impact of timber-related policies and land management practices, it is important to grasp the relative size of the timber industry and its components, how these have changed over time, and how local trends compare to trends in other locations. Important issues to consider are whether policies or management actions stimulate growth or decline in the industry, how proposed actions relate to ongoing trends shown in the data, whether some locations would be affected more than others, and given the relative size of the industry whether changes to it will affect the broader economy.

Timber

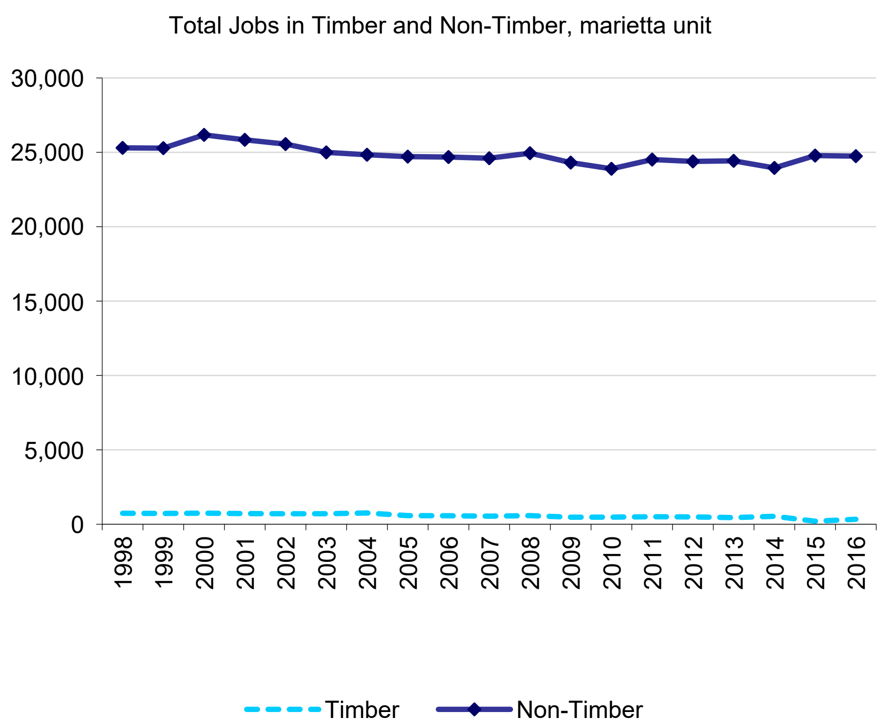
marietta unit

Timber Employment Trends

- In 1998, timber represented 2.83 percent of total employment. By 2016, timber represented 1.33 percent of total employment.



- From 1998 to 2016, timber employment shrank from 737 to 333 jobs, a 54.8 percent decrease.
- From 1998 to 2016, non-timber employment shrank from 25,299 to 24,743 jobs, a 2.2 percent decrease.



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Timber Employment Trends

What do we measure on this page?

This page describes long-term trends in timber employment as a percent of all jobs and compares timber to non-timber employment over time.

The figures on this page start in 1998 because that is the year the U.S. Census Bureau (and County Business Patterns) shifted to using the new North American Industrial Classification System (NAICS).

Data on this page were obtained from the U.S. Census Bureau's County Business Patterns (CBP) series. We use this source because, compared to other sources, it has fewer data gaps (instances when the federal government will not release information to protect the confidentiality of individual businesses). It also includes both full- and part-time employment. The disadvantage of CBP data is that they do not include employment in government, agriculture, railroads, or the self-employed and as a result under-count the size of industry sectors. Also, CBP data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing the relationship between sectors over time.

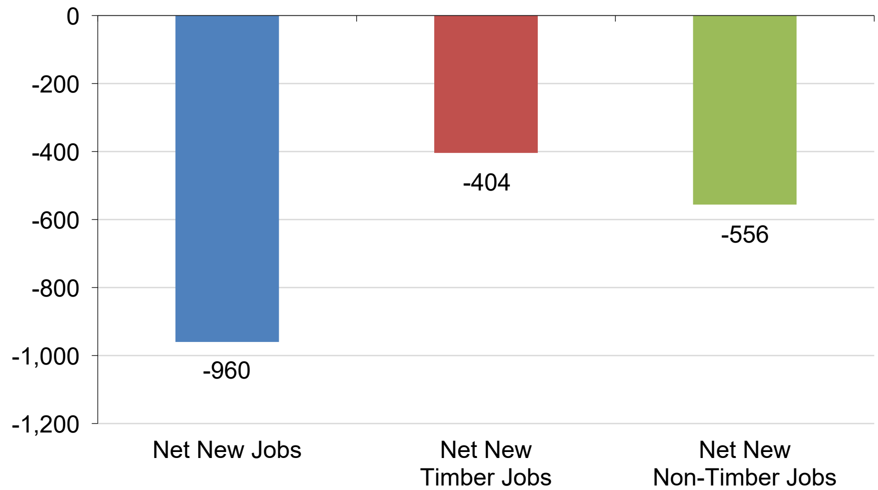
Why is it important?

When the timber industry is a significant driver of the economy, other sectors of the economy, total employment, and total personal income will likely follow trends in the timber industry.[6, 7] In timber-dependent communities, policies and management actions that impact the timber industry can impact the overall economy. If, on the other hand, jobs in the rest of the economy are growing independently of trends in the timber industry, then policies and management actions that potentially affect the timber industry may have impacts that are limited to that industry.

Timber Employment Trends (cont.)

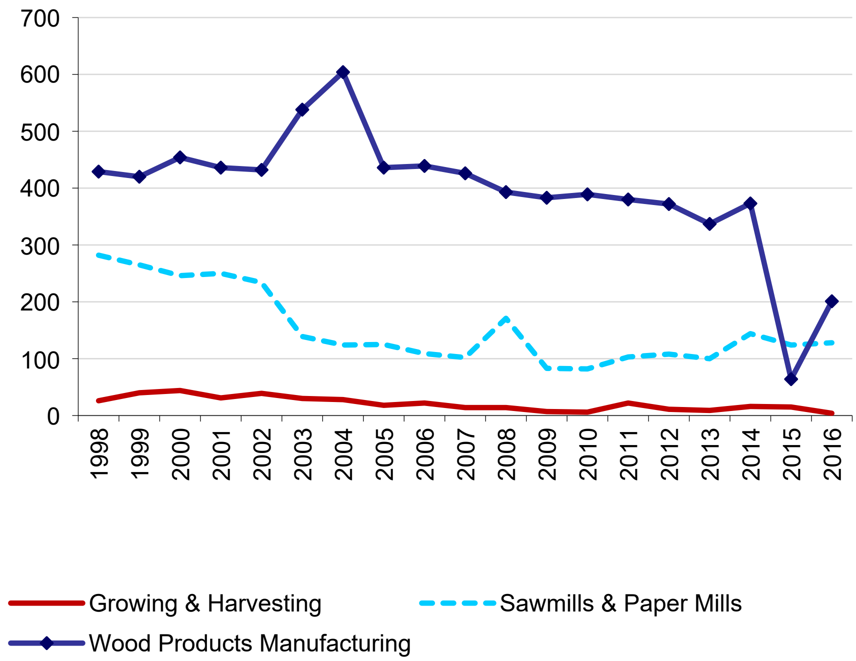
- From 1998 to 2016, timber employment shrank by 404 jobs.
- From 1998 to 2016, non-timber employment shrank by 556 jobs.

New Jobs in Timber and Non-Timber, marietta unit, 1998-2016



- From 1998 to 2016, Harvest shrank from 26 to 4 jobs, a 84.6% decrease.
- From 1998 to 2016, Mills shrank from 282 to 128 jobs, a 54.6% decrease.
- From 1998 to 2016, Mfg shrank from 429 to 201 jobs, a 53.1% decrease.

Jobs in Timber Sectors, marietta unit



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Timber Employment Trends (cont.)

What do we measure on this page?

This page describes the change in timber jobs compared to the change in non-timber jobs and compares how employment in various timber sectors has changed over time.[8]

The bottom chart on this page starts in 1998 because that is the year the U.S. Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS).

Data on this page were obtained from County Business Patterns. We use this source because, compared to other sources, it has fewer data gaps (instances when the federal government will not release information to protect confidentiality of individual businesses). It also includes both full- and part-time employment.

The disadvantage of the County Business Patterns data is that they do not include employment in government, agriculture, railroads, or the self-employed and, as a result, undercount the size of industry sectors. Also, County Business Patterns data are based on mid-March employment and do not take into account seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between locations, and showing the relationship among sectors over time.

Why is it important?

To understand the importance of timber and wood products in the local economy, it is useful to grasp the source of new jobs and the relative contribution of the timber industry to net new jobs.[7]

Components of the timber industry may create or lose jobs at different rates. A growth in wood products manufacturing employment, for example, can indicate increased value-added activity. Alternatively, a loss of employment at sawmills and paper mills can indicate the closure of a mill with important impacts on the community.

Some places are more dependent on timber-related employment than others. This is important to understand because policies and management activities that impact the timber industry may affect other sectors of the economy.

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth.

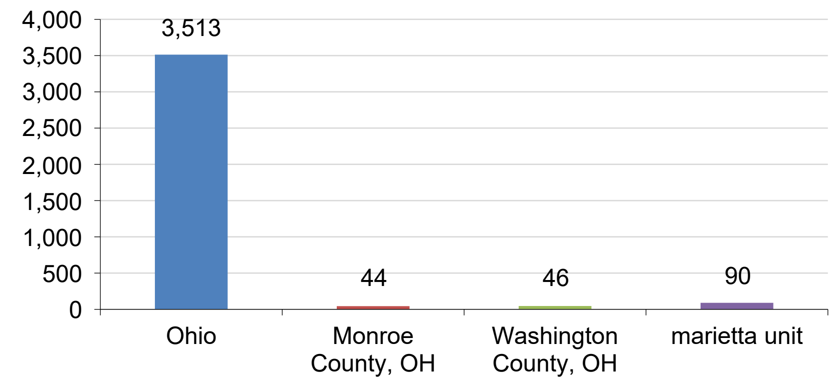
In the case of timber and wood products, mechanization, rising transportation costs, volatile prices, competition from abroad, shifting public values related to the management of public lands, the restructuring of timber companies as Real Estate Investment Trusts, and other factors have led to business and employment declines in many communities.[9]

Self-Employment

	Ohio	Monroe County, OH	Washington County, OH	marietta unit	U.S.
Total Proprietors, 2016	768,858	1,026	3,755	4,781	24,813,048
Timber	3,513	44	46	90	71,891
Forestry & Logging	1,857	37	31	68	44,862
Wood Products Manufacturing	1,602	7	15	22	25,699
Paper Manufacturing	54	0	0	0	1,330
Non-Timber	765,345	982	3,709	4,691	24,741,157
Percent of Total					
Timber	0.5%	4.3%	1.2%	1.9%	0.3%
Forestry & Logging	0.2%	3.6%	0.8%	1.4%	0.2%
Wood Products Manufacturing	0.2%	0.7%	0.4%	0.5%	0.1%
Paper Manufacturing	0.0%	0.0%	0.0%	0.0%	0.0%
Non-Timber	99.5%	95.7%	98.8%	98.1%	99.7%

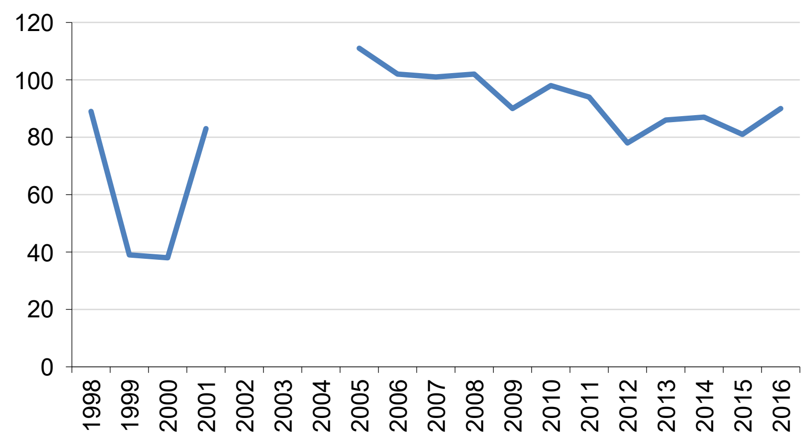
- In 2016, Ohio had the largest number of timber proprietors (3513), and Monroe County, OH had the smallest (44).

Timber Proprietors, marietta unit, 2016



- From 1998 to 2016, timber proprietors in the marietta unit grew from 89 to 90, a 1.1% increase.

Timber Proprietors, marietta unit



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, Nonemployer Statistics, Washington, D.C.

Self-Employment

What do we measure on this page?

This page describes the number of nonemployer businesses (in most cases self-employed individuals) in timber by sector and location. It offers data to supplement previous pages of this report that do not include the self-employed.

Nonemployer Business: A business with no paid employees, with annual business receipts of $1,000 or more, and subject to federal income taxes. Nonemployer businesses can be individual proprietorships, partnerships, or corporations. Most nonemployers are self-employed individuals operating very small unincorporated businesses that may or may not be the owner's principal source of income.[10]

The U.S. Census Bureau's Nonemployer Statistics database provides the only source of detailed and comprehensive data on the scope, nature, and activities of U.S. businesses with no paid employment and payroll.[11]

The three timber sub-categories in the upper table Proprietors in Timber are 3-digit NAICS categories from Nonemployer Statistics.[12] They are different from the three summary categories (from County Business Patterns) shown on previous pages.

Depending on the geographies selected, some data may not be available due to disclosure restrictions.

Why is it important?

Significant portions of the timber industry—especially those related to forestry and logging activities that include activities such as cutting, harvesting, and transporting timber—may be conducted by nonemployer businesses. These nonemployer businesses are not reported by County Business Patterns but are reported by Nonemployer Statistics. It is important to use these two data sources in tandem when evaluating the size and trends in timber employment.

Timber

marietta unit

Wages and Employment

Wages*, 2017	Ohio	Monroe County, OH	Washington County, OH	marietta unit	U.S.
All Sectors, 2017 (2017 $s)	$49,153	$32,918	$45,076	$43,887	$55,390
Private	$48,577	$32,282	$45,741	$44,677	$55,338
Timber	$52,382	˜$0	˜$33,668	$33,668	$54,394
Forestry & Logging	$34,231	na	na	na	$44,407
Wood Products Manufacturing	$40,926	na	$33,668	$33,668	$44,273
Paper Manufacturing	$60,078	$0	$0	$0	$66,798
Non-Timber	$48,535	˜$36,522	˜$46,299	$45,775	$55,344
Government	$52,885	$34,390	$40,091	$38,855	$55,686

Percent of Employment*, 2017	Ohio	Monroe County, OH	Washington County, OH	marietta unit	U.S.
Private	86.6%	69.8%	88.2%	86.4%	85.1%
Timber	0.6%	˜0.0%	˜0.7%	0.6%	0.6%
Forestry & Logging	0.0%	na	na	na	0.0%
Wood Products Manufacturing	0.2%	na	0.7%	0.6%	0.3%
Paper Manufacturing	0.4%	0.0%	0.0%	0.0%	0.3%
Non-Timber	86.0%	˜38.1%	˜73.0%	69.6%	84.5%
Government	13.4%	30.2%	11.8%	13.6%	14.9%

* These tables show data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on previous pages of this report.

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment

What do we measure on this page?

This page describes wages (in real terms) from employment in the timber industry, including sub-sectors, compared to wages from employment in all non-timber sectors combined.[13] It also describes the percent of jobs in each category. These are shown together to illustrate the relative wage levels in timber, including sub-sectors, and how many people are employed in each sub-sector.

The wage and employment data on this page are from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[14, 15, 16]

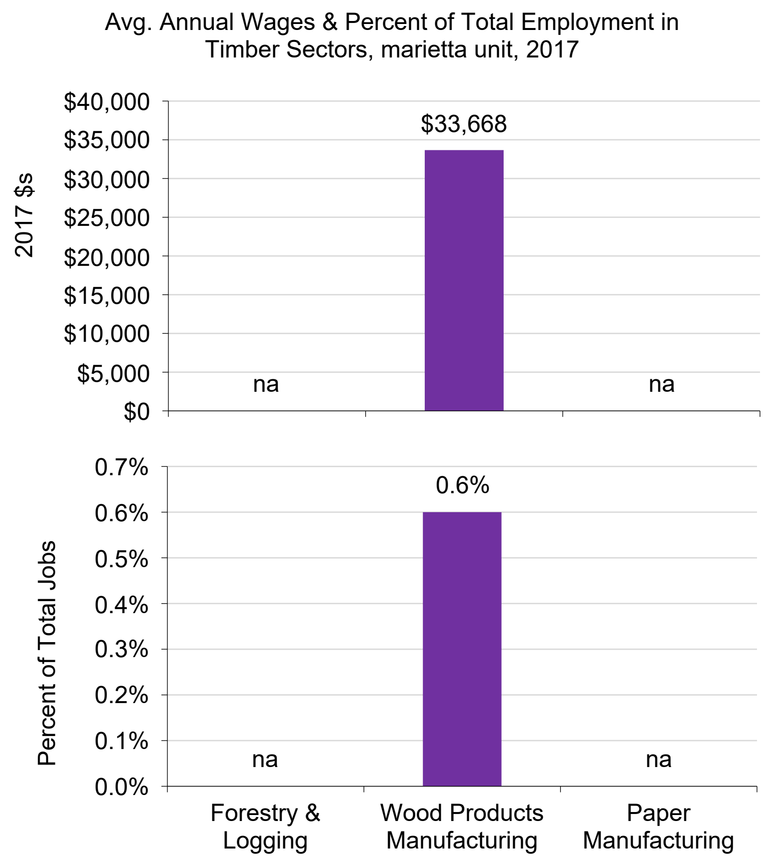
The three timber sub-sectors in the tables are 3-digit NAICS categories from Quarterly Census of Employment and Wages[17] and are different than the three summary categories (from County Business Patterns) shown on the initial pages of this report.

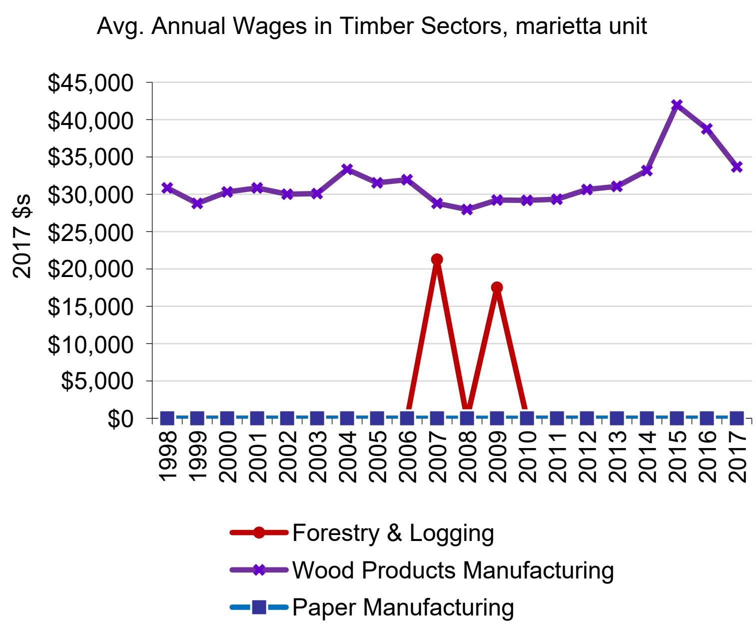
Depending on the locations selected, some data may not be available due to disclosure restrictions.[18]

Why is it important?

The timber industry has the potential to provide high-wage jobs, but this may differ by timber sub-sector and by location. Important issues to consider are how timber industry wages compare to wages in other sectors, whether some components of the timber industry pay higher wages than others, and whether there are significant wage differences between locations.

Wages and Employment (cont.)





- From 1998 to 2017, average wages in wood products manufacturing grew (in real terms) from $30,853 to $33,668, a 9% increase.

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment (cont.)

What do we measure on this page?

This page describes wages (in real terms) and employment levels in different timber sectors. It also shows average wage trends (in real terms) for timber sectors.

The wage and employment data on this page are from the Bureau of Labor Statistics, which does not report data for proprietors nor the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[14, 15]

The three timber sub-sectors in the tables are 3-digit NAICS categories (from Quarterly Census of Employment and Wages)[17] and are different than the three summary categories (from County Business Patterns) shown on the initial pages of this report.

The chart *Avg. Annual Wages in Timber Sectors* starts in 1998 to be consistent with the start date of figures on earlier pages of this report.

Depending on the locations selected, some data may not be available due to disclosure restrictions.[18]

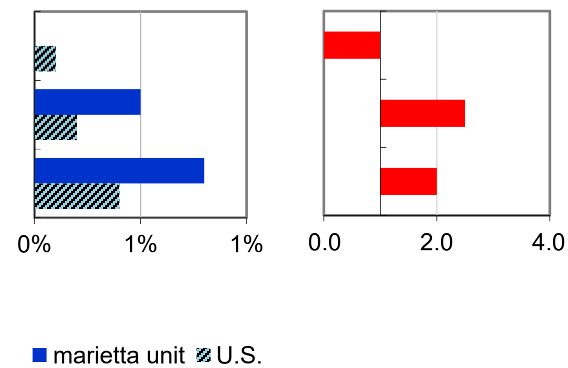
Why is it important?

While the timber industry has the potential to offer high wages, not all components of the timber industry pay the same wages or employ the same number of people. A significant increase in timber jobs that pay above the average for all industries will increase overall average earnings per job. On the other hand, a significant increase in timber jobs that pay below the average for all industries will decrease overall average earnings per job. A modest change in timber employment, especially when this industry is a small share of total employment, will not likely affect average earnings in a local area.

Comparisons

Timber Sector	Employment Share, 2016 marietta unit	Employment Share, 2016 U.S.	Location Quotient
Growing & Harvesting	˜0.0%	0.1%	0.0
Sawmills & Paper Mills	˜0.5%	0.2%	2.5
Wood Products Mfg.	˜0.8%	0.4%	2.0

Employment Share — marietta unit vs. U.S. Location Quotient — marietta unit vs. U.S.



- In 2016, sawmills & paper mills had the highest location quotient score (2.5), and growing & harvesting had the lowest (0).

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Comparisons

What do we measure on this page?

This page describes whether the region is specialized (or under-specialized) in timber employment. The chart illustrates the difference between the selected region and the selected benchmark area.[19] (If no custom benchmark area was selected, EPS defaults to benchmarking against the U.S.)

Location Quotient[20]: A ratio that compares an industry's share of total employment in a region to the benchmark. More precisely, it is the percent of local employment in a sector divided by the percent employment in the same sector in the benchmark area. In other words, it is a ratio that measures specialization using the benchmark area for comparison. A location quotient of more than 1.0 means the local area is more specialized in that sector relative to the benchmark area. A location quotient of less than 1.0 means it is less specialized.[21]

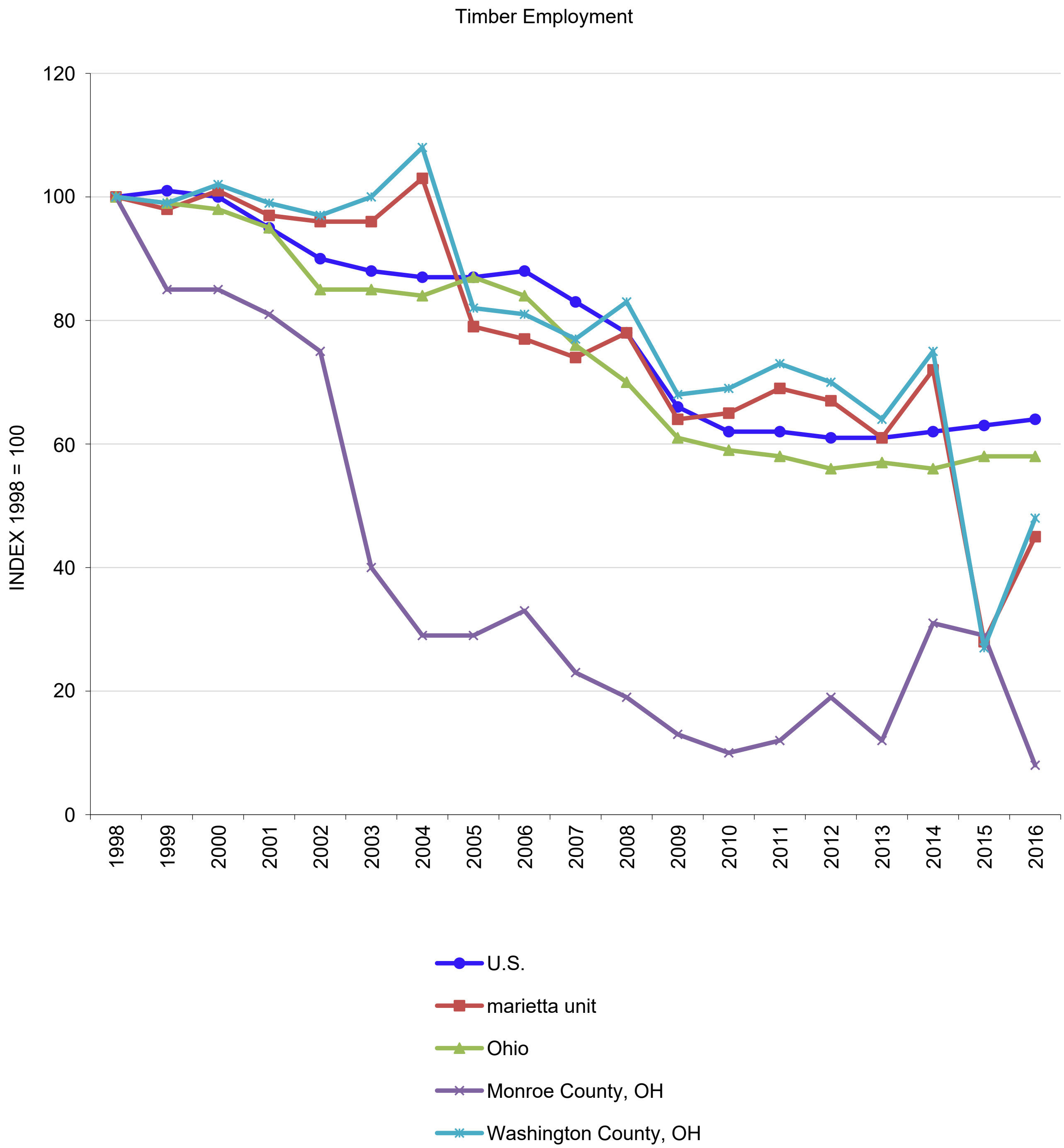
Another way to think about location quotients is as a measure of whether a place produces enough goods or services from an industry to satisfy local demand for those goods or services. Results above or below the 1.0 standard indicate the degree to which a place may import or export a good or service. Although there is no precise cutoff, location quotients above 2.0 indicate a strong industry concentration (and that an area is likely exporting goods or services) and those less than 0.5 indicate a weak industry concentration (and that an area is likely importing goods or services).

Why is it important?

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth. In the case of timber and wood products, mechanization, rising transportation costs, volatile prices, competition from abroad, shifting public values related to the management of public lands, the restructuring of timber companies as Real Estate Investment Trusts, and other factors have led to business and employment declines in many communities. In some cases, rural economies that have historically been tied to commodity production are becoming more diverse.[9, 22]

A few caveats: (1) A large location quotient for a particular sector does not necessarily mean that sector is a significant contributor to the economy. (2) LQs greater than 1.0 only suggest potential export capacity when compared to the benchmark area and do not take into account local demand. Local demand may be greater than average, and therefore all goods and services may be consumed locally (i.e., not exported). (3) LQs can change from year to year. (4) LQs can vary when one uses income or wage data rather than employment.

Comparisons Over Time



- From 1998 to 2016, marietta unit had the fastest rate of change in timber employment, and Ohio had the slowest.

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Comparisons Over Time

What do we measure on this page?

This page describes the change in mining employment for all selected locations and the benchmark area.[19] The information is indexed (1998=100) so that data from locations with different-sized economies can be compared. Indexing makes it easier to understand the relative rate of growth or decline of mining employment over time.

Index: Indexed numbers are compared with a base value. In the line chart, employment in 1998 is the base value and is set to 100. The employment values for subsequent years are expressed as 100 times the ratio to the base value. The indexing used in the line chart enables easier comparisons between locations over time. (If many locations are selected, it may be difficult to read the figure on this page.)

The chart begins in 1998 because that is the year the Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS).

Why is it important?

Not all locations have attracted or lost timber industries and employment at the same rate.[8] An index makes it clear where the rate of timber growth or decline has been the fastest. Lines above 100 indicate positive absolute growth while those below 100 show absolute decline. The steeper the curve, the faster the rate of change.

It may be helpful to look for large year-to-year rises or dips in the lines on the chart to identify rapid employment changes. If the reasons behind these fluctuations are not evident, it may be helpful to talk with regional experts or locals to learn more about what caused abrupt changes.[23]

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth.

Locations with economies that focus on resource extraction and commodity production can be subject to boom-and-bust cycles as well as other economic challenges such as slower long-term economic growth. In the case of timber and wood products, mechanization, rising transportation costs, volatile prices, competition from abroad, shifting public values related to the management of public lands, the restructuring of timber companies as Real Estate Investment Trusts, and other factors have led to business and employment declines in many communities. In some cases, rural economies that have historically been tied to commodity production are becoming more diverse.[6, 9]

Data Sources & Methods

This EPS Timber report uses national statistics from public government sources. All data used in EPS can be readily verified with the original sources:

- **County Business Patterns**
  Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/cbp.html
  Contacts:
  https://www.census.gov/about/contact-us.html

- **Quarterly Census of Employment and Wages**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/cew/
  Contact
  https://www.bls.gov/bls/contact.htm

- **Nonemployer Statistics**
  Bureau of the Census, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/nonemployer-statistics.html
  Contacts:
  https://www.census.gov/programs-surveys/nonemployer-statistics/about/contact-us.html

EPS core approaches
EPS is designed to focus on long-term trends across a range of important measures. Trend analysis provides a more comprehensive view of changes than spot data for select years. We encourage users to focus on major trends rather than absolute numbers. EPS displays detailed industry-level data to show changes in the composition of the economy over time and the mix of industries at points in time. EPS employs cross-sectional benchmarking—comparing smaller areas such as counties to larger regions, states, and the nation—to give a sense of relative performance. EPS allows users to aggregate data for multiple locations to allow for more sophisticated cross-sectional comparisons.

Data Limitations
Much of the data in this report were obtained from the U.S. Census Bureau’s County Business Patterns (CBP) series. Compared to other sources, CBP has fewer data gaps (instances when the federal government will not release data to protect confidentiality of individual businesses). It also includes both full- and part-time employment.

However, CBP data do not include employment in government, agriculture, railroads, or the self-employed. Also, CBP data are based on mid-March employment and do not account for seasonal fluctuations. Since March is a "shoulder" season for several tourism activities, CBP may underrepresent employment in industries associated with tourism. Despite these limitations, the data are most useful for showing long-term trends, displaying differences between places, and showing relationships between sectors over time.

Adjusting dollar figures for inflation
Because a dollar in the past was worth more than a dollar today, data reported in current dollar terms should be adjusted for inflation. The U.S. Department of Commerce reports personal income figures in terms of current dollars. All income data in EPS are adjusted to real (or constant) dollars using the Consumer Price Index. Figures are adjusted to the latest date for which the annual Consumer Price Index is available.

Data gaps and estimation
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses supplemental data from the U.S. Department of Commerce to estimate these data gaps. These are indicated in italics in tables. Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

Endnotes

1 - The three timber and wood products categories are made up of the following NAICS codes:
Growing and Harvesting: forestry and logging (113), support activities for forestry (1153).
Sawmills and Paper Mills: sawmills and wood preservation (3211), pulp, paper, and paperboard mills (3221), veneer, plywood, and engineered wood product manufacturing (3212).
Wood Products Manufacturing: other wood product manufacturing (3219) and converted paper product manufacturing (3222).

2 - For an online listing of all NAICS codes, see: naics.com/search.htm.

3 - For additional online manuals and definitions of industry codes, see: bls.gov/bls/naics.htm and census.gov/eos/www/naics.

4 - For an illustration of how Americans use their land to create wealth (including forestry), see Merrill D and L Leatherby. 2018. Here's How America Uses Its Land. Bloomberg. https://www.bloomberg.com/graphics/2018-us-land-use/.

5 - See the U.S. Forest Service's Forest Inventory and Analysis Program at https://www.fia.fs.fed.us/.

6 - The Forest Service produces a number of publications about the timber industry, including Resources Planning Act (RPA) Assessment reports on the status and trends of the Nation's renewable resources on all forests. See https://www.fs.fed.us/research/rpa/.

7 - The Bureau of Business and Economic Research's (BBER) Forest Industry Research Program monitors forest products operations in the West and researches the industry's size, diversity, and economic impacts. BBER is located at the University of Montana in Missoula, MT. http://www.bber.umt.edu/FIR/Default.asp.

8 - The Bureau of Labor Statistics provides an overview and outlook of the timber industry (as part of agriculture, forestry, and fishing). See https://www.bls.gov/ooh/farming-fishing-and-forestry/.

9 - In 2017 Headwaters Economics analyzed the economic performance of formerly timber-dependent counties. See Lessons from the Timber Transition at https://headwaterseconomics.org/economic-development/trends-performance/timber-transition/.

10 - Nonemployer definitions can be found at https://www.census.gov/epcd/nonemployer/view/define.html.

11 - Nonemployer Statistics data can be found at https://www.census.gov/programs-surveys/nonemployer-statistics.html.

12 - Timber in the table and charts on this page is the sum of the following NAICS codes: Forestry and Logging (113), Wood Products Manufacturing (321), and Paper Manufacturing (322).

13 - The EPS Socioeconomic Measures report provides more information on wages in non-timber industries: https://headwaterseconomics.org/eps.

Endnotes (cont.)

14 - For an overview of how the Bureau of Labor Statistics treats pay and benefits, see https://www.bls.gov/bls/blswage.htm.

15 - For an overview of how the Bureau of Labor Statistics treats employment, see https://www.bls.gov/bls/employment.htm.

16 - Employment and wage estimates are also available from the Bureau of Labor Statistics for more than 800 occupations. Looking at timber by occupation rather than by sector or industry is helpful because wages can vary dramatically across occupations. For more information, see https://www.bls.gov/oes/.

17 - Timber in the tables on this page is the sum of the following NAICS codes: Forestry and Logging (113), Woods Product Manufacturing (321), and Paper Manufacturing (322).

18 - If there are significant undisclosed data on this page, other sources for timber wage data include: The Bureau of Labor Statistics' Quarterly Census of Employment and Wages, which has data for industries at the state level (https://www.bls.gov/cew/);

the Bureau of Labor Statistics' Occupational Outlook Handbook, which has detailed industry earnings and wages data at the national level (https://www.bls.gov/ooh/); and the County Business Patterns database, which reports industry-level employment and payroll and can be used to estimate earnings (https://www.census.gov/programs-surveys/cbp.html).

19 - The term "benchmark" in this report should not be construed as having the same meaning as in the National Forest Management Act (NFMA).

20 - LQ = (ei/e) divided by (Ei/E)
Where: ei = Local employment in industry i; e = Total local employment; Ei = U.S. employment in industry i; E = Total U.S. employment.

21 - A succinct definition of a location quotient is offered by Indiana Business Research Center at IU's Kelley School of Business. See http://www.incontext.indiana.edu/2006/march/1.asp.

22 - For a review of literature on economic diversity, see Sterling A. 1998. On the Economics and Analysis of Diversity. Electronic Working Papers Series, Paper No, 28. Brighton, UK: University of Sussex http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.144.8865&rep=rep1&type=pdf; and Malizia EE and Shanzai K. 2006. The Influence of Economic Diversity on Unemployment and Stability. Journal of Regional Science 33(2):221-235.

23 - Useful resources for investigating trends related to timber harvest on public lands are the National Forest Timber Sales and Timber Cuts and Gross Receipts from Commercial Activities data visualizations available online at https://headwaterseconomics.org/dataviz/national-forests-timber-cut-sold/ and

https://headwaterseconomics.org/dataviz/national-forests-gross-receipts/.

A Profile of Industries that Include Travel & Tourism

athens unit

Selected Geographies:

Athens County, OH; Perry County, OH; Hocking County, OH; Vinton County, OH

Benchmark Geographies:

U.S.

Produced by
Headwaters Economics'
Economic Profile System (EPS)
https://headwaterseconomics.org/eps
December 18, 2018

About the Economic Profile System (EPS)

EPS is a free web tool created by Headwaters Economics to build customized socioeconomic reports of U.S. counties, states, and regions. Reports can be easily created to compare or aggregate different areas. EPS uses published statistics from federal data sources, including the U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

The Bureau of Land Management and Forest Service have made significant financial and intellectual contributions to the operation and content of EPS.

See https://headwaterseconomics.org/eps for more information about the capabilities of EPS. For technical questions, contact Patty Gude at eps@headwaterseconomics.org or telephone 406-599-7425.

HEADWATERS ECONOMICS

headwaterseconomics.org

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions.

www.blm.gov

The Bureau of Land Management, an agency within the U.S. Department of Interior, administers 249.8 million acres of America's public lands, located primarily in western states. It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

www.fs.fed.us

The Forest Service, an agency of the U.S. Department of Agriculture, administers national forests and grasslands encompassing 193 million acres. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Travel & Tourism

athens unit

Table of Contents

Note to Users:

This is one of 14 reports that can be created and downloaded from EPS. Topics include land use, demographics, specific industry sectors, the role of non-labor income, the wildland-urban interface, the role of amenities in economic development, and payments to county governments from federal lands. The EPS reports are downloadable as Excel or PDF documents. See https://headwaterseconomics.org/eps.

Travel & Tourism

athens unit

Travel & Tourism Sectors

	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
Total Private Employment, 2016	12,856	4,175	5,309	1,704	24,044	126,752,238
Travel & Tourism Related	~3,392	~574	~1,299	~249	~5,514	19,977,824
Retail Trade	513	151	167	104	935	3,466,865
Gasoline Stations	267	130	92	87	576	947,656
Clothing & Accessory Stores	140	0	41	0	181	1,738,095
Misc. Store Retailers	106	21	34	17	178	781,114
Passenger Transportation	~1	0	0	0	~1	495,505
Air Transportation	0	0	0	0	0	466,440
Scenic & Sightseeing Transport	~1	0	0	0	~1	29,065
Arts, Entertainment, & Recreation	~74	~37	~13	0	~124	2,311,437
Performing Arts & Spectator Sports	10	~1	~3	0	~14	503,751
Museums, Parks, & Historic Sites	~20	0	0	0	~20	151,270
Amusement, Gambling, & Rec.	44	36	10	0	90	1,656,416
Accommodation & Food	2,804	386	1,119	~145	~4,454	13,704,017
Accommodation	198	0	238	~16	~452	2,067,377
Food Services & Drinking Places	2,606	386	881	129	4,002	11,636,640
Non-Travel & Tourism	~9,464	~3,601	~4,010	~1,455	~18,530	106,774,414

Percent of Total

	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
Travel & Tourism Related	~26.4%	~13.7%	~24.5%	~14.6%	~22.9%	15.8%
Retail Trade	4.0%	3.6%	3.1%	6.1%	3.9%	2.7%
Gasoline Stations	2.1%	3.1%	1.7%	5.1%	2.4%	0.7%
Clothing & Accessory Stores	1.1%	0.0%	0.8%	0.0%	0.8%	1.4%
Misc. Store Retailers	0.8%	0.5%	0.6%	1.0%	0.7%	0.6%
Passenger Transportation	~0.0%	0.0%	0.0%	0.0%	~0.0%	0.4%
Air Transportation	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%
Scenic & Sightseeing Transport	~0.0%	0.0%	0.0%	0.0%	~0.0%	0.0%
Arts, Entertainment, & Recreation	~0.6%	~0.9%	~0.2%	0.0%	~0.5%	1.8%
Performing Arts & Spectator Sports	0.1%	~0.0%	~0.1%	0.0%	~0.1%	0.4%
Museums, Parks, & Historic Sites	~0.2%	0.0%	0.0%	0.0%	~0.1%	0.1%
Amusement, Gambling, & Rec.	0.3%	0.9%	0.2%	0.0%	0.4%	1.3%
Accommodation & Food	21.8%	9.2%	21.1%	~8.5%	~18.5%	10.8%
Accommodation	1.5%	0.0%	4.5%	~0.9%	~1.9%	1.6%
Food Services & Drinking Places	20.3%	9.2%	16.6%	7.6%	16.6%	9.2%
Non-Travel & Tourism	~73.6%	~86.3%	~75.5%	~85.4%	~77.1%	84.2%

The major industry categories (retail trade; passenger transportation; arts, entertainment, and recreation; and accommodation and food) in the table above are the sum of the sub-categories underneath them and as shown here do not represent NAICS codes. The data does not include employment in government, agriculture, railroads, or the self-employed because these are not reported by County Business Patterns. Estimates for data that were not disclosed are indicated with tildes (~).

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Travel & Tourism Sectors

What do we measure on this page?

This page describes the number of jobs (full- and part-time) and the share of total jobs in industries that include travel and tourism.

Travel and Tourism: Sectors that provide goods and services to visitors as well as to the local population. These industries are Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services.[1]

The exact proportion of jobs in these sectors attributable to expenditures by visitors, including business and pleasure travelers, is not known without additional research such as surveys. Some researchers refer to these sectors as “tourism-sensitive.” They could also be called “travel and tourism-potential sectors” because they have the potential of being influenced by expenditures by non-locals. In this report, they are referred to as "industries that include travel and tourism."

There is no single industrial classification for travel and tourism under the North American Industrial Classification System (NAICS). However, there are sectors that provide goods and services to visitors to a local economy. We reviewed the published literature to discern how others identified industries that are part of travel and tourism.[2] These industries (identified by 3-digit NAICS codes in parentheses[3]) include:

Retail Trade: Gasoline Stations (447), Clothing and Accessory Stores (448), Miscellaneous Store Retailers (453; includes Gift, Novelty, and Souvenir)

Passenger Transportation: Air Transportation (481), Scenic and Sightseeing Transportation (487)

Arts, Entertainment, and Recreation: Performing Arts and Spectator Sports (711); Museums, Parks, and Historical Sites (712; includes National Parks, Conservation Areas); Amusement, Gambling, and Recreation (713; includes Golf Courses, Alpine and Cross Country Skiing Facilities)

Accommodation and Food: Accommodation (721; includes ski resorts, hotels, casino hotels, campgrounds, guest ranches), Food Services and Drinking Places (722)

Data on this page were obtained from the U.S. Census Bureau’s County Business Patterns (CBP) series. Compared to other sources, CBP has fewer data gaps (instances when the federal government will not release data to protect confidentiality of individual businesses). It also includes both full- and part-time employment. However, CBP data do not include employment in government, agriculture, railroads, or the self-employed. Also, CBP data are based on mid-March employment and do not account for seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between places, and showing relationships between sectors over time.

Why is it important?

The information on this page is useful for explaining whether sectors that are likely to be associated with travel or tourism exist within the selected location. Travel and tourism related sectors are often a larger component of overall employment in locations where visitors spend money on hotels, restaurants, ski resorts, gift shops, and other expenses associated with recreation.[4, 5]

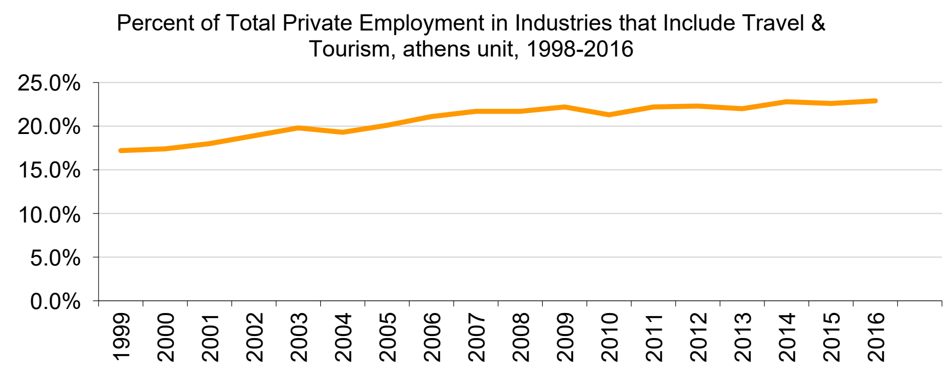
While the information in this report is not an exact measure of the size of the travel and tourism sectors, it can be used to understand whether travel and tourism-related economic activity is present, how it has changed over time, and whether there are differences between locations.

Travel & Tourism

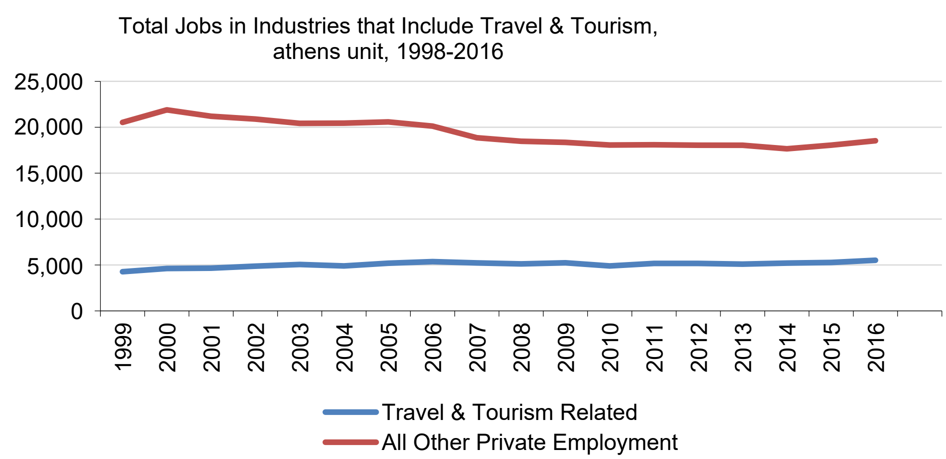
athens unit

Travel & Tourism Employment Trends

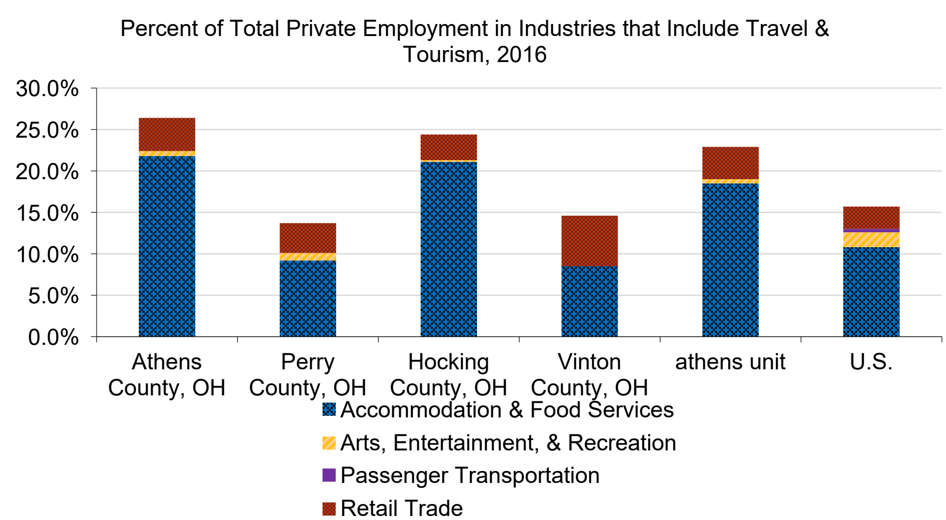
- In 1998, travel & tourism represented 17% of total employment. By 2016, travel & tourism represented 23% of total employment.



- From 1998 to 2016, travel & tourism employment grew from 4,341 to 5,514 jobs, a 27% increase.
- From 1998 to 2016, non-travel & tourism employment shrank from 20,862 to 18,530 jobs, a 11.2% decrease.



- In 2016, Athens County, OH had the largest percent of total travel & tourism employment (26.4%), and Perry County, OH had the smallest (13.7%).



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Travel & Tourism Employment Trends

What do we measure on this page?

This page describes trends in industries that include travel and tourism as a percent of all jobs and compares industries containing travel and tourism to the rest of the economy. It also shows jobs in industries that include travel and tourism as a percent of total employment.

Importantly, the charts on this page show the size of sectors that generally contain travel and tourism as components. The share of the sectors that corresponds to travel and tourism activities will vary among locations.

It may be useful to supplement the information in this report with surveys and data from: 1) state tourism offices, which sometimes track indicators such as tourism employment, hotel receipts, bed taxes, etc.; 2) local Chambers of Commerce and tourism promotion groups; and 3) visitor information from land management agencies including the U.S. Forest Service,[6] Bureau of Land Management, Fish & Wildlife Service, and National Park Service offices. In addition, it may be useful to supplement published statistics with computer models such as IMPLAN.[7]

The top two charts on this page start in 1998 because that is the year the U.S. Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS). The major industry categories (Retail Trade; Passenger Transportation; Arts, Entertainment, & Recreation; and Accommodation & Food Services) in the bottom chart are the sum of the sub-categories from the initial page of this report and as shown here do not represent NAICS codes.

Why is it important?

This information is useful to understand whether sectors that are likely to be associated with travel and tourism are growing or declining. It is less useful as a measure of the absolute size of employment in travel and tourism. A detailed knowledge, obtained through surveys and other means, is required to determine the proportion of a sector's employment that is due to local expenditures versus expenditures from visitors.[8, 9]

In some locations, travel and tourism are significant drivers of the economy. This can be true for "resort" economies but also for areas that have abundant natural and social amenities, and offer recreational opportunities.[10] In some of these places, travel and tourism-related employment is growing faster than overall employment.[4] While pleasure travel and recreation are important economic activities in and of themselves, they also stimulate other forms of economic development when people move families and businesses to communities they first visited as tourists.

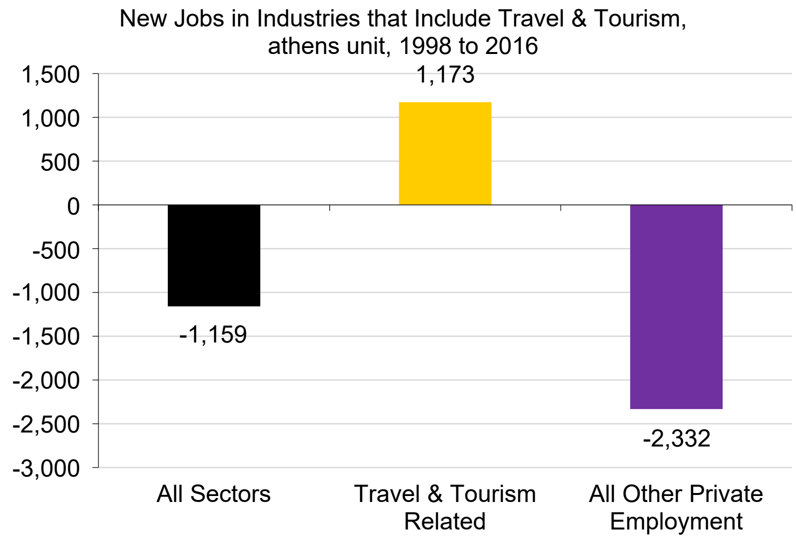
The EPS Public Land Amenities report provides additional information about amenity-led migration: https://headwaterseconomics.org/eps.

Travel & Tourism

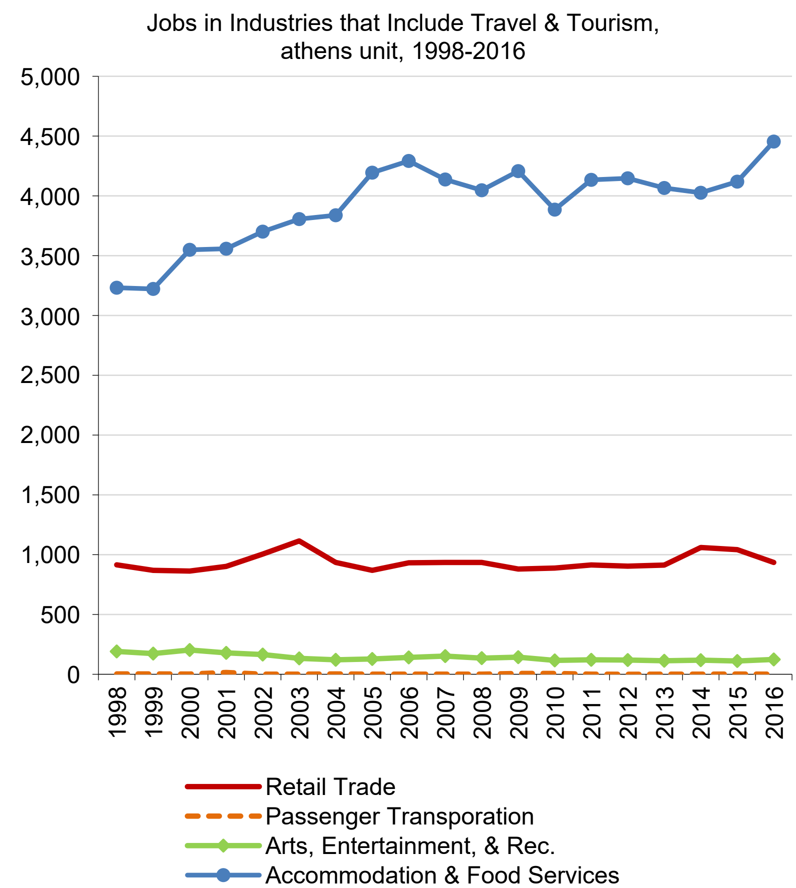
athens unit

Travel & Tourism Employment Trends (cont.)

- From 1998 to 2016, travel & tourism employment grew by 1,173 jobs.
- From 1998 to 2016, non-travel & tourism employment shrank by 2,332 jobs.



- From 1998 to 2016, retail trade grew from 915 to 935 jobs, a 2.2% increase.
- From 1998 to 2016, passenger transportation shrank from 3 to 1 jobs, a 66.7% decrease.
- From 1998 to 2016, arts, entertainment, and recreation shrank from 191 to 124 jobs, a 35.1% decrease.
- From 1998 to 2016, accommodation and food services grew from 3,232 to 4,454 jobs, a 37.8% increase.



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Travel & Tourism Employment Trends (cont.)

What do we measure on this page?

This page compares employment in sectors that include travel and tourism to other sectors and compares how the various industries that include travel and tourism have changed over time.

The charts on this page start in 1998 because that is the year the U.S. Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS). The major industry categories (Retail Trade; Passenger Transportation; Arts, Entertainment, & Recreation; and Accommodation & Food Services) in the bottom chart are the sum of the sub-categories from the initial page of this report and as shown here do not represent NAICS codes.

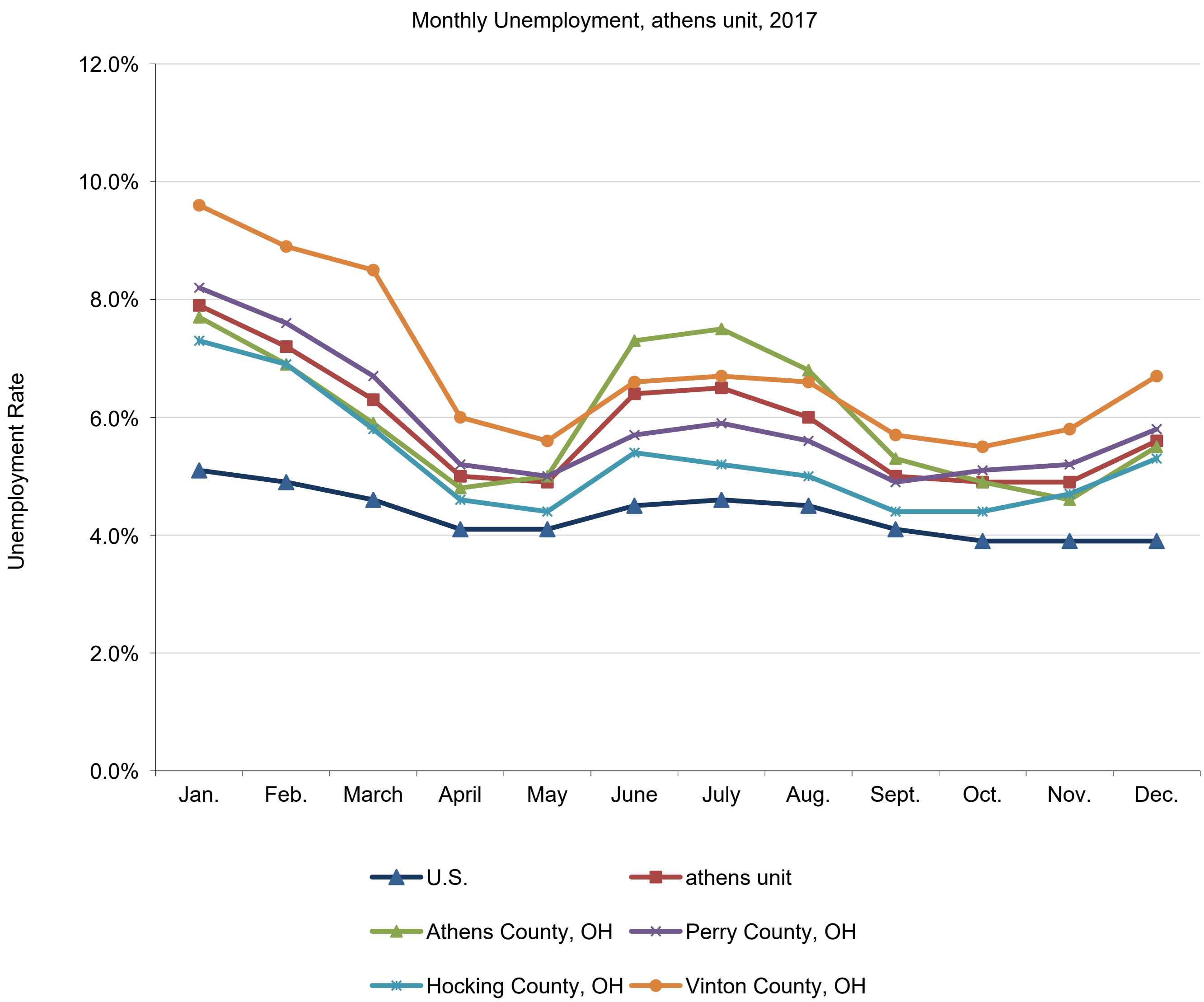
Why is it important?

This information is useful to understand whether sectors that are likely to be associated with travel and tourism are growing or declining. It is less useful as a measure of the absolute size of employment in travel and tourism. A detailed knowledge, obtained through surveys and other means, is required to determine the proportion of a sector's employment that is due to local expenditures versus expenditures from visitors.[8, 9]

In some locations, travel and tourism are significant drivers of the economy. This can be true for "resort" economies but also for areas that have abundant natural and social amenities, and offer recreational opportunities.[10, 11] In some of these places, travel and tourism-related employment is growing faster than overall employment. While pleasure travel and recreation are important economic activities in and of themselves, they also stimulate other forms of economic development when people move families and businesses to communities they first visited as tourists.

The EPS Public Land Amenities report provides additional information about amenity-led migration: https://headwaterseconomics.org/eps.

Seasonality of Unemployment



- In 2017, Vinton County, OH had the most change in unemployment (biggest absolute value of difference between min and max), and U.S. had the least (smallest absolute value of difference between min and max).

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Local Area Unemployment Statistics, Washington, D.C.

Seasonality of Unemployment

What do we measure on this page?

This page describes differences in the seasonality of unemployment, which occurs when people are unemployed at times of the year when demand for labor is lower than usual. Tourism is often associated with seasonal unemployment since work is only available for part(s) of the year when visitation is high.

This page uses data from the Bureau of Labor Statistics to show the change in month-to-month unemployment.[12]

Unemployed people are those who are jobless, available for work, and looking for jobs.

People with full- or part-time jobs are considered employed, and those people who are neither employed nor unemployed are not considered to be in the labor force.

Note: If many locations are selected, it may be difficult to read the figure on this page.

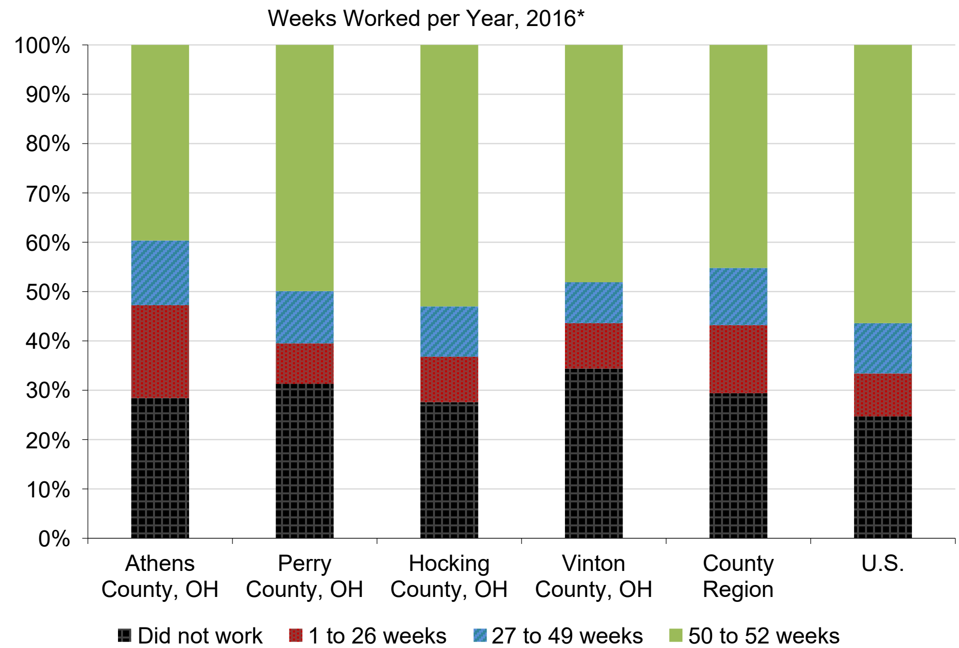
Why is it important?

Unemployment rate fluctuations reflect the hiring and layoff patterns that can accompany tourism due to visitation changes in winter holidays and summer vacations. It is possible that some seasonal workers may not live in the location selected and therefore are not accounted in the unemployment figures. Seasonal unemployment also occurs in places that have a relatively high concentration in construction, fishing, and agriculture sectors.

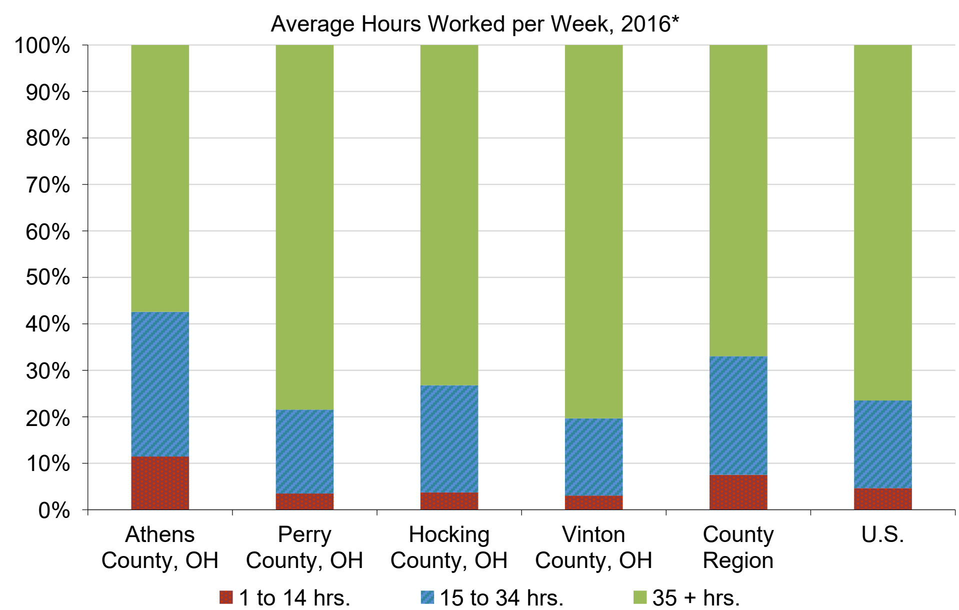
The EPS Socioeconomic Measures report provides further analysis of long-term trends in unemployment: https://headwaterseconomics.org/eps.

Part-Time Employment

- In 2016, 43.2 percent of workers in athens unit worked less than 40 weeks over the course of the year, compared to 33.4 percent for the U.S..



- In 2016, 23.3 percent of workers in athens unit worked less than 35 hours per week on average, compared to 17.7 percent for the the U.S..



* ACS 5-year estimates used. 2016 represents average characteristics from 2012-2016.

Data Sources: U.S. Department of Commerce. 2017. Census Bureau, American Community Survey Office, Washington, D.C.

Part-Time Employment

What do we measure on this page?

This page describes part-time work, which can be more common in tourism-related industries.

The U.S. Census Bureau provides two standard measures of part-time work: weeks worked per year and average hours worked per week. The Census reports these data for the population of age 16 to 64.

Why is it important?

Places that rely economically on tourism can have higher rates of part-time workers. While part-time work along is not a measure of tourism, it can be used to complement other data in this report and from elsewhere to evaluate the nature and extent of tourism activities in the selected locations.[7]

Travel & Tourism

athens unit

Wages and Employment

	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
All Sectors, 2017 (2017 $s)	$41,108	$38,292	$32,395	$35,295	$38,678	$55,390
Private	$32,551	$39,171	$28,964	$33,997	$33,109	$55,338
Travel & Tourism	$14,413	$13,405	$15,779	$15,463	$14,687	$24,782
Retail Trade	$18,683	$16,773	$18,654	$15,463	$17,842	$22,979
Gasoline Stations	$17,015	$15,937	$19,883	$14,959	$16,885	$21,516
Clothing & Accessories	$22,560	na	$15,853	$0	$21,466	$21,902
Misc. Store Retailers	$17,488	$21,155	$16,534	$17,986	$18,037	$26,411
Passenger Transportation	$0	$0	$0	$0	$0	$83,634
Air Transportation	$0	$0	$0	$0	$0	$87,053
Scenic & Sightseeing	$0	$0	$0	$0	$0	$33,331
Arts, Entertainment, & Rec.	$27,646	$0	$14,883	$0	$19,222	$37,759
Performing Arts & Spectator Sports	na	na	na	$0	$0	$91,180
Museums, Parks, & Historic Sites	$27,646	$0	na	$0	$27,646	$34,795
Amusement, Gambling, & Rec.	na	na	$14,883	na	$14,883	$22,384
Accommodations & Food	$13,706	$12,104	$15,445	$0	$14,031	$20,731
Accommodation	$19,356	$0	$21,406	$0	$20,479	$31,081
Food Services & Drinking Places	$13,233	$12,104	$13,767	na	$13,244	$18,963
Non-Travel & Tourism	$38,157	$44,724	$32,712	$31,394	$37,924	$61,154
Government	$59,376	$35,854	$42,337	$38,467	$40,197	$55,686

This table shows wage data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits; the major industry categories (retail trade, passenger transportation; arts, entertainment, and recreation; and accommodation and food) are the sum of the sub-categories underneath them and as shown here do not represent NAICS codes.

Percent of Total Employment

	Athens County, OH	Perry County, OH	Hocking County, OH	Vinton County, OH	athens unit	U.S.
Private, 2017	61.1%	73.5%	74.3%	71.0%	66.2%	85.1%
Travel & Tourism	15.0%	9.3%	20.3%	5.7%	14.5%	13.6%
Retail Trade	1.9%	2.6%	2.2%	5.7%	2.3%	2.2%
Gasoline Stations	1.1%	2.2%	1.5%	4.8%	1.5%	0.6%
Clothing & Accessories	0.5%	na	0.3%	0.0%	0.4%	1.0%
Misc. Store Retailers	0.3%	0.4%	0.4%	1.0%	0.4%	0.6%
Passenger Transportation	0.0%	0.0%	0.0%	0.0%	0.0%	0.4%
Air Transportation	0.0%	0.0%	0.0%	0.0%	0.0%	0.3%
Scenic & Sightseeing	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Arts, Entertainment, & Rec.	0.1%	0.0%	0.5%	0.0%	0.1%	1.6%
Performing Arts & Spectator Sports	na	na	na	0.0%	0.0%	0.3%
Museums, Parks, & Historic Sites	0.1%	0.0%	na	0.0%	0.0%	0.1%
Amusement, Gambling, & Rec.	na	na	0.5%	na	0.1%	1.1%
Accommodations & Food	13.0%	6.7%	17.6%	0.0%	12.0%	9.5%
Accommodation	1.0%	0.0%	3.9%	0.0%	1.3%	1.4%
Food Services & Drinking Places	12.0%	6.7%	13.8%	na	10.7%	8.1%
Non-Travel & Tourism	37.7%	46.4%	44.9%	35.0%	40.3%	71.5%
Government, 2017	1.0%	26.5%	25.7%	29.0%	11.5%	14.9%

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment

What do we measure on this page?

This page describes wages (in real terms) from employment in industries that include travel and tourism, including sub-sectors, compared to wages from employment in all non-travel-and-tourism sectors combined. It also describes the percent of jobs in each category. These are shown together to illustrate the relative wage levels in industries that include travel and tourism, and how many people are employed in each sub-sector.

The primary purpose of this page is to compare the average annual wages between sectors and to investigate the relative number of people employed in high- and low-wage sectors.

Travel and Tourism: Sectors that provide goods and services to visitors as well as to the local population. These industries are Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services. The exact proportion of jobs in these sectors attributable to expenditures by visitors, including business and pleasure travelers, is not known without additional research such as surveys. Some researchers refer to these sectors as “travel and tourism-potential sectors” because they have the potential of being influenced by expenditures by non-locals. In this report, they are referred to as “industries that include travel and tourism.”

The tables use wage and employment data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[13, 14]

Why is it important?

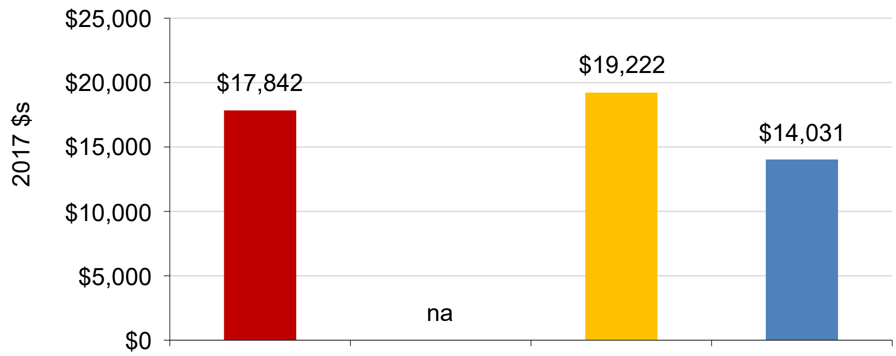
Industries that contain travel and tourism often pay relatively low wages, though this varies by industry sub-sector and by location. Some important issues to consider are how travel and tourism related industry wages compare to wages in other sectors, whether some components of travel- and tourism-related industries pay higher wages than others, and whether there are significant wage differences between locations.[15, 16] When comparing wage levels, it is also useful to remember that many travel and tourism related jobs are seasonal and/or part-time.

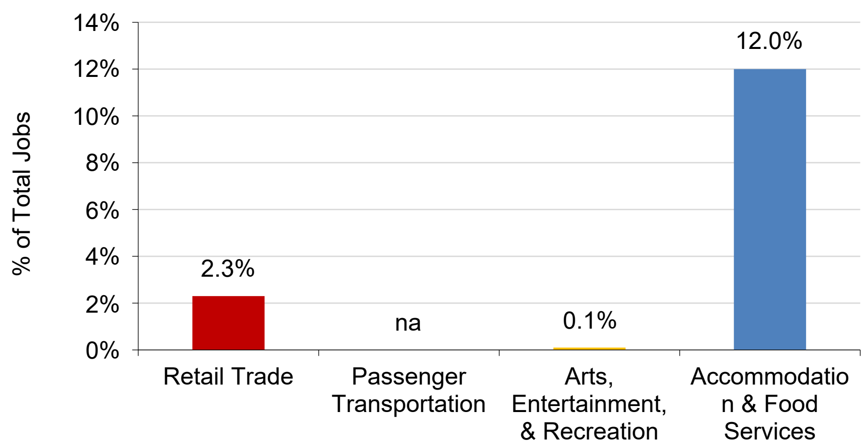
Wages and Employment (cont.)

- In 2017, travel & tourism sector average wages, from highest to lowest, were: arts, entertainment, & recreation ($19,222); retail trade ($17,842); accommodation & food services ($14,031); and passenger transportation ($0).

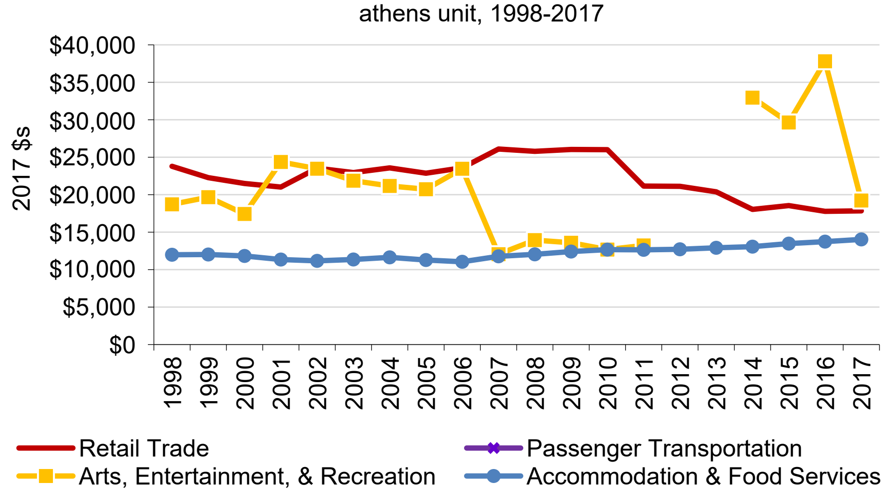
- In 2017, travel & tourism sector percent of total employment, from highest to lowest, were: accommodation & food services (12%); retail trade (2.3%); arts, entertainment, & recreation (0.1%); and passenger transportation (0%).

Avg. Annual Wages and Percent of Total Jobs in Industries that Include Travel & Tourism, athens unit, 2017





Avg. Annual Wages in Industries that Include Travel & Tourism, athens unit, 1998-2017



Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment (cont.)

What do we measure on this page?

This page describes average wages (in real terms) and employment levels in industries that include travel and tourism. It also shows average wage trends (in real terms) for industries that include travel and tourism.

The chart *Avg. Annual Wages and Percent of Total Jobs in Industries that Include Travel & Tourism* describes how many people are working in relatively high- and low-wage travel and tourism related industries. The chart *Avg. Annual Wages in Industries that Include Travel & Tourism* is useful for comparing wage trends by sector.

The charts use wage and employment data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[13, 14] As a result, the percent-of-employment values may not exactly match values derived from County Business Patterns that are reported on previous pages. The bottom chart on this page starts in 1998 to be consistent with the start date of figures on earlier pages of this report.

The major industry categories (Retail Trade; Passenger Transportation; Arts, Entertainment, and Recreation; and Accommodation and Food Services) are the sum of the sub-categories from the previous page of this report and as shown here do not represent NAICS codes.

If your report results in significant undisclosed data, other sources for travel and tourism wage data include the state-level Bureau of Labor Statistics' Quarterly Census of Employment and Wages https://www.bls.gov/cew/; the Bureau of Labor Statistics' Occupational Outlook Handbook, which has detailed industry earnings and wages data at the national level https://www.bls.gov/ooh/; and the County Business Patterns database, which reports industry-level employment and payroll and can be used to estimate earnings https://www.census.gov/programs-surveys/cbp.html.

Why is it important?

While industries that include travel and tourism often pay relatively low wages, wages and the number of people employed can vary greatly among travel and tourism related industries.

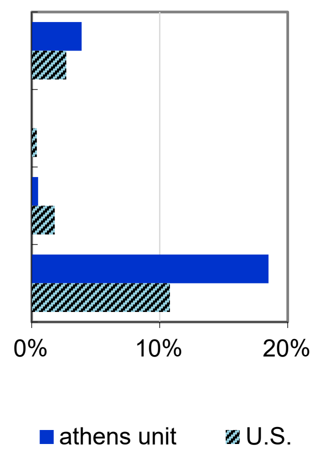
The trend data on this page can be useful for understanding whether wages in sectors that are likely to be associated with travel and tourism have changed over time.

Comparisons

Industries Including Travel and Tourism, 2016	Employment Share: athens unit	Employment Share: U.S.	Location Quotient
Retail Trade	3.9%	2.7%	1.4
Passenger Transportation	0.0%	0.4%	0.0
Arts, Entertainment, & Recreation	0.5%	1.8%	0.3
Accommodation & Food	18.5%	10.8%	1.7

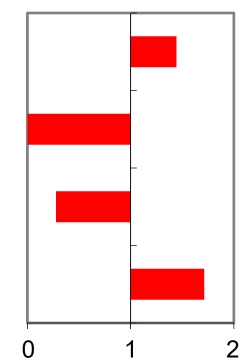
Employment Share

athens unit vs. U.S.



Location Quotient

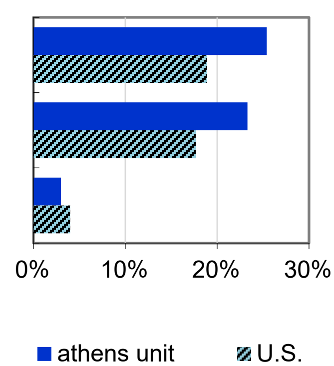
athens unit vs. U.S.



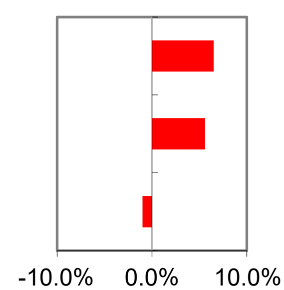
Other Possible Measures of the Presence of Travel and Tourism

Indicators of Seasonal Work and Housing , 2016*	athens unit	U.S.	Diff.
Part-Time Work (less than 50 weeks per year)	25.4%	18.9%	6.5%
Part-Time Work (less than 35 hours per week)	23.3%	17.7%	5.6%
Second Homes	3.0%	4.0%	-1.0%

athens unit vs. U.S.



Difference in Percent, athens unit vs. U.S.



* ACS 5-year estimates used. 2016 represents average characteristics from 2012-2016.

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.; U.S. Department of Commerce. 2017. Census Bureau, American Community Survey Office, Washington, D.C.

Comparisons

What do we measure on this page?

This page describes whether the region is specialized in travel and tourism related employment. The chart illustrates the difference between the selected location(s) and the selected benchmark area.[17] (If no custom benchmark area was selected, EPS defaults to benchmarking against the U.S.)

Location Quotient[18]: A ratio that compares an industry's share of total employment in a region to the benchmark. More precisely, it is the percent of local employment in a sector divided by the percent employment in the same sector in the benchmark area. In other words, it is a ratio that measures specialization using the benchmark area for comparison. A location quotient of more than 1.0 means the local area is more specialized in that sector relative to the benchmark area. A location quotient of less than 1.0 means it is less specialized.[19]

Another way to think about location quotients is as a measure of whether a place produces enough goods or services from an industry to satisfy local demand for those goods or services. Results above or below the 1.0 standard indicate the degree to which a place may import or export a good or service. Although there is no precise cutoff, location quotients above 2.0 indicate a strong industry concentration (and that an area is likely exporting goods or services) and those less than 0.5 indicate a weak industry concentration (and that an area is likely importing goods or services).

Second Homes: The number of second homes is not available as a single variable from the U.S. Census Bureau. We have calculated second homes as a percent of total homes as follows: seasonally occupied homes (Census SF1 H005005) are added to other vacant homes (Census SF1 H005007) and then divided by total homes. By this definition, second homes do not include homes that are vacant because they are for rent or sale.

Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses data from the U.S. Department of Commerce to estimate these data gaps.[20]

Why is it important?

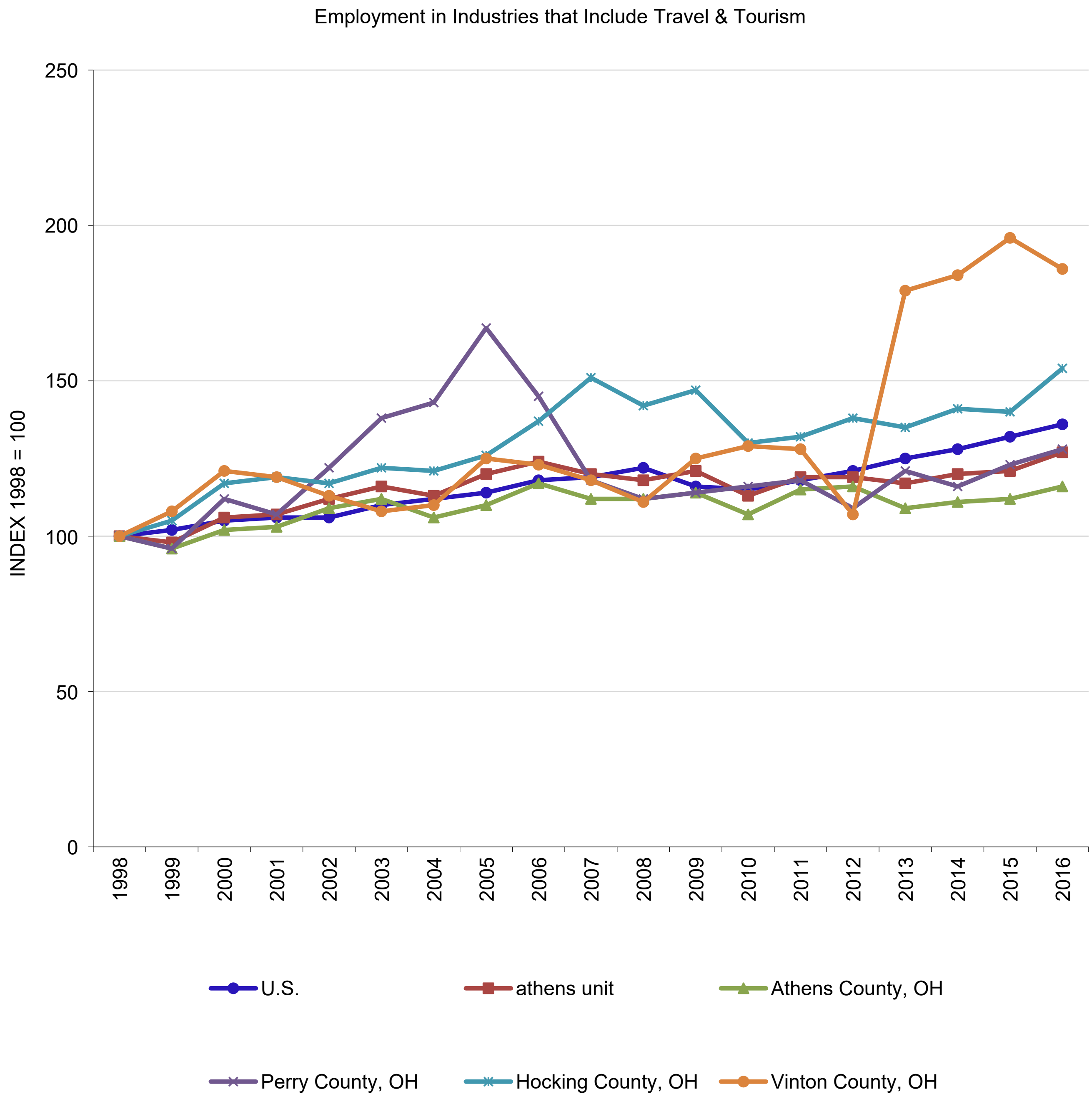
Locations with economies that focus on travel and tourism may have a competitive advantages,[21, 22] but can also be sensitive to business cycles and other changes (for example, a rise in fuel costs) that affect pleasure travel and recreation spending. Natural amenities such as public lands can increase travel and tourism activities, benefiting local communities and in some cases diversify rural economies that have historically been tied to commodity production.[5, 23, 24] The growth of travel and tourism activities is also associated with in-migration that can lead to business relocation and new business development across a range of business sectors.[25]

A few caveats: (1) A large location quotient for a particular sector does not necessarily mean that sector is a significant contributor to the economy. (2) LQs greater than 1.0 only suggest potential export capacity when compared to the benchmark area and do not take into account local demand. Local demand may be greater than average, and therefore all goods and services may be consumed locally (i.e., not exported). (3) LQs can change from year to year. (4) LQs can vary when one uses income or wage data rather than employment.

Travel & Tourism

athens unit

Comparisons Over Time



- From 1998 to 2016, athens unit had the fastest rate of change in travel & tourism employment, and Athens County, OH had the slowest.

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Comparisons Over Time

What do we measure on this page?

This page describes the change in travel and tourism employment for all selected locations and the benchmark area.[17] The information is indexed (1998=100) so that data from locations with different-sized economies can be compared. Indexing makes it easier to understand the relative rate of growth or decline of mining employment over time.

Index: Indexed numbers are compared with a base value. In the line chart, employment in 1998 is the base value and is set to 100. The employment values for subsequent years are expressed as 100 times the ratio to the base value. The indexing used in the line chart enables easier comparisons between locations over time. (If many locations are selected, it may be difficult to read the figure on this page.)

The chart begins in 1998 because that is the year the Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS).

Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses data from the U.S. Department of Commerce to estimate these data gaps.[20]

Why is it important?

This information is useful to understand whether sectors likely to be associated with travel and tourism are growing or declining. These data do not measure the absolute size of employment in travel and tourism. Detailed knowledge, obtained through surveys and other means, is required to determine the proportion of a sector's employment that is due to local expenditures versus expenditures from visitors.

Not all locations have attracted or lost travel- and tourism-related employment at the same rate.[26] An index makes it clear where the rate of travel-and-tourism-related growth or decline has been the fastest. Lines above 100 indicate positive absolute growth while those below 100 show absolute decline. The steeper the curve, the faster the rate of change.

It may be helpful to look for large year-to-year rises or dips to identify rapid employment changes. If the reasons behind these fluctuations are not evident, it may be helpful to talk with regional experts or local residents to learn more about what caused abrupt changes.

Locations with economies that focus on travel and tourism may have competitive advantages,[21, 22] but can also be sensitive to business cycles and other changes (for example, a rise in fuel costs) that affect pleasure travel and recreation spending. Natural amenities such as public lands can increase travel and tourism activities, benefiting local communities and in some cases diversify rural economies that have historically been tied to commodity production.[5, 23, 24] The growth of travel and tourism activities is also associated with in-migration that can lead to business relocation and new business development across a range of business sectors.[25]

Data Sources & Methods

The EPS Travel & Tourism report uses national statistics from public government sources. All data used in EPS can be readily verified with original sources:

- **County Business Patterns**
  Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/cbp.html
  Contacts
  https://www.census.gov/about/contact-us.html
- **Quarterly Census of Employment and Wages**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/cew
  Contacts
  https://www.bls.gov/bls/contact.htm
- **American Community Survey**
  U.S. Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/acs/
  https://www.census.gov/acs/www/data/data-tables-and-tools/index.php
  Contacts
  https://www.census.gov/about/contact-us.html
- **Local Area Unemployment Statistics**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/lau/
  Contacts
  https://www.bls.gov/bls/contact.htm

EPS core approaches
EPS is designed to focus on long-term trends across a range of important measures. Trend analysis provides a more comprehensive view of changes than spot data for select years. We encourage users to focus on major trends rather than absolute numbers. EPS displays detailed industry-level data to show changes in the composition of the economy over time and the mix of industries at points in time. EPS employs cross-sectional benchmarking—comparing smaller areas such as counties to larger regions, states, and the nation—to give a sense of relative performance. EPS allows users to aggregate data for multiple locations to allow for more sophisticated cross-sectional comparisons.

Data Limitations
Much of the data in this report were obtained from the U.S. Census Bureau's County Business Patterns (CBP) series. Compared to other sources, CBP has fewer data gaps (instances when the federal government will not release data to protect confidentiality of individual businesses). It also includes both full- and part-time employment.

However, CBP data do not include employment in government, agriculture, railroads, or the self-employed. Also, CBP data are based on mid-March employment and do not account for seasonal fluctuations. Since March is a "shoulder" season for several tourism activities, CBP may underrepresent employment in industries associated with tourism. Despite these limitations, the data are most useful for showing long-term trends, displaying differences between places, and showing relationships between sectors over time.

Adjusting dollar figures for inflation
Because a dollar in the past was worth more than a dollar today, data reported in current dollar terms should be adjusted for inflation. The U.S. Department of Commerce reports personal income figures in terms of current dollars. All income data in EPS are adjusted to real (or constant) dollars using the Consumer Price Index. Figures are adjusted to the latest date for which the annual Consumer Price Index is available.

Data gaps and estimation
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses supplemental data from the U.S. Department of Commerce to estimate these data gaps. These are indicated in italics in tables. Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

Endnotes

1 - In 2018 the Dept. of Commerce for the first time developed statistics illustrating the economic impact of outdoor recreation in the United States. See the Bureau of Economic Analysis's Outdoor Recreation Satellite Account at https://www.bea.gov/data/special-topics/outdoor-recreation.

2 - The Federal Reserve Bank of Kansas City has defined travel and tourism as consisting of hotels, air travel, and amusement and recreation services. See Wilkerson CR. 2003. Travel and Tourism: An Overlooked Industry in the U.S. and Tenth District. Economic Review. QIII(2003):45-71. https://www.kansascityfed.org/publicat/econrev/PDF/3q03wilk.pdf Wilkerson points out that travel- and tourism-related sectors outperformed the nation, including during recessions.

3 - The list of NAICS codes associated with travel and tourism were obtained from Marcouiller DW and Xia X. 2008. Distribution of Income from Tourism-Sensitive Employment. Tourism Economics 14(3):545-565. http://journals.sagepub.com/doi/abs/10.5367/000000008785633622?journalCode=teua. For a similar definition of travel and tourism, see Wilkerson C. 2003. Travel and Tourism: An Overlooked Industry in the U.S. and Tenth District. Federal Reserve Bank of Kansas City Economic Review. QIII(2003):45-71. https://www.kansascityfed.org/publicat/econrev/PDF/3q03wilk.pdf.

4 - It is estimated that outdoor recreation alone generates $887 billion in consumer spending annually and 7.6 million jobs. Outdoor Industry Association. 2018. Advocacy: Outdoor Recreation Economy. https://outdoorindustry.org/advocacy/.

5 - Allen T, D Kary, and R Southwick. 2017. The Economic Contributions of Outdoor Recreation. Boulder, CO: Outdoor Industry Association. https://outdoorindustry.org/wp-content/uploads/2015/03/OIA_Recreation_Economy_Contributions_Technical_Report_2017-08-24.pdf.

6 - The Forest Service collects information on visitor satisfaction and use. Annual summary reports and individual forest and grassland reports are available from https://www.fs.fed.us/recreation/programs/nvum.

7 - Stynes DJ and White EM. 2006. Reflections on Measuring Recreation and Travel Spending. Journal of Travel Research. 45:8-16. See http://journals.sagepub.com/doi/10.1177/0047287506288873.

8 - The U.S. Census Bureau conducts an Economic Census every five years for selected industries. Users can search the Economic Census for information on the number of establishments, sales, employees, and payroll, for selected industries. https://www.census.gov/programs-surveys/economic-census.html.

9 - The U.S. Department of Commerce developed the U.S. Travel and Tourism Satellite Accounts to estimate the proportion of every sector in the economy that is attributable to travel and tourism at the national level. This information is useful for detecting sectors that have a higher potential to serve the needs of visitors. The resulting ratios should not be applied to local economies. https://www.bea.gov/data/special-topics/travel-and-tourism.

Endnotes

10 - Outdoor recreation accounted for 2 percent ($373.3 billion) of GDP in 2016. The outdoor recreation economy grew 3.8 percent in 2016, compared to 2.8 percent in the overall economy. https://www.bea.gov/news/2018/outdoor-recreation-satellite-account-prototype-estimates-2012-2016.

11 - Almost half the U.S. population participated in an outdoor activity at least once in 2017. Outdoor Foundation. 2018. Outdoor Participation Report 2018. Washington, DC: Outdoor Foundation. https://outdoorindustry.org/resource/2018-outdoor-participation-report/.

12 - For detailed information on how the government measures unemployment, see https://www.bls.gov/cps/.

13 - For an overview of how the Bureau of Labor Statistics treats employment, see https://www.bls.gov/bls/employment.htm.

14 - For an overview of how the Bureau of Labor Statistics treats pay and benefits, see https://www.bls.gov/bls/wages.htm.

15 - Employment and wage estimates are also available from the Bureau of Labor Statistics for more than 800 occupations. Looking at travel and tourism by occupation, rather than by sector or industry, is helpful because wages can vary dramatically across occupations. For more information, see https://www.bls.gov/oes/.

16 - The EPS Socioeconomic Measures report provides additional information about wages in non-travel-and-tourism industries. https://headwaterseconomics.org/eps.

17 - The term "benchmark" in this report should not be construed as having the same meaning as in the National Forest Management Act (NFMA).

18 - LQ = (ei/e) divided by (Ei/E)
Where: ei = Local employment in industry i; e = Total local employment; Ei = U.S. employment in industry i; E = Total U.S. employment.

19 - A succinct definition of a location quotient is offered by Indiana Business Research Center at IU's Kelley School of Business. http://www.incontext.indiana.edu/2006/march/1.asp.

20 - Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

21 - Reeder RJ and Brown DM. 2005. Recreation, Tourism, and Rural Well-Being. USDA Economic Research Service Economic Research Report No. 7. https://www.ers.usda.gov/webdocs/publications/46126/15112_err7_1_.pdf?v=41056

Endnotes

22 - English DBK, Marcouiller DW, and Cordell HK. 2000. Tourism Dependence in Rural America: Estimates and Effects. Society and Natural Resources 13(3):185-202. https://www.srs.fs.usda.gov/pubs/ja/ja_english004.pdf The study found that counties relatively dependent on tourism have higher growth in per capita income in comparison to non-dependent counties; less economic diversity; fewer manufacturing jobs, in particular in wood products sectors; more expensive housing; faster population growth; and higher levels of education. They also found that average household income in tourism-dependent counties was about the same as in non-dependent counties.

23 - For a review of literature on economic diversity, see Sterling A. 1998. On the Economics and Analysis of Diversity. Electronic Working Papers Series, No. 28. University of Sussex, Brighton, UK. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.144.8865&rep=rep1&type=pdf.

24 - A useful book on the evolving competitive environment for rural areas is Galston WA and Baehler KJ. 1995. Rural Development in the United States: Connecting Theory, Practice, and Possibilities. Washington, DC: Island Press.

25 - Snepenger D, Johnson J, and Rasker R. 1994. Travel Stimulated Entrepreneurial Migration. Journal of Travel Research 34(1):40-44. http://journals.sagepub.com/doi/abs/10.1177/004728759503400105 Snepenger et al. found that tourism can stimulate permanent migration of entrepreneurs.

26 - The Economic Research Service of the U.S. Dept. of Agriculture has developed a widely-used classification system for identifying non-metropolitan recreation counties. See Johnson KM and Beale CL. 2002. Non-Metro Recreation Counties: Their Identification and Rapid Growth. Rural America 17(4):2-19. https://www.ers.usda.gov/webdocs/publications/46984/19347_ra174b_1_.pdf?v=41056.

A Profile of Industries that Include Travel & Tourism

ironton unit

Selected Geographies:

Lawrence County, OH; Gallia County, OH

Benchmark Geographies:

U.S.

Produced by
Headwaters Economics'
Economic Profile System (EPS)
https://headwaterseconomics.org/eps
December 18, 2018

About the Economic Profile System (EPS)

EPS is a free web tool created by Headwaters Economics to build customized socioeconomic reports of U.S. counties, states, and regions. Reports can be easily created to compare or aggregate different areas. EPS uses published statistics from federal data sources, including the U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

The Bureau of Land Management and Forest Service have made significant financial and intellectual contributions to the operation and content of EPS.

See https://headwaterseconomics.org/eps for more information about the capabilities of EPS. For technical questions, contact Patty Gude at eps@headwaterseconomics.org or telephone 406-599-7425.

HEADWATERS ECONOMICS

headwaterseconomics.org

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions.

www.blm.gov

The Bureau of Land Management, an agency within the U.S. Department of Interior, administers 249.8 million acres of America's public lands, located primarily in western states. It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

www.fs.fed.us

The Forest Service, an agency of the U.S. Department of Agriculture, administers national forests and grasslands encompassing 193 million acres. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Travel & Tourism

ironton unit

Table of Contents

Note to Users:

This is one of 14 reports that can be created and downloaded from EPS. Topics include land use, demographics, specific industry sectors, the role of non-labor income, the wildland-urban interface, the role of amenities in economic development, and payments to county governments from federal lands. The EPS reports are downloadable as Excel or PDF documents. See https://headwaterseconomics.org/eps.

Travel & Tourism

ironton unit

Travel & Tourism Sectors

	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
Total Private Employment, 2016	10,533	9,487	4,790,178	20,020	126,752,238
Travel & Tourism Related	~1,508	~1,350	674,392	~2,858	19,977,824
Retail Trade	228	295	113,319	523	3,466,865
Gasoline Stations	149	205	35,967	354	947,656
Clothing & Accessory Stores	37	47	47,689	84	1,738,095
Misc. Store Retailers	42	43	29,663	85	781,114
Passenger Transportation	~2	0	10,355	~2	495,505
Air Transportation	~2	0	10,169	~2	466,440
Scenic & Sightseeing Transport	0	0	186	0	29,065
Arts, Entertainment, & Recreation	~37	~22	68,762	~59	2,311,437
Performing Arts & Spectator Sports	~1	~3	16,016	~4	503,751
Museums, Parks, & Historic Sites	0	~3	6,521	~3	151,270
Amusement, Gambling, & Rec.	36	~16	46,225	~52	1,656,416
Accommodation & Food	1,241	1,033	481,956	2,274	13,704,017
Accommodation	31	82	38,071	113	2,067,377
Food Services & Drinking Places	1,210	951	443,885	2,161	11,636,640
Non-Travel & Tourism	~9,025	~8,137	4,115,786	~17,162	106,774,414

Percent of Total

	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
Travel & Tourism Related	~14.3%	~14.2%	14.1%	~14.3%	15.8%
Retail Trade	2.2%	3.1%	2.4%	2.6%	2.7%
Gasoline Stations	1.4%	2.2%	0.8%	1.8%	0.7%
Clothing & Accessory Stores	0.4%	0.5%	1.0%	0.4%	1.4%
Misc. Store Retailers	0.4%	0.5%	0.6%	0.4%	0.6%
Passenger Transportation	~0.0%	0.0%	0.2%	~0.0%	0.4%
Air Transportation	~0.0%	0.0%	0.2%	~0.0%	0.4%
Scenic & Sightseeing Transport	0.0%	0.0%	0.0%	0.0%	0.0%
Arts, Entertainment, & Recreation	~0.4%	~0.2%	1.4%	~0.3%	1.8%
Performing Arts & Spectator Sports	~0.0%	~0.0%	0.3%	~0.0%	0.4%
Museums, Parks, & Historic Sites	0.0%	~0.0%	0.1%	~0.0%	0.1%
Amusement, Gambling, & Rec.	0.3%	~0.2%	1.0%	~0.3%	1.3%
Accommodation & Food	11.8%	10.9%	10.1%	11.4%	10.8%
Accommodation	0.3%	0.9%	0.8%	0.6%	1.6%
Food Services & Drinking Places	11.5%	10.0%	9.3%	10.8%	9.2%
Non-Travel & Tourism	~85.7%	~85.8%	85.9%	~85.7%	84.2%

The major industry categories (retail trade; passenger transportation; arts, entertainment, and recreation; and accommodation and food) in the table above are the sum of the sub-categories underneath them and as shown here do not represent NAICS codes. The data does not include employment in government, agriculture, railroads, or the self-employed because these are not reported by County Business Patterns. Estimates for data that were not disclosed are indicated with tildes (~).

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Travel & Tourism Sectors

What do we measure on this page?

This page describes the number of jobs (full- and part-time) and the share of total jobs in industries that include travel and tourism.

Travel and Tourism: Sectors that provide goods and services to visitors as well as to the local population. These industries are Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services.[1]

The exact proportion of jobs in these sectors attributable to expenditures by visitors, including business and pleasure travelers, is not known without additional research such as surveys. Some researchers refer to these sectors as “tourism-sensitive.” They could also be called “travel and tourism-potential sectors” because they have the potential of being influenced by expenditures by non-locals. In this report, they are referred to as "industries that include travel and tourism."

There is no single industrial classification for travel and tourism under the North American Industrial Classification System (NAICS). However, there are sectors that provide goods and services to visitors to a local economy. We reviewed the published literature to discern how others identified industries that are part of travel and tourism.[2] These industries (identified by 3-digit NAICS codes in parentheses[3]) include:

Retail Trade: Gasoline Stations (447), Clothing and Accessory Stores (448), Miscellaneous Store Retailers (453; includes Gift, Novelty, and Souvenir)

Passenger Transportation: Air Transportation (481), Scenic and Sightseeing Transportation (487)

Arts, Entertainment, and Recreation: Performing Arts and Spectator Sports (711); Museums, Parks, and Historical Sites (712; includes National Parks, Conservation Areas); Amusement, Gambling, and Recreation (713; includes Golf Courses, Alpine and Cross Country Skiing Facilities)

Accommodation and Food: Accommodation (721; includes ski resorts, hotels, casino hotels, campgrounds, guest ranches), Food Services and Drinking Places (722)

Data on this page were obtained from the U.S. Census Bureau’s County Business Patterns (CBP) series. Compared to other sources, CBP has fewer data gaps (instances when the federal government will not release data to protect confidentiality of individual businesses). It also includes both full- and part-time employment. However, CBP data do not include employment in government, agriculture, railroads, or the self-employed. Also, CBP data are based on mid-March employment and do not account for seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between places, and showing relationships between sectors over time.

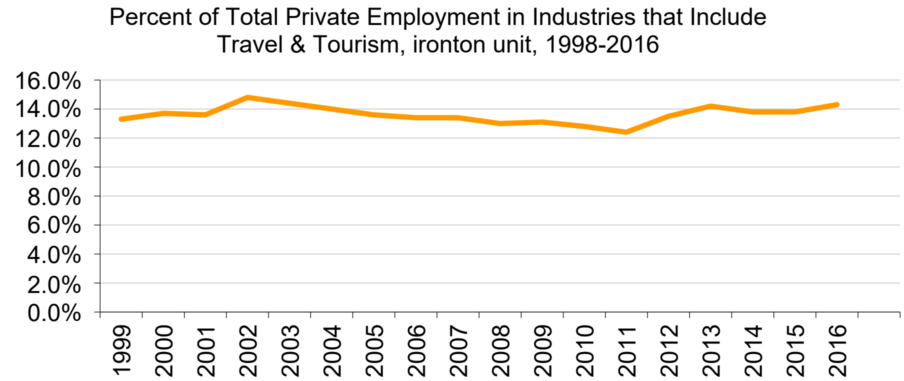
Why is it important?

The information on this page is useful for explaining whether sectors that are likely to be associated with travel or tourism exist within the selected location. Travel and tourism related sectors are often a larger component of overall employment in locations where visitors spend money on hotels, restaurants, ski resorts, gift shops, and other expenses associated with recreation.[4, 5]

While the information in this report is not an exact measure of the size of the travel and tourism sectors, it can be used to understand whether travel and tourism-related economic activity is present, how it has changed over time, and whether there are differences between locations.

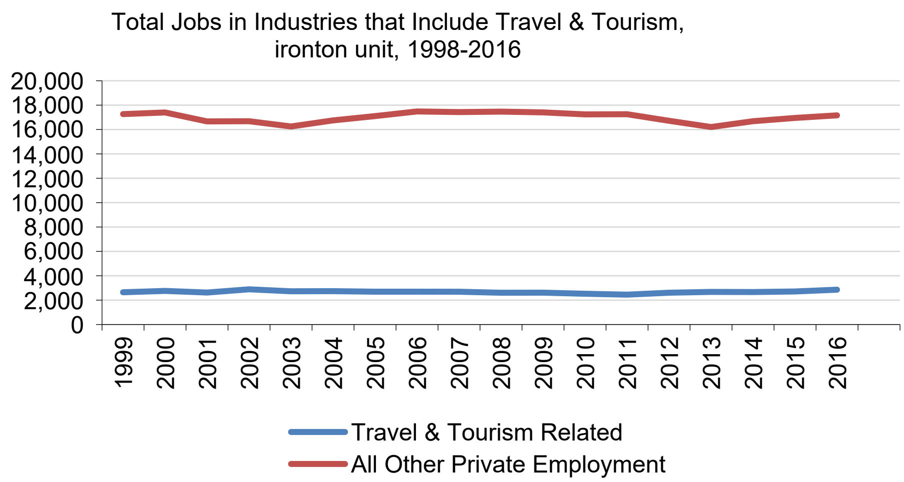
Travel & Tourism Employment Trends

- In 1998, travel & tourism represented 14% of total employment. By 2016, travel & tourism represented 14% of total employment.

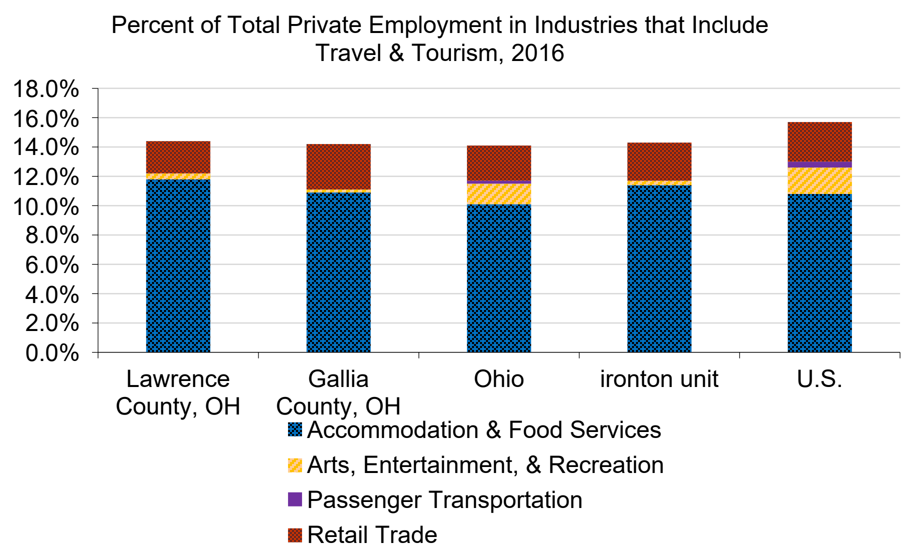


- From 1998 to 2016, travel & tourism employment grew from 2,815 to 2,858 jobs, a 1.5% increase.

- From 1998 to 2016, non-travel & tourism employment grew from 16,948 to 17,162 jobs, a 1.3% increase.



- In 2016, U.S. had the largest percent of total travel & tourism employment (15.8%), and Ohio had the smallest (14.1%).



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Travel & Tourism Employment Trends

What do we measure on this page?

This page describes trends in industries that include travel and tourism as a percent of all jobs and compares industries containing travel and tourism to the rest of the economy. It also shows jobs in industries that include travel and tourism as a percent of total employment.

Importantly, the charts on this page show the size of sectors that generally contain travel and tourism as components. The share of the sectors that corresponds to travel and tourism activities will vary among locations.

It may be useful to supplement the information in this report with surveys and data from: 1) state tourism offices, which sometimes track indicators such as tourism employment, hotel receipts, bed taxes, etc.; 2) local Chambers of Commerce and tourism promotion groups; and 3) visitor information from land management agencies including the U.S. Forest Service,[6] Bureau of Land Management, Fish & Wildlife Service, and National Park Service offices. In addition, it may be useful to supplement published statistics with computer models such as IMPLAN.[7]

The top two charts on this page start in 1998 because that is the year the U.S. Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS). The major industry categories (Retail Trade; Passenger Transportation; Arts, Entertainment, & Recreation; and Accommodation & Food Services) in the bottom chart are the sum of the sub-categories from the initial page of this report and as shown here do not represent NAICS codes.

Why is it important?

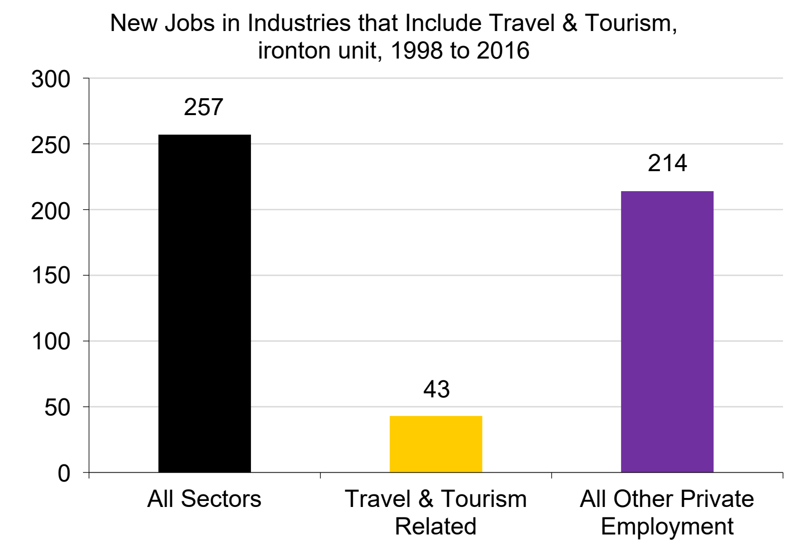
This information is useful to understand whether sectors that are likely to be associated with travel and tourism are growing or declining. It is less useful as a measure of the absolute size of employment in travel and tourism. A detailed knowledge, obtained through surveys and other means, is required to determine the proportion of a sector's employment that is due to local expenditures versus expenditures from visitors.[8, 9]

In some locations, travel and tourism are significant drivers of the economy. This can be true for "resort" economies but also for areas that have abundant natural and social amenities, and offer recreational opportunities.[10] In some of these places, travel and tourism-related employment is growing faster than overall employment.[4] While pleasure travel and recreation are important economic activities in and of themselves, they also stimulate other forms of economic development when people move families and businesses to communities they first visited as tourists.

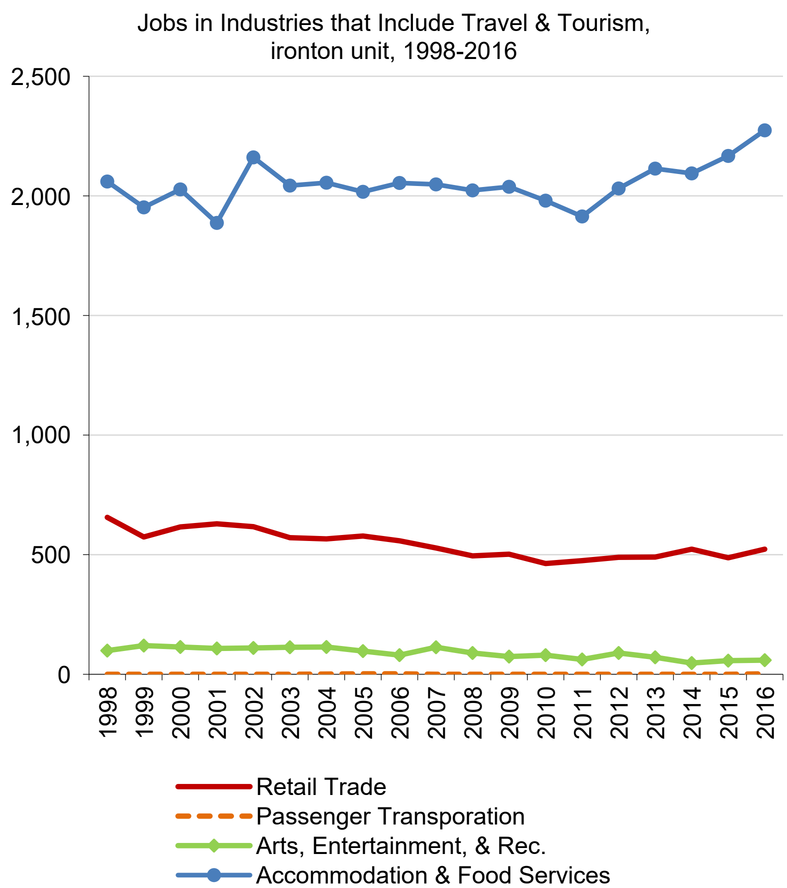
The EPS Public Land Amenities report provides additional information about amenity-led migration: https://headwaterseconomics.org/eps.

Travel & Tourism Employment Trends (cont.)

- From 1998 to 2016, travel & tourism employment grew by 43 jobs.
- From 1998 to 2016, non-travel & tourism employment grew by 214 jobs.



- From 1998 to 2016, retail trade shrank from 656 to 523 jobs, a 20.3% decrease.
- From 1998 to 2016, arts, entertainment, and recreation shrank from 99 to 59 jobs, a 40.4% decrease.
- From 1998 to 2016, accommodation and food services grew from 2,060 to 2,274 jobs, a 10.4% increase.



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Travel & Tourism Employment Trends (cont.)

What do we measure on this page?

This page compares employment in sectors that include travel and tourism to other sectors and compares how the various industries that include travel and tourism have changed over time.

The charts on this page start in 1998 because that is the year the U.S. Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS). The major industry categories (Retail Trade; Passenger Transportation; Arts, Entertainment, & Recreation; and Accommodation & Food Services) in the bottom chart are the sum of the sub-categories from the initial page of this report and as shown here do not represent NAICS codes.

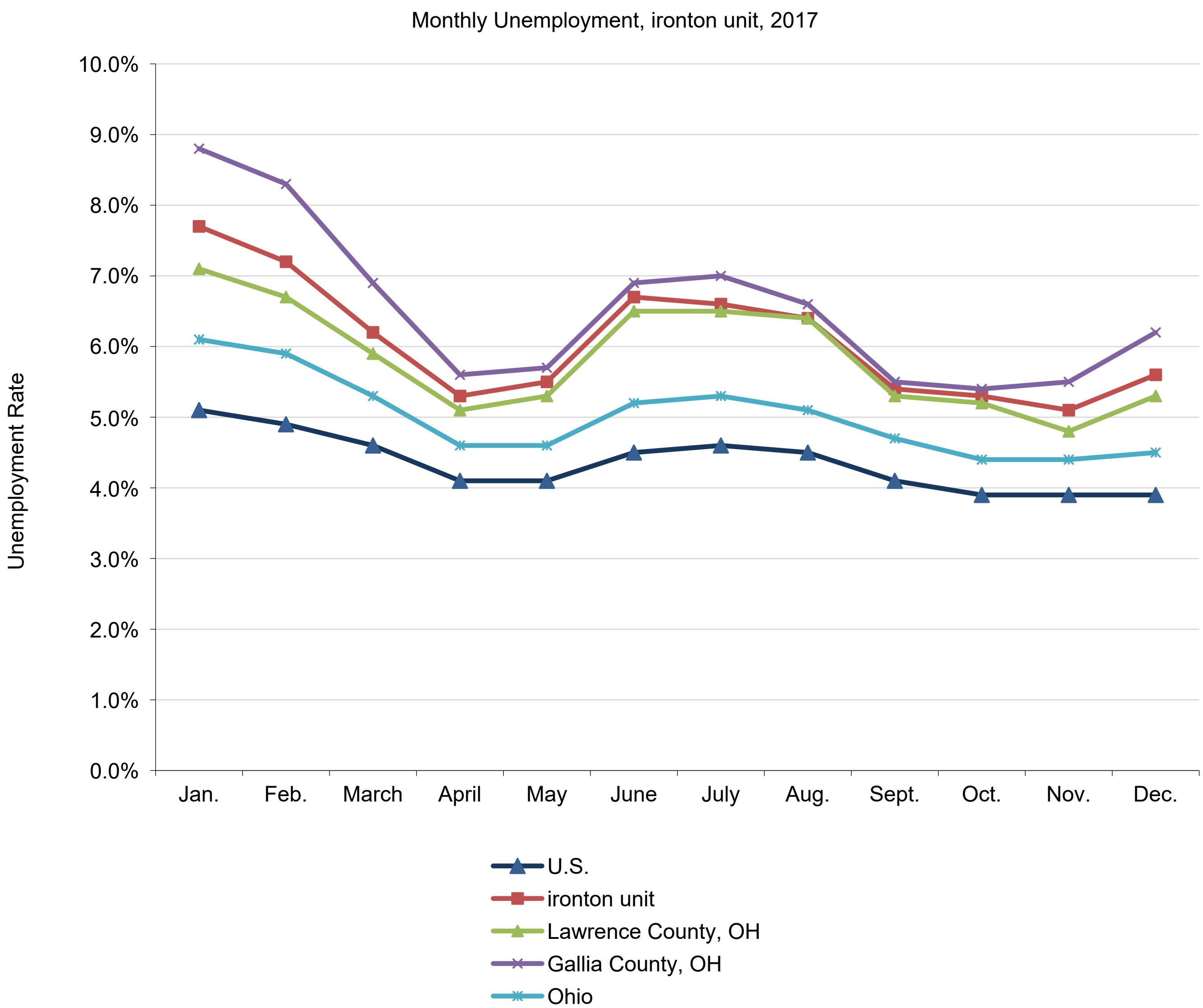
Why is it important?

This information is useful to understand whether sectors that are likely to be associated with travel and tourism are growing or declining. It is less useful as a measure of the absolute size of employment in travel and tourism. A detailed knowledge, obtained through surveys and other means, is required to determine the proportion of a sector's employment that is due to local expenditures versus expenditures from visitors.[8, 9]

In some locations, travel and tourism are significant drivers of the economy. This can be true for "resort" economies but also for areas that have abundant natural and social amenities, and offer recreational opportunities.[10, 11] In some of these places, travel and tourism-related employment is growing faster than overall employment. While pleasure travel and recreation are important economic activities in and of themselves, they also stimulate other forms of economic development when people move families and businesses to communities they first visited as tourists.

The EPS Public Land Amenities report provides additional information about amenity-led migration: https://headwaterseconomics.org/eps.

Seasonality of Unemployment



- In 2017, Gallia County, OH had the most change in unemployment (biggest absolute value of difference between min and max), and U.S. had the least (smallest absolute value of difference between min and max).

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Local Area Unemployment Statistics, Washington, D.C.

Seasonality of Unemployment

What do we measure on this page?

This page describes differences in the seasonality of unemployment, which occurs when people are unemployed at times of the year when demand for labor is lower than usual. Tourism is often associated with seasonal unemployment since work is only available for part(s) of the year when visitation is high.

This page uses data from the Bureau of Labor Statistics to show the change in month-to-month unemployment.[12]

Unemployed people are those who are jobless, available for work, and looking for jobs.

People with full- or part-time jobs are considered employed, and those people who are neither employed nor unemployed are not considered to be in the labor force.

Note: If many locations are selected, it may be difficult to read the figure on this page.

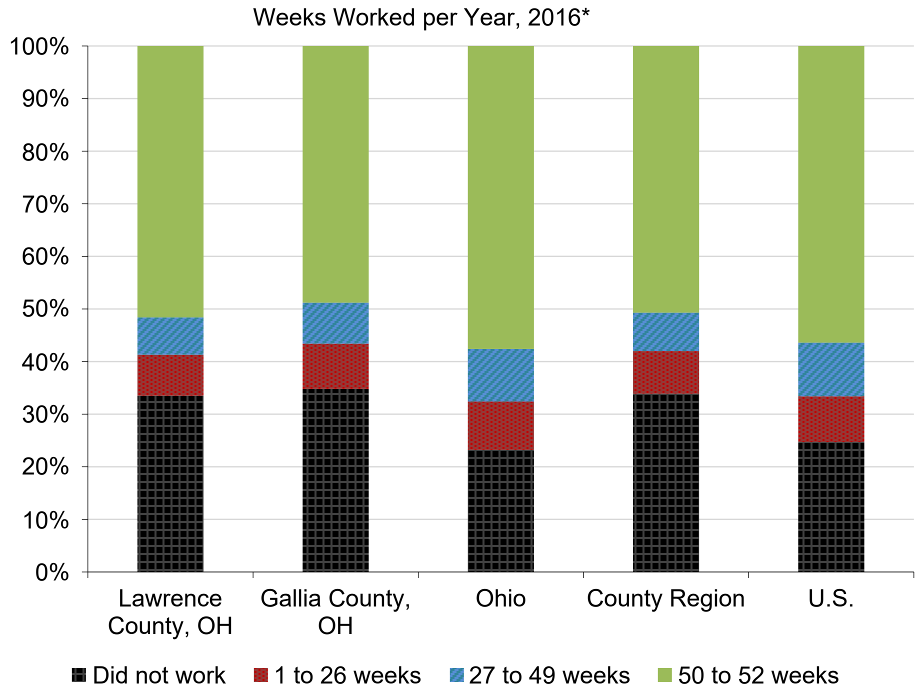
Why is it important?

Unemployment rate fluctuations reflect the hiring and layoff patterns that can accompany tourism due to visitation changes in winter holidays and summer vacations. It is possible that some seasonal workers may not live in the location selected and therefore are not accounted in the unemployment figures. Seasonal unemployment also occurs in places that have a relatively high concentration in construction, fishing, and agriculture sectors.

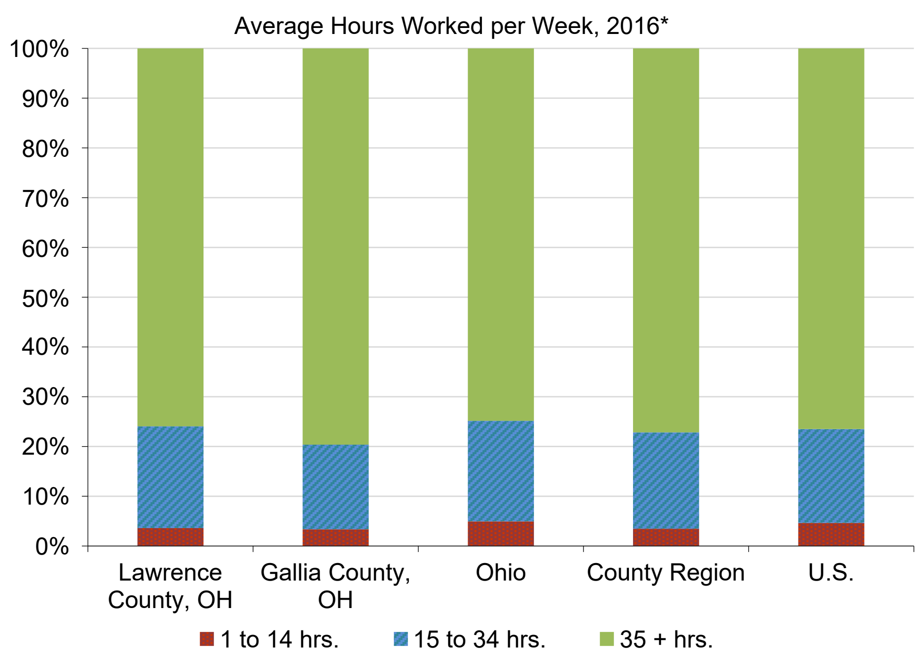
The EPS Socioeconomic Measures report provides further analysis of long-term trends in unemployment: https://headwaterseconomics.org/eps.

Part-Time Employment

- In 2016, 42 percent of workers in ironton unit worked less than 40 weeks over the course of the year, compared to 33.4 percent for the U.S..



- In 2016, 15.1 percent of workers in ironton unit worked less than 35 hours per week on average, compared to 17.7 percent for the the U.S..



* ACS 5-year estimates used. 2016 represents average characteristics from 2012-2016.

Data Sources: U.S. Department of Commerce. 2017. Census Bureau, American Community Survey Office, Washington, D.C.

Part-Time Employment

What do we measure on this page?

This page describes part-time work, which can be more common in tourism-related industries.

The U.S. Census Bureau provides two standard measures of part-time work: weeks worked per year and average hours worked per week. The Census reports these data for the population of age 16 to 64.

Why is it important?

Places that rely economically on tourism can have higher rates of part-time workers. While part-time work along is not a measure of tourism, it can be used to complement other data in this report and from elsewhere to evaluate the nature and extent of tourism activities in the selected locations.[7]

Travel & Tourism

ironton unit

Wages and Employment

	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
All Sectors, 2017 (2017 $s)	$34,102	$35,754	$49,153	$34,875	$55,390
Private	$32,500	$35,824	$48,577	$34,106	$55,338
Travel & Tourism	$15,060	$16,066	$20,319	$15,533	$24,782
Retail Trade	$17,307	$19,127	$20,184	$18,320	$22,979
Gasoline Stations	$16,667	$19,423	$20,691	$18,174	$21,516
Clothing & Accessories	$23,363	$14,496	$18,883	$16,542	$21,902
Misc. Store Retailers	$16,354	$28,718	$21,285	$20,718	$26,411
Passenger Transportation	$0	$0	$100,232	$0	$83,634
Air Transportation	$0	$0	$101,887	$0	$87,053
Scenic & Sightseeing	$0	$0	$20,759	$0	$33,331
Arts, Entertainment, & Rec.	$0	$0	$34,106	$0	$37,759
Performing Arts & Spectator Sports	na	na	$93,300	na	$91,180
Museums, Parks, & Historic Sites	$0	na	$29,096	$0	$34,795
Amusement, Gambling, & Rec.	na	na	$19,522	na	$22,384
Accommodations & Food	$14,525	$14,922	$16,337	$14,701	$20,731
Accommodation	$16,300	$14,161	$21,786	$14,967	$31,081
Food Services & Drinking Places	$14,452	$14,990	$15,869	$14,685	$18,963
Non-Travel & Tourism	$35,634	$40,423	$53,378	$37,440	$61,154
Government	$39,697	$35,400	$52,885	$37,951	$55,686

This table shows wage data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits; the major industry categories (retail trade, passenger transportation; arts, entertainment, and recreation; and accommodation and food) are the sum of the sub-categories underneath them and as shown here do not represent NAICS codes.

Percent of Total Employment

	Lawrence County, OH	Gallia County, OH	Ohio	ironton unit	U.S.
Private, 2017	77.7%	82.7%	86.6%	80.0%	85.1%
Travel & Tourism	11.4%	11.5%	12.6%	11.4%	13.6%
Retail Trade	2.2%	3.1%	2.0%	2.6%	2.2%
Gasoline Stations	1.3%	1.8%	0.7%	1.6%	0.6%
Clothing & Accessories	0.2%	0.9%	0.7%	0.5%	1.0%
Misc. Store Retailers	0.6%	0.4%	0.6%	0.5%	0.6%
Passenger Transportation	0.0%	0.0%	0.2%	0.0%	0.4%
Air Transportation	0.0%	0.0%	0.2%	0.0%	0.3%
Scenic & Sightseeing	0.0%	0.0%	0.0%	0.0%	0.0%
Arts, Entertainment, & Rec.	0.0%	0.0%	1.5%	0.0%	1.6%
Performing Arts & Spectator Sports	na	na	0.3%	na	0.3%
Museums, Parks, & Historic Sites	0.0%	na	0.1%	0.0%	0.1%
Amusement, Gambling, & Rec.	na	na	1.1%	na	1.1%
Accommodations & Food	9.2%	8.3%	9.0%	8.8%	9.5%
Accommodation	0.4%	0.7%	0.7%	0.5%	1.4%
Food Services & Drinking Places	8.8%	7.7%	8.3%	8.3%	8.1%
Non-Travel & Tourism	60.9%	41.9%	74.0%	52.0%	71.5%
Government, 2017	22.3%	17.3%	13.4%	20.0%	14.9%

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment

What do we measure on this page?

This page describes wages (in real terms) from employment in industries that include travel and tourism, including sub-sectors, compared to wages from employment in all non-travel-and-tourism sectors combined. It also describes the percent of jobs in each category. These are shown together to illustrate the relative wage levels in industries that include travel and tourism, and how many people are employed in each sub-sector.

The primary purpose of this page is to compare the average annual wages between sectors and to investigate the relative number of people employed in high- and low-wage sectors.

Travel and Tourism: Sectors that provide goods and services to visitors as well as to the local population. These industries are Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services. The exact proportion of jobs in these sectors attributable to expenditures by visitors, including business and pleasure travelers, is not known without additional research such as surveys. Some researchers refer to these sectors as “travel and tourism-potential sectors” because they have the potential of being influenced by expenditures by non-locals. In this report, they are referred to as “industries that include travel and tourism.”

The tables use wage and employment data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[13, 14]

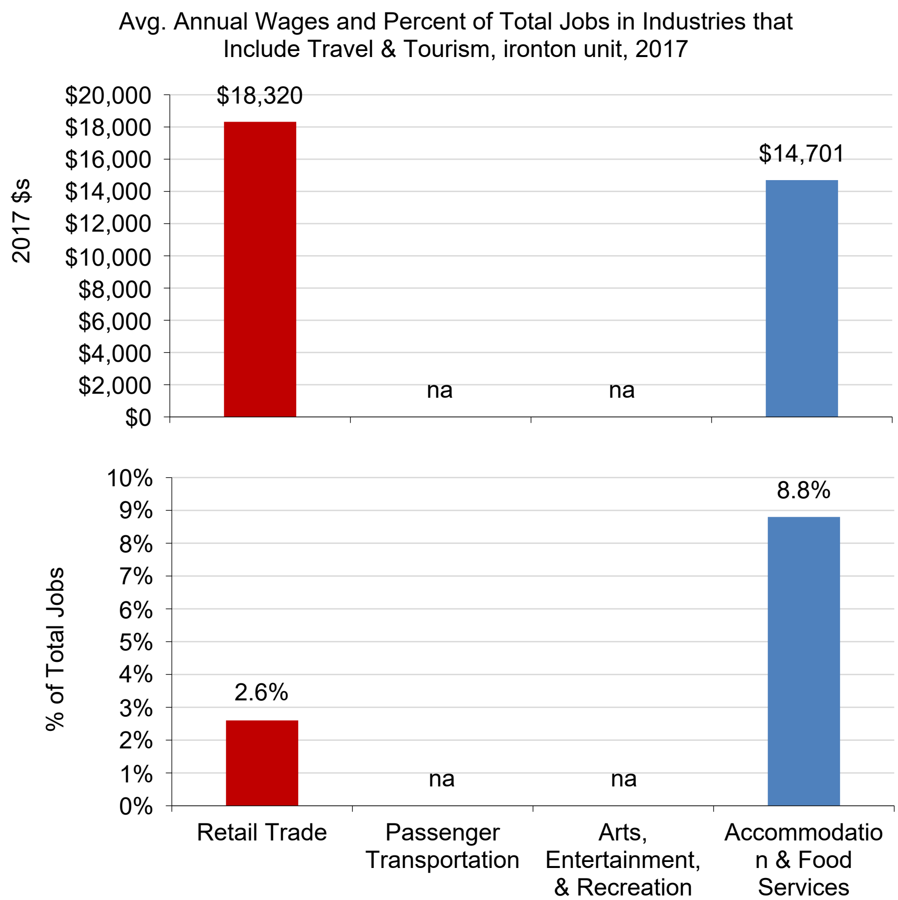
Why is it important?

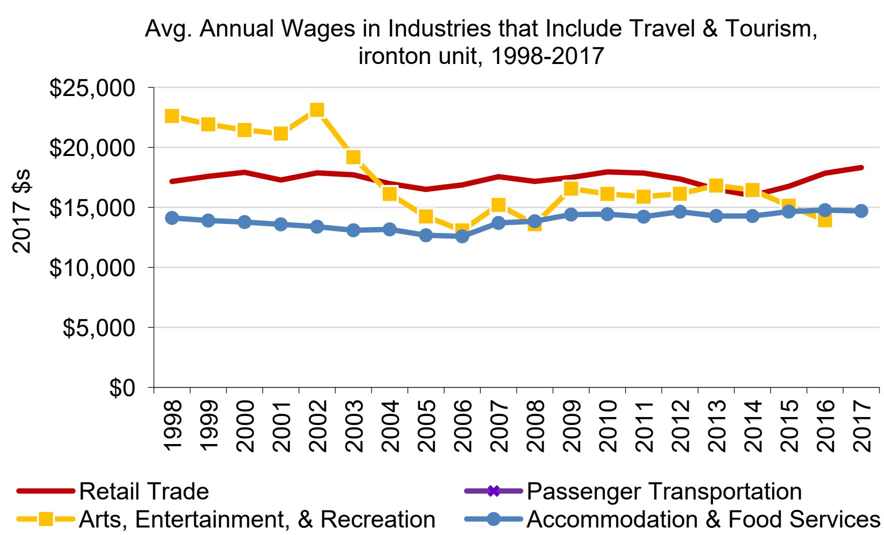
Industries that contain travel and tourism often pay relatively low wages, though this varies by industry sub-sector and by location. Some important issues to consider are how travel and tourism related industry wages compare to wages in other sectors, whether some components of travel- and tourism-related industries pay higher wages than others, and whether there are significant wage differences between locations.[15, 16] When comparing wage levels, it is also useful to remember that many travel and tourism related jobs are seasonal and/or part-time.

Wages and Employment (cont.)

- In 2017, travel & tourism sector average wages, from highest to lowest, were: retail trade ($18,320); accommodation & food services ($14,701); passenger transportation ($0); and passenger transportation ($0).

- In 2017, travel & tourism sector percent of total employment, from highest to lowest, were: accommodation & food services (8.8%); retail trade (2.6%); passenger transportation (0%); and passenger transportation (0%).





Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment (cont.)

What do we measure on this page?

This page describes average wages (in real terms) and employment levels in industries that include travel and tourism. It also shows average wage trends (in real terms) for industries that include travel and tourism.

The chart *Avg. Annual Wages and Percent of Total Jobs in Industries that Include Travel & Tourism* describes how many people are working in relatively high- and low-wage travel and tourism related industries. The chart *Avg. Annual Wages in Industries that Include Travel & Tourism* is useful for comparing wage trends by sector.

The charts use wage and employment data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[13, 14] As a result, the percent-of-employment values may not exactly match values derived from County Business Patterns that are reported on previous pages. The bottom chart on this page starts in 1998 to be consistent with the start date of figures on earlier pages of this report.

The major industry categories (Retail Trade; Passenger Transportation; Arts, Entertainment, and Recreation; and Accommodation and Food Services) are the sum of the sub-categories from the previous page of this report and as shown here do not represent NAICS codes.

If your report results in significant undisclosed data, other sources for travel and tourism wage data include the state-level Bureau of Labor Statistics' Quarterly Census of Employment and Wages https://www.bls.gov/cew/; the Bureau of Labor Statistics' Occupational Outlook Handbook, which has detailed industry earnings and wages data at the national level https://www.bls.gov/ooh/; and the County Business Patterns database, which reports industry-level employment and payroll and can be used to estimate earnings https://www.census.gov/programs-surveys/cbp.html.

Why is it important?

While industries that include travel and tourism often pay relatively low wages, wages and the number of people employed can vary greatly among travel and tourism related industries.

The trend data on this page can be useful for understanding whether wages in sectors that are likely to be associated with travel and tourism have changed over time.

Travel & Tourism

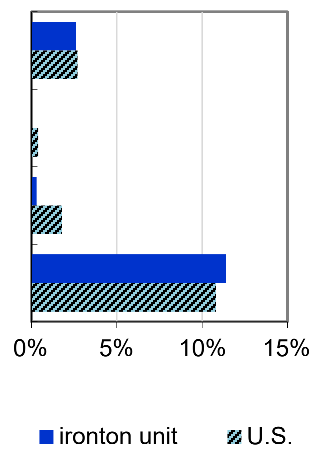
ironton unit

Comparisons

Industries Including Travel and Tourism, 2016	Employment Share: ironton unit	Employment Share: U.S.	Location Quotient
Retail Trade	2.6%	2.7%	1.0
Passenger Transportation	0.0%	0.4%	0.0
Arts, Entertainment, & Recreation	0.3%	1.8%	0.2
Accommodation & Food	11.4%	10.8%	1.1

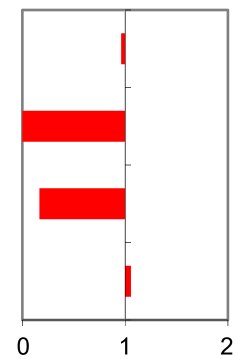
Employment Share

ironton unit vs. U.S.



Location Quotient

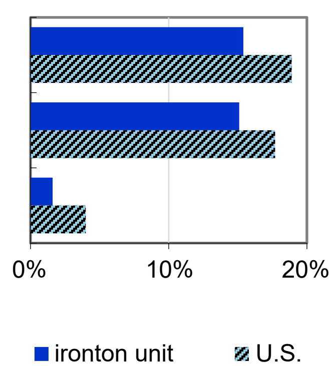
ironton unit vs. U.S.



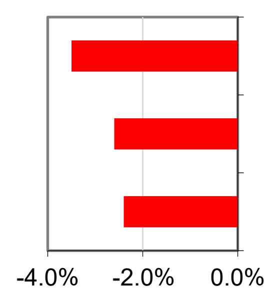
Other Possible Measures of the Presence of Travel and Tourism

Indicators of Seasonal Work and Housing , 2016*	ironton unit	U.S.	Diff.
Part-Time Work (less than 50 weeks per year)	15.4%	18.9%	-3.5%
Part-Time Work (less than 35 hours per week)	15.1%	17.7%	-2.6%
Second Homes	1.6%	4.0%	-2.4%

ironton unit vs. U.S.



Difference in Percent, ironton unit vs. U.S.



* ACS 5-year estimates used. 2016 represents average characteristics from 2012-2016.

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.; U.S. Department of Commerce. 2017. Census Bureau, American Community Survey Office, Washington, D.C.

Comparisons

What do we measure on this page?

This page describes whether the region is specialized in travel and tourism related employment. The chart illustrates the difference between the selected location(s) and the selected benchmark area.[17] (If no custom benchmark area was selected, EPS defaults to benchmarking against the U.S.)

Location Quotient[18]: A ratio that compares an industry's share of total employment in a region to the benchmark. More precisely, it is the percent of local employment in a sector divided by the percent employment in the same sector in the benchmark area. In other words, it is a ratio that measures specialization using the benchmark area for comparison. A location quotient of more than 1.0 means the local area is more specialized in that sector relative to the benchmark area. A location quotient of less than 1.0 means it is less specialized.[19]

Another way to think about location quotients is as a measure of whether a place produces enough goods or services from an industry to satisfy local demand for those goods or services. Results above or below the 1.0 standard indicate the degree to which a place may import or export a good or service. Although there is no precise cutoff, location quotients above 2.0 indicate a strong industry concentration (and that an area is likely exporting goods or services) and those less than 0.5 indicate a weak industry concentration (and that an area is likely importing goods or services).

Second Homes: The number of second homes is not available as a single variable from the U.S. Census Bureau. We have calculated second homes as a percent of total homes as follows: seasonally occupied homes (Census SF1 H005005) are added to other vacant homes (Census SF1 H005007) and then divided by total homes. By this definition, second homes do not include homes that are vacant because they are for rent or sale.

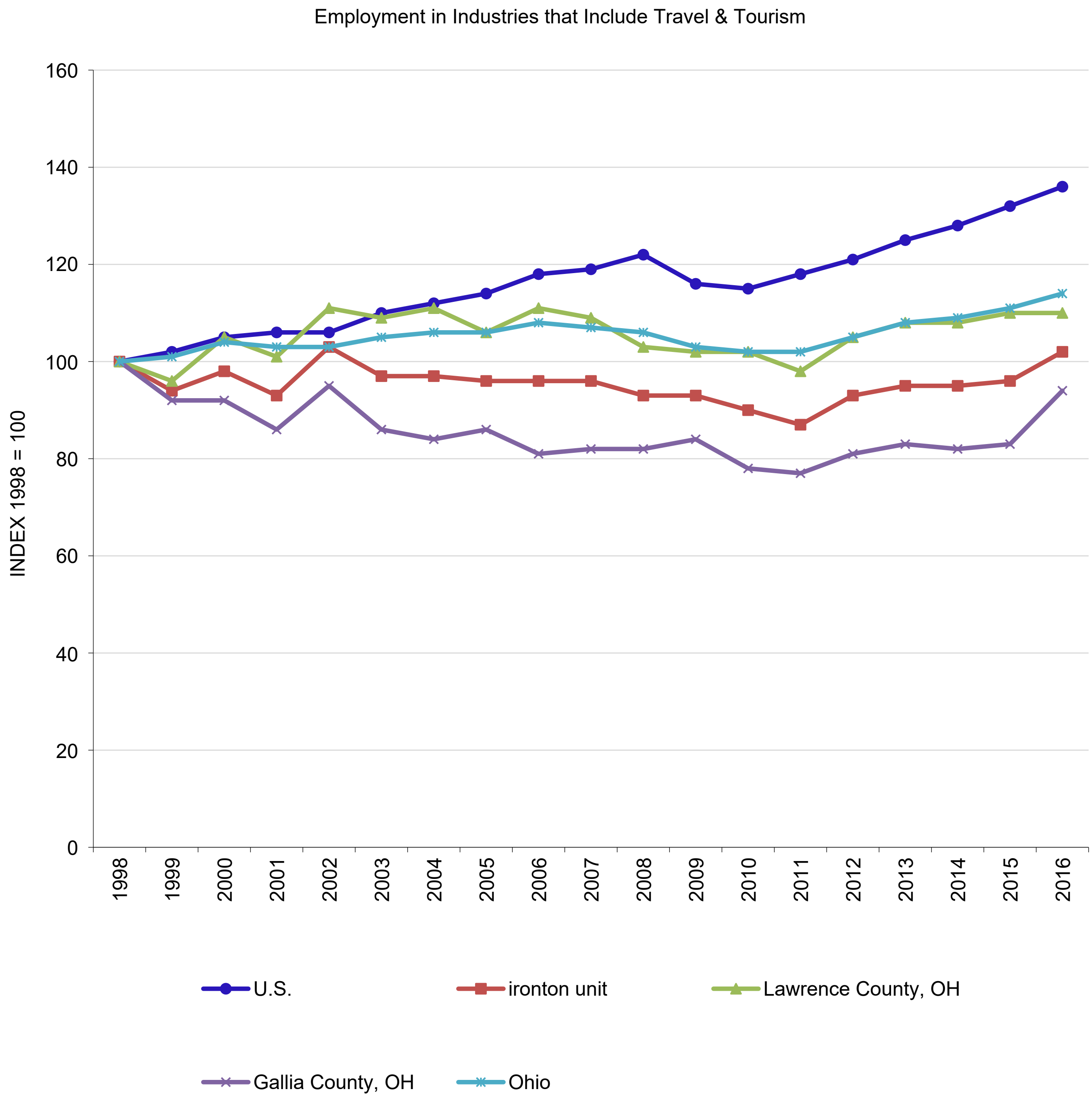
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses data from the U.S. Department of Commerce to estimate these data gaps.[20]

Why is it important?

Locations with economies that focus on travel and tourism may have a competitive advantages,[21, 22] but can also be sensitive to business cycles and other changes (for example, a rise in fuel costs) that affect pleasure travel and recreation spending. Natural amenities such as public lands can increase travel and tourism activities, benefiting local communities and in some cases diversify rural economies that have historically been tied to commodity production.[5, 23, 24] The growth of travel and tourism activities is also associated with in-migration that can lead to business relocation and new business development across a range of business sectors.[25]

A few caveats: (1) A large location quotient for a particular sector does not necessarily mean that sector is a significant contributor to the economy. (2) LQs greater than 1.0 only suggest potential export capacity when compared to the benchmark area and do not take into account local demand. Local demand may be greater than average, and therefore all goods and services may be consumed locally (i.e., not exported). (3) LQs can change from year to year. (4) LQs can vary when one uses income or wage data rather than employment.

Comparisons Over Time



- From 1998 to 2016, Lawrence County, OH had the fastest rate of change in travel & tourism employment, and ironton unit had the slowest.

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Comparisons Over Time

What do we measure on this page?

This page describes the change in travel and tourism employment for all selected locations and the benchmark area.[17] The information is indexed (1998=100) so that data from locations with different-sized economies can be compared. Indexing makes it easier to understand the relative rate of growth or decline of mining employment over time.

Index: Indexed numbers are compared with a base value. In the line chart, employment in 1998 is the base value and is set to 100. The employment values for subsequent years are expressed as 100 times the ratio to the base value. The indexing used in the line chart enables easier comparisons between locations over time. (If many locations are selected, it may be difficult to read the figure on this page.)

The chart begins in 1998 because that is the year the Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS).

Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses data from the U.S. Department of Commerce to estimate these data gaps.[20]

Why is it important?

This information is useful to understand whether sectors likely to be associated with travel and tourism are growing or declining. These data do not measure the absolute size of employment in travel and tourism. Detailed knowledge, obtained through surveys and other means, is required to determine the proportion of a sector's employment that is due to local expenditures versus expenditures from visitors.

Not all locations have attracted or lost travel- and tourism-related employment at the same rate.[26] An index makes it clear where the rate of travel-and-tourism-related growth or decline has been the fastest. Lines above 100 indicate positive absolute growth while those below 100 show absolute decline. The steeper the curve, the faster the rate of change.

It may be helpful to look for large year-to-year rises or dips to identify rapid employment changes. If the reasons behind these fluctuations are not evident, it may be helpful to talk with regional experts or local residents to learn more about what caused abrupt changes.

Locations with economies that focus on travel and tourism may have competitive advantages,[21, 22] but can also be sensitive to business cycles and other changes (for example, a rise in fuel costs) that affect pleasure travel and recreation spending. Natural amenities such as public lands can increase travel and tourism activities, benefiting local communities and in some cases diversify rural economies that have historically been tied to commodity production.[5, 23, 24] The growth of travel and tourism activities is also associated with in-migration that can lead to business relocation and new business development across a range of business sectors.[25]

Data Sources & Methods

The EPS Travel & Tourism report uses national statistics from public government sources. All data used in EPS can be readily verified with original sources:

- **County Business Patterns**
  Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/cbp.html
  Contacts
  https://www.census.gov/about/contact-us.html

- **Quarterly Census of Employment and Wages**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/cew
  Contacts
  https://www.bls.gov/bls/contact.htm

- **American Community Survey**
  U.S. Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/acs/
  https://www.census.gov/acs/www/data/data-tables-and-tools/index.php
  Contacts
  https://www.census.gov/about/contact-us.html

- **Local Area Unemployment Statistics**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/lau/
  Contacts
  https://www.bls.gov/bls/contact.htm

EPS core approaches
EPS is designed to focus on long-term trends across a range of important measures. Trend analysis provides a more comprehensive view of changes than spot data for select years. We encourage users to focus on major trends rather than absolute numbers. EPS displays detailed industry-level data to show changes in the composition of the economy over time and the mix of industries at points in time. EPS employs cross-sectional benchmarking—comparing smaller areas such as counties to larger regions, states, and the nation—to give a sense of relative performance. EPS allows users to aggregate data for multiple locations to allow for more sophisticated cross-sectional comparisons.

Data Limitations
Much of the data in this report were obtained from the U.S. Census Bureau's County Business Patterns (CBP) series. Compared to other sources, CBP has fewer data gaps (instances when the federal government will not release data to protect confidentiality of individual businesses). It also includes both full- and part-time employment.

However, CBP data do not include employment in government, agriculture, railroads, or the self-employed. Also, CBP data are based on mid-March employment and do not account for seasonal fluctuations. Since March is a "shoulder" season for several tourism activities, CBP may underrepresent employment in industries associated with tourism. Despite these limitations, the data are most useful for showing long-term trends, displaying differences between places, and showing relationships between sectors over time.

Adjusting dollar figures for inflation
Because a dollar in the past was worth more than a dollar today, data reported in current dollar terms should be adjusted for inflation. The U.S. Department of Commerce reports personal income figures in terms of current dollars. All income data in EPS are adjusted to real (or constant) dollars using the Consumer Price Index. Figures are adjusted to the latest date for which the annual Consumer Price Index is available.

Data gaps and estimation
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses supplemental data from the U.S. Department of Commerce to estimate these data gaps. These are indicated in italics in tables. Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

Endnotes

1 - In 2018 the Dept. of Commerce for the first time developed statistics illustrating the economic impact of outdoor recreation in the United States. See the Bureau of Economic Analysis's Outdoor Recreation Satellite Account at https://www.bea.gov/data/special-topics/outdoor-recreation.

2 - The Federal Reserve Bank of Kansas City has defined travel and tourism as consisting of hotels, air travel, and amusement and recreation services. See Wilkerson CR. 2003. Travel and Tourism: An Overlooked Industry in the U.S. and Tenth District. Economic Review. QIII(2003):45-71. https://www.kansascityfed.org/publicat/econrev/PDF/3q03wilk.pdf Wilkerson points out that travel- and tourism-related sectors outperformed the nation, including during recessions.

3 - The list of NAICS codes associated with travel and tourism were obtained from Marcouiller DW and Xia X. 2008. Distribution of Income from Tourism-Sensitive Employment. Tourism Economics 14(3):545-565. http://journals.sagepub.com/doi/abs/10.5367/000000008785633622?journalCode=teua. For a similar definition of travel and tourism, see Wilkerson C. 2003. Travel and Tourism: An Overlooked Industry in the U.S. and Tenth District. Federal Reserve Bank of Kansas City Economic Review. QIII(2003):45-71. https://www.kansascityfed.org/publicat/econrev/PDF/3q03wilk.pdf.

4 - It is estimated that outdoor recreation alone generates $887 billion in consumer spending annually and 7.6 million jobs. Outdoor Industry Association. 2018. Advocacy: Outdoor Recreation Economy. https://outdoorindustry.org/advocacy/.

5 - Allen T, D Kary, and R Southwick. 2017. The Economic Contributions of Outdoor Recreation. Boulder, CO: Outdoor Industry Association. https://outdoorindustry.org/wp-content/uploads/2015/03/OIA_Recreation_Economy_Contributions_Technical_Report_2017-08-24.pdf.

6 - The Forest Service collects information on visitor satisfaction and use. Annual summary reports and individual forest and grassland reports are available from https://www.fs.fed.us/recreation/programs/nvum.

7 - Stynes DJ and White EM. 2006. Reflections on Measuring Recreation and Travel Spending. Journal of Travel Research. 45:8-16. See http://journals.sagepub.com/doi/10.1177/0047287506288873.

8 - The U.S. Census Bureau conducts an Economic Census every five years for selected industries. Users can search the Economic Census for information on the number of establishments, sales, employees, and payroll, for selected industries. https://www.census.gov/programs-surveys/economic-census.html.

9 - The U.S. Department of Commerce developed the U.S. Travel and Tourism Satellite Accounts to estimate the proportion of every sector in the economy that is attributable to travel and tourism at the national level. This information is useful for detecting sectors that have a higher potential to serve the needs of visitors. The resulting ratios should not be applied to local economies. https://www.bea.gov/data/special-topics/travel-and-tourism.

Endnotes

10 - Outdoor recreation accounted for 2 percent ($373.3 billion) of GDP in 2016. The outdoor recreation economy grew 3.8 percent in 2016, compared to 2.8 percent in the overall economy. https://www.bea.gov/news/2018/outdoor-recreation-satellite-account-prototype-estimates-2012-2016.

11 - Almost half the U.S. population participated in an outdoor activity at least once in 2017. Outdoor Foundation. 2018. Outdoor Participation Report 2018. Washington, DC: Outdoor Foundation. https://outdoorindustry.org/resource/2018-outdoor-participation-report/.

12 - For detailed information on how the government measures unemployment, see https://www.bls.gov/cps/.

13 - For an overview of how the Bureau of Labor Statistics treats employment, see https://www.bls.gov/bls/employment.htm.

14 - For an overview of how the Bureau of Labor Statistics treats pay and benefits, see https://www.bls.gov/bls/wages.htm.

15 - Employment and wage estimates are also available from the Bureau of Labor Statistics for more than 800 occupations. Looking at travel and tourism by occupation, rather than by sector or industry, is helpful because wages can vary dramatically across occupations. For more information, see https://www.bls.gov/oes/.

16 - The EPS Socioeconomic Measures report provides additional information about wages in non-travel-and-tourism industries. https://headwaterseconomics.org/eps.

17 - The term "benchmark" in this report should not be construed as having the same meaning as in the National Forest Management Act (NFMA).

18 - LQ = (ei/e) divided by (Ei/E)
Where: ei = Local employment in industry i; e = Total local employment; Ei = U.S. employment in industry i; E = Total U.S. employment.

19 - A succinct definition of a location quotient is offered by Indiana Business Research Center at IU's Kelley School of Business. http://www.incontext.indiana.edu/2006/march/1.asp.

20 - Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

21 - Reeder RJ and Brown DM. 2005. Recreation, Tourism, and Rural Well-Being. USDA Economic Research Service Economic Research Report No. 7. https://www.ers.usda.gov/webdocs/publications/46126/15112_err7_1_.pdf?v=41056

Endnotes

22 - English DBK, Marcouiller DW, and Cordell HK. 2000. Tourism Dependence in Rural America: Estimates and Effects. Society and Natural Resources 13(3):185-202. https://www.srs.fs.usda.gov/pubs/ja/ja_english004.pdf The study found that counties relatively dependent on tourism have higher growth in per capita income in comparison to non-dependent counties; less economic diversity; fewer manufacturing jobs, in particular in wood products sectors; more expensive housing; faster population growth; and higher levels of education. They also found that average household income in tourism-dependent counties was about the same as in non-dependent counties.

23 - For a review of literature on economic diversity, see Sterling A. 1998. On the Economics and Analysis of Diversity. Electronic Working Papers Series, No. 28. University of Sussex, Brighton, UK. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.144.8865&rep=rep1&type=pdf.

24 - A useful book on the evolving competitive environment for rural areas is Galston WA and Baehler KJ. 1995. Rural Development in the United States: Connecting Theory, Practice, and Possibilities. Washington, DC: Island Press.

25 - Snepenger D, Johnson J, and Rasker R. 1994. Travel Stimulated Entrepreneurial Migration. Journal of Travel Research 34(1):40-44. http://journals.sagepub.com/doi/abs/10.1177/004728759503400105 Snepenger et al. found that tourism can stimulate permanent migration of entrepreneurs.

26 - The Economic Research Service of the U.S. Dept. of Agriculture has developed a widely-used classification system for identifying non-metropolitan recreation counties. See Johnson KM and Beale CL. 2002. Non-Metro Recreation Counties: Their Identification and Rapid Growth. Rural America 17(4):2-19. https://www.ers.usda.gov/webdocs/publications/46984/19347_ra174b_1_.pdf?v=41056.

A Profile of Industries that Include Travel & Tourism

marietta unit

Selected Geographies:

Monroe County, OH; Washington County, OH

Benchmark Geographies:

U.S.

Produced by
Headwaters Economics'
Economic Profile System (EPS)
https://headwaterseconomics.org/eps
December 18, 2018

About the Economic Profile System (EPS)

EPS is a free web tool created by Headwaters Economics to build customized socioeconomic reports of U.S. counties, states, and regions. Reports can be easily created to compare or aggregate different areas. EPS uses published statistics from federal data sources, including the U.S. Census Bureau, Bureau of Economic Analysis, and Bureau of Labor Statistics.

The Bureau of Land Management and Forest Service have made significant financial and intellectual contributions to the operation and content of EPS.

See https://headwaterseconomics.org/eps for more information about the capabilities of EPS. For technical questions, contact Patty Gude at eps@headwaterseconomics.org or telephone 406-599-7425.

HEADWATERS ECONOMICS

headwaterseconomics.org

Headwaters Economics is an independent, nonprofit research group. Our mission is to improve community development and land management decisions.

www.blm.gov

The Bureau of Land Management, an agency within the U.S. Department of Interior, administers 249.8 million acres of America's public lands, located primarily in western states. It is the mission of the Bureau of Land Management to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

www.fs.fed.us

The Forest Service, an agency of the U.S. Department of Agriculture, administers national forests and grasslands encompassing 193 million acres. The Forest Service's mission is to sustain the health, diversity, and productivity of the nation's forests and grasslands to meet the needs of present and future generations.

Travel & Tourism

marietta unit

Table of Contents

Note to Users:

This is one of 14 reports that can be created and downloaded from EPS. Topics include land use, demographics, specific industry sectors, the role of non-labor income, the wildland-urban interface, the role of amenities in economic development, and payments to county governments from federal lands. The EPS reports are downloadable as Excel or PDF documents. See https://headwaterseconomics.org/eps.

Travel & Tourism

marietta unit

Travel & Tourism Sectors

	Ohio	Monroe County, OH	Washington County, OH	marietta unit	U.S.
Total Private Employment, 2016	4,790,178	2,315	22,761	25,076	126,752,238
Travel & Tourism Related	674,392	~276	~2,985	~3,261	19,977,824
Retail Trade	113,319	~82	634	~716	3,466,865
Gasoline Stations	35,967	59	378	437	947,656
Clothing & Accessory Stores	47,689	~2	104	~106	1,738,095
Misc. Store Retailers	29,663	21	152	173	781,114
Passenger Transportation	10,355	0	~2	~2	495,505
Air Transportation	10,169	0	0	0	466,440
Scenic & Sightseeing Transport	186	0	~2	~2	29,065
Arts, Entertainment, & Recreation	68,762	11	~116	~127	2,311,437
Performing Arts & Spectator Sports	16,016	0	~13	~13	503,751
Museums, Parks, & Historic Sites	6,521	0	~6	~6	151,270
Amusement, Gambling, & Rec.	46,225	11	97	108	1,656,416
Accommodation & Food	481,956	183	2,233	2,416	13,704,017
Accommodation	38,071	0	177	177	2,067,377
Food Services & Drinking Places	443,885	183	2,056	2,239	11,636,640
Non-Travel & Tourism	4,115,786	~2,039	~19,776	~21,815	106,774,414
Percent of Total					
Travel & Tourism Related	14.1%	~11.9%	~13.1%	~13.0%	15.8%
Retail Trade	2.4%	~3.5%	2.8%	~2.9%	2.7%
Gasoline Stations	0.8%	2.5%	1.7%	1.7%	0.7%
Clothing & Accessory Stores	1.0%	~0.1%	0.5%	~0.4%	1.4%
Misc. Store Retailers	0.6%	0.9%	0.7%	0.7%	0.6%
Passenger Transportation	0.2%	0.0%	~0.0%	~0.0%	0.4%
Air Transportation	0.2%	0.0%	0.0%	0.0%	0.4%
Scenic & Sightseeing Transport	0.0%	0.0%	~0.0%	~0.0%	0.0%
Arts, Entertainment, & Recreation	1.4%	0.5%	~0.5%	~0.5%	1.8%
Performing Arts & Spectator Sports	0.3%	0.0%	~0.1%	~0.1%	0.4%
Museums, Parks, & Historic Sites	0.1%	0.0%	~0.0%	~0.0%	0.1%
Amusement, Gambling, & Rec.	1.0%	0.5%	0.4%	0.4%	1.3%
Accommodation & Food	10.1%	7.9%	9.8%	9.6%	10.8%
Accommodation	0.8%	0.0%	0.8%	0.7%	1.6%
Food Services & Drinking Places	9.3%	7.9%	9.0%	8.9%	9.2%
Non-Travel & Tourism	85.9%	~88.1%	~86.9%	~87.0%	84.2%

The major industry categories (retail trade; passenger transportation; arts, entertainment, and recreation; and accommodation and food) in the table above are the sum of the sub-categories underneath them and as shown here do not represent NAICS codes. The data does not include employment in government, agriculture, railroads, or the self-employed because these are not reported by County Business Patterns. Estimates for data that were not disclosed are indicated with tildes (~).

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Travel & Tourism Sectors

What do we measure on this page?

This page describes the number of jobs (full- and part-time) and the share of total jobs in industries that include travel and tourism.

Travel and Tourism: Sectors that provide goods and services to visitors as well as to the local population. These industries are Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services.[1]

The exact proportion of jobs in these sectors attributable to expenditures by visitors, including business and pleasure travelers, is not known without additional research such as surveys. Some researchers refer to these sectors as “tourism-sensitive.” They could also be called “travel and tourism-potential sectors” because they have the potential of being influenced by expenditures by non-locals. In this report, they are referred to as "industries that include travel and tourism."

There is no single industrial classification for travel and tourism under the North American Industrial Classification System (NAICS). However, there are sectors that provide goods and services to visitors to a local economy. We reviewed the published literature to discern how others identified industries that are part of travel and tourism.[2] These industries (identified by 3-digit NAICS codes in parentheses[3]) include:

Retail Trade: Gasoline Stations (447), Clothing and Accessory Stores (448), Miscellaneous Store Retailers (453; includes Gift, Novelty, and Souvenir)

Passenger Transportation: Air Transportation (481), Scenic and Sightseeing Transportation (487)

Arts, Entertainment, and Recreation: Performing Arts and Spectator Sports (711); Museums, Parks, and Historical Sites (712; includes National Parks, Conservation Areas); Amusement, Gambling, and Recreation (713; includes Golf Courses, Alpine and Cross Country Skiing Facilities)

Accommodation and Food: Accommodation (721; includes ski resorts, hotels, casino hotels, campgrounds, guest ranches), Food Services and Drinking Places (722)

Data on this page were obtained from the U.S. Census Bureau’s County Business Patterns (CBP) series. Compared to other sources, CBP has fewer data gaps (instances when the federal government will not release data to protect confidentiality of individual businesses). It also includes both full- and part-time employment. However, CBP data do not include employment in government, agriculture, railroads, or the self-employed. Also, CBP data are based on mid-March employment and do not account for seasonal fluctuations. For these reasons, the data are most useful for showing long-term trends, displaying differences between places, and showing relationships between sectors over time.

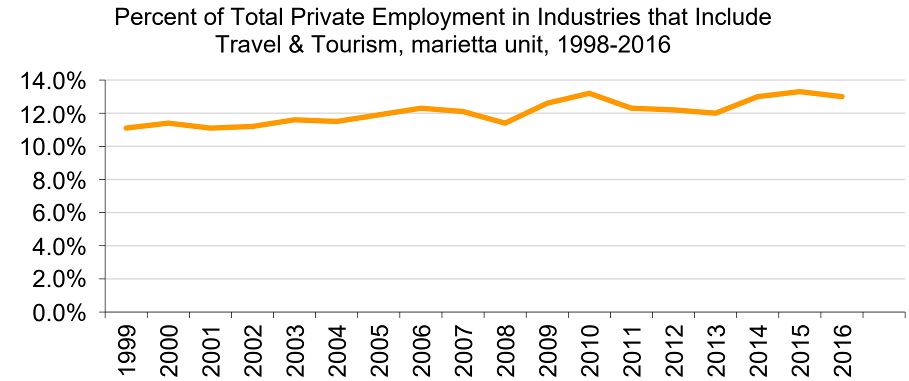
Why is it important?

The information on this page is useful for explaining whether sectors that are likely to be associated with travel or tourism exist within the selected location. Travel and tourism related sectors are often a larger component of overall employment in locations where visitors spend money on hotels, restaurants, ski resorts, gift shops, and other expenses associated with recreation.[4, 5]

While the information in this report is not an exact measure of the size of the travel and tourism sectors, it can be used to understand whether travel and tourism-related economic activity is present, how it has changed over time, and whether there are differences between locations.

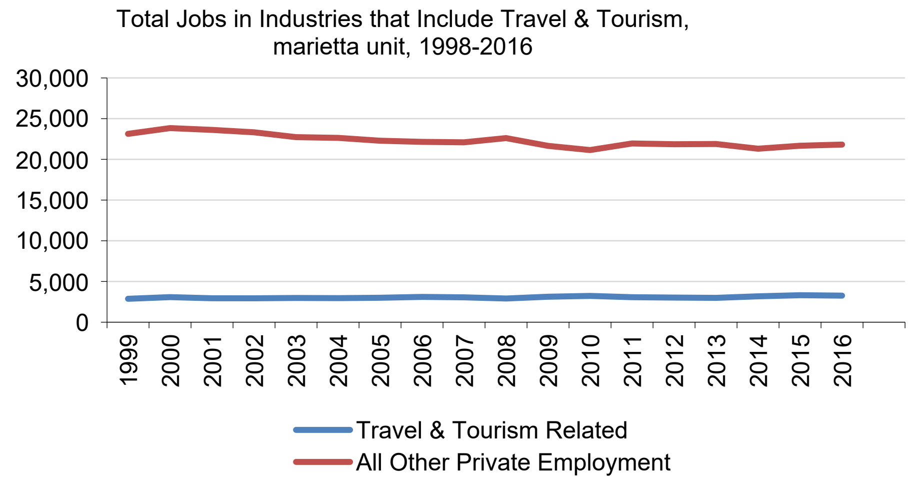
Travel & Tourism Employment Trends

- In 1998, travel & tourism represented 12% of total employment. By 2016, travel & tourism represented 13% of total employment.

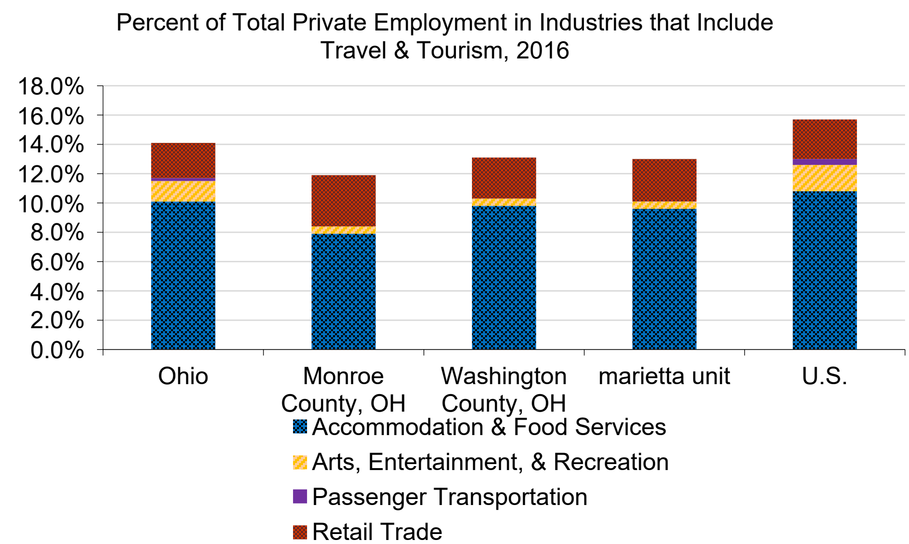


- From 1998 to 2016, travel & tourism employment grew from 2,998 to 3,261 jobs, a 8.8% increase.

- From 1998 to 2016, non-travel & tourism employment shrank from 23,038 to 21,815 jobs, a 5.3% decrease.



- In 2016, U.S. had the largest percent of total travel & tourism employment (15.8%), and Monroe County, OH had the smallest (11.9%).



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Travel & Tourism Employment Trends

What do we measure on this page?

This page describes trends in industries that include travel and tourism as a percent of all jobs and compares industries containing travel and tourism to the rest of the economy. It also shows jobs in industries that include travel and tourism as a percent of total employment.

Importantly, the charts on this page show the size of sectors that generally contain travel and tourism as components. The share of the sectors that corresponds to travel and tourism activities will vary among locations.

It may be useful to supplement the information in this report with surveys and data from: 1) state tourism offices, which sometimes track indicators such as tourism employment, hotel receipts, bed taxes, etc.; 2) local Chambers of Commerce and tourism promotion groups; and 3) visitor information from land management agencies including the U.S. Forest Service,[6] Bureau of Land Management, Fish & Wildlife Service, and National Park Service offices. In addition, it may be useful to supplement published statistics with computer models such as IMPLAN.[7]

The top two charts on this page start in 1998 because that is the year the U.S. Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS). The major industry categories (Retail Trade; Passenger Transportation; Arts, Entertainment, & Recreation; and Accommodation & Food Services) in the bottom chart are the sum of the sub-categories from the initial page of this report and as shown here do not represent NAICS codes.

Why is it important?

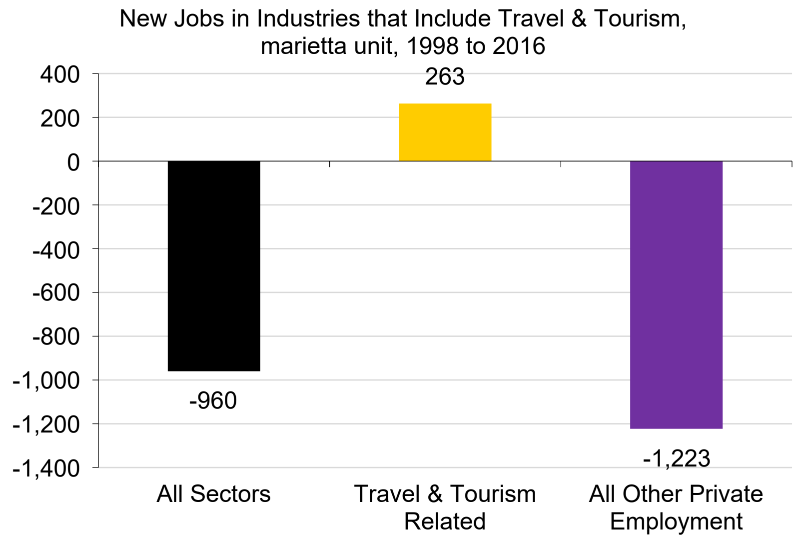
This information is useful to understand whether sectors that are likely to be associated with travel and tourism are growing or declining. It is less useful as a measure of the absolute size of employment in travel and tourism. A detailed knowledge, obtained through surveys and other means, is required to determine the proportion of a sector's employment that is due to local expenditures versus expenditures from visitors.[8, 9]

In some locations, travel and tourism are significant drivers of the economy. This can be true for "resort" economies but also for areas that have abundant natural and social amenities, and offer recreational opportunities.[10] In some of these places, travel and tourism-related employment is growing faster than overall employment.[4] While pleasure travel and recreation are important economic activities in and of themselves, they also stimulate other forms of economic development when people move families and businesses to communities they first visited as tourists.

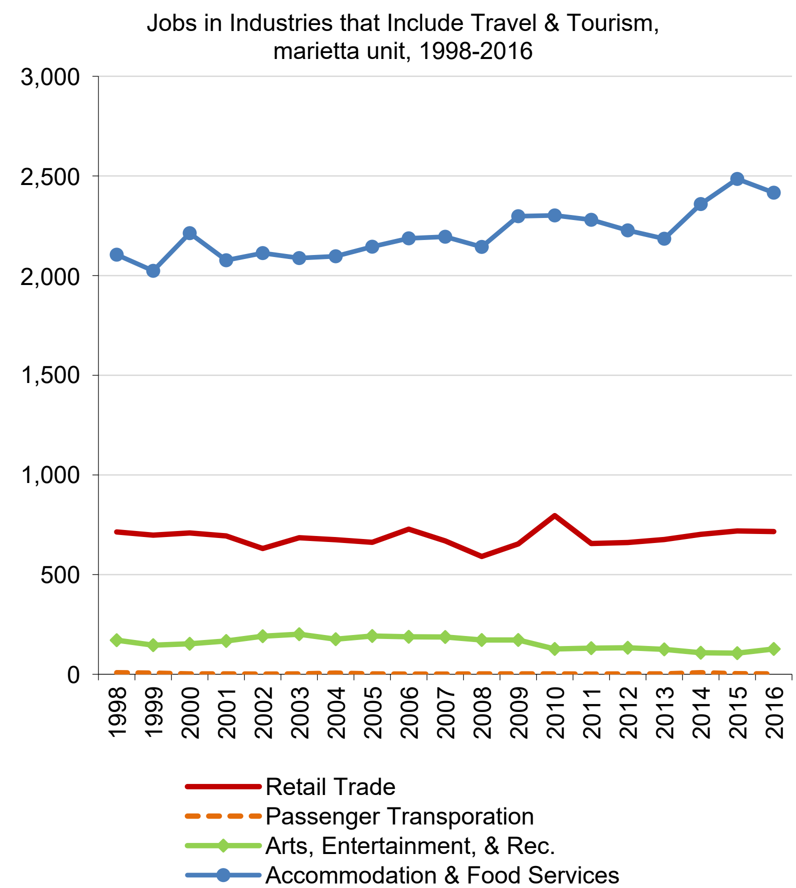
The EPS Public Land Amenities report provides additional information about amenity-led migration: https://headwaterseconomics.org/eps.

Travel & Tourism Employment Trends (cont.)

- From 1998 to 2016, travel & tourism employment grew by 263 jobs.
- From 1998 to 2016, non-travel & tourism employment shrank by 1,223 jobs.



- From 1998 to 2016, retail trade grew from 714 to 716 jobs, a 0.3% increase.
- From 1998 to 2016, passenger transportation shrank from 8 to 2 jobs, a 75% decrease.
- From 1998 to 2016, arts, entertainment, and recreation shrank from 171 to 127 jobs, a 25.7% decrease.
- From 1998 to 2016, accommodation and food services grew from 2,105 to 2,416 jobs, a 14.8% increase.



Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Travel & Tourism Employment Trends (cont.)

What do we measure on this page?

This page compares employment in sectors that include travel and tourism to other sectors and compares how the various industries that include travel and tourism have changed over time.

The charts on this page start in 1998 because that is the year the U.S. Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS). The major industry categories (Retail Trade; Passenger Transportation; Arts, Entertainment, & Recreation; and Accommodation & Food Services) in the bottom chart are the sum of the sub-categories from the initial page of this report and as shown here do not represent NAICS codes.

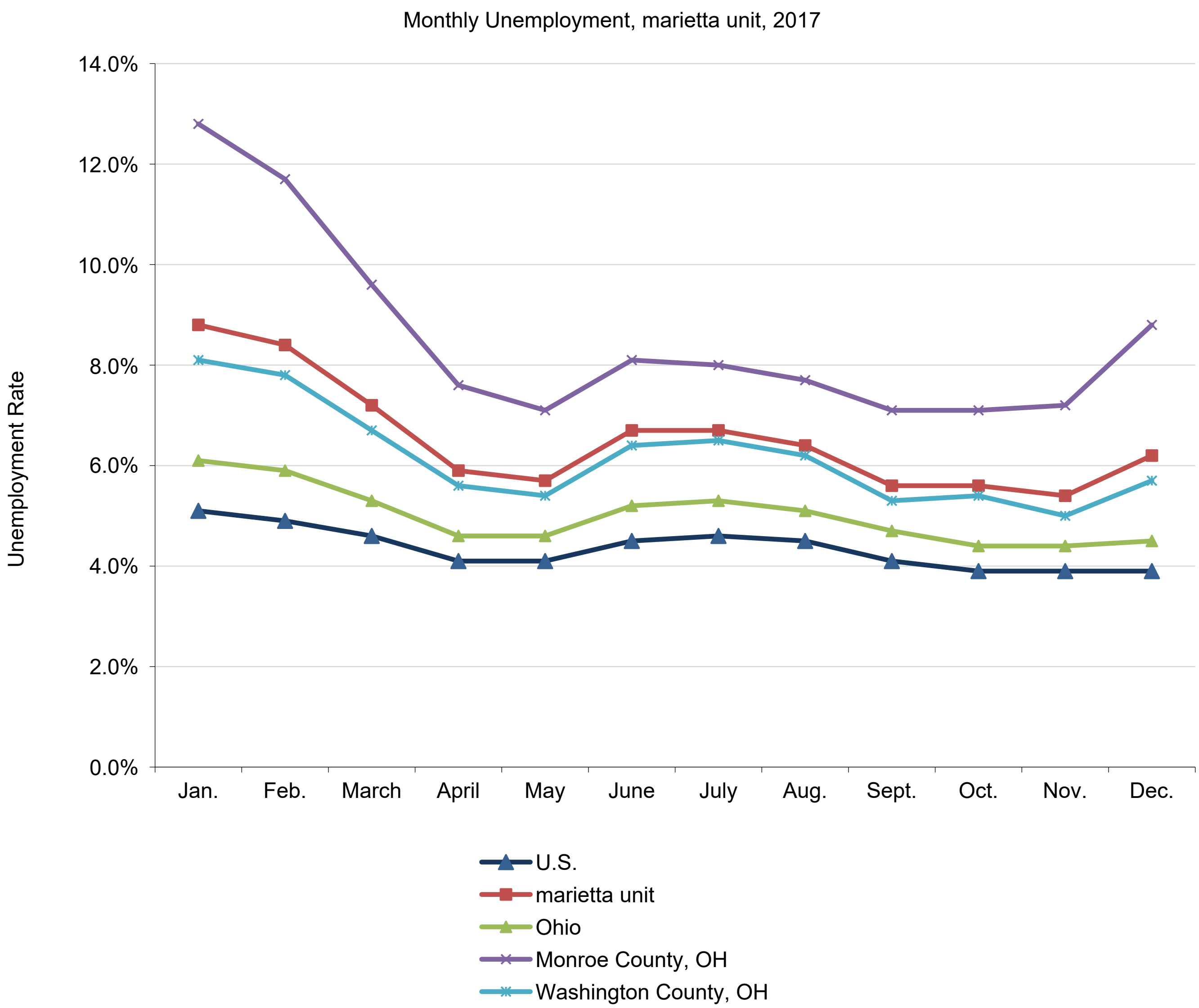
Why is it important?

This information is useful to understand whether sectors that are likely to be associated with travel and tourism are growing or declining. It is less useful as a measure of the absolute size of employment in travel and tourism. A detailed knowledge, obtained through surveys and other means, is required to determine the proportion of a sector's employment that is due to local expenditures versus expenditures from visitors.[8, 9]

In some locations, travel and tourism are significant drivers of the economy. This can be true for "resort" economies but also for areas that have abundant natural and social amenities, and offer recreational opportunities.[10, 11] In some of these places, travel and tourism-related employment is growing faster than overall employment. While pleasure travel and recreation are important economic activities in and of themselves, they also stimulate other forms of economic development when people move families and businesses to communities they first visited as tourists.

The EPS Public Land Amenities report provides additional information about amenity-led migration: https://headwaterseconomics.org/eps.

Seasonality of Unemployment



- In 2017, Monroe County, OH had the most change in unemployment (biggest absolute value of difference between min and max), and U.S. had the least (smallest absolute value of difference between min and max).

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Local Area Unemployment Statistics, Washington, D.C.

Seasonality of Unemployment

What do we measure on this page?

This page describes differences in the seasonality of unemployment, which occurs when people are unemployed at times of the year when demand for labor is lower than usual. Tourism is often associated with seasonal unemployment since work is only available for part(s) of the year when visitation is high.

This page uses data from the Bureau of Labor Statistics to show the change in month-to-month unemployment.[12]

Unemployed people are those who are jobless, available for work, and looking for jobs.

People with full- or part-time jobs are considered employed, and those people who are neither employed nor unemployed are not considered to be in the labor force.

Note: If many locations are selected, it may be difficult to read the figure on this page.

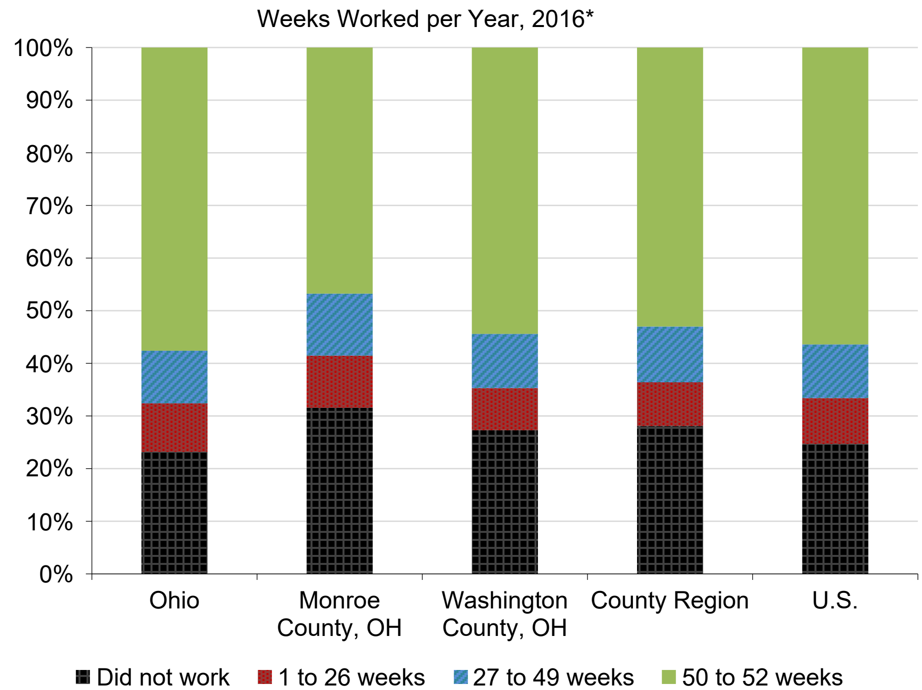
Why is it important?

Unemployment rate fluctuations reflect the hiring and layoff patterns that can accompany tourism due to visitation changes in winter holidays and summer vacations. It is possible that some seasonal workers may not live in the location selected and therefore are not accounted in the unemployment figures. Seasonal unemployment also occurs in places that have a relatively high concentration in construction, fishing, and agriculture sectors.

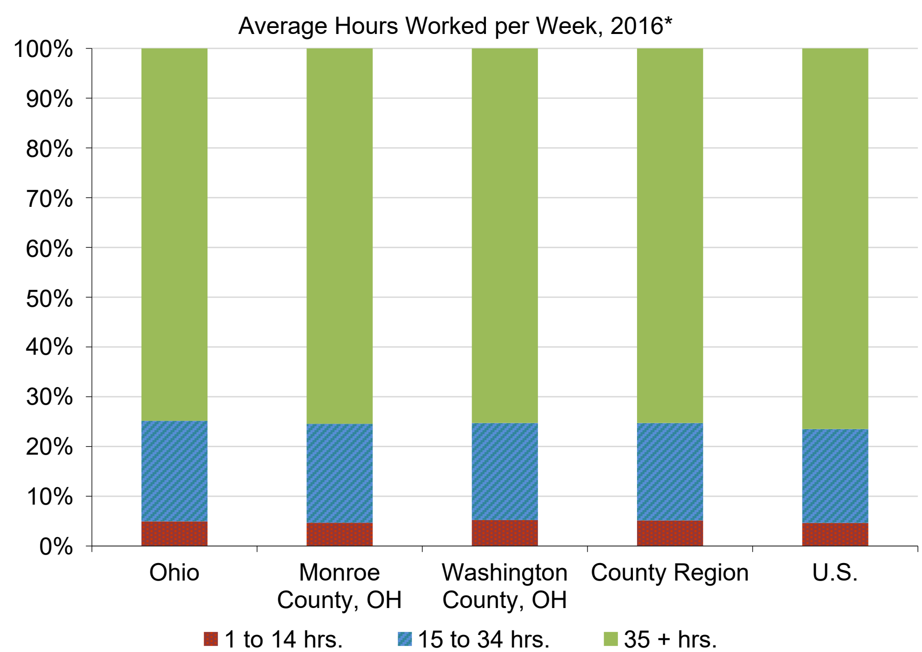
The EPS Socioeconomic Measures report provides further analysis of long-term trends in unemployment: https://headwaterseconomics.org/eps.

Part-Time Employment

- In 2016, 36.4 percent of workers in marietta unit worked less than 40 weeks over the course of the year, compared to 33.4 percent for the U.S..



- In 2016, 17.8 percent of workers in marietta unit worked less than 35 hours per week on average, compared to 17.7 percent for the the U.S..



* ACS 5-year estimates used. 2016 represents average characteristics from 2012-2016.

Data Sources: U.S. Department of Commerce. 2017. Census Bureau, American Community Survey Office, Washington, D.C.

Part-Time Employment

What do we measure on this page?

This page describes part-time work, which can be more common in tourism-related industries.

The U.S. Census Bureau provides two standard measures of part-time work: weeks worked per year and average hours worked per week. The Census reports these data for the population of age 16 to 64.

Why is it important?

Places that rely economically on tourism can have higher rates of part-time workers. While part-time work along is not a measure of tourism, it can be used to complement other data in this report and from elsewhere to evaluate the nature and extent of tourism activities in the selected locations.[7]

Travel & Tourism

marietta unit

Wages and Employment

	Ohio	Monroe County, OH	Washington County, OH	marietta unit	U.S.
All Sectors, 2017 (2017 $s)	$49,153	$32,918	$45,076	$43,887	$55,390
Private	$48,577	$32,282	$45,741	$44,677	$55,338
Travel & Tourism	$20,319	$14,739	$15,147	$15,134	$24,782
Retail Trade	$20,184	$15,838	$17,827	$17,568	$22,979
Gasoline Stations	$20,691	$15,838	$16,342	$16,243	$21,516
Clothing & Accessories	$18,883	na	$23,141	$23,141	$21,902
Misc. Store Retailers	$21,285	na	$19,059	$19,059	$26,411
Passenger Transportation	$100,232	$0	$0	$0	$83,634
Air Transportation	$101,887	$0	$0	$0	$87,053
Scenic & Sightseeing	$20,759	$0	na	$0	$33,331
Arts, Entertainment, & Rec.	$34,106	$8,142	$12,342	$11,782	$37,759
Performing Arts & Spectator Sports	$93,300	$0	na	$0	$91,180
Museums, Parks, & Historic Sites	$29,096	$0	na	$0	$34,795
Amusement, Gambling, & Rec.	$19,522	$8,142	$12,342	$11,782	$22,384
Accommodations & Food	$16,337	$0	$14,575	$14,575	$20,731
Accommodation	$21,786	na	$16,668	$16,668	$31,081
Food Services & Drinking Places	$15,869	na	$14,346	$14,346	$18,963
Non-Travel & Tourism	$53,378	$38,801	$51,805	$51,069	$61,154
Government	$52,885	$34,390	$40,091	$38,855	$55,686

This table shows wage data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits; the major industry categories (retail trade, passenger transportation; arts, entertainment, and recreation; and accommodation and food) are the sum of the sub-categories underneath them and as shown here do not represent NAICS codes.

Percent of Total Employment

	Ohio	Monroe County, OH	Washington County, OH	marietta unit	U.S.
Private, 2017	86.6%	69.8%	88.2%	86.4%	85.1%
Travel & Tourism	12.6%	3.6%	11.3%	10.6%	13.6%
Retail Trade	2.0%	3.1%	2.2%	2.3%	2.2%
Gasoline Stations	0.7%	3.1%	1.4%	1.5%	0.6%
Clothing & Accessories	0.7%	na	0.2%	0.2%	1.0%
Misc. Store Retailers	0.6%	na	0.6%	0.6%	0.6%
Passenger Transportation	0.2%	0.0%	0.0%	0.0%	0.4%
Air Transportation	0.2%	0.0%	0.0%	0.0%	0.3%
Scenic & Sightseeing	0.0%	0.0%	na	0.0%	0.0%
Arts, Entertainment, & Rec.	1.5%	0.5%	0.4%	0.4%	1.6%
Performing Arts & Spectator Sports	0.3%	0.0%	na	0.0%	0.3%
Museums, Parks, & Historic Sites	0.1%	0.0%	na	0.0%	0.1%
Amusement, Gambling, & Rec.	1.1%	0.5%	0.4%	0.4%	1.1%
Accommodations & Food	9.0%	0.0%	8.7%	7.9%	9.5%
Accommodation	0.7%	na	0.9%	0.8%	1.4%
Food Services & Drinking Places	8.3%	na	7.8%	7.1%	8.1%
Non-Travel & Tourism	74.0%	34.5%	62.4%	59.7%	71.5%
Government, 2017	13.4%	30.2%	11.8%	13.6%	14.9%

Data Sources: U.S. Department of Labor. 2018. Bureau of Labor Statistics, Quarterly Census of Employment and Wages, Washington, D.C.

Wages and Employment

What do we measure on this page?

This page describes wages (in real terms) from employment in industries that include travel and tourism, including sub-sectors, compared to wages from employment in all non-travel-and-tourism sectors combined. It also describes the percent of jobs in each category. These are shown together to illustrate the relative wage levels in industries that include travel and tourism, and how many people are employed in each sub-sector.

The primary purpose of this page is to compare the average annual wages between sectors and to investigate the relative number of people employed in high- and low-wage sectors.

Travel and Tourism: Sectors that provide goods and services to visitors as well as to the local population. These industries are Retail Trade, Passenger Transportation, Arts & Entertainment & Recreation, and Accommodation & Food Services. The exact proportion of jobs in these sectors attributable to expenditures by visitors, including business and pleasure travelers, is not known without additional research such as surveys. Some researchers refer to these sectors as “travel and tourism-potential sectors” because they have the potential of being influenced by expenditures by non-locals. In this report, they are referred to as “industries that include travel and tourism.”

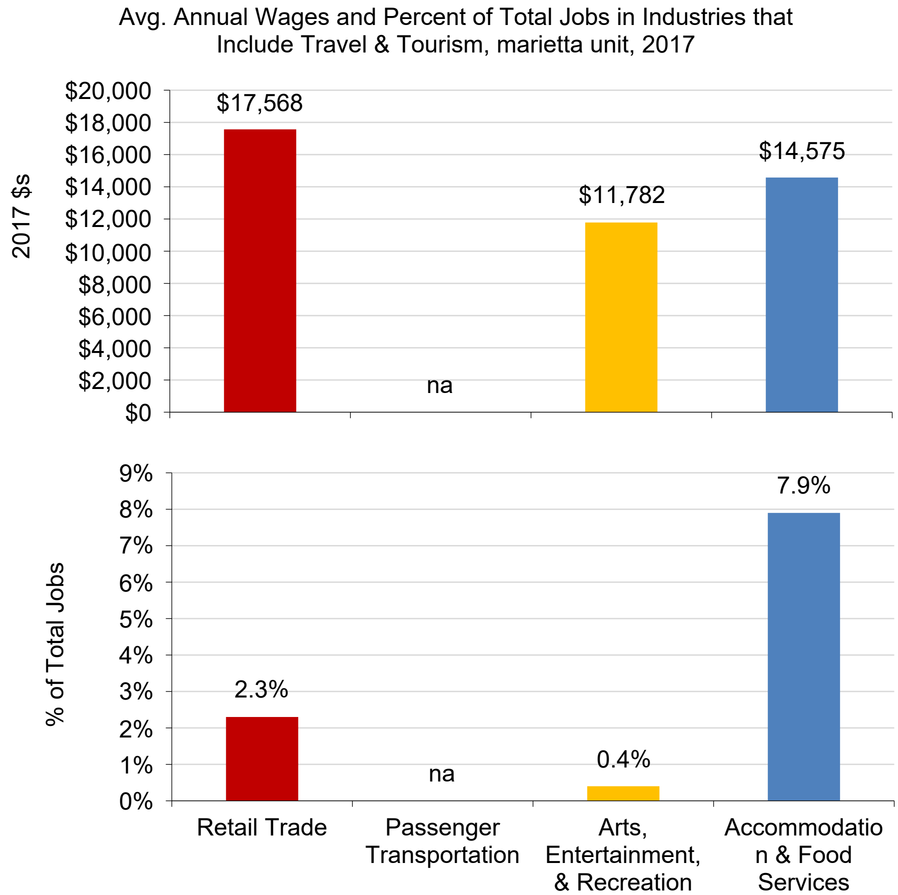
The tables use wage and employment data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[13, 14]

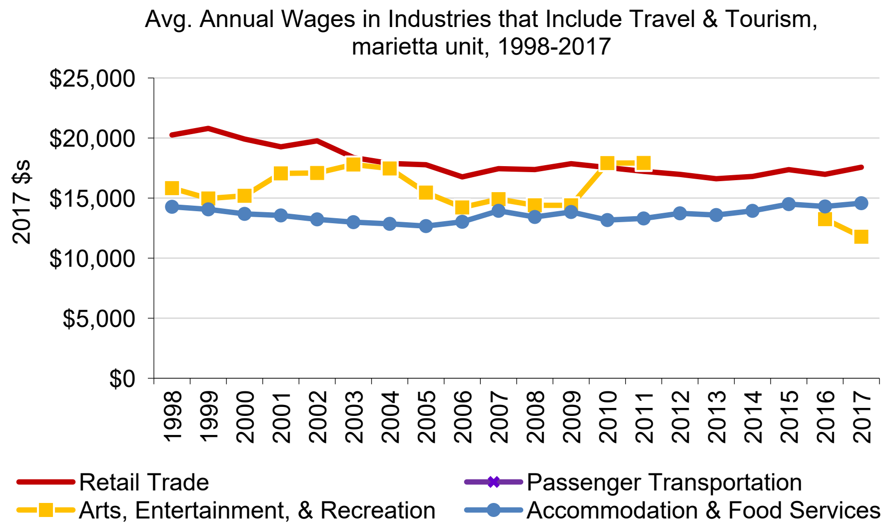
Why is it important?

Industries that contain travel and tourism often pay relatively low wages, though this varies by industry sub-sector and by location. Some important issues to consider are how travel and tourism related industry wages compare to wages in other sectors, whether some components of travel- and tourism-related industries pay higher wages than others, and whether there are significant wage differences between locations.[15, 16] When comparing wage levels, it is also useful to remember that many travel and tourism related jobs are seasonal and/or part-time.

Wages and Employment (cont.)

- In 2017, travel & tourism sector average wages, from highest to lowest, were: retail trade ($17,568); accommodation & food services ($14,575); arts, entertainment, & recreation ($11,782); and passenger transportation ($0).
- In 2017, travel & tourism sector percent of total employment, from highest to lowest, were: accommodation & food services (7.9%); retail trade (2.3%); arts, entertainment, & recreation (0.4%); and passenger transportation (0%).





Wages and Employment (cont.)

What do we measure on this page?

This page describes average wages (in real terms) and employment levels in industries that include travel and tourism. It also shows average wage trends (in real terms) for industries that include travel and tourism.

The chart *Avg. Annual Wages and Percent of Total Jobs in Industries that Include Travel & Tourism* describes how many people are working in relatively high- and low-wage travel and tourism related industries. The chart *Avg. Annual Wages in Industries that Include Travel & Tourism* is useful for comparing wage trends by sector.

The charts use wage and employment data from the Bureau of Labor Statistics, which does not report data for proprietors or the value of benefits and uses slightly different industry categories than those shown on the initial pages of this report.[13, 14] As a result, the percent-of-employment values may not exactly match values derived from County Business Patterns that are reported on previous pages. The bottom chart on this page starts in 1998 to be consistent with the start date of figures on earlier pages of this report.

The major industry categories (Retail Trade; Passenger Transportation; Arts, Entertainment, and Recreation; and Accommodation and Food Services) are the sum of the sub-categories from the previous page of this report and as shown here do not represent NAICS codes.

If your report results in significant undisclosed data, other sources for travel and tourism wage data include the state-level Bureau of Labor Statistics' Quarterly Census of Employment and Wages https://www.bls.gov/cew/; the Bureau of Labor Statistics' Occupational Outlook Handbook, which has detailed industry earnings and wages data at the national level https://www.bls.gov/ooh/; and the County Business Patterns database, which reports industry-level employment and payroll and can be used to estimate earnings https://www.census.gov/programs-surveys/cbp.html.

Why is it important?

While industries that include travel and tourism often pay relatively low wages, wages and the number of people employed can vary greatly among travel and tourism related industries.

The trend data on this page can be useful for understanding whether wages in sectors that are likely to be associated with travel and tourism have changed over time.

Travel & Tourism

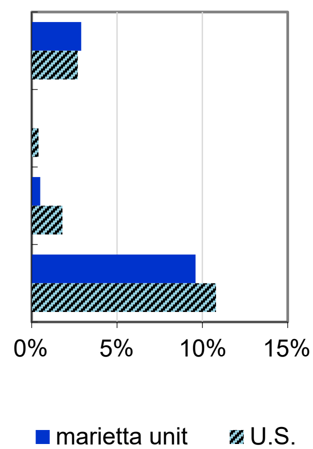
marietta unit

Comparisons

Industries Including Travel and Tourism, 2016	Employment Share: marietta unit	Employment Share: U.S.	Location Quotient
Retail Trade	2.9%	2.7%	1.1
Passenger Transportation	0.0%	0.4%	0.0
Arts, Entertainment, & Recreation	0.5%	1.8%	0.3
Accommodation & Food	9.6%	10.8%	0.9

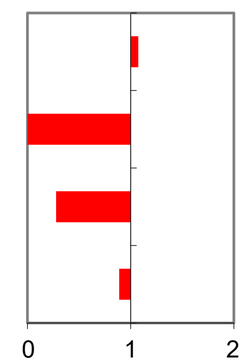
Employment Share

marietta unit vs. U.S.



Location Quotient

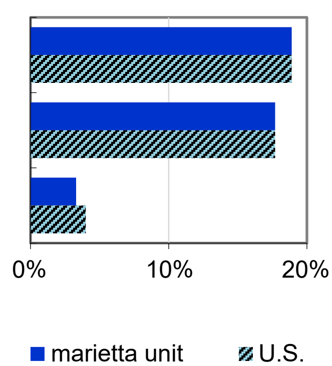
marietta unit vs. U.S.



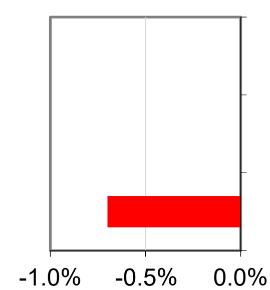
Other Possible Measures of the Presence of Travel and Tourism

Indicators of Seasonal Work and Housing , 2016*	marietta unit	U.S.	Diff.
Part-Time Work (less than 50 weeks per year)	18.9%	18.9%	0.0%
Part-Time Work (less than 35 hours per week)	17.7%	17.7%	0.0%
Second Homes	3.3%	4.0%	-0.7%

marietta unit vs. U.S.



Difference in Percent, marietta unit vs. U.S.



* ACS 5-year estimates used. 2016 represents average characteristics from 2012-2016.

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.; U.S. Department of Commerce. 2017. Census Bureau, American Community Survey Office, Washington, D.C.

Comparisons

What do we measure on this page?

This page describes whether the region is specialized in travel and tourism related employment. The chart illustrates the difference between the selected location(s) and the selected benchmark area.[17] (If no custom benchmark area was selected, EPS defaults to benchmarking against the U.S.)

Location Quotient[18]: A ratio that compares an industry's share of total employment in a region to the benchmark. More precisely, it is the percent of local employment in a sector divided by the percent employment in the same sector in the benchmark area. In other words, it is a ratio that measures specialization using the benchmark area for comparison. A location quotient of more than 1.0 means the local area is more specialized in that sector relative to the benchmark area. A location quotient of less than 1.0 means it is less specialized.[19]

Another way to think about location quotients is as a measure of whether a place produces enough goods or services from an industry to satisfy local demand for those goods or services. Results above or below the 1.0 standard indicate the degree to which a place may import or export a good or service. Although there is no precise cutoff, location quotients above 2.0 indicate a strong industry concentration (and that an area is likely exporting goods or services) and those less than 0.5 indicate a weak industry concentration (and that an area is likely importing goods or services).

Second Homes: The number of second homes is not available as a single variable from the U.S. Census Bureau. We have calculated second homes as a percent of total homes as follows: seasonally occupied homes (Census SF1 H005005) are added to other vacant homes (Census SF1 H005007) and then divided by total homes. By this definition, second homes do not include homes that are vacant because they are for rent or sale.

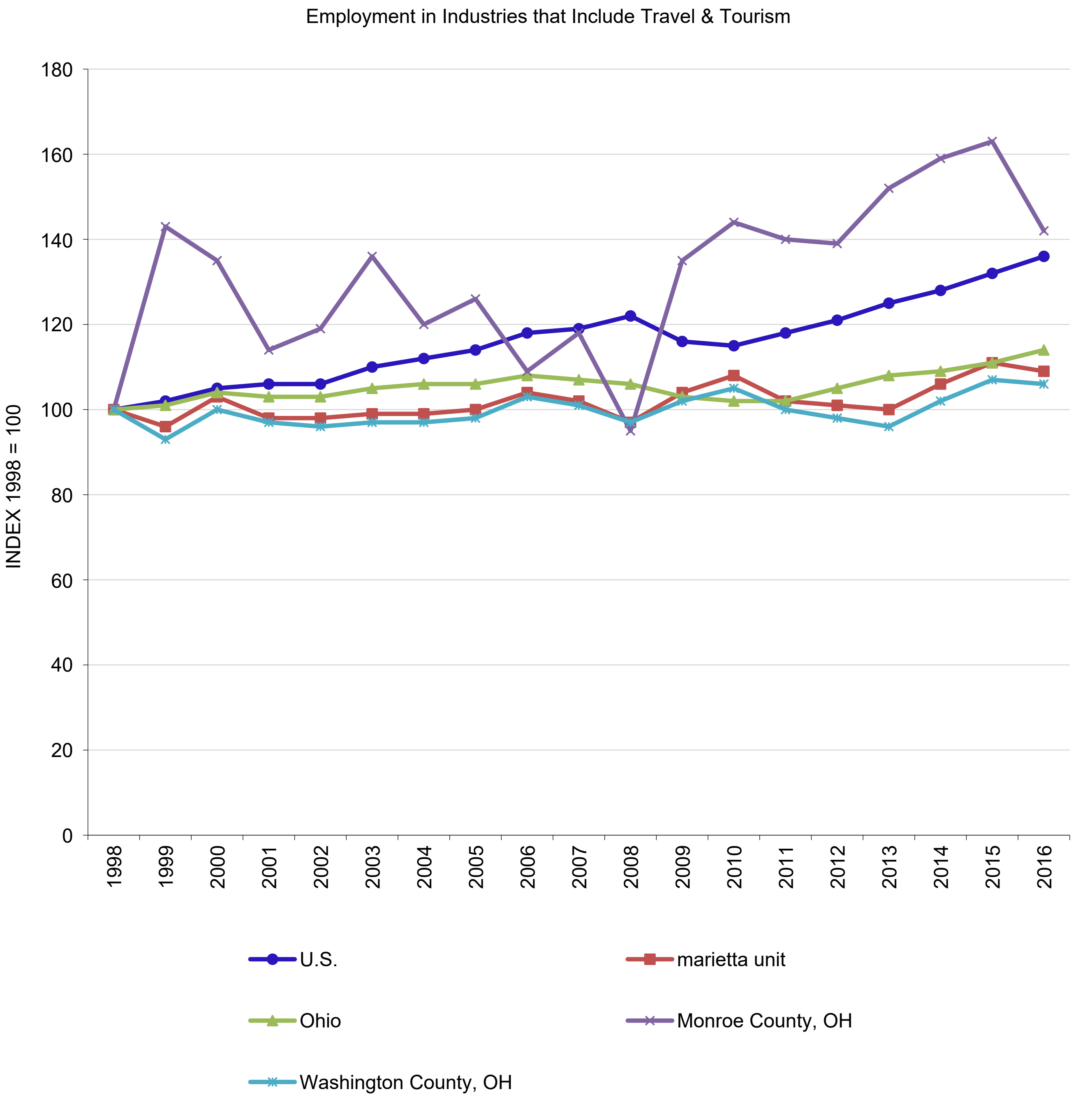
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses data from the U.S. Department of Commerce to estimate these data gaps.[20]

Why is it important?

Locations with economies that focus on travel and tourism may have a competitive advantages,[21, 22] but can also be sensitive to business cycles and other changes (for example, a rise in fuel costs) that affect pleasure travel and recreation spending. Natural amenities such as public lands can increase travel and tourism activities, benefiting local communities and in some cases diversify rural economies that have historically been tied to commodity production.[5, 23, 24] The growth of travel and tourism activities is also associated with in-migration that can lead to business relocation and new business development across a range of business sectors.[25]

A few caveats: (1) A large location quotient for a particular sector does not necessarily mean that sector is a significant contributor to the economy. (2) LQs greater than 1.0 only suggest potential export capacity when compared to the benchmark area and do not take into account local demand. Local demand may be greater than average, and therefore all goods and services may be consumed locally (i.e., not exported). (3) LQs can change from year to year. (4) LQs can vary when one uses income or wage data rather than employment.

Comparisons Over Time



- From 1998 to 2016, Ohio had the fastest rate of change in travel & tourism employment, and marietta unit had the slowest.

Data Sources: U.S. Department of Commerce. 2018. Census Bureau, County Business Patterns, Washington, D.C.

Comparisons Over Time

What do we measure on this page?

This page describes the change in travel and tourism employment for all selected locations and the benchmark area.[17] The information is indexed (1998=100) so that data from locations with different-sized economies can be compared. Indexing makes it easier to understand the relative rate of growth or decline of mining employment over time.

Index: Indexed numbers are compared with a base value. In the line chart, employment in 1998 is the base value and is set to 100. The employment values for subsequent years are expressed as 100 times the ratio to the base value. The indexing used in the line chart enables easier comparisons between locations over time. (If many locations are selected, it may be difficult to read the figure on this page.)

The chart begins in 1998 because that is the year the Census Bureau and County Business Patterns shifted to using the new North American Industrial Classification System (NAICS).

Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses data from the U.S. Department of Commerce to estimate these data gaps.[20]

Why is it important?

This information is useful to understand whether sectors likely to be associated with travel and tourism are growing or declining. These data do not measure the absolute size of employment in travel and tourism. Detailed knowledge, obtained through surveys and other means, is required to determine the proportion of a sector's employment that is due to local expenditures versus expenditures from visitors.

Not all locations have attracted or lost travel- and tourism-related employment at the same rate.[26] An index makes it clear where the rate of travel-and-tourism-related growth or decline has been the fastest. Lines above 100 indicate positive absolute growth while those below 100 show absolute decline. The steeper the curve, the faster the rate of change.

It may be helpful to look for large year-to-year rises or dips to identify rapid employment changes. If the reasons behind these fluctuations are not evident, it may be helpful to talk with regional experts or local residents to learn more about what caused abrupt changes.

Locations with economies that focus on travel and tourism may have competitive advantages,[21, 22] but can also be sensitive to business cycles and other changes (for example, a rise in fuel costs) that affect pleasure travel and recreation spending. Natural amenities such as public lands can increase travel and tourism activities, benefiting local communities and in some cases diversify rural economies that have historically been tied to commodity production.[5, 23, 24] The growth of travel and tourism activities is also associated with in-migration that can lead to business relocation and new business development across a range of business sectors.[25]

Data Sources & Methods

The EPS Travel & Tourism report uses national statistics from public government sources. All data used in EPS can be readily verified with original sources:

- **County Business Patterns**
  Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/cbp.html
  Contacts
  https://www.census.gov/about/contact-us.html

- **Quarterly Census of Employment and Wages**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/cew
  Contacts
  https://www.bls.gov/bls/contact.htm

- **American Community Survey**
  U.S. Census Bureau, U.S. Department of Commerce
  https://www.census.gov/programs-surveys/acs/
  https://www.census.gov/acs/www/data/data-tables-and-tools/index.php
  Contacts
  https://www.census.gov/about/contact-us.html

- **Local Area Unemployment Statistics**
  Bureau of Labor Statistics, U.S. Department of Labor
  https://www.bls.gov/lau/
  Contacts
  https://www.bls.gov/bls/contact.htm

EPS core approaches
EPS is designed to focus on long-term trends across a range of important measures. Trend analysis provides a more comprehensive view of changes than spot data for select years. We encourage users to focus on major trends rather than absolute numbers. EPS displays detailed industry-level data to show changes in the composition of the economy over time and the mix of industries at points in time. EPS employs cross-sectional benchmarking—comparing smaller areas such as counties to larger regions, states, and the nation—to give a sense of relative performance. EPS allows users to aggregate data for multiple locations to allow for more sophisticated cross-sectional comparisons.

Data Limitations
Much of the data in this report were obtained from the U.S. Census Bureau’s County Business Patterns (CBP) series. Compared to other sources, CBP has fewer data gaps (instances when the federal government will not release data to protect confidentiality of individual businesses). It also includes both full- and part-time employment.

However, CBP data do not include employment in government, agriculture, railroads, or the self-employed. Also, CBP data are based on mid-March employment and do not account for seasonal fluctuations. Since March is a "shoulder" season for several tourism activities, CBP may underrepresent employment in industries associated with tourism. Despite these limitations, the data are most useful for showing long-term trends, displaying differences between places, and showing relationships between sectors over time.

Adjusting dollar figures for inflation
Because a dollar in the past was worth more than a dollar today, data reported in current dollar terms should be adjusted for inflation. The U.S. Department of Commerce reports personal income figures in terms of current dollars. All income data in EPS are adjusted to real (or constant) dollars using the Consumer Price Index. Figures are adjusted to the latest date for which the annual Consumer Price Index is available.

Data gaps and estimation
Some data are withheld by the federal government to avoid the disclosure of potentially confidential information. Headwaters Economics uses supplemental data from the U.S. Department of Commerce to estimate these data gaps. These are indicated in italics in tables. Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

Endnotes

1 - In 2018 the Dept. of Commerce for the first time developed statistics illustrating the economic impact of outdoor recreation in the United States. See the Bureau of Economic Analysis's Outdoor Recreation Satellite Account at https://www.bea.gov/data/special-topics/outdoor-recreation.

2 - The Federal Reserve Bank of Kansas City has defined travel and tourism as consisting of hotels, air travel, and amusement and recreation services. See Wilkerson CR. 2003. Travel and Tourism: An Overlooked Industry in the U.S. and Tenth District. Economic Review. QIII(2003):45-71. https://www.kansascityfed.org/publicat/econrev/PDF/3q03wilk.pdf Wilkerson points out that travel- and tourism-related sectors outperformed the nation, including during recessions.

3 - The list of NAICS codes associated with travel and tourism were obtained from Marcouiller DW and Xia X. 2008. Distribution of Income from Tourism-Sensitive Employment. Tourism Economics 14(3):545-565. http://journals.sagepub.com/doi/abs/10.5367/000000008785633622?journalCode=teua. For a similar definition of travel and tourism, see Wilkerson C. 2003. Travel and Tourism: An Overlooked Industry in the U.S. and Tenth District. Federal Reserve Bank of Kansas City Economic Review. QIII(2003):45-71. https://www.kansascityfed.org/publicat/econrev/PDF/3q03wilk.pdf.

4 - It is estimated that outdoor recreation alone generates $887 billion in consumer spending annually and 7.6 million jobs. Outdoor Industry Association. 2018. Advocacy: Outdoor Recreation Economy. https://outdoorindustry.org/advocacy/.

5 - Allen T, D Kary, and R Southwick. 2017. The Economic Contributions of Outdoor Recreation. Boulder, CO: Outdoor Industry Association. https://outdoorindustry.org/wp-content/uploads/2015/03/OIA_Recreation_Economy_Contributions_Technical_Report_2017-08-24.pdf.

6 - The Forest Service collects information on visitor satisfaction and use. Annual summary reports and individual forest and grassland reports are available from https://www.fs.fed.us/recreation/programs/nvum.

7 - Stynes DJ and White EM. 2006. Reflections on Measuring Recreation and Travel Spending. Journal of Travel Research. 45:8-16. See http://journals.sagepub.com/doi/10.1177/0047287506288873.

8 - The U.S. Census Bureau conducts an Economic Census every five years for selected industries. Users can search the Economic Census for information on the number of establishments, sales, employees, and payroll, for selected industries. https://www.census.gov/programs-surveys/economic-census.html.

9 - The U.S. Department of Commerce developed the U.S. Travel and Tourism Satellite Accounts to estimate the proportion of every sector in the economy that is attributable to travel and tourism at the national level. This information is useful for detecting sectors that have a higher potential to serve the needs of visitors. The resulting ratios should not be applied to local economies. https://www.bea.gov/data/special-topics/travel-and-tourism.

Endnotes

10 - Outdoor recreation accounted for 2 percent ($373.3 billion) of GDP in 2016. The outdoor recreation economy grew 3.8 percent in 2016, compared to 2.8 percent in the overall economy. https://www.bea.gov/news/2018/outdoor-recreation-satellite-account-prototype-estimates-2012-2016.

11 - Almost half the U.S. population participated in an outdoor activity at least once in 2017. Outdoor Foundation. 2018. Outdoor Participation Report 2018. Washington, DC: Outdoor Foundation. https://outdoorindustry.org/resource/2018-outdoor-participation-report/.

12 - For detailed information on how the government measures unemployment, see https://www.bls.gov/cps/.

13 - For an overview of how the Bureau of Labor Statistics treats employment, see https://www.bls.gov/bls/employment.htm.

14 - For an overview of how the Bureau of Labor Statistics treats pay and benefits, see https://www.bls.gov/bls/wages.htm.

15 - Employment and wage estimates are also available from the Bureau of Labor Statistics for more than 800 occupations. Looking at travel and tourism by occupation, rather than by sector or industry, is helpful because wages can vary dramatically across occupations. For more information, see https://www.bls.gov/oes/.

16 - The EPS Socioeconomic Measures report provides additional information about wages in non-travel-and-tourism industries. https://headwaterseconomics.org/eps.

17 - The term "benchmark" in this report should not be construed as having the same meaning as in the National Forest Management Act (NFMA).

18 - LQ = (ei/e) divided by (Ei/E)
Where: ei = Local employment in industry i; e = Total local employment; Ei = U.S. employment in industry i; E = Total U.S. employment.

19 - A succinct definition of a location quotient is offered by Indiana Business Research Center at IU's Kelley School of Business. http://www.incontext.indiana.edu/2006/march/1.asp.

20 - Documentation explaining methods developed by Headwaters Economics for estimating disclosure gaps is available at https://headwaterseconomics.org/eps.

21 - Reeder RJ and Brown DM. 2005. Recreation, Tourism, and Rural Well-Being. USDA Economic Research Service Economic Research Report No. 7. https://www.ers.usda.gov/webdocs/publications/46126/15112_err7_1_.pdf?v=41056

Endnotes

22 - English DBK, Marcouiller DW, and Cordell HK. 2000. Tourism Dependence in Rural America: Estimates and Effects. Society and Natural Resources 13(3):185-202. https://www.srs.fs.usda.gov/pubs/ja/ja_english004.pdf The study found that counties relatively dependent on tourism have higher growth in per capita income in comparison to non-dependent counties; less economic diversity; fewer manufacturing jobs, in particular in wood products sectors; more expensive housing; faster population growth; and higher levels of education. They also found that average household income in tourism-dependent counties was about the same as in non-dependent counties.

23 - For a review of literature on economic diversity, see Sterling A. 1998. On the Economics and Analysis of Diversity. Electronic Working Papers Series, No. 28. University of Sussex, Brighton, UK. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.144.8865&rep=rep1&type=pdf.

24 - A useful book on the evolving competitive environment for rural areas is Galston WA and Baehler KJ. 1995. Rural Development in the United States: Connecting Theory, Practice, and Possibilities. Washington, DC: Island Press.

25 - Snepenger D, Johnson J, and Rasker R. 1994. Travel Stimulated Entrepreneurial Migration. Journal of Travel Research 34(1):40-44. http://journals.sagepub.com/doi/abs/10.1177/004728759503400105 Snepenger et al. found that tourism can stimulate permanent migration of entrepreneurs.

26 - The Economic Research Service of the U.S. Dept. of Agriculture has developed a widely-used classification system for identifying non-metropolitan recreation counties. See Johnson KM and Beale CL. 2002. Non-Metro Recreation Counties: Their Identification and Rapid Growth. Rural America 17(4):2-19. https://www.ers.usda.gov/webdocs/publications/46984/19347_ra174b_1_.pdf?v=41056.

Appendix 2: Annotated Bibliography on Economic Benefits of Protected Public Lands

Several studies discuss the forces behind the changing economy of much of rural America. Many of these studies attribute strong economic and population growth to "lifestyle migrants." These are residents who either rely on investment or retirement income or who have businesses or employment which is not tied to a particular location. These migrants seek locations with high levels of amenities, including those that are associated with an abundance of protected public lands such as wilderness and national monuments.

Berrens, R., J. Talberth, J. Thacher, M. Hand. 2006. *Economic and Community Benefits of Protecting New Mexico's Inventoried Roadless Areas*. Sante Fe, NM: Center for Sustainable Economy. 69 pp. Available online at http://www.sustainable-economy.org/main/send_client_files?f=Final%2520Report.pdf.

Berrens et al. (2006) examine several categories of non-market economic values associated with the 1.6 million acres of inventoried roadless areas on National Forests in New Mexico. These authors use specific data on roadless area size and characteristics, data on the economic values of recreation in New Mexico, the economic value of clean water and other non-market values to estimate the total annual value of retaining the wilderness character associated with inventoried roadless areas: "Annual economic benefits range up to $42 million for maintenance of water quality, $24 million for carbon sequestration, $26 million for outdoor recreation, $14 million for passive uses, and $1.4 million in enhanced property values. Annual community effects range up to 938 jobs and $23 million in personal income." (p. 3)

Duffy-Deno, K.T. 1998. The effect of federal wilderness on county growth in the intermountain western United States. *Journal of Regional Science*. 38(1):109-136.

Duffy-Deno (1998) examines 250 non-urban counties in the eight intermountain west states. He finds that there is no evidence that the existence of federal wilderness is directly or indirectly associated with population or employment changes in these counties. The study also finds that there is no evidence that wilderness has any affect on resource extraction employment in these western counties.

Holmes, F. P. and W.E. Hecox. 2004. Does wilderness impoverish rural regions? *International Journal of Wilderness*. 10(3): 34-39. Available online at http://www.wilderness.net/library/documents/IJWDec04_Holmes.pdf.

In a study of 113 rural Western Counties, Holmes and Hecox (2004) find a positive correlation between the percent of land in designated wilderness and population, income and employment growth. They also find that wilderness is correlated with higher growth in investment income and entrepreneurial activity.

Loomis, J.B. and R. Richardson. 2000. Economic Values of Protecting Roadless Areas in the United States. Prepared for The Wilderness Society and Heritage Forests Campaign. 44pp. Available online at http://www.sierraforestlegacy.org/Resources/Conservation/FireForestEcology/ForestEconomics/Economics-Loomis00.pdf.

According to research by Loomis and Richardson (2000), the 42 million acres of roadless lands "…can be expected to provide almost $600 million in recreation benefits each year, more than $280 million in passive use values, and nearly 24,000 jobs. (p. iii)" In additions, these research find that roadless areas also produce between $490 million and $1 billion in carbon sequestration services and $490 million in waste treatment services.

Loomis, J.B. 2000. Economic values of wilderness recreation and passive use: What we think we know at the beginning of the 21st century. In: McCool, Stephen F.; Cole, David N.; Borrie, William T.; O'Loughlin, Jennifer, comps. 2000. Wilderness science in a time of change conference—Volume 2: Wilderness within the context of larger systems; 1999 May 23–27;Missoula, MT. Proceedings RMRS-P-15-VOL-2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 5-13. Available online at http://www.fs.fed.us/rm/pubs/rmrs_p015_2/rmrs_p015_2_005_013.pdf.

Loomis (2000) estimates that the value of recreation on all U.S. wilderness lands is $574 million per year. The economic value of Western wilderness (not including Alaska) is estimated to be $168/acre or $7 billion per year. The economic value of Eastern wilderness is $468 million annually.

Lorah, P.A. 2000. Population growth, economic security, and cultural change in wilderness counties. In: McCool, Stephen F.; Cole, David N.; Borrie, William T.; O'Loughlin, Jennifer, comps. 2000. Wilderness science in a time of change conference—Volume 2: Wilderness within the context of larger systems; 1999 May 23–27;Missoula, MT. Proceedings RMRS-P-15-VOL-2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 230-237. Available online at http://www.fs.fed.us/rm/pubs/rmrs_p015_2/rmrs_p015_2_230_237.pdf.

Counter to many people's beliefs, Lorah (2000) finds that counties with wilderness showed growth in income, population and employment. He also finds that the presence of wilderness in these counties has also helped them to diversify economies that had been stagnant due to over-reliance on declining resource extraction industries.

Phillips, S. 2000. Windfalls for wilderness: Land protection and land value in the Green Mountains. In: McCool, Stephen F.; Cole, David N.; Borrie, William T.; O'Loughlin, Jennifer, comps. 2000. Wilderness science in a time of change conference—Volume 2: Wilderness within the context of larger systems; 1999 May 23–27;Missoula, MT. Proceedings RMRS-P-15-VOL-2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 258-267. Available online at http://www.wilderness.net/library/documents/Phillips_2-33.pdf.

Final results described in Phillips, S. 2004.Windfalls for Wilderness: Land Protection and Land Value in the Green Mountains. Ph.D. Dissertation. Virginia Polytechnic Institute and State University, Blacksburg, VA. (A summary of the doctoral thesis is provided in The Economic Benefits of Wilderness: Focus on Property Value Enhancement, Wilderness Society Science and Policy Brief, no. 2, March 2004. 8 pages.)

Data on land sales near Green Mountain National Forest wilderness areas show that the presence of wilderness areas, proximity to these wilderness areas and the extent of the wilderness areas each is associated with higher residential property values.

Rosenberger, R.S. and D.B.K. English 2005. Impacts of Wilderness on Local Economic Development. In: Cordell, H.K., J.C. Bergstrom and J.M. Bowker (eds). The Multiple Values of Wilderness. Venture Publishing: State College, PA.

While wilderness recreation generates some economic activity for local communities, the more important impact lies in what Rosenberger and English (2005) call a "wilderness-related advantage." They cite several research studies which together indicate that rural counties with wilderness or other protected federal lands experience greater population and economic growth than those without wilderness.

Rudzitis, G. and R. Johnson. 2000. The impact of wilderness and other wildlands on local economies and regional development trends. In: McCool, Stephen F.; Cole, David N.; Borrie, William T.; O'Loughlin, Jennifer, comps. 2000. Wilderness science in a time of change conference—Volume 2: Wilderness within the context of larger systems; 1999 May 23–27;Missoula, MT. Proceedings RMRS-P-15-VOL-2. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 14-26. Available online at http://www.wilderness.net/library/documents/science1999/Volume2/Rudzitis_2-4.pdf.

This study (Rudzitis and Johnson 2000) also finds that while wilderness recreation benefits to local communities are modest, the presence of wilderness appears to draw residents and new economic activity that does have a substantial positive impact on local economies.

Appendix 3: An Annotated Bibliography on Equitable Access to Public Lands
The Wilderness Society, Last Updated October 2018

Literature Reviews

Chavez, Deborah J. "Invite, Include, and Involve! Racial Groups, Ethnic Groups, and Leisure." ***Diversity and the Recreation Profession: Organizational Perspectives*****, 2000, 179–1 91.**

This article functions as a review of 20th century research on the topic of diversity in recreation, and a summary of the state of the issue at the turn of the century. Key points include:

- The United States population is expected to grow and become more diverse in the coming decades, and assumptions (or stereotypes) about what types of activities these groups enjoy may be inaccurate.
- Places and activities can have different meanings and levels of significance for different racial and ethnic groups.
- These differences might be responsible for distinct levels and patterns of participation in leisure activities between racial and ethnic groups along with economic condition.

The authors offer general advice to agency leaders:

- Embrace the "I" triad, which includes *i*nviting racial and ethnic groups to use an agency's services, *i*ncluding them in decision making, and *i*nvolving them in non-symbolic ways, such as hiring for senior management positions.
- Educate yourself and your agency on the needs of different groups.
- Communicate effectively to ethnic and racial minority groups.
- Recognize that significant changes, *i*nnovations, may be required.

Pease, James L. "Parks and Underserved Audiences: An Annotated Literature Review." ***Journal of Interpretation Research*** **20, no. 1 (2011): 11–56.**

This review of recent academic research into diversity on parks and public natural spaces is a comprehensive introduction to the state of the field. Pease believes that the process of identifying barriers to access and the societal constructions behind them, which was a focus of research at the turn of the century, has been settled. The new research challenge is documenting successful instances of overcoming these barriers and expanding these practices to more parks and forests. Pease stresses the importance of park personnel remaining open to new ways of communication and expressing a willingness to learn from the audiences they hope to serve. Key points include:

- Of the four theories explaining non-use of parks by racial and ethnic minorities outlined by Floyd, the marginality hypothesis has risen to prominence, though the other three (subcultural hypothesis, assimilation theory, discrimination hypothesis) are still useful in many cases. Research today is increasingly focused on solving the problem, rather than explaining it.

- Recent detailed studies into perceptions and values that different racial and ethnic groups hold towards wilderness and the outdoors have produced a complicated picture. Factors like education can be more predictive than race.
- The prevailing wisdom of the last century was that African Americans were "less environmentally concerned" than Caucasians, but that has been mostly debunked. However, African Americans are rarely portrayed in outdoor settings by the media and continue to face more barriers in accessing nature.
- Hispanics, the fastest-growing sub-section of the American population (though there is broad diversity within the Hispanic label), have a stronger tendency to see humans as a part of nature than Caucasion Americans, though this tendency is more pronounced in recent immigrants than in long-time residents. The under-utilization of natural spaces by Spanish-speakers continues to be attributed to language barriers.
- Asian-Americans have a slightly higher connection to nature than Caucasians but are not often studied.
- Native Americans have historically close ties to land and nature. In relation to parks, the "Traditional Ecological Knowledge" that Native Americans can provide is being integrated into interpretation of parks and resource management, though the author stresses the need to meaningfully engage tribal elders as experts in decision making.

There is a summary of best-practices research, some highlights of which follow:

- Find a balanced approach that caters to the diverse needs of a diverse audience without assuming that race or ethnicity labels represent homogenous groups.
- Involve members of different sub-groups in meaningful, non-token ways.
- Consider cultural norms that are included in the design of parks.
- Prioritize equity in the workplace of park managers.
- Interact with visitors instead of educating/lecturing them.
- Offer incentives for new visitors

Roberts, Nina S. "Across Cultures: There's No App for That!" *Journal of Interpretation Research* 20, no. 1 (2011): 7–10

This essay is the introduction to James Pease's literature review on the subject of underserved audiences in parks. This essay discusses the potential to reach new audiences through the traditional park tools of interpretation, education, and recreation. However, at the same time, many "minority" communities already engage with parks and public lands in ways that might not be visible in a traditional lens. In either case, current park models are unprepared to serve the increasingly diverse American public and risk sliding into irrelevancy. More research, especially social research, could chart a path forward.

Original Research

Burns, Robert C., and Alan R. Graefe. "Constraints to Outdoor Recreation: Exploring the Effects of Disabilities on Perceptions and Participation." ***Journal of Leisure Research*** **39, no. 1 (March 13, 2007**

Like all groups, households constrained by a disability were most likely to report lack of time or desire as the thing preventing them from visiting national forests. Lack of physical ability and poor health were the most disproportionately cited reasons by households constrained by a disability.

Conducted as a phone survey in Oregon, Washington, and Colorado, the study found that 60% of households that contained a person with a disability were "constrained" in their recreation by the disability. These "constrained' households visited national forests "about half as often" as those without a constraining disability.

Crano, William, Ryan Quist, and Patricia L Winter. "Chapter 15: Forest Visitation, Media Consumption, and Diverse Publics: Lessons for Outreach."

This paper addresses the frequently cited "communication" challenge to increasing minority participation in national forests.

The national campaign against drug use is identified as an example of a successful intervention through media to reach a diversity of audiences. However, the authors mention there is the high chance of failure unless care is taken in the media outreach. The authors find that minority communities, especially Latinos and African Americans, have higher trust levels for "ethnic media" that tends to cater to and feature members of their communities. Differences in media consumption patterns between race and ethnicity groups are also discussed, for example, African-Americans spend the most time watching television while Latinos spend the most time listening to radio.

Flores, David, Gennaro Falco, Nina S. Roberts, and Francisco P. Valenzuela. "Recreation Equity: Is the Forest Service Serving Its Diverse Publics?" ***Journal of Forestry*** **116, no. 3 (2018): 266–72.**

The study "examines whether there is disproportionate utilization of recreation resources on US Forest Service lands across the entire national US Forest Service system."

Though this is the most comprehensive nation-wide survey of inequitable recreation in national forests, it does face some methodological limitations. The "Inequity Index" at the core of this paper compares visitors to a national forest with the county that surrounds that forest and doesn't account for visitors who travelled more than 50 miles to a national forest. The authors acknowledge this limitation and note that some forests report that up to 80% of their visitors are non-local. The two regions that had the lowest equity gap, Regions

1 and 9, were also the regions with the lowest percentage minority population. This suggests that these regions haven't addressed equity so much as they have a lower target to reach equity.

Caucasions made up the overwhelming majority (94.6%) of visitors to national forests between 2010 and 2014, despite a national population that is becoming less white. The national inequity gap was -23.8%. This is the difference between the portion of people of color who live near forests and people of color who recreate in forests. The greatest "inequity indices" existed in national forests surrounded by highly diverse counties.

The study recommends the following:

- Continuing the study of these measures in all national forest properties
- Building relationships with communities of interest
- Expanding recreation and education programs that appeal to minority communities.

Johnson, Cassandra Y, J M Bowker, John C Bergstrom, and H Ken Cordell. "Wilderness Values in America: Does Immigrant Status or Ethnicity Matter?" Society and Natural Resources 17, no. 7 (2004): 611–28.

Based on the 2000 National Survey of Recreation and the Environment, this research highlights the differences between ethnic groups and immigrant status groups on the value of wilderness in America.

Highlights of the results:

- There are significant difference between native-born Americans and immigrants, with immigrants less likely to agree with statements on the value of wilderness.
- Among US-born Americans, Blacks and Latinos seemed to put slightly less value on wilderness and Asians slightly more than Caucasians. The biggest differences were in visitation, where Caucasians were more likely to have visited wilderness areas than any other group.
- Values concerning off-site and passive uses, including intrinsic value and value for future generations, showed almost no difference between groups.

Li, Chieh-Lu, James D Absher, Yi-Chung Hsu, and Alan R Graefe. "Chapter 17: Approaches to Measuring Cultural Diversity in Recreation." ***Recreation Visitor Research: Studies of Diversity*****, 2008.**

This article discusses best practices and approaches when measuring cultural diversity in recreation.

- Identify separate groups based on meaningful factors, such as shared definitions, common ideas, self-identification, etc.
- Don't assume homogeneity within ethnic or racial groups.

- Ethnic groups should be constructed from a scientific perspective in a way that is meaningful to the present research question.

Outley, Corliss Wilson. "Recreation Visitor Research: Studies of Diversity Chapter 12: Perceptions of Agriculture and Natural Resource Careers Among Minority Students in a National Organization." Recreation Visitor Research: Studies of Diversity, 2008, 139–53.

This study focused on students who belonged to minority communities and were studying resource sciences. It is intended to identify issues in the hiring of diverse staffs for land management agencies.

- The strongest influence in students choosing their field of study was their mother.
- Students identified a lack of information as the strongest barrier preventing more minorities from entering the field. Students suggested getting information about careers in agricultural or resource management fields to minority communities.
- Students also identified negative perceptions and associations towards agriculture, especially in African American communities, with references to cultural histories.
- Students suggested beginning recruitment efforts at younger ages and advertising the benefits of the job (such as pay).

<u>Case Studies: Challenges</u>

Alm, Janet E, Dale J Blahna, and Deborah J Chavez. "Recreation Visitor Research: Studies of Diversity Chapter 8: Management Assumptions and Program Realities: A Case Study of Noncommercial Fern Gathering." Accessed November 21, 2018.

The USFS tried to curb an increase in picking of bracken fern from a California forest by charging a commercially based fee. Subsequent researchers found this fee actually interfered with a cultural activity, and that there was neither harm nor profit in the unregulated picking.

Concerns of the USFS in creating the fee were:

- Commercially motivated gatherers were making a large profit from public land.
- Over-picking was endangering the resource and interfering with threatened species.
- The USFS fee set a minimum of 40 pounds and charged a fee per pound, with accompanying designated picking areas.

A subsequent study of those who picked ferns found the following:

- Picking bracken ferns is done primarily by families. Spending time with family was the primary motivation, followed by spending time with nature. Selling the ferns was the least popular reason.
- Specifically, most pickers were from southeast Asia, with moderate family incomes.

- The forests in question were the only place where these ferns were known to be available.
- Most pickers cited stewardship actions they had taken on their own, without intervention. Specifically, gatherers only took what they needed or planned to eat. This amount was much less than the 40 pound minimum instituted by the USFS, meaning most families paid for much more than they took.

Bengston, David, Michele Schermann, Maikia Moua, and Tou Thai Lee. "Listening to Neglected Voices: Hmong and Public Lands in Minnesota and Wisconsin." ***Society and Natural Resources*** **21, no. 10 (2008)**

Hmong immigrants have deep cultural ties to natural resources and their management but are largely ignored by researchers and land managers.

Hmong are avid hunters and fishers, and often gather edible plants from public plants. These activities were typical of life in their country, from which Hmong-American immigrants are now displaced.

- When interviewed in focus groups, Hmong-Americans recounted many positive experiences on public lands, especially with family.
- But they were also quick to share experiences of discrimination by park rangers or harassment by the public.
- Some expressed concerns with signage and regulations, which many older members of their community were unable to understand because they did not speak English.
- There was also concern with the disrepair and pollution of public land facilities and natural areas.

Top suggestions provided by the Hmong-Americans interviewed were:

- Cultural training for land managers to dispel misconceptions and minimize discrimination.
- Hiring Hmong and other minority groups.
- Participants also expressed desire for training for the Hmong on American land laws and hunting and fishing regulations, that focused on the traditional practices of the Hmong and how they could work legally in the United States.

Roberts, Nina S , and Donald A Rodriguez. "Ethnic Studies Review." ***Ethnic Studies Review*****. Vol. 31, 2008.**

This study focuses on perceived and actual constraints to access, identified by African Americans and Latinos in the nearby Colorado Front Range and by a panel of minority resource professionals. It focuses on Rocky Mountain National Park.

- Participants identified perceptions of discrimination as a top reason for not visiting the park.
- There were no "blatant" acts of discrimination identified by the study.
- Gender and income were found to be more closely tied to recreation constraints than race and ethnicity, and race or ethnicity-based constraints varied between racial or ethnic groups.

Roberts, Nina S, and Tendai Chitewere. "Research Article: Speaking of Justice: Exploring Ethnic Minority Perspectives of the Golden Gate National Recreation Area." *Environmental Practice* 13, no. 4 (2011): 354–69.

This case-study of Golden Gate NRA in California focuses on "silent exclusion", which includes subtle racism, limited physical access, and general cultural exclusion.

GGNRA is unique because, though a unit of the National Park Service, its proximity to downtown San Francisco makes it more like a city park. The authors do not distinguish their data based on specific race or ethnic group, but rather combine non-White participants into one group.

The analysis highlights:

- Disparate narratives about what the park is and what it offers.
- Lack of knowledge about how to get to the park (or even that it exists).
- Unrepresentative park staff.
- Unwillingness by the Park Service to communicate through means traditionally used by minority communities.
- Non-explicit discrimination (getting "eyed").
- Various forms of inaccessibility (transportation, language, cost).

<u>Case Studies: Solutions</u>

Esparza, Andres. "Engaging the Hispanic Community with Public Lands: A multi-agency study and recommendations for the City of Montrose, CO." Completed in furtherance of a Masters for Environmental Management, Western Colorado University, Gunnison, CO. 42 pages.

This report explores various potential strategies for successfully engaging the Hispanic community with public lands near Montrose, CO through partnerships in the community. Through analysis of interview data (19 interviews with 20 participants) conducted with local land managers, representatives of the Hispanic Community, and city officials, this report offers three key recommendations for engaging the local Hispanic community with the public lands surrounding Montrose, CO:

- Focus on city parks as gateways to public lands
- Create a multi-agency public lands liaison to community

- Establish a partnership between local land management agencies and the local university, Colorado Mesa University (CMU) Montrose, with the goals of:
    - Supporting local Hispanic youth to attend and complete a 4 year college degree;
    - Building leadership and community engagement skills in Hispanic youth;
    - Engaging Hispanic youth in public lands management through targeted course loads, academic majors and summer internship opportunities with local public land agencies;
    - Connecting college graduates with career opportunities in local land management; and
    - Building a recruitment stream of local, college-educated Hispanic youth for future job placement in public land agencies.

Hoagland, Serra Jeanette. "Integrating Traditional Ecological Knowledge with Western Science for Optimal Natural Resource Management." Ik: Other Ways of Knowing 3, no. 1 (2017): 1–15.

Traditional ecological knowledge (TEK) is a set of practices and beliefs handed down through generations, commonly attributed to indigenous peoples. Federal resource managers are realizing the need to supplement their western science methods with TEK practices.

- TEK encourages a land-use ethic that treats nature with respect and allows for different species to coexist.
- TEK is transmitted orally. Learning requires patience, respect, and care. It often prioritizes pronunciation, and respect for the ideas of ancestors. This makes it difficult to share TEK broadly, a potentially critical problem as TEK is being lost over time.
- Managing forests and other resources using TEK can produce a sustainable harvest with minimal disruption. Treaties that allowed tribes to manage resources on their land independently have been successful.
- However, there are many instances where modern western resource management was imposed on native peoples, prohibiting them from their historic practices. This hurt the tribes and members, and could result in less sustainable practices.

However, there are instances when TEK was successfully combined with western science to great success:

- Experts with intercultural skills, including TEK, have been employed by scientists and researchers in an inventory of birch trees and a monitoring program for grizzly bears.
- Many environmental disasters, such as broad use of DDT, could have been prevented with application of TEK.
- Ecology often requires understanding of a time scale larger than what Western science can offer, but within grasp with TEK.
- Research interest in TEK is growing, and several agencies have committed to working towards integration of TEK in their work.

Roberts, Nina S, Sami Reist, Kristen M Pozzoboni, and Tanvi Sikand. "Outside Your Door: Young Producers Bride the Divide between Urban Youth and Public Lands," 2014

Forest Service investigated the relationship between youth and media when campaigning to engage young people in the outdoors. While they uncovered a complex and conflicting series of feelings and relationships, a few unified themes came through, such as the importance of considering who is delivering a message.

Researchers from San Francisco State University partnered with BAYCAT, "a nonprofit social enterprise that educates, empowers and employs young people from historically underserved Bay Area communities in the digital media arts." A background report was prepared on modern youth engagement in different forms of media. Twenty-six youth (ages 11-17) were recruited to learn about video production and produce a television program about outdoors called "Zoom In 29: Outside Your Door". The videos produced as part of the television program, as well as interviews and questionnaires conducted with the youth in the program, and responses by other young people who watched the videos, were analyzed by the team.

The authors found the following:

- The most common response from audiences was that they appreciated that the messages were coming from other young people and identified with the youth in the videos.
- Less common, but still significant, was an appreciation for the diversity of races shown in the videos, though not for representation of any specific racial group.
- Youth involved in the program were excited by the idea that participation in the outdoors did not have to cost money.
- Many other themes presented conflicting conclusions. For example, while some identified the outdoors as a place to "disconnect", others were excited by the potential to use technology outdoors in creative ways. Exposure to nature was identified as calming by some, but others expressed stress because of encounters with other people, or a feeling of "not belonging".
- The most popular media among youth audiences were music (usually rap) or humorous videos.
- Audience members who recognized the locations in the videos reflected on these places positively, while viewers who didn't recognize filmed locations felt the themes weren't applicable to their home.

Based on their experience, the researchers made the following recommendations to the Forest Service:

- Draw from local frames to create statewide or national messaging campaigns.
- Show activities and include youth.
- Use cultural media to encourage youth involvement.
- Remember that "messengers matter".
- Use social media to reach specific youth.

- Involve youth in the planning, production, and post-production process.

<u>Agency Planning Documents</u>

Cooke, Brian, and Dudley Edmondson. "Recreating in Color: Promoting Ethnic Diversity in Public Lands." ***Science You Can Use Bulletin*****, no. 30 (2018): 1–8**

This newsletter is an accessible introduction to the Forest Service's work on equity and diversity on its properties. It primarily cites other studies and offers no original research, but the authors combine these studies into a compelling narrative, and also provide biographies of some of the key scientists.

The key findings the authors identify are:

- Recent research indicates disproportionate utilization of U.S. national forest recreation opportunities by several racial and ethnic minority groups.
- From the perspective of public land management in the United States, these findings demonstrate the need for the Forest Service and other public land agencies to scrutinize and evaluate strategies that would enhance greater racial and ethnic inclusion in outdoor recreation.
- The inequity index was recently adopted by the Southwestern Region of the Forest Service as a recreation performance measure through their 2014 Sustainable Recreation Strategy.

Charnley, Susan, Delilah Jaworski, Heidi Huber-Stearns, Eric M White, Elisabeth Grinspoon, Rebecca J Mclain, and Lee Cerveny. "Synthesis of Science to Inform Land Management Within the Northwest Forest Plan Area Chapter 10-Environmental Justice, Low-Income and Minority Populations, and Forest Management in the Northwest Forest Plan Area."

This report covers the regulations governing the Forest Service's obligations to minority and low-income communities and offers an introduction to how those communities interact with Forest Service areas. In addition to recreation, various forms of employment are discussed, including environmental work, agricultural gathering, and wildfire fighting. Homeless and environmental justice are also discussed.

Furr, Chris W, Josh Hall, Pat Jackson, Kyung Koh, Mindi Lehew, James Melonas, Danny Montoya, et al. "Southwestern Region Sustainable Recreation Strategy," 2014, 1–12

This document is meant to guide the agency's planning toward a recreation program that is "vital to the well-being of our visitors and communities and is essential to the future of the Forest Service." This is based on the finding that, in the decade from 2000 to 2010, use of the forests declined while population in the area increased. The report blames this decline on an underfunded and overworked program that creates a huge amount of lost opportunity. Although an increasingly diverse population is mentioned, it is not discussed extensively.

Key components of the strategy include:

- Better accountability, goals, evaluation, and planning.
- Work with local stakeholders and create a more diverse and inclusive coalition to build equity between forests and communities.
- Better communication within agency and between agency and community.

Parker, Susan E, and Gary T Green. "A Comparative Study of Recreation Constraints to National Forest Use by Ethnic and Minority Groups in North Georgia." *JOURNAL OF FORESTRY* 114, no. 4 (2016): 449–57.

This article offers a useful taxonomy for categorizing constraints to recreation:

- structural (external barriers)
- interpersonal (social)
- intrapersonal (attitudes, values, and beliefs)

It focuses on national forests in the southeastern United States.

The top constraints identified by people studied were lack of time, lack of information, facility condition, and distance to the forest. These were all categorized as structural constraints. However, race-related interpersonal issues, such as lack of staff diversity, were of greater concern for non-white respondents. Fear (of staff, wild pests, or in general) were concerns for Asian and African American respondents, but not as much for whites or Hispanics.

The authors suggest that studies treating "non-white" or "minority" respondents as a homogenous block should be treated skeptically.

Roberts, Nina S, Deborah J Chavez, Benjamin M Lara, and Emilyn A Sheffield. "Serving Culturally Diverse Visitors to Forests in California: A Resource Guide," 2009

This resource guide was assembled by the Forest Service as a tool in service of their effort to reach a continuously changing population through education and engagement. It is intended for USFS managers and staff, as well as outside academics and researchers looking further into cultural diversity. It is specifically focused on serving the culturally diverse publics of California, and the 18 national forests therein. It includes background information, specific policy recommendations, and practical tips for field workers.

Topline research findings include:

- A growing population lives increasingly in urban areas. While some city-dwellers become committed outdoor recreationists, many find it difficult to enjoy the outdoors due to various barriers. Recreation has historically been an important part of the "California Lifestyle", though this is being challenged by an increasingly time-pressed technology-obsessed culture.

- Barriers cited include: lack of interest, transportation, lack of information, health or physical limitation, feeling unwelcome, no one to go with.
- As non-White ethnicities make up a larger share of California's population, different styles of recreation are becoming more popular. For example, Latino recreationists tend to prefer day-long outings in large groups centered around family and children, which many national forests are not currently designed to accommodate.
- In many studies, ethnic minorities identify noticing a lack of representation among rangers and staff at national forests.

The report makes the following recommendations:

- Translate materials and use international iconography.
- Audit existing facilities and consider expanding developed outdoor areas (like picnic sites), which tend to be more popular with visitors from less-frequently-seen ethnicities.
- Expand affordable transportation. Partner and engage with respected groups in communities to provide education and information.

Appendix 4
Environmental Effects of Transportation Infrastructure on National Forests and Grasslands - A Literature Review
May 2014

Introduction

The Forest Service transportation system is very large with 374,883 miles (603,316 km) of system roads and 143,346 miles (230,693 km) of system trails. The system extends broadly across every national forest and grasslands and through a variety of habitats, ecosystems and terrains. An impressive body of scientific literature exists addressing the various effects of roads on the physical, biological and cultural environment – so much so, in the last few decades a new field of "road ecology" has emerged. In recent years, the scientific literature has expanded to address the effects of roads on climate change adaptation and conversely the effects of climate change on roads, as well as the effects of restoring lands occupied by roads on the physical, biological and cultural environments.

The following literature review summarizes the most recent thinking related to the environmental impacts of forest roads and motorized routes and ways to address them. The literature review is divided into three sections that address the environmental effects of transportation infrastructure on forests, climate change and infrastructure, and creating sustainable forest transportation systems.

I. Impacts of Transportation Infrastructure and Access to the Ecological Integrity of Terrestrial and Aquatic Ecosystems and Watersheds

It is well understood that transportation infrastructure and access management impact aquatic and terrestrial environments at multiple scales, and, in general, the more roads and motorized routes the greater the impact. In fact, in the past 20 years or so, scientists having realized the magnitude and breadth of ecological issues related to roads; entire books have been written on the topic, e.g., Forman et al. (2003), and a new scientific field called "road ecology" has emerged. Road ecology research centers have been created including the Western

Transportation Institute at Montana State University and the Road Ecology Center at the University of California - Davis.[1]

Below, we provide a summary of the current understanding on the impacts of roads and access allowed by road networks to terrestrial and aquatic ecosystems, drawing heavily on Gucinski et al. (2000). Other notable recent peer-reviewed literature reviews on roads include Trombulak and Frissell (2000), Switalski et al. (2004), Coffin (2007), Fahrig and Rytwinski (2009), and Robinson et al. (2010). Recent reviews on the impact of motorized recreation include Joslin and Youmans (1999), Gaines et al. (2003), Davenport and Switalski (2006), Ouren et al. (2007), and Switalski and Jones (2012). These peer-reviewed summaries provide additional information to help managers develop more sustainable transportation systems

Impact on geomorphology and hydrology

The construction or presence of forest roads can dramatically change the hydrology and geomorphology of a forest system leading to reductions in the quantity and quality of aquatic habitat. While there are several mechanisms that cause these impacts (Wemple et al. 2001 , Figure 1), most fundamentally, compacted roadbeds reduce rainfall infiltration, intercepting and concentrating water, and providing a ready source of sediment for transport (Wemple et al. 1996, Wemple et al. 2001). In fact, roads contribute more sediment to streams than any other land management activity (Gucinski et al. 2000). Surface erosion rates from roads are typically at least an order of magnitude greater than rates from harvested areas, and three orders of magnitude greater than erosion rates from undisturbed forest soils (Endicott 2008).

[1] See http://www.westerntransportationinstitute.org/research/roadecology and http://roadecology.ucdavis.edu/

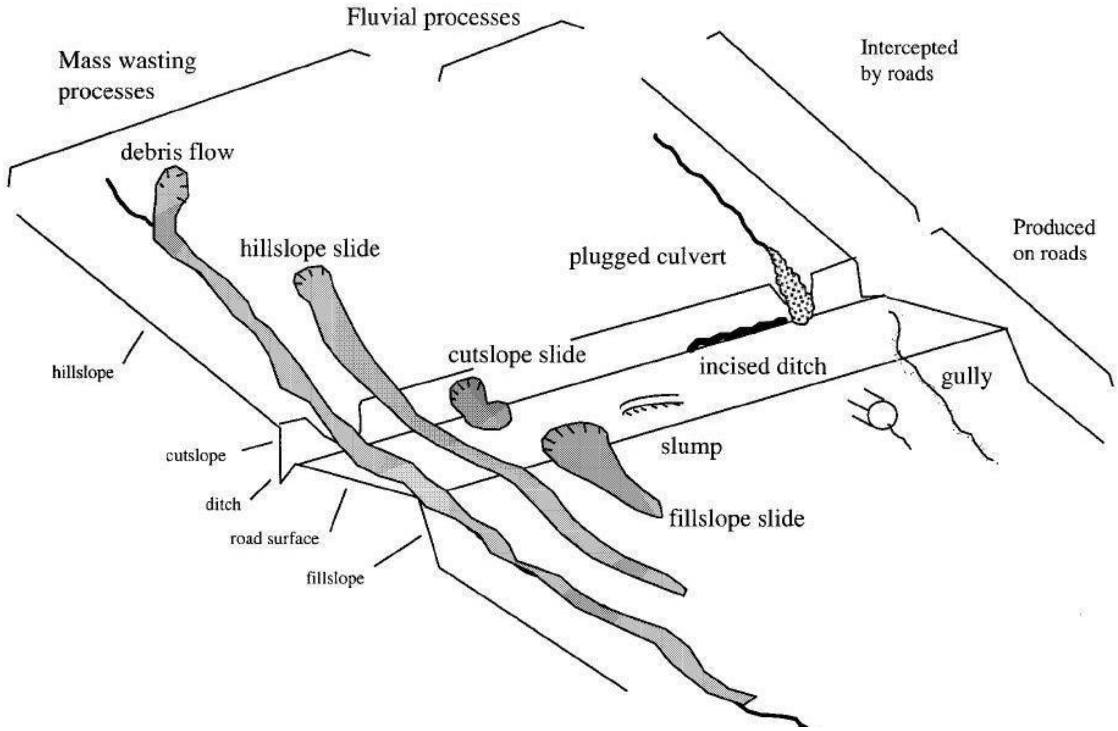


Figure 1: Typology of erosional and depositional features produced by mass-wasting and fluvial processes associate with forest roads (reprinted from Wemple et al. 2001)

Erosion of sediment from roads occurs both chronically and catastrophically. Every time it rains, sediment from the road surface and from cut- and fill-slopes is picked up by rainwater that flows into and on roads (fluvial erosion). The sediment that is entrained in surface flows are often concentrated into road ditches and culverts and directed into streams. The degree of fluvial erosion varies by geology and geography, and increases with increased motorized use (Robichaud et al. 2010). Closed roads produce less sediment, and Foltz et al. (2009) found a significant increase in erosion when closed roads were opened and driven upon.

Roads also precipitate catastrophic failures of road beds and fills (mass wasting) during large storm events leading to massive slugs of sediment moving into waterways (Endicott 2008; Gucinski et al. 2000). This typically occurs when culverts are undersized and cannot handle the volume of water, or they simply become plugged with debris. The saturated roadbed can fail entirely and result in a landslide, or the blocked stream crossing can erode the entire fill down to the original stream channel.

The erosion of road- and trail-related sediment and its subsequent movement into stream systems affects the geomorphology of the drainage system in a number of ways. The magnitude of their effects varies by climate, geology, road age, construction / maintenance practices and storm history. It directly alters channel morphology by embedding larger gravels as well as filling pools. It can also have the opposite effect of increasing peak discharges and scouring channels, which can lead to disconnection of the channel and floodplain, and lowered base flows (Furniss et al. 1991; Joslin and Youmans 1999). The width/depth ratio of the stream changes which then can trigger changes in water temperature, sinuosity and other geomorphic factors important for aquatic species survival (Joslin and Youmans 1999; Trombulak and Frissell 2000).

Roads also can modify flowpaths in the larger drainage network. Roads intercept subsurface flow as well as concentrate surface flow, which results in new flowpaths that otherwise would not exist, and the extension of the drainage network into previously unchannelized portions of the hillslope (Gucinski et al. 2000; Joslin and Youmans 1999). Severe aggradation of sediment at stream structures or confluences can force streams to actually go subsurface or make them too shallow for fish passage (Endicott 2008; Furniss et al. 1991).

Impacts on aquatic habitat and fish

Roads can have dramatic and lasting impacts on fish and aquatic habitat. Increased sedimentation in stream beds has been linked to decreased fry emergence, decreased juvenile densities, loss of winter carrying capacity, and increased predation of fishes, and reductions in macro-invertebrate populations that are a food source to many fish species (Rhodes et al. 1994, Joslin and Youmans 1999, Gucinski et al. 2000, Endicott 2008). On a landscape scale, these effects can add up to: changes in the frequency, timing and magnitude of disturbance to aquatic habitat and changes to aquatic habitat structures (e.g., pools, riffles, spawning gravels and in-channel debris), and conditions (food sources, refugi, and water temperature) (Gucinski et al. 2000).

Roads can also act as barriers to migration (Gucinski et al. 2000). Where roads cross streams, road engineers usually place culverts or bridges. Culverts in particular can and often interfere with sediment transport and channel processes such that the road/stream crossing becomes a barrier for fish and aquatic species movement up and down stream. For instance, a culvert may scour on the downstream side of the crossing, actually forming a waterfall up which fish cannot move. Undersized culverts and bridges can infringe upon the channel or floodplain and trap sediment causing the stream to become too shallow and/or warm such that fish will not migrate past the structure. This is problematic for many aquatic species but especially for anadromous species that must migrate upstream to spawn. Well-known native aquatic species affected by roads include salmon such as coho (*Oncorhynchus kisutch*), chinook (*O. tshawytscha*), and chum (*O. keta*); steelhead (*O. mykiss*); and a variety of trout species including bull trout (*Salvelinus confluentus*) and cutthroat trout (*O. clarki*), as well as other native fishes and amphibians (Endicott 2008).

Impacts on terrestrial habitat and wildlife

Roads and trails impact wildlife through a number of mechanisms including: direct mortality (poaching, hunting/trapping) changes in movement and habitat use patterns (disturbance/avoidance), as well as indirect impacts including alteration of the adjacent habitat and interference with predatory/prey relationships (Wisdom et al. 2000, Trombulak and Frissell 2000). Some of these impacts result from the road itself, and some result from the uses on and around the roads (access). Ultimately, roads have been found to reduce the abundance and distribution of several forest species (Fayrig and Ritwinski 2009, Benítez-López et al. 2010).

Table 1: Road- and recreation trail-associated factors for wide-ranging carnivores (Reprinted from Gaines et al. (2003)[2]

[2] For a list of citations see Gaines et al. (2003)

Focal species	Road-associated factors	Motorized trail-associated factors	Nonmotorized trail-associated factors
Grizzly bear	Poaching Collisions Negative human interactions Displacement or avoidance	Poaching Negative human interactions Displacement or avoidance	Poaching Negative human interactions Displacement or avoidance
Lynx	Down log reduction Trapping Collisions Disturbance at a specific site	Disturbance at a specific site Trapping	Disturbance at a specific site
Gray wolf	Trapping Poaching Collisions Negative human interactions Disturbance at a specific site Displacement or avoidance	Trapping Disturbance at a specific site	Trapping Disturbance at a specific site
Wolverine	Down log reduction Trapping Disturbance at a specific site Collisions	Trapping Disturbance at a specific site	Trapping Disturbance at a specific site

Direct mortality and disturbance from road and trail use impacts many different types of species. For example, wide-ranging carnivores can be significantly impacted by a number of factors including trapping, poaching, collisions, negative human interactions, disturbance and displacement (Gaines et al. 2003, Table 1). Hunted game species such as elk (*Cervus canadensis*), become more vulnerable from access allowed by roads and motorized trails resulting in a reduction in effective habitat among other impacts (Rowland et al. 2005, Switalski and Jones 2012). Slow-moving migratory animals such as amphibians, and reptiles who use roads to regulate temperature are also vulnerable (Gucinski et al. 2000, Brehme et al. 2013).

Habitat alteration is a significant consequence of roads as well. At the landscape scale, roads fragment habitat blocks into smaller patches that may not be able to support successfully interior forest species. Smaller habitat patches also results in diminished genetic variability, increased inbreeding, and at times local extinctions (Gucinski et al. 2000; Trombulak and Frissell 2000). Roads also change the composition and structure of ecosystems along buffer zones, called edge-affected zones. The width of edge-affected zones varies by what metric is being discussed; however, researchers have documented road-avoidance zones a kilometer or more away from a road (Table 2). In heavily roaded landscapes, edge-affected acres can be a significant fraction of total acres. For example, in a landscape area where the road density is 3 mi/mi^2 (not an uncommon road density in national forests) and where the edge-affected zone is estimated to be 500 ft from the center of the road to each side, the edge-affected zone is 56% of the total acreage.

Table 2: A summary of some documented road-avoidance zones for various species (adapted from Robinson et al. 2010).

Species	Avoidance zone m (ft)	Type of disturbance	Reference
Snakes	650 (2133)	Forestry roads	Bowles (1997)
Salamander	35 (115)	Narrow forestry road, light traffic	Semlitsch (2003)
Woodland birds	150 (492)	Unpaved roads	Ortega and Capen (2002)
Spotted owl	400 (1312)	Forestry roads, light traffic	Wasser et al. (1997)
Marten	<100 (<328)	Any forest opening	Hargis et al. (1999)
Elk	500–1000 (1640-3281)	Logging roads, light traffic	Edge and Marcum (1985)
	100–300 (328-984)	Mountain roads depending on traffic volume	Rost and Bailey (1979)
Grizzly bear	3000 (9840)	Fall	Mattson et al. (1996)
	500 (1640)	Spring and summer	
	883 (2897)	Heavily traveled trail	Kasworm and Manley (1990)
	274 (899)	Lightly traveled trail	
	1122 (3681)	Open road	Kasworm and Manley (1990)
	665 (2182)	Closed road	
Black bear	274 (899)	Spring, unpaved roads	Kasworm and Manley (1990)
	914 (2999)	Fall, unpaved roads	

Roads and trails also affect ecosystems and habitats because they are also a major vector of non-native plant and animal species. This can have significant ecological and economic impacts when the invading species are aggressive and can overwhelm or significantly alter native species and systems. In addition, roads can increase harassment, poaching and collisions with vehicles, all of which lead to stress or mortality (Wisdom et al. 2000).

Recent reviews have synthesized the impacts of roads on animal abundance and distribution. Fahrig and Rytwinski (2009) did a complete review of the empirical literature on effects of roads and traffic on animal abundance and distribution looking at 79 studies that addressed 131 species and 30 species groups. They found that the number of documented negative effects of roads on animal abundance outnumbered the number of positive effects by a factor of 5. Amphibians, reptiles, most birds tended to show negative effects. Small mammals generally showed either positive effects or no effect, mid-sized mammals showed either negative effects or no effect, and large mammals showed predominantly negative effects. Benítez-López et al. (2010) conducted a meta-analysis on the effects of roads and infrastructure proximity on mammal and bird populations. They found a significant pattern of avoidance and a reduction in bird and mammal populations in the vicinity of infrastructure.

Road density[3] thresholds for fish and wildlife

[3] We intend the term "road density" to refer to the density all roads within national forests, including system roads, closed roads, non-system roads administered by other jurisdictions (private, county, state), temporary roads and motorized trails. Please see Attachment 2 for the relevant existing scientific information supporting this approach.

It is well documented that beyond specific road density thresholds, certain species will be negatively affected, and some will be extirpated. Most studies that look into the relationship between road density and wildlife focus on the impacts to large endangered carnivores or hunted game species, although high road densities certainly affect other species – for instance, reptiles and amphibians. Gray wolves (*Canis lupus*) in the Great Lakes region and elk in Montana and Idaho have undergone the most long-term and in depth analysis. Forman and Hersperger (1996) found that in order to maintain a naturally functioning landscape with sustained populations of large mammals, road density must be below 0.6 km/km² (1.0 mi/mi²). Several studies have since substantiated their claim (Robinson et al. 2010, Table 3).

A number of studies at broad scales have also shown that higher road densities generally lead to greater impacts to aquatic habitats and fish density (Table 3). Carnefix and Frissell (2009) provide a concise review of studies that correlate cold water fish abundance and road density, and from the cited evidence concluded that "1) no truly "safe" threshold road density exists, but rather negative impacts begin to accrue and be expressed with incursion of the very first road segment; and 2) highly significant impacts (e.g., threat of extirpation of sensitive species) are already apparent at road densities on the order of 0.6 km/km^2 (1.0 mi/mi²) or less" (p. 1).

Table 3: A summary of some road-density thresholds and correlations for terrestrial and aquatic species and ecosystems (reprinted from Robinson et al. 2010).

Species (Location)	Road density (mean, guideline, threshold, correlation)	Reference
Wolf (Minnesota)	0.36 km/km2 (mean road density in primary range); 0.54 km/km^2 (mean road density in peripheral range)	Mech et al. (1988)
Wolf	>0.6 km/km^2 (absent at this density)	Jalkotzy et al. (1997)
Wolf (Northern Great Lakes region)	>0.45 km/km^2 (few packs exist above this threshold); >1.0 km/km^2 (no pack exist above this threshold)	Mladenoff et al. (1995)
Wolf (Wisconsin)	0.63 km/km^2 (increasing due to greater human tolerance	Wydeven et al. (2001)
Wolf, mountain lion (Minnesota, Wisconsin, Michigan)	0.6 km/km^2 (apparent threshold value for a naturally functioning landscape containing sustained populations)	Thiel (1985); van Dyke et al. (1986); Jensen et al. (1986); Mech et al. (1988); Mech (1989)
Elk (Idaho)	1.9 km/km^2 (density standard for habitat effectiveness)	Woodley 2000 cited in Beazley et al. 2004
Elk (Northern US)	1.24 km/km^2 (habitat effectiveness decline by at least 50%)	Lyon (1983)
Elk, bear, wolverine, lynx, and others	0.63 km/km^2 (reduced habitat security and increased mortality)	Wisdom et al. (2000)
Moose (Ontario)	0.2-0.4 km/km2 (threshold for pronounced response)	Beyer et al. (2013)
Grizzly bear (Montana)	>0.6 km/km^2	Mace et al. (1996); Mattson et al. (1996)
Black bear (North Carolina)	>1.25 km/km^2 (open roads); >0.5 km/km2 (logging roads); (interference with use of habitat)	Brody and Pelton (1989)
Black bear	0.25 km/km^2 (road density should not exceed)	Jalkotzy et al. (1997)
Bobcat (Wisconsin)	1.5 km/km^2 (density of all road types in home range)	Jalkotzy et al. (1997)

Large mammals	>0.6 km/km^2 (apparent threshold value for a naturally functioning landscape containing sustained popula-tions)	Forman and Hersperger (1996)
Bull trout (Montana)	Inverse relationship of population and road density	Rieman et al. (1997); Baxter et al. (1999)
Fish populations (Medicine Bow National Forest)	(1) Positive correlation of numbers of culverts and stream crossings and amount of fine sediment in stream channels (2) Negative correlation of fish density and numbers of culverts	Eaglin and Hubert (1993) cited in Gucinski et al. (2001)
Macroinvertebrates	Species richness negatively correlated with an index of road density	McGurk and Fong (1995)
Non-anadromous salmonids (Upper Columbia River basin)	(1) Negative correlation likelihood of spawning and rearing and road density (2) Negative correlation of fish density and road density	Lee et al. (1997)

Where both stream and road densities are high, the incidence of connections between roads and streams can also be expected to be high, resulting in more common and pronounced effects of roads on streams (Gucinski et al. 2000). For example, a study on the Medicine Bow National Forest (WY) found as the number of culverts and stream crossings increased, so did the amount of sediment in stream channels (Eaglin and Hubert 1993). They also found a negative correlation with fish density and the number of culverts. Invertebrate communities can also be impacted. McGurk and Fong (1995) report a negative correlation between an index of road density with macroinvertebrate diversity.

The U.S. Fish and Wildlife Service's Final Rule listing bull trout as threatened (USDI Fish and Wildlife Service 1999) addressed road density, stating:

> "… assessment of the interior Columbia Basin ecosystem revealed that increasing road densities were associated with declines in four non-anadromous salmonid species (bull trout, Yellowstone cutthroat trout, westslope cutthroat trout, and redband trout) within the Columbia River Basin, likely through a variety of factors associated with roads (Quigley & Arbelbide 1997). Bull trout were less likely to use highly roaded basins for spawning and rearing, and if present, were likely to be at lower population levels (Quigley and Arbelbide 1997). Quigley et al. (1996) demonstrated that when average road densities were between 0.4 to 1.1 km/km^2 (0.7 and 1.7 mi/mi^2) on USFS lands, the proportion of subwatersheds supporting "strong" populations of key salmonids dropped substantially. Higher road densities were associated with further declines" (USDI Fish and Wildlife Service 1999, p. 58922).

Anderson et al. (2012) also showed that watershed conditions tend to be best in areas protected from road construction and development. Using the US Forest Service's Watershed Condition Framework assessment data, they showed that National Forest lands that are protected under the Wilderness Act, which provides the strongest safeguards, tend to have the healthiest watersheds. Watersheds in Inventoried Roadless Areas – which are protected from road building and logging by the Roadless Area Conservation Rule – tend to be less healthy than watersheds in designated Wilderness, but they are considerably healthier than watersheds in the managed landscape.

Impacts on other resources
Roads and motorized trails also play a role in affecting wildfire occurrence. Research shows that human-ignited wildfires, which account for more than 90% of fires on national lands, is almost five times more likely in areas with roads (USDA Forest Service 1996a; USDA Forest Service 1998). Furthermore, Baxter (2002) found that off-road vehicles (ORVs) can be a significant source of fire ignitions on forestlands. Roads can affect where and how forests burn and, by extension, the vegetative condition of the forest. See Attachment 1 for more information documenting the relationship between roads and wildfire occurrence.

Finally, access allowed by roads and trails can increase of ORV and motorized use in remote areas threatening archaeological and historic sites. Increased visitation has resulted in intentional and unintentional damage to many cultural sites (USDI Bureau of Land Management 2000, Schiffman 2005).

II. Climate Change and Transportation Infrastructure including the value of roadless areas for climate change adaptation

As climate change impacts grow more profound, forest managers must consider the impacts on the transportation system as well as from the transportation system. In terms of the former, changes in precipitation and hydrologic patterns will strain infrastructure at times to the breaking point resulting in damage to streams, fish habitat, and water quality as well as threats to public safety. In terms of the latter, the fragmenting effect of roads on habitat will impede the movement of species which is a fundamental element of adaptation. Through planning, forest managers can proactively address threats to infrastructure, and can actually enhance forest resilience by removing unneeded roads to create larger patches of connected habitat.

Impact of climate change and roads on transportation infrastructure
It is expected that climate change will be responsible for more extreme weather events, leading to increasing flood severity, more frequent landslides, changing hydrographs (peak, annual mean flows, etc.), and changes in erosion and sedimentation rates and delivery processes. Roads and trails in national forests, if designed by an engineering standard at all, were designed for storms and water flows typical of past decades, and hence may not be designed for the storms in future decades. Hence, climate driven changes may cause transportation infrastructure to malfunction or fail (ASHTO 2012, USDA Forest Service 2010). The likelihood is higher for facilities in high-risk settings—such as rain-on-snow zones, coastal areas, and landscapes with unstable geology (USDA Forest Service 2010).

Forests fragmented by roads will likely demonstrate less resistance and resilience to stressors, like those associated with climate change (Noss 2001). First, the more a forest is fragmented (and therefore the higher the edge/interior ratio), the more the forest loses its inertia characteristic, and becoming less resilient and resistant to climate change. Second, the more a forest is fragmented characterized by isolated patches, the more likely the fragmentation will interfere with the ability of species to track shifting climatic conditions over time and space. Noss (2001) predicts that weedy species with effective dispersal mechanisms might benefit from fragmentation at the expense of native species.

Modifying infrastructure to increase resilience

To prevent or reduce road failures, culvert blow-outs, and other associated hazards, forest managers will need to take a series of actions. These include replacing undersized culverts with larger ones, prioritizing maintenance and upgrades (e.g., installing drivable dips and more outflow structures), and obliterating roads that are no longer needed and pose erosion hazards (USDA Forest Service 2010, USDA Forest Service 2012a, USDA Forest Service 2011, Table 4).

Olympic National Forest has developed a number of documents oriented at oriented at protecting watershed health and species in the face of climate change, including a 2003 travel management strategy and a report entitled Adapting to Climate Change in Olympic National Park and National Forest. In the travel management strategy, Olympic National Forest recommended that 1/3rd of its road system be decommissioned and obliterated (USDA Forest Service 2011a). In addition, the plan called for addressing fish migration barriers in a prioritized and strategic way – most of these are associated with roads. The report calls for road decommissioning, relocation of roads away from streams, enlarging culverts as well as replacing culverts with fish-friendly crossings (USDA Forest Service 2011a, Table 4).

Table 4: Current and expected sensitivities of fish to climate change on the Olympic Peninsula, associated adaptation strategies and action for fisheries and fish habitat management and relevant to transportation management at Olympic National Forest and Olympic National Park (excerpt reprinted from USDA Forest Service 2011a).

Current and expected sensitivites	Adaptation strategies and actions
Changes in habitat quantity and quality	• Implement habitat restoration projects that focus on re-creating watershed processes and functions and that create diverse, resilient habitat.
Increase in culvert failures, fill-slope failures, stream adjacent road failures, and encroachment from stream-adjacent road segments	• Decommission unneeded roads. • Remove sidecast, improve drainage, and increase culvert sizing on remaining roads. • Relocate stream-adjacent roads.
Greater difficulty disconnecting roads from stream channels	• Design more resilient stream crossing structures.
Major changes in quantity and timing of streamflow in transitional watersheds	• Make road and culvert designs more conservative in transitional watersheds to accommodate expected changes.
Decrease in area of headwater streams	• Continue to correct culvert fish passage barriers. • Consider re-prioritizing culvert fish barrier correction projects.
Decrease in habitat quantity and connectivity for species that use headwater streams	• Restore habitat in degraded headwater streams that are expected to retain adequate summer streamflow (ONF).

In December 2012, the USDA Forest Service published a report entitled "Assessing the Vulnerability of Watersheds to Climate Change." This document reinforces the concept expressed by Olympic National Forest that forest managers need to be proactive in reducing erosion potential from roads:

> "Road improvements were identified as a key action to improve condition and resilience of watersheds on all the pilot Forests. In addition to treatments that reduce erosion, road improvements can reduce the delivery of runoff from road segments to channels, prevent diversion of flow during large events, and restore aquatic habitat connectivity by providing for passage of aquatic organisms. As stated previously, watershed sensitivity is determined by both inherent and management-related factors. Managers have no control over the inherent factors, so to improve resilience, efforts must be directed at anthropogenic influences such as instream flows, roads, rangeland, and vegetation management….
>
> [Watershed Vulnerability Analysis] results can also help guide implementation of travel management planning by informing priority setting for decommissioning roads and road reconstruction/maintenance. As with the Ouachita NF example, disconnecting roads from the stream network is a key objective of such work. Similarly, WVA analysis could also help prioritize aquatic organism passage projects at road-stream crossings to allow migration by aquatic residents to suitable habitat as streamflow and temperatures change" (USDA Forest Service 2012a, p. 22-23).

Reducing fragmentation to enhance aquatic and terrestrial species adaptation
Decommissioning and upgrading roads and thus reducing the amount of fine sediment deposited on salmonid nests can increase the likelihood of egg survival and spawning success (McCaffery et al. 2007). In addition, this would reconnect stream channels and remove barriers such as culverts. Decommissioning roads in riparian areas may provide further benefits to salmon and other aquatic organisms by permitting reestablishment of streamside vegetation, which provides shade and maintains a cooler, more moderated microclimate over the stream (Battin et al. 2007).

One of the most well documented impacts of climate change on wildlife is a shift in the ranges of species (Parmesan 2006). As animals migrate, landscape connectivity will be increasingly important (Holman et al. 2005). Decommissioning roads in key wildlife corridors will improve connectivity and be an important mitigation measure to increase resiliency of wildlife to climate change. For wildlife, road decommissioning can reduce the many stressors associated with roads. Road decommissioning restores habitat by providing security and food such as grasses and fruiting shrubs for wildlife (Switalski and Nelson 2011).

Forests fragmented by roads and motorized trail networks will likely demonstrate less resistance and resilience to stressors, such as weeds. As a forest is fragmented and there is more edge habitat, Noss (2001) predicts that weedy species with effective dispersal mechanisms will increasingly benefit at the expense of native species. However, decommissioned roads when seeded with native species can reduce the spread of invasive species (Grant et al. 2011), and help restore fragmented forestlands. Off-road vehicles with large knobby tires and large undercarriages are also a key vector for weed spread (e.g., Rooney 2006). Strategically closing and decommissioning motorized routes, especially in roadless areas, will reduce the spread of weeds on forestlands (Gelbard and Harrison 2003).

Transportation infrastructure and carbon sequestration
The topic of the relationship of road restoration and carbon has only recently been explored. There is the potential for large amounts of carbon (C) to be sequestered by reclaiming roads. When roads are decompacted during reclamation, vegetation and soils can develop more

rapidly and sequester large amounts of carbon. A recent study estimated total soil C storage increased 6 fold to 6.5 x 107g C/km (to 25 cm depth) in the northwestern US compared to untreated abandoned roads (Lloyd et al. 2013). Another recent study concluded that reclaiming 425 km of logging roads over the last 30 years in Redwood National Park in Northern California resulted in net carbon savings of 49,000 Mg carbon to date (Madej et al. 2013, Table 5).

Kerekvliet et al. (2008) published a Wilderness Society briefing memo on the impact to carbon sequestration from road decommissioning. Using Forest Service estimates of the fraction of road miles that are unneeded, the authors calculated that restoring 126,000 miles of roads to a natural state would be equivalent to revegetating an area larger than Rhode Island. In addition, they calculate that the net economic benefit of road treatments are always positive and range from US$0.925-1.444 billion.

Table 5. Carbon budget implications in road decommissioning projects (reprinted from Madej et al. 2013).

Road Decommissioning Activities and Processes	Carbon Cost	Carbon Savings
Transportation of staff to restoration sites (fuel emissions)	X	
Use of heavy equipment in excavations (fuel emissions)	X	
Cutting trees along road alignment during hillslope recontouring	X	
Excavation of road fill from stream crossings		X
Removal of road fill from unstable locations		X
Reduces risk of mass movement		X
Post-restoration channel erosion at excavation sites	X	
Natural revegetation following road decompaction		X
Replanting trees		X
Soil development following decompaction		X

Benefits of roadless areas and roadless area networks to climate change adaptation
Undeveloped natural lands provide numerous ecological benefits. They contribute to biodiversity, enhance ecosystem representation, and facilitate connectivity (Loucks et al. 2003; Crist and Wilmer 2002, Wilcove 1990, The Wilderness Society 2004, Strittholt and Dellasala 2001, DeVelice and Martin 2001), and provide high quality or undisturbed water, soil and air (Anderson et al. 2012, Dellasalla et al. 2011). They also can serve as ecological baselines to help us better understand our impacts to other landscapes, and contribute to landscape resilience to climate change.

Forest Service roadless lands, in particular, are heralded for the conservation values they provide. These are described at length in the preamble of the Roadless Area Conservation Rule (RACR)[4] as well as in the Final Environmental Impact Statement (FEIS) for the RACR[5], and

[4] Federal Register .Vol. 66, No. 9. January 12, 2001. Pages 3245-3247.

include: high quality or undisturbed soil, water, and air; sources of public drinking water; diversity of plant and animal communities; habitat for threatened, endangered, proposed, candidate, and sensitive species and for those species dependent on large, undisturbed areas of land; primitive, semi-primitive non- motorized, and semi-primitive motorized classes of dispersed recreation; reference landscapes; natural appearing landscapes with high scenic quality; traditional cultural properties and sacred sites; and other locally identified unique characteristics (e.g., include uncommon geological formations, unique wetland complexes, exceptional hunting and fishing opportunities).

The Forest Service, National Park Service, and US Fish and Wildlife Service recognize that protecting and connecting roadless or lightly roaded areas is an important action agencies can take to enhance climate change adaptation. For example, the Forest Service National Roadmap for Responding to Climate Change (USDA Forest Service 2011b) establishes that increasing connectivity and reducing fragmentation are short and long term actions the Forest Service should take to facilitate adaptation to climate change.[6] The National Park Service also identifies connectivity as a key factor for climate change adaptation along with establishing "blocks of natural landscape large enough to be resilient to large-scale disturbances and long-term changes" and other factors. The agency states that: "The success of adaptation strategies will be enhanced by taking a broad approach that identifies connections and barriers across the landscape. Networks of protected areas within a larger mixed landscape can provide the highest level of resilience to climate change."[7] Similarly, the National Fish, Wildlife and Plants Climate Adaptation Partnership's Adaptation Strategy (2012) calls for creating an ecologically-connected network of conservation areas.[8]

---

[5] Final Environmental Impact Statement, Vol. 1, 3–3 to 3–7

[6] Forest Service, 2011. *National Roadmap for Responding to Climate Change*. US Department of Agriculture. FS-957b. Page 26.

[7] National Park Service. *Climate Change Response Program Brief.* http://www.nature.nps.gov/climatechange/adaptationplanning.cfm. Also see: National Park Service, 2010. *Climate Change Response Strategy*. http://www.nature.nps.gov/climatechange/docs/NPS_CCRS.pdf. Objective 6.3 is to "Collaborate to develop cross-jurisdictional conservation plans to protect and restore connectivity and other landscape-scale components of resilience."

[8] See http://www.wildlifeadaptationstrategy.gov/pdf/NFWPCAS-Chapter-3.pdf. Pages 55- 59. The first goal and related strategies are:

> Goal 1: Conserve habitat to support healthy fish, wildlife, and plant populations and ecosystem functions in a changing climate.
>
>> Strategy 1.1: identify areas for an ecologically-connected network of terrestrial, freshwater, coastal, and marine conservation areas that are likely to be resilient to climate change and to support a broad range of fish, wildlife, and plants under changed conditions.
>>
>> Strategy 1.2: Secure appropriate conservation status on areas identified in Strategy 1.1 to complete an ecologically-connected network of public and private conservation areas that will be resilient to climate change and support a broad range of species under changed conditions.
>>
>> Strategy 1.4: Conserve, restore, and as appropriate and practicable, establish new ecological connections among conservation areas to facilitate fish, wildlife, and plant migration, range shifts, and other transitions caused by climate change.

Crist and Wilmer (2002) looked at the ecological value of roadless lands in the Northern Rockies and found that protection of national forest roadless areas, when added to existing federal conservation lands in the study area, would 1) increase the representation of virtually all land cover types on conservation lands at both the regional and ecosystem scales, some by more than 100%; 2) help protect rare, species-rich, and often-declining vegetation communities; and 3) connect conservation units to create bigger and more cohesive habitat "patches."

Roadless lands also are responsible for higher quality water and watersheds. Anderson et al. (2012) assessed the relationship of watershed condition and land management status and found a strong spatial association between watershed health and protective designations. Dellasalla et al. (2011) found that undeveloped and roadless watersheds are important for supplying downstream users with high-quality drinking water, and developing these watersheds comes at significant costs associated with declining water quality and availability. The authors recommend a light-touch ecological footprint to sustain the many values that derive from roadless areas including healthy watersheds.

III. Sustainable Transportation Management in National Forests as Part of Ecological Restoration

At 375,000 miles strong, the Forest Service road system is one of the largest in the world – it is eight times the size of the National Highway System. It is also indisputably unsustainable – that is, roads are not designed, located, or maintained according to best management practices, and environmental impacts are not minimized. It is largely recognized that forest roads, especially unpaved ones, are a primary source of sediment pollution to surface waters (Endicott 2008, Gucinski et al. 2000), and that the system has about 1/3rd more miles than it needs (USDA Forest Service 2001). In addition, the majority of the roads were constructed decades ago when road design and management techniques did not meet current standards (Gucinski et al. 2000, Endicott 2008), making them more vulnerable to erosion and decay than if they had been designed today. Road densities in national forests often exceed accepted thresholds for wildlife.

Only a small portion of the road system is regularly used. All but 18% of the road system is inaccessible to passenger vehicles. Fifty-five percent of the roads are accessible only by high clearance vehicles and 27% are closed. The 18% that is accessible to cars is used for about 80% of the trips made within National Forests.[9] Most of the road maintenance funding is directed to the passenger car roads, while the remaining roads suffer from neglect. As a result, the Forest Service currently has a $3.7 billion road maintenance backlog that grows every year. In other words, only about 1/5th of the roads in the national forest system are used most of the time, and the fraction that is used often is the best designed and maintained because they are higher level access roads. The remaining roads sit generally unneeded and under-maintained – arguably a growing ecological and fiscal liability.

Current Forest Service management direction is to identify and implement a sustainable transportation system.[10] The challenge for forest managers is figuring out what is a sustainable road system and how to achieve it – a challenge that is exacerbated by climate change. It is

[9] USDA Forest Service. Road Management Website Q&As. Available online at http://www.fs.fed.us/eng/road_mgt/qanda.shtml.

[10] See Forest Service directive memo dated March 29, 2012 entitled "Travel Management, Implementation of 36 CFR, Part 202, Subpart A (36 CFR 212.5(b))"

reasonable to define a sustainable transportation system as one where all the routes are constructed, located, and maintained with best management practices, and social and environmental impacts are minimized. This, of course, is easier said than done, since the reality is that even the best roads and trail networks can be problematic simply because they exist and usher in land uses that without the access would not occur (Trombulak and Frissell 2000, Carnefix and Frissell 2009, USDA Forest Service 1996b), and when they are not maintained to the designed level they result in environmental problems (Endicott 2008; Gucinski et al. 2000). Moreover, what was sustainable may no longer be sustainable under climate change since roads designed to meet older climate criteria may no longer hold up under new climate scenarios (USDA Forest Service 2010, USDA Forest Service 2011b, USDA Forest Service 2012a, AASHTO 2012).

Forest Service efforts to move toward a more sustainable transportation system

The Forest Service has made efforts to make its transportation system more sustainable, but still has considerable work to do. In 2001, the Forest Service tried to address the issue by promulgating the Roads Rule[11] with the purpose of working toward a sustainable road system (USDA 2001). The Rule directed every national forest to identify a minimum necessary road system and identify unneeded roads for decommissioning. To do this, the Forest Service developed the Roads Analysis Process (RAP), and published Gucinski et al. (2000) to provide the scientific foundation to complement the RAP. In describing the RAP, Gucinski et al. (2000) writes:

> "Roads Analysis is intended to be an integrated, ecological, social, and economic approach to transportation planning. It uses a multiscale approach to ensure that the identified issues are examined in context. Roads Analysis is to be based on science. Analysts are expected to locate, correctly interpret, and use relevant existing scientific literature in the analysis, disclose any assumptions made during the analysis, and reveal the limitations of the information on which the analysis is based. The analysis methods and the report are to be subjected to critical technical review" (p. 10).

Most national forests have completed RAPs, although most only looked at passenger vehicle roads which account for less than 20% of the system's miles. The Forest Service Washington Office in 2010 directed that forests complete a Travel Analysis Process (TAP) by the end of fiscal year 2015, which must address all roads and create a map and list of roads identifying which are likely needed and which are not. Completed TAPs will provide a blueprint for future road decommissioning and management, they will not constitute compliance with the Roads Rule, which clearly requires the identification of the minimum roads system and roads for decommissioning. Almost all forests have yet to comply with subpart A.

The Forest Service in 2005 then tried to address the off-road portion of this issue by promulgating subpart B of the Travel Managemenr Rule,[12] with the purpose of curbing the most serious impacts associated with off-road vehicle use. Without a doubt, securing summer-time travel management plans was an important step to curbing the worst damage. However, much work remains to be done to approach sustainability, especially since many national forests used the travel management planning process to simply freeze the footprint of motorized routes, and did not try to re-design the system to make it more ecologically or socially sustainable. Adams

[11] 36 CFR 215 subpart A

[12] 36 CFR 212 subpart B

and McCool (2009) considered this question of how to achieve sustainable motorized recreation and concluded that:

> As the agencies move to revise [off-road vehicle] allocations, they need to clearly define how they intend to locate routes so as to minimize impacts to natural resources and other recreationists in accordance with Executive Order 11644....[13]
>
> …As they proceed with designation, the FS and BLM need to acknowledge that current allocations are the product of agency failure to act, not design. Ideally, ORV routes would be allocated as if the map were currently empty of ORV routes. Reliance on the current baseline will encourage inefficient allocations that likely disproportionately impact natural resources and non- motorized recreationists. While acknowledging existing use, the agencies need to do their best to imagine the best possible arrangement of ORV routes, rather than simply tinkering around the edges of the current allocations.[14]

The Forest Service only now is contemplating addressing the winter portion of the issue, forced by a lawsuit challenging the Forest Service's inadequate management of snowmobiles. The agency is expected to issue a third rule in the fall of 2014 that will trigger winter travel management planning.

Strategies for identifying a minimum road system and prioritizing restoration

Transportation Management plays an integral role in the restoration of Forestlands. Reclaiming and obliterating roads is key to developing a sustainable transportation system. Numerous authors have suggested removing roads 1) to restore water quality and aquatic habitats Gucinski et al. 2000), and 2) to improve habitat security and restore terrestrial habitat (e.g., USDI USFWS 1993, Hebblewhite et al. 2009).

Creating a minimum road system through road removal will increase connectivity and decrease fragmentation across the entire forest system. However, at a landscape scale, certain roads and road segments pose greater risks to terrestrial and aquatic integrity than others. Hence, restoration strategies must focus on identifying and removing/mitigating the higher risk roads. Additionally, areas with the highest ecological values, such as being adjacent to a roadless area, may also be prioritized for restoration efforts. Several methods have been developed to help prioritize road reclamation efforts including GIS-based tools and best management practices (BMPs). It is our hope that even with limited resources, restoration efforts can be prioritized and a more sustainable transportation system created.

GIS-based tools

---

[13] Recent court decisions have made it clear that the minimization requirements in the Executive Orders are not discretionary and that the Executive Orders are enforceable. See

- *Idaho Conservation League v. Guzman ,* 766 F. Supp. 2d 1056 (D. Idaho 2011) (Salmon-Challis National Forest TMP) .
- *The Wilderness Society v. U.S. Forest Service*, CV 08-363 (D. Idaho 2012) (Sawtooth-Minidoka district National Forest TMP).
- *Central Sierra Environmental Resource Center v. US Forest Service*, CV 10-2172 (E.D. CA 2012) (Stanislaus National Forest TMP).

[14] Page 105.

Girvetz and Shilling (2003) developed a novel and inexpensive way to analyze environmental impacts from road systems using the Ecosystem Management Decision Support program (EMDS). EMDS was originally developed by the United States Forest Service, as a GIS-based decision support tool to conduct ecological analysis and planning (Reynolds 1999). Working in conjunction with Tahoe National Forest managers, Girvetz and Shilling (2003) used spatial data on a number of aquatic and terrestrial variables and modeled the impact of the forest's road network. The network analysis showed that out of 8233 km of road analyzed, only 3483 km (42%) was needed to ensure current and future access to key points. They found that the modified network had improved patch characteristics, such as significantly fewer "cherry stem" roads intruding into patches, and larger roadlessness.

Shilling et al. (2012) later developed a recreational route optimization model using a similar methodology and with the goal of identifying a sustainable motorized transportation system for the Tahoe National Forest (Figure 2). Again using a variety of environmental factors, the model identified routes with high recreational benefits, lower conflict, lower maintenance and management requirements, and lower potential for environmental impact operating under the presumption that such routes would be more sustainable and preferable in the long term. The authors combined the impact and benefit analyses into a recreation system analysis "that was effectively a cost-benefit accounting, consistent with requirements of both the federal Travel Management Rule (TMR) and the National Environmental Policy Act" (p. 392**).**

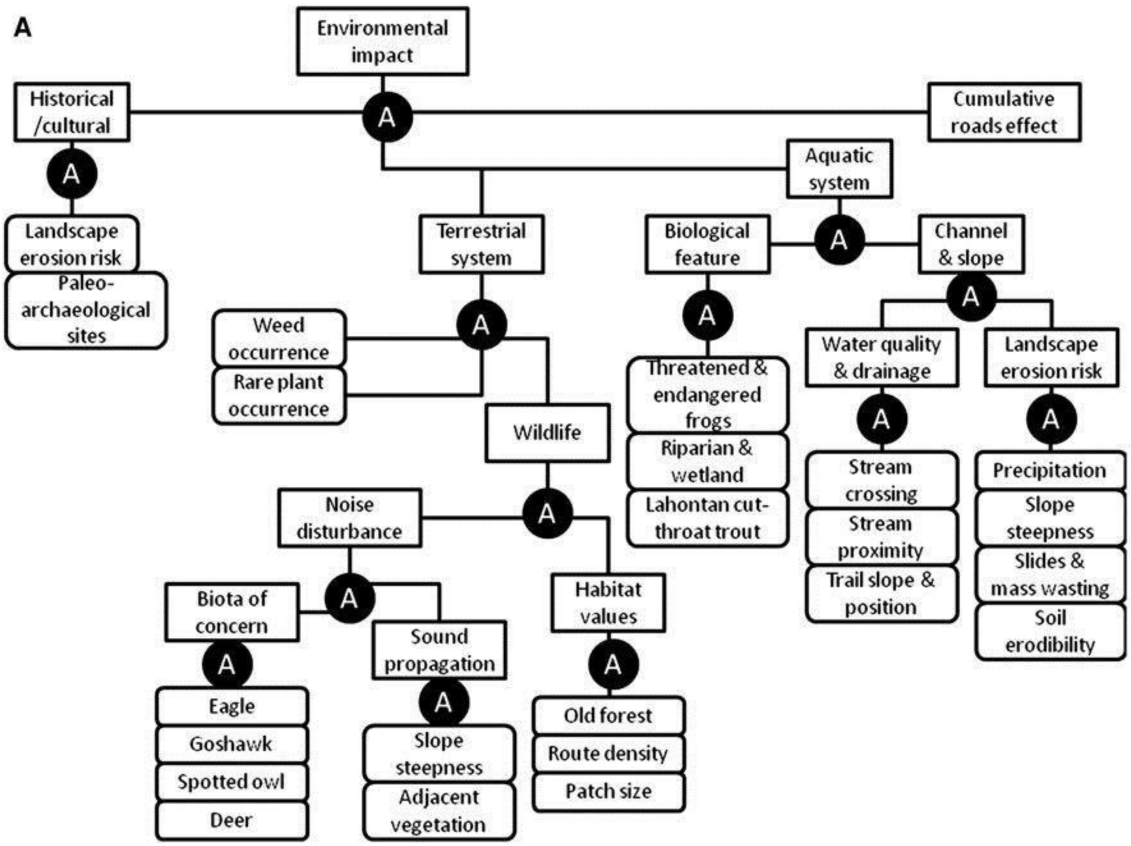


Figure 2: A knowledge base of contributions of various environmental conditions to the concept ''environmental impact'' [of motorized trails]. Rectangles indicate concepts, circles indicate Boolean logic operators, and rounded rectangles indicate sources of environmental data. (Reprinted from Shilling et al. 2012)

The Wilderness Society in 2012 also developed a GIS decision support tool called "RoadRight" that identifies high risk road segments to a variety of forest resources including water, wildlife, and roadlessness (The Wilderness Society 2012, The Wilderness Society 2013). The GIS system is designed to provide information that will help forest planners identify and minimize road related environmental risks. See the summary of and user guide for RoadRight that provides more information including where to access the open source software.[15]

---

[15] The Wilderness Society, 2012. Rightsizing the National Forest Road System: A Decision Support Tool. Available at http://www.landscapecollaborative.org/download/attachments/12747016/Road+decommissioning+model+-overview+2012-02-29.pdf?version=1&modificationDate=1331595972330.

The Wilderness Society, 2013.
RoadRight: A Spatial Decision Support System to Prioritize Decommissioning and Repairing Roads in

Best management practices (BMPs)

BMPs have also been developed to help create more sustainable transportation systems and identify restoration opportunities. BMPs provide science-based criteria and standards that land managers follow in making and implementing decisions about human uses and projects that affect natural resources. Several states have developed BMPs for road construction, maintenance and decommissioning practices (e.g., Logan 2001, Merrill and Cassaday 2003, USDA Forest Service 2012b).

Recently, BMPs have been developed for addressing motorized recreation. Switalski and Jones (2012) published, "*Off-Road Vehicle Best Management Practices for Forestlands: A Review of Scientific Literature and Guidance for Managers*." This document reviews the current literature on the environmental and social impacts of off-road vehicles (ORVs), and establishes a set of Best Management Practices (BMPs) for the planning and management of ORV routes on forestlands. The BMPs were designed to be used by land managers on all forestlands, and is consistent with current forest management policy and regulations. They give guidance to transportation planners on where how to place ORV routes in areas where they will reduce use conflicts and cause as little harm to the environment as possible. These BMPs also help guide managers on how to best remove and restore routes that are redundant or where there is an unacceptable environmental or social cost.

References

AASHTO. 2012. Adapting Infrastructure to Extreme Weather Events: Best Practices and Key Challenges. Background Paper. AASHTO Workshop. Traverse City, Michigan, May 20, 2012. Available at: http://climatechange.transportation.org/pdf/adapt_background5-20-12.pdf.

Adams, J.C., and S.F. McCool. 2009. Finite recreation opportunities: The Forest Service, the Bureau of Land Management, and off-road vehicle management. Natural Areas Journal 49: 45–116.

Anderson, H.M., C. Gaolach, J. Thomson, and G. Aplet. 2012. Watershed Health in Wilderness, Roadless, and Roaded Areas of the National Forest System. Wilderness Society Report. 11 p.

Battin J., M.W. Wiley, M.H. Ruckelshaus, R.N. Palmer, E. Korb, K.K. Bartz, and H. Imaki. 2007. Projected impacts of climate change on salmon habitat restoration. Proceedings of the National Academy of Sciences of the United States of America 104: 6720–6725.

Baxter, C.V., C.A. Frissell, and F.R. Hauer. 1999. Geomorphology, logging roads, and the distribution of bull trout spawning in a forested river basin: implications for management and conservation. Transactions of the American Fisheries Society 128: 854–867.

Baxter, G. 2002. All terrain vehicles as a cause of fire ignition in Alberta forests. Advantage (Publication of the Forest Engineering Research Institute of Canada) 3(44): 1-7.

National Forests User Guide. RoadRight version: 2.2, User Guide version: February, 2013. Available at http://www.landscapecollaborative.org/download/attachments/18415665/RoadRight%20User%20Guide%20v22.pdf?api=v2

Beazley, K., T. Snaith, F. MacKinnon, and D. Colville. 2004. Road density and the potential impacts on wildlife species such as American moose in mainland Nova Scotia. Proceedings of the Nova Scotia Institute of Science 42: 339-357.

Benítez-López , A., R. Alkemade, and P.A. Verweij. 2010. The impacts of roads and other infrastructure on mammal and bird populations: a meta-analysis. Biological Conservation 143: 1307-1316.

Beyer, H.L., R. Ung, D.L. Murray, and M.J. Fortin. 2013 Functional responses, seasonal variation and thresholds in behavioural responses of moose to road density. Journal of Applied Ecology 50: 286–294.

Brehme, C.S., and J.A. Tracey, L.R. McClenaghan, and R.N. Fisher. 2013. Permeability of roads to movement of scrubland lizards and small mammals. Conservation Biology 27(4): 710–720.

Bowles, A.E. 1997. Responses of wildlife to noise. In Wildlife and recreationists: coexistence through management and research. Edited by R.L. Knight and K.J. Gutzwiller. Island Press, Washington, DC. p. 109–156.

Brody, A.J., and M.R. Pelton. 1989. Effects of roads on black bear movements in western North Carolina. Wildlife Society Bulletin 17: 5-10.

Carnefix, G., and C. A. Frissell. 2009. Aquatic and Other Environmental Impacts of Roads: The Case for Road Density as Indicator of Human Disturbance and Road-Density Reduction as Restoration Target; A Concise Review. Pacific Rivers Council Science Publication 09-001. Pacific Rivers Council, Portland, OR and Polson, MT. Available at: http://www.pacificrivers.org/science-research/resources-publications/road-density-as-indicator/download

Coffin, A. 2006. From roadkill to road ecology: A review of the ecological effects of roads. Journal of Transport Geography 15: 396-406.

Crist, M.R., and B. Wilmer. 2002. Roadless Areas: The Missing Link in Conservation. The Wilderness Society, Washington D.C.

Davenport, J., and T.A. Switalski. 2006. Environmental impacts of transport related to tourism and leisure activities. In: The ecology of transportation: managing mobility for the environment, editors: J Davenport and Julia Davenport. Dordrecht, Netherlands: Kluwer Academic Publishers. 333-360. Available at: http://www.wildlandscpr.org/files/uploads/PDFs/d_Switalski_2006_Enviro_impacts_of_transport.pdf

DellaSala, D., J. Karr, and D. Olson. 2011. Roadless areas and clean water. Journal of Soil and Water Conservation, vol. 66, no. 3. May/June 2011.

DeVelice, R., and J.R. Martin. 2001. Assessing the extent to which roadless areas complement the conservation of biological diversity. Ecological Applications 11(4): 1008-1018.

Endicott, D. 2008. National Level Assessment of Water Quality Impairments Related to Forest Roads and Their Prevention by Best Management Practices. A Report Prepared by the Great Lakes Environmental Center for the Environmental Protection Agency, Office of Water, December 4, 2008. 259 pp.

Edge, W.D., and C.L. Marcum. 1985. Movements of elk in relation to logging disturbances. Journal of Wildlife Management 49(4): 926–930.

Fahrig, L., and T. Rytwinski. 2009. Effects of roads on animal abundance: an empirical review and synthesis. Ecology and Society 14(1): 21. Available at: http://www.ecologyandsociety.org/vol14/iss1/art21/.

Foltz, R.B. N.S. Copeland, and W.J. Elliot. 2009. Reopening abandoned forest roads in northern Idaho, USA: Quantification of runoff, sediment concentration, infiltration, and interrill erosion parameters. Journal of Environmental Management 90: 2542–2550.

Forman, R. T. T., and A.M. Hersperger. 1996. Road ecology and road density in different landscapes, with international planning and mitigation solutions. Pages 1–22. IN: G. L. Evink, P. Garrett, D. Zeigler, and J. Berry (eds.), Trends in Addressing Transportation Related Wildlife Mortality. No. FLER- 58-96, Florida Department of Transportation, Tallahassee, Florida.

Foreman, R.T.T., D. Sperling, J.A. Bissonette et al. 2003. Road Ecology – Science and Solutions. Island Press. Washington, D.C. 504 p.

Furniss, M.J., T.D. Roelofs, and C.S. Yee. 1991. Road construction and maintenance. In: Meehan, W.R., ed. Influences of forest and rangeland management on salmonid fishes and their habitats. Spec. Publ. 19. Bethesda, MD: American Fisheries Society. p. 297-323.

Gaines, W.L., P. Singleton, and R.C. Ross. 2003. Assessing the cumulative effects of linear recreation routes on wildlife habitats on the Okanogan and Wenatchee National Forests. Gen. Tech. Rep. PNW-GTR-586. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 79 p. Available at: http://www.montanawildlife.com/projectsissues/Assessingthecumulativeeffectsoflinearrecreationroutesonwildlifehabitats.pdf

Gelbard, J.L., and S. Harrison. 2003. Roadless habitats as refuges for native grasslands: interactions with soil, aspect, and grazing. Ecological Applications 13(2): 404-415.

Girvetz, E., and F. Shilling. 2003. Decision Support for Road System Analysis and Modification on the Tahoe National Forest. Environmental Management 32(2): 218–233

Grant, A., C.R. Nelson, T.A. Switalski, and S.M. Rinehart. 2011. Restoration of native plant communities after road decommissioning in the Rocky Mountains: effect of seed mix composition & soil properties on vegetatative establishment. Restoration Ecology 19: 160-169.

Gucinski, M., J. Furniss, R. Ziemer, and M.H. Brookes. 2000. Forest Roads: A Synthesis of Scientific Information. Gen. Tech. Rep. PNWGTR-509. Portland, OR: U.S. Department of

Agriculture, Forest Service, Pacific Northwest Research Station. 103 p. Available at: http://www.fs.fed.us/pnw/pubs/gtr509.pdf.

Hargis, C.D., J.A. Bissonette, and D.T. Turner. 1999. The influence of forest fragmentation and landscape pattern on American martens. Journal of Applied Ecology 36(1): 157–172.

Hebblewhite, M., R.H. Munro, E.H Merrill. 2009. Trophic consequences of postfire logging in a wolf-ungulate system. Forest Ecology and Management 257(3): 1053-1062.

Holman, I.P., R.J. Nicholls, P.M. Berry, P.A. Harrison, E. Audsley, S. Shackley, and M.D.A. Rounsevell. 2005. A regional, multi-sectoral and integrated assessment of the impacts of climate and socio-economic change in the UK. Part II. Results. Climatic Change 71: 43-73.

Jalkotzy, M.G., P.I. Ross, and M.D. Nasserden. 1997. The effects of linear developments on wildlife: a review of selected scientific literature. Prepared for Canadian Association of Petroleum Producers. Arc Wildlife Services, Ltd., Calgary, AB. 115 p.

Jensen W.F., T.K. Fuller, and W.L. Robinson. 1986. Wolf (*Canis lupus*) distribution on the Onterio-Michigan border near Sault Ste. Marie. Canadian Field-Naturalist 100: 363-366.

Joslin, G., and H. Youmans, coordinators. 1999. Effects of recreation on Rocky Mountain wildlife: A Review for Montana. Committee on Effects of Recreation on Wildlife, Montana Chapter of The Wildlife Society. 307 p. Available at: http://joomla.wildlife.org/Montana/index

Kasworm, W.F., and T.L. Manley. 1990. Road and trail influences on grizzly bears and black bears in northwest Montana. International Conference on Bear Research and Management 8: 79-84.

Kerkvliet, J., J. Hicks, and B. Wilmer. 2008. Carbon Sequestered when Unneeded National Forest Roads are Revegetated. The Wilderness Society Briefing Memo. Available at: http://wilderness.org/sites/default/files/legacy/brief_carbonandroads.pdf.

Lee, D., J. Sedell, B.E. Rieman, R. Thurow, and J. Williams. 1997. Broad-scale assessment of aquatic species and habitats. In: An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins. Edited by T.M. Quigley and S.J. Arbelbide. General Technical ReportPNW-GTR-405. USDA Forest Service, Pacific Northwest Research Station, Portland, OR. Vol III. p. 183–196.

Lloyd, R., K. Lohse, and T.P.A. Ferre. 2013. Influence of road reclamation techniques on forest ecosystem recovery. Frontiers in Ecology and the Environment 11(2): 75-81.

Loucks, C., N. Brown, A. Loucks, and K. 2003. USDA Forest Service roadless areas: potential biodiversity conservation reserves. Conservation Ecology 7(2): 5. Available at: http://www.ecologyandsociety.org/vol7/iss2/art5/

Logan, R. 2001. Water Quality BMPs for Montana Forests. Montana Department of Environmental Quality. Missoula, MT. 60p. Available at:

https://dnrc.mt.gov/Forestry/Assistance/Practices/Documents/2001WaterQualityBMPGuide.pdf

Lyon, L.J. 1983. Road density models describing habitat effectiveness for elk. Journal of Forestry 81: 592-595.

Mace, R.D., J.S. Waller, T.L. Manley, L.J. Lyon, and H. Zuuring. 1996. Relationships among grizzly bears, roads and habitat in the Swan Mountains, MT. Journal of Applied Ecology. 33: 1395-1404.

Madej, M., J. Seney, and P. van Mantgem. 2013. Effects of road decommissioning on carbon stocks, losses, and emissions in north coastal California. Restoration Ecology 21(4): 439–446.

Mattson, D.J., S. Herrero, R.G. Wright, and C.M. Pease. 1996. Science and management of Rocky Mountain grizzly bears. Conservation Biology 10(4): 1013-1025.

McCaffery M., T.A. Switalski, and L. Eby. 2007. Effects of road decommissioning on stream habitat characteristics in the South Fork Flathead River, Montana. Transactions of the American Fisheries Society 136: 553-561.

McGurk, B.J., and D.R. Fong, 1995. Equivalent roaded area as a measure of cumulative effect of logging. Environmental Management 19: 609-621.

Mech, L D. 1989. Wolf population survival in an area of high road density. American Midland Naturalist 121: 387-389.

Mech, L. D., S.H. Fritts, G.L. Radde, and W.J. Paul. 1988. Wolf distribution and road density in Minnesota. Wildlife Society Bulletin 16: 85-87.

Merrilll, B.R., and E. Cassaday. 2003. Best Management Practices for Road Rehabilitation – Road – Stream Crossing Manual. California State Parks. Eureka, CA. 25p. Available at: http://www.parks.ca.gov/pages/23071/files/streamcrossingremovalbmp5_03.pdf

Mladenoff, D.J., T.A. Sickley, R.G. Haight, and A.P. Wydeven. 1995. A regional landscape analysis and prediction of favorable gray wolf habitat in the Northern Great Lakes region. Conservation Biology 9: 279-294.

Moore, T. 2007. [unpublished draft]. National Forest System Road Trends, Trends Analysis Submitted to Office of Management and Budget. United States Department of Agriculture, Forest Service, Engineering Staff, Washington Office, Washington, DC.

National Fish, Wildlife and Plants Climate Adaptation Partnership (NFWPCAP). 2012. National Fish, Wildlife and Plants Climate Adaptation Strategy. Association of Fish and Wildlife Agencies, Council on environmental Quality, Great Lakes Indian Fish and Wildlife Commission, National Oceanic and Atmospheric Administration, and U.S. Fish and Wildlife Service. Washington, DC.

Noss, R.F. 2001. Beyond Kyoto: forest management in a time of rapid climate change. Conservation Biology 15(3): 578-590.

Ortega, Y.K., and D.E. Capen. 2002. Roads as edges: effects on birds in forested landscapes. Forest Science 48(2): 381–396.

Ouren, D.S., C. Haas, C.P. Melcher, S.C. Stewart, P.D. Ponds, N.R. Sexton, L. Burris, T. Fancher, and Z.H. Bowen. 2007. Environmental effects of off-highway vehicles on Bureau of Land Management lands: A literature synthesis, annotated bibliographies, extensive bibliographies, and internet resources: U.S. Geological Survey, Open-File Report 2007-1353, 225 p.

Parmesan, C. 2006. Ecological and evolutionary responses to recent climate change. Annual Review of Ecology, Evolution, and Systematics 37: 637-669.

Quigley, T.M., and S.J. Arbelbide, tech. eds. 1997. An assessment of ecosystem components in the interior Columbia basin and portions of the Klamath and Great Basins: volume 1 and volume 3. Gen. Tech. Rep. PNW-GTR-405. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.
Available at: http://www.fs.fed.us/pnw/publications/pnw_gtr405/.

Reynolds, K. 1999. Netweaver for EMDS user guide (version1.1); a knowledge base development system. General technical Report PNW-GTR-471. USDA Forest Service, Pacific Northwest Research Station, Portland, OR.

Rhodes, J.J., McCullough, D.A., and F.A. Espinosa. 1994. A coarse screening process for evaluation of the effects of land management activities on salmon spawning and rearing habitat in ESA consultations. Tech. Rep. 94-4. Portland, OR: Columbia River Intertribal Fish Commission. 127 p.

Rieman, B., D. Lee, G. Chandler, and D. Myers. 1997. Does wildfire threaten extinction for salmonids? Responses of Redband Trout and Bull Trout Following Recent Large Fires on the Boise National Forest, in Greenlee, J. M., Proceedings: First Conference on Fire Effects on Rare and Endangered Species and Habitats. Coeur d'Alene, Idaho. International Association of Wildland Fire. Fairfield, WA. p. 47-57.

Robichaud, P.R., L.H. MacDonald, and R.B. Foltz. 2010. Fuel management and Erosion. In: Cumulative Watershed Effects of Fuels Management in the Western United States. USDA Forest Service RMRS-GTR-231. P. 79-100. Available at:
http://www.fs.fed.us/rm/pubs/rmrs_gtr231/rmrs_gtr231_079_100.pdf

Robinson, C., P.N. Duinker, and K.F. Beazley. 2010. A conceptual framework for understanding, assessing, and mitigation effects for forest roads. Environmental Review 18: 61-86.

Rooney, T.P. 2006. Distribution of ecologically-invasive plants along off-road vehicle trails in the Chequamegon National Forest, Wisconsin. The Michigan Botanist 44:178-182

Rost, G.R., and J.A. Bailey. 1979. Distribution of mule deer and elk in relation to roads. Journal of Wildlife Management 43(3): 634–641.

Rowland, M.M., M.J. Wisdom, B.K. Johnson, and M.A. Penninger. 2005. Effects of roads on elk: implications for management in forested ecosystems. Pages 42-52. IN: Wisdom, M.J., technical editor, The Starkey Project: a Synthesis of Long-term Studies of Elk and Mule Deer. Reprinted from the 2004 Transactions of the North American Wildlife and Natural Resources Conference, Alliance Communications Group, Lawrence, KS.

Schiffman, L. 2005. Archaeology, Off-Road Vehicles, and the BLM. Published online April 20, 2005. Archeaology.
Available at: http://www.archaeology.org/online/features/southwest/

Semlitsch, R.D., T.J. Ryan, K. Hamed, M. Chatfield, B. Brehman, N. Pekarek, M. Spath, and A. Watland. 2007. Salamander abundance along road edges and within abandoned logging roads in Appalachian forests. Conservation Biology 21: 159-167.

Shilling, F., J. Boggs, and S. Reed. 2012. Recreational System Optimization to Reduce Conflict on Public Lands. Environmental Management 50: 381–395.

Strittholt, J., and D. Dellasala. 2001. Importance of Roadless Area Conservation in Forested Ecosystems: Case Study of the Klamath-Siskiyou Region of the United States. In Conservation Biology 15(6): 1742-1754.

Switalski, T.A., J.A. Bissonette, T.H. DeLuca, C.H. Luce, and M.A. Madej. 2004. Benefits and impacts of road removal. Frontiers in Ecology and the Environment. 2(1): 21-28.
Available at: http://www.fs.fed.us/rm/pubs_other/rmrs_2004_switalski_t001.pdf

Switalski, T.A., and C.R. Nelson. 2011. Efficacy of road removal for restoring wildlife habitat: black bear in the Northern Rocky Mountains, USA. Biological Conservation 144: 2666-2673.

Switalski, T.A., and A. Jones. 2012. Off-road vehicle best management practices for forestlands: A review of scientific literature and guidance for managers. Journal of Conservation Planning 8: 12-24.

The Wilderness Society. 2004. Landscape Connectivity: An Essential Element of Land Management. Policy Brief. Number 1.

The Wilderness Society. 2012. Rightsizing the National Forest Road System: A Decision Support Tool.   Available at:
http://www.landscapecollaborative.org/download/attachments/12747016/Road+decommissioning+model+-overview+2012-02-29.pdf?version=1&modificationDate=1331595972330.

The Wilderness Society. 2013. RoadRight: A Spatial Decision Support System to Prioritize Decommissioning and Repairing Roads in National Forests User Guide. RoadRight version: 2.2, User Guide version: February, 2013.

Available at:
http://www.landscapecollaborative.org/download/attachments/18415665/RoadRight%20User%20Guide%20v22.pdf?api=v2

Thiel, R.P. 1985. The relationships between road densities and wolf habitat in Wisconsin. American Midland Naturalist 113: 404-407.

Trombulak S., and C. Frissell. 2000. Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology 14(1): 18-30.

USDA Forest Service. 1996a. National Forest Fire Report, 1994. Washington DC.

USDA Forest Service. 1996b. Status of the interior Columbia basin: summary of scientific findings. Gen. Tech. Rep. PNW-GTR-385. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station; U.S. Department of the Interior, Bureau of Land Management. 144 p.

USDA Forest Service. 1998. 1991-1997 Wildland Fire Statistics. Fire and Aviation Management, Washington, D.C.

USDA Forest Service. 1999. Roads Analysis: Informing Decisions about Managing the National Forest Transportation System. Misc. Rep. FS-643. Washington, D.C.: USDA Forest Service. 222 p. Available at: http://www.fs.fed.us/eng/road_mgt/DOCSroad-analysis.shtml

USDA Forest Service. 2001a. Final National Forest System Road Management Strategy Environmental Assessment and Civil Rights Impact Analysis. U.S. Department of Agriculture Forest Service Washington Office, January 2001.

USDA Forest Service. 2010. Water, Climate Change, and Forests: Watershed Stewardship for a Changing Climate, PNW-GTR-812, June 2010, 72 p.
Available at: http://www.fs.fed.us/pnw/pubs/pnw_gtr812.pdf.

USDA Forest Service. 2011a. Adapting to Climate Change at Olympic National Forest and Olympic National Park. Forest Service Pacific Northwest Research Station General Technical Report, PNW-GTR-844, August 2011.
Available at: http://www.fs.fed.us/pnw/pubs/pnw_gtr844.pdf

USDA Forest Service. 2011b. National Roadmap for Responding to Climate Change. US Department of Agriculture. FS-957b. 26 p.
Available at: http://www.fs.fed.us/climatechange/pdf/Roadmap_pub.pdf.

USDA Forest Service. 2012a. Assessing the Vulnerability of Watersheds to Climate Change: Results of National Forest Watershed Vulnerability Pilot Assessments. Climate Change Resource Center.

USDA Forest Service. 2012b. National Best Management Practices for Water Quality Management on National Forest System Lands. Report# FS-990. 177p. Available at:

http://www.fs.fed.us/biology/resources/pubs/watershed/FS_National_Core_BMPs_April2012.pdf

USDI Fish and Wildlife Service. 1993. Grizzly bear recovery plan. Missoula, MT. 181p.

USDI Fish and Wildlife Service. 1999. Endangered and Threatened Wildlife and Plants; Determination of Threatened Status for Bull Trout in the Coterminous United States; Final Rule. Federal Register Volume 64, Number 210 (Monday, November 1, 1999). p. 58922.

USDI Bureau of Land Management. 2000. Strategic paper on cultural resources at risk. Bureau of Land Management, Washington, D.C. 18 p.

USDI National Park Service. 2010. Climate Change Response Strategy. National Park Service Climate Change Response Program, Fort Collins, Colorado. Available at: http://www.nature.nps.gov/climatechange/docs/NPS_CCRS.pdf.

van Dyke, F.G., R.H. Brocke, H.G. Shaw, B.B Ackerman, T.P. Hemker, and F.G. Lindzey. 1986. Reactions of mountain lions to logging and human activity. Journal of Wildlife Management. 50(1): 95–102.

Wasser, S.K., K. Bevis, G. King, and E. Hanson. 1997. Noninvasive physiological measures of disturbance in the northern spotted owl. Conservation Biology 11(4): 1019–1022.

Wemple, B.C., J.A. Jones, and G.E. Grant. 1996. Channel network extension by logging roads in two basins, western Cascades, OR. Water Resources Bulletin 32: 1195-1207.

Wemple, B.C., F.J. Swanson, and J.A. Jones. 2001. Forest Roads and geomorphic process interactions, Cascade Range, Oregon. Earth Surface Process and Landforms 26: 191-204. Available at: http://andrewsforest.oregonstate.edu/pubs/pdf/pub2731.pdf

Wilcove, D.S. 1990. The role of wilderness in protecting biodiversity. Natural Resources and Environmental Issues: Vol. 0, Article 7.

Wisdom, M.J., R.S. Holthausen, B.C. Wales, C.D. Hargis, V.A. Saab, D.C. Lee, W.J. Hann, T.D. Rich, M.M. Rowland, W.J. Murphy, and M.R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: Broad-scale trends and management implications. Volume 1 – Overview. Gen. Tech. Rep. PNW-GTR-485. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.
Wydeven, A.P, D.J. Mladenoff, T.A. Sickley, B.E. Kohn, R.P. Thiel, and J.L. Hansen. 2001. Road density as a factor in habitat selection by wolves and other carnivores in the Great Lakes Region. Endangered Species Update 18(4): 110-114.

Attachments

Attachment 1: Wildfire and Roads Fact Sheet

Attachment 2: Using Road Density as a Metric for Ecological Health in National Forests: What Roads and Routes should be Included? Summary of Scientific Information

Roads and Fire: A Proven Relationship

Photo: Lou Anegli Digital

Roaded Forests Are at a Greater Risk of Experiencing Wildfires than Unroaded Forests

- A wildland fire ignition is almost twice as likely to occur in a roaded area than in a roadless area. (USDA 2000, Table 3-18)
- The location of large wildfires is often correlated with proximity to busy roads. (Sierra Nevada Ecosystem Project, 1996)
- High road density increases the probability of fire occurrence due to human-caused ignitions. (Hann, W.J., et al. 1997)
- Unroaded areas have lower potential for high-intensity fires than roaded areas because they are less prone to human-caused ignitions. (DellaSala, et al. 1995)
- The median size of large fires on national forests is greater outside of roadless areas. (USDA 2000, Table 3-22)
- A positive correlation exists between lightning fire frequency and road density due to increased availability of flammable fine fuels near roads. (Arienti, M. Cecilia, et al. 2009)
- Human caused wildfires are strongly associated with access to natural landscapes, with the proximity to urban areas and roads being the most important factor (Romero-Calcerrada, et al. 2008)

For more information, contact Gregory H. Aplet, Ph.D., Senior Forest Scientist, at greg_aplet@tws.org or 303-650-5818 x104.

Human Activity and Wildfire

- Sparks from cars, off-road vehicles, and neglected campfires caused nearly 50,000 wildfire ignitions in 2000. (USDA 2000, Fuel Management and Fire Suppression Specialist Report, Table 4.)
- More than 90% of fires on national lands are caused by humans (USDA 1996 and 1998)
- Human-ignited wildfire is almost 5 times more likely to occur in a roaded area than in a roadless area (USDA 2000, Table 3-19).

There are 375,000 miles of roads in our national forests.

The Wilderness Society

1615 M St. N.W.
Washington, D.C. 20036

(202) 833-2300

wilderness.org

Roads and Fire: A Proven Relationship

Photo: USDA Forest Service, Coconino National Forest

References

Arienti, M. Cecilia; Cumming, Steven G., et al. 2009. Road network density correlated with increased lightning fire incidence in the Canadian western boreal forest. International Journal of Wildland Fire 2009, 18, 970–982

DellaSala, D.A., D.M. Olson and S.L. Crane. 1995. Ecosystem management and biodiversity conservation: Applications to in-landPacific Northwest forests. Pp. 139-160 in: R.L. Everett and D.M. Baumgartner, eds. Symposium Proceedings: Ecosystem Management inWestern Interior Forests. May 3-5, 1994, Spokane, WA. Washington State University Cooperative Extension, Pullman, WA.

Hann, W.J., et al. 1997. An Assessment of Ecosystem Components in the Interior Columbia Basin and Portions of the Klamath and Great Basins: Volume II, Ch. 3, p. 882

Romer-Calcerrada, Raul. 2008. GIS analysis of spatial patterns of human-caused wildfire ignoition risk in the SW of Madrid (Central Spain). Landscape Ecol. 23:341-354.

Sierra Nevada Ecosystem Project. 1996. Status of the Sierra Nevada: Sierra Nevada Ecosystem Project, Final Report to Congress Volume I: Assessment summaries and management strategies. Wildland Resources Center Report No. 37. Center for Water and Wildland Resources, Unversity of California, Davis, CA.

USDA Forest Service. 1996. National Forest Fire Report 1994.Washington, D.C.

USDA Forest Service. 1998. 1991-1997 Wildland fire statistics. Fire and Aviation Management, Washington, D.C.

USDA. 2000. Forest Service Roadless Area Conservation Rule Final Environmental Impact Statement, Ch. 3,.

THE WILDERNESS SOCIETY

1615 M St. N.W.
Washington, D.C. 20036

(202) 833-2300

wilderness.org

Attachment 2: Using Road Density as a Metric for Ecological Health in National Forests: What Roads and Routes should be Included?
Summary of Scientific Information
Last Updated, November 22, 2012

I. Density analysis should include closed roads, non-system roads administered by other jurisdictions (private, county, state), temporary roads and motorized trails.

Typically, the Forest Service has calculated road density by looking only at open system road density. From an ecological standpoint, this approach may be flawed since it leaves out of the density calculations a significant percent of the total motorized routes on the landscape. For instance, the motorized route system in the entire National Forest System measures well over 549,000 miles.[1] By our calculation, a density analysis limited to open system roads would consider less than 260,000 miles of road, which accounts for less than half of the entire motorized transportation system estimated to exist on our national forests.[2] These additional roads and motorized trails impact fish, wildlife, and water quality, just as open system roads do. In this section, we provide justification for why a road density analysis used for the purposes of assessing ecological health and the effects of proposed alternatives in a planning document should include closed system roads, non-system roads administered by other jurisdictions, temporary roads, and motorized trails.

Impacts of closed roads

It is crucial to distinguish the density of roads physically present on the landscape, whether closed to vehicle use or not, from "open-road density" (Pacific Rivers Council, 2010). An open-road density of 1.5 mi/mi² has been established as a standard in some national forests as protective of some terrestrial wildlife species. However, many areas with an open road density of 1.5 mi/mi² have a much higher inventoried or extant hydrologically effective road density, which may be several-fold as high with significant aquatic impacts. This higher density occurs because many road "closures" block vehicle access, but do nothing to mitigate the hydrologic alterations that the road causes. The problem is

[1] The National Forest System has about 372,000 miles of system roads. The forest service also has an estimated 47,000 miles of motorized trails. As of 1998, there were approximately 130,000 miles of non-system roads in our forests. Non-system roads include public roads such as state, county, and local jurisdiction and private roads. (USFS, 1998) The Forest Service does not track temporary roads but is reasonable to assume that there are likely several thousand miles located on National Forest System lands.

[2] About 30% of system roads, or 116,108 miles, are in Maintenance Level 1 status, meaning they are closed to all motorized use. (372,000 miles of NFS roads - 116,108 miles of ML 1 roads = 255,892). This number is likely conservative given that thousands of more miles of system roads are closed to public motorized use but categorized in other Maintenance Levels.

further compounded in many places by the existence of "ghost" roads that are not captured in agency inventories, but that are nevertheless physically present and causing hydrologic alteration (Pacific Watershed Associates, 2005).

Closing a road to public motorized use can mitigate the impacts on water, wildlife, and soils only if proper closure and storage technique is followed. Flow diversions, sediment runoff, and illegal incursions will continue unabated if necessary measures are not taken. The Forest Service's National Best Management Practices for non-point source pollution recommends the following management techniques for minimizing the aquatic impacts from closed system roads: eliminate flow diversion onto the road surface, reshape the channel and streambanks at the crossing-site to pass expected flows without scouring or ponding, maintain continuation of channel dimensions and longitudinal profile through the crossing site, and remove culverts, fill material, and other structures that present a risk of failure or diversion. Despite good intentions, it is unlikely given our current fiscal situation and past history that the Forest Service is able to apply best management practices to all stored roads,[3] and that these roads continue to have impacts. This reality argues for assuming that roads closed to the public continue to have some level of impact on water quality, and therefore, should be included in road density calculations.

As noted above, many species benefit when roads are closed to public use. However, the fact remains that closed system roads are often breached resulting in impacts to wildlife. Research shows that a significant portion of off-road vehicle (ORV) users violates rules even when they know what they are (Lewis, M.S., and R. Paige, 2006; Frueh, LM, 2001; Fischer, A.L., et. al, 2002; USFWS, 2007.). For instance, the Rio Grande National Forest's Roads Analysis Report notes that a common travel management violation occurs when people drive around road closures on Level 1 roads (USDA Forest Service, 1994). Similarly, in a recent legal decision from the Utah District Court , *Sierra Club v. USFS*, Case No. 1:09-cv-131 CW (D. Utah March 7, 2012), the court found that, as part of analyzing alternatives in a proposed travel management plan, the Forest Service failed to take a hard look at the impact of continued illegal use. In part, the court based its decision on the Forest Service's acknowledgement that illegal motorized use is a significant problem and that the mere presence of roads is likely to result in illegal use.

In addition to the disturbance to wildlife from ORVs, incursions and the accompanying human access can also result in illegal hunting and trapping of animals. The Tongass National Forest refers to this in its EIS to amend the Land and Resources Management Plan. Specifically, the Forest Service notes in the EIS that Alexander Archipelego wolf mortality due to legal and illegal hunting and trapping is related not only to roads open to motorized access, but to all roads, and that *total road densities* of 0.7-1.0 mi/mi^2 or less may be necessary (USDA Forest Service, 2008).

As described below, a number of scientific studies have found that ORV use on roads and trails can have serious impacts on water, soil and wildlife resources. It should be expected that ORV use will continue to

[3] The Forest Service generally reports that it can maintain 20-30% of its open road system to standard.

some degree to occur illegally on closed routes and that this use will affect forest resources. Given this, roads closed to the general public should be considered in the density analysis.

Impacts of non-system roads administered by other jurisdictions (private, county, state)

As of 1998, there were approximately 130,000 miles of non-system roads in national forests (USDA Forest Service, 1998). These roads contribute to the environmental impacts of the transportation system on forest resources, just as forest system roads do. Because the purpose of a road density analysis is to measure the impacts of roads at a landscape level, the Forest Service should include all roads, including non-system, when measuring impacts on water and wildlife. An all-inclusive analysis will provide a more accurate representation of the environmental impacts of the road network within the analysis area.

Impacts of temporary roads

Temporary roads are not considered system roads. Most often they are constructed in conjunction with timber sales. Temporary roads have the same types environmental impacts as system roads, although at times the impacts can be worse if the road persists on the landscape because they are not built to last.

It is important to note that although they are termed temporary roads, their impacts are not temporary. According to Forest Service Manual (FSM) 7703.1, the agency is required to "Reestablish vegetative cover on any unnecessary roadway or area disturbed by road construction on National Forest System lands within 10 years after the termination of the activity that required its use and construction." Regardless of the FSM 10-year rule, temporary roads can remain for much longer. For example, timber sales typically last 3-5 years or more. If a temporary road is built in the first year of a six year timber sale, its intended use does not end until the sale is complete. The timber contract often requires the purchaser to close and obliterate the road a few years after the Forest Service completes revegetation work. The temporary road, therefore, could remain open 8-9 years before the ten year clock starts ticking per the FSM. Therefore, temporary roads can legally remain on the ground for up to 20 years or more, yet they are constructed with less environmental safeguards than modern system roads.

Impacts of motorized trails

Scientific research and agency publications generally do not decipher between the impacts from motorized trails and roads, often collapsing the assessment of impacts from unmanaged ORV use with those of the designated system of roads and trails. The following section summarizes potential impacts resulting from roads and motorized trails and the ORV use that occurs on them.

Aquatic Resources
While driving on roads has long been identified as a major contributor to stream sedimentation (for review, see Gucinski, 2001), recent studies have identified ORV routes as a significant cause of stream sedimentation as well (Sack and da Luz, 2004; Chin et al.; 2004, Ayala et al.; 2005, Welsh et al;. 2006). It has been demonstrated that sediment loss increases with increased ORV traffic (Foltz, 2006). A study by

Sack and da Luz (2004) found that ORV use resulted in a loss of more than 200 pounds of soil off of every 100 feet of trail each year. Another study (Welsh et al., 2006) found that ORV trails produced five times more sediment than unpaved roads. Chin et al. (2004) found that watersheds with ORV use as opposed to those without exhibited higher percentages of channel sands and fines, lower depths, and lower volume – all characteristics of degraded stream habitat.

Soil Resources [4]

Ouren, et al. (2007), in an extensive literature review, suggests ORV use causes soil compaction and accelerated erosion rates, and may cause compaction with very few passes. Weighing several hundred pounds, ORVs can compress and compact soil (Nakata et al., 1976; Snyder et al., 1976; Vollmer et al., 1976; Wilshire and Nakata, 1976), reducing its ability to absorb and retain water (Dregne, 1983), and decreasing soil fertility by harming the microscopic organisms that would otherwise break down the soil and produce nutrients important for plant growth (Wilshire et al., 1977). An increase in compaction decreases soil permeability, resulting in increased flow of water across the ground and reduced absorption of water into the soil. This increase in surface flow concentrates water and increases erosion of soils (Wilshire, 1980; Webb, 1983; Misak et al., 2002).

Erosion of soil is accelerated in ORV-use areas directly by the vehicles, and indirectly by increased runoff of precipitation and the creation of conditions favorable to wind erosion (Wilshire, 1980). Knobby and cup-shaped protrusions from ORV tires that aid the vehicles in traversing steep slopes are responsible for major direct erosional losses of soil. As the tire protrusions dig into the soil, forces far exceeding the strength of the soil are exerted to allow the vehicles to climb slopes. The result is that the soil and small plants are thrown downslope in a "rooster tail" behind the vehicle. This is known as mechanical erosion, which on steep slopes (about 15° or more) with soft soils may erode as much as 40 tons/mi (Wilshire, 1992). The rates of erosion measured on ORV trails on moderate slopes exceed natural rates by factors of 10 to 20 (Iverson et al., 1981; Hinckley et al., 1983), whereas use on steep slopes has commonly removed the entire soil mantle exposing bedrock. Measured erosional losses in high use ORV areas range from 1.4-242 lbs/ft^2 (Wilshire et al., 1978) and 102-614 lbs/ft^2 (Webb et al., 1978). A more recent study by Sack and da Luz (2003) found that ORV use resulted in a loss of more than 200 lbs of soil off of every 100 feet of trail each year.

Furthermore, the destruction of cryptobiotic soils by ORVs can reduce nitrogen fixation by cyanobacteria, and set the nitrogen economy of nitrogen-limited arid ecosystems back decades. Even small reductions in crust can lead to diminished productivity and health of the associated plant community, with cascading effects on plant consumers (Davidson et al., 1996). In general, the deleterious effects of ORV use on cryptobiotic crusts is not easily repaired or regenerated. The recovery time for the lichen component of crusts has been estimated at about 45 years (Belnap, 1993). After this time the crusts may appear to have regenerated to the untrained eye. However, careful observation will reveal that the 45 year-old crusts will not have recovered their moss component, which will take an additional 200 years to fully come back (Belnap and Gillette, 1997).

[4] For a full review see Switalski, T. A. and A. Jones (2012).

Wildlife Resources [5]

Studies have shown a variety of possible wildlife disturbance vectors from ORVs. While these impacts are difficult to measure, repeated harassment of wildlife can result in increased energy expenditure and reduced reproduction. Noise and disturbance from ORVs can result in a range of impacts including increased stress (Nash et al., 1970; Millspaugh et al., 2001), loss of hearing (Brattstrom and Bondello, 1979), altered movement patterns (e.g., Wisdom et al. 2004; Preisler et al. 2006), avoidance of high-use areas or routes (Janis and Clark 2002; Wisdom 2007), and disrupted nesting activities (e.g., Strauss 1990).

Wisdom et al. (2004) found that elk moved when ORVs passed within 2,000 yards but tolerated hikers within 500 ft. Wisdom (2007) reported preliminary results suggesting that ORVs are causing a shift in the spatial distribution of elk that could increase energy expenditures and decrease foraging opportunities for the herd. Elk have been found to readily avoid and be displaced from roaded areas (Irwin and Peek, 1979; Hershey and Leege, 1982; Millspaugh, 1995). Additional concomitant effects can occur, such as major declines in survival of elk calves due to repeated displacement of elk during the calving season (Phillips, 1998). Alternatively, closing or decommissioning roads has been found to decrease elk disturbance (Millspaugh et al., 2000; Rowland et al., 2005).

Disruption of breeding and nesting birds is particularly well-documented. Several species are sensitive to human disturbance with the potential disruption of courtship activities, over-exposure of eggs or young birds to weather, and premature fledging of juveniles (Hamann et al., 1999). Repeated disturbance can eventually lead to nest abandonment. These short-term disturbances can lead to long-term bird community changes (Anderson et al., 1990). However when road densities decrease, there is an observable benefit. For example, on the Loa Ranger District of the Fishlake National Forest in southern Utah, successful goshawk nests occur in areas where the localized road density is at or below 2-3 mi/mi^2 (USDA, 2005).

Examples of Forest Service planning documents that use total motorized route density or a variant

Below, we offer examples of where total motorized route density or a variant has been used by the Forest Service in planning documents.

- The Mt. Taylor RD of the Cibola NF analyzed open and closed system roads and motorized trails together in a single motorized *route* density analysis. Cibola NF: Mt. Taylor RD Environmental Assessment for Travel Management Planning, Ch.3, p 55. http://prdp2fs.ess.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5282504.pdf.

- The Grizzly Bear Record of Decision (ROD) for the Forest Plan Amendments for Motorized Access

[5] For a full review see:Switalski, T. A. and A. Jones (2012).

Management within the Selkirk and Cabinet-Yaak Grizzly Bear Recovery Zones (Kootenai, Lolo, and Idaho Panhandle National Forests) assigned route densities for the designated recovery zones. One of the three densities was for Total Motorized Route Density (TMRD) which includes open roads, restricted roads, roads not meeting all reclaimed criteria, and open motorized trails. The agency's decision to use TMRD was based on the Endangered Species Act's requirement to use best available science, and monitoring showed that both open and closed roads and motorized trails were impacting grizzly. Grizzly Bear Plan Amendment ROD. Online at cache.eco system-m anagem ent.o rg /4 85 36 FSP LT1 00 97 20 .pdf .

- The Chequamegon-Nicolet National Forest set forest-wide goals in its forest plan for both open road density and total road density to improve water quality and wildlife habitat.

> *I decided to continue reducing the amount of total roads and the amount of open road to resolve conflict with quieter forms of recreation, impacts on streams, and effects on some wildlife species.* ROD, p 13.

Chequamegon-Nicolet National Forest Land and Resource Management Plan Record of Decision. Online at http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5117609.pdf.

- The Tongass National Forest's EIS to amend the forest plan notes that Alexander Archipelago wolf mortality due to legal and illegal hunting and trapping is related not only to roads open to motorized access, but to all roads, and that *total road densities* of 0.7-1.0 mi/mi² or less may be necessary.

> *Another concern in some areas is the potentially unsustainable level of hunting and trapping of wolves, when both legal and illegal harvest is considered. The 1997 Forest Plan EIS acknowledged that open road access contributes to excessive mortality by facilitating access for hunters and trappers. Landscapes with open-road densities of 0.7 to 1.0 mile of road per square mile were identified as places where human-induced mortality may pose risks to wolf conservation. The amended Forest Plan requires participation in cooperative interagency monitoring and analysis to identify areas where wolf mortality is excessive, determine whether the mortality is unsustainable, and identify the probable causes of the excessive mortality.*
>
> *More recent information indicates that wolf mortality is related not only to roads open to motorized access, but to all roads, because hunters and trappers use all roads to access wolf habitat, by vehicle or on foot. Consequently, this decision amends the pertinent standard and guideline contained in Alternative 6 as displayed in the Final EIS in areas where road access and associated human caused mortality has been determined to be the significant contributing factor to unsustainable wolf mortality. The standard and guideline has been modified to ensure that a range of options to reduce mortality risk will be considered in these areas, and to specify that total road densities of 0.7 to 1.0 mile per square mile or less may be necessary.* ROD, p 24.

Tongass National Forest Amendment to the Land and Resource Management Plan Record of Decision and Final EIS. January 2008. http://tongass-fpadjust.net/Documents/Record_of_Decision.pdf

References

Anderson, D.E., O.J. Rongstad, and W.R. Mytton. 1990. Home range changes in raptors exposed to increased human activity levels in southeastern Colorado. Wildlife Bulletin 18:134-142.

Ayala, R.D., P. Srivastava, C.J. Brodbeck, E.A. Carter, and T.P. McDonald. 2005. Modeling Sediment Transport from an Off-Road Vehicle Trail Stream Crossing Using WEPP Model. American Society of Agricultural and Biological Engineers, 2005 ASAE Annual International Meeting, Paper No: 052017.

Belnap, J. 1993. Recovery rates of cryptobiotic crusts: inoculant use and assessment methods. Great Basin Naturalist 53:89-95.

Belnap, J. and D.A. Gillette. 1997. Disturbance of biological soil crusts: impacts on potential wind erodibility of sandy desert soils in SE Utah. Land Degradation and Development 8: 355-362.

Brattstrom, B.H., and M.C. Bondello. 1979. The effects of dune buggy sounds on the telencephalic auditory evoke response in the Mojave fringe-toed lizard, Uma scoparia. Unpublished report to the U.S. Bureau of Land Management, California Desert Program, Riverside, CA. 31p.

Chin, A., D.M. Rohrer, D.A. Marion, and J.A. Clingenpeel. 2004. Effects of all terrain vehicles on stream dynamics. Pages:292-296 in Guldin, J.M. technical compiler, Ovachita and Ozark Mountains Symposium: ecosystem management research. General technical report SRS-74. Ashville, NC: USDA, FS, Southern Research Station.

Davidson, D.W, W.D. Newmark, J.W. Sites, D.K. Shiozawa, E.A. Rickart, K.T. Harper, and R.B. Keiter. 1996. Selecting Wilderness areas to conserve Utah's biological diversity. Great Basin Naturalist 56: 95-118.

Dregne, H.E. 1983. Physical effects of off-road vehicle use. Pages 15-30 in R.H. Webb and H.G. Wilshire. Environmental Effects of Off-Road Vehicles: Impacts and Management in Arid Regions. Springer-Verlag, New York.

Foltz, R.B. 2006. Erosion from all terrain vehicle (ATV) trails on National Forest lands. The American Society of Agricultural and Biological engineers (ASABE). Paper# 068012. St. Joseph, MI.

Frueh, LM. 2001. Status and Summary Report on OHV Responsible Riding Campaign. Prepared by Monaghan and Associates for the Colorado Coalition for Responsible OHV Riding. Available at http://www.wildlandscpr.org/files/CO%20OHV%20Focus%20Group%20StatusSummaryReport_1.pdf.

Gucinski, H., M. J. Furniss, R. R. Ziemer, and M. H. Brookes. 2001. Forest roads: a synthesis of scientific information. Gen. Tech. Rep. PNWGTR-509. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. http://www.fs.fed.us/pnw/pubs/gtr509.pdf

Hamann, B., H. Johnston, P. McClelland, S. Johnson, L. Kelly, and J. Gobielle. 1999. Birds. Pages 3.1-3.34 in Joslin, G. and H. Youmans, coordinators Effects of Recreation on Rocky Mountain Wildlife: A Review for Montana.

Hershey, T.J., and T.A. Leege. 1982. Elk movements and habitat use on a managed forest in north-central Idaho. Idaho Department of Fish and Game. 32p.

Hinckley, B.S., Iverson, R.M. and B. Hallet. 1983. Accelerated water erosion in ORV-use areas. Pages 81-96 in Webb, R.H. and H.G. Wilshire, editors, Environmental Effects of Off-Road Vehicles. Springer-Verlag, New York.

Irwin, L.L., and J.M. Peek. 1979. Relationship between road closure and elk behavior in northern Idaho. Pages 199-205 in Boyce, M.S. and L.D. Hayden-Wing, editors, North American Elk: Ecology, Behavior, and Management. Laramie, WY: University of Wyoming.

Iverson, R.M., Hinckley, B.S., and R.H. Webb. 1981. Physical effects of vehicular disturbance on arid landscapes. Science 212: 915-917.

Janis, M.W., and J.D. Clark. 2002. Responses of Florida panthers to recreational deer and hog hunting. Journal of Wildlife Management 66(3): 839-848.

Lewis, M.S., and R. Paige. 2006. Selected Results From a 2006 Survey of Registered Off-Highway Vehicle (OHV) Owners in Montana. Responsive Management Unit Research Summary No. 21. Prepared for Montana Fish, Wildlife and Parks. http://fwp.mt.gov/content/getItem.aspx?id=19238

Millspaugh, J.J. 1995. Seasonal movements, habitat use patterns and the effects of human disturbances on elk in Custer State Park, South Dakota. M.S. Thesis. Brookings, SD: South Dakota State University.

Millspaugh, J.J., G.C. Brundige, R.A. Gitzen, and K.J. Raedeke. 2000. Elk and hunter space-use sharing in South Dakota. Journal of Wildlife Management 64(4): 994-1003.

Millspaugh, J.J., Woods, R.J. and K.E. Hunt. 2001. Fecal glucocorticoid assays and the physiological stress response in elk. Wildlife Society Bulletin 29: 899-907.

Misak, R.F., J.M. Al Awadhi, S.A. Omar, and S.A. Shahid. 2002. Soil degradation in Kabad area, southwestern Kuwait City. Land Degradation & Development. 13(5): 403-415.

Nakata, J.K., H.G. Wilshire, and G.G. Barnes. 1976. Origin of Mojave Desert dust plumes photographed from space. Geology 4(11): 644-648.

Nash, R.F., G.G. Gallup, jr., and M.K. McClure. 1970. The immobility reaction in leopard frogs (Rana pipiens) as a function of noise induced fear. Psychonometric Science 21(3): 155-156.

Ouren, D.S., Haas, Christopher, Melcher, C.P., Stewart, S.C., Ponds, P.D., Sexton, N.R., Burris, Lucy, Fancher, Tammy, and Bowen, Z.H., 2007, Environmental effects of off-highway vehicles on Bureau of Land Management lands: A literature synthesis, annotated bibliographies, extensive bibliographies, and internet resources: U.S. Geological Survey, Open-File Report 2007-1353, 225 p.

Pacific Rivers Council. 2010. Roads and Rivers 2: An Assessment of National Forest Roads Analyses. Portland, OR http://pacificrivers.org/science-research/resources-publications/roads-and-rivers-ii/download

Pacific Watershed Associates. 2005. Erosion Assessment and Erosion Prevention Planning Project for Forest Roads in the Biscuit Fire Area, Southern Oregon. Prepared for Pacific Rivers Council and The Siskiyou Project. Pacific Watershed Associates, Arcata, California. http://pacificrivers.org/files/post-fire-management-and-sound-science/Final%20Biscuit%20PWA%20Report.pdf

Phillips, G.E. 1998. Effects of human-induced disturbance during calving season on reproductive success of elk in the upper Eagle River Valley. Dissertation. Fort Collins, CO: Colorado State University.

Preisler, H.K., A.A. Ager, and M.J. Wisdom. 2006. Statistical methods for analyzing responses of wildlife to human disturbance. Journal of Applied Ecology 43: 164-172.

Rowland, M.M., M.J. Wisdom, B.K. Johnson, and M.A. Penninger. 2005. Effects of roads on elk: implications for management in forested ecosystems. Pages 42-52. IN: Wisdom, M.J., technical editor, The Starkey Project: a Synthesis of Long-term Studies of Elk and Mule Deer. Reprinted from the 2004 Transactions of the North American Wildlife and Natural Resources Conference, Alliance Communications Group, Lawrence, KS.

Sack, D., and S. da Luz, Jr. 2003. Sediment Flux and Compaction Trends on Off-Road Vehicle (ORV) and other Trails in an Appalachian Forest Setting. Physical Geography 24 (6): 536-554.

Snyder, C.T., D.G. Frickel, R.E. Hadley, and R.F. Miller. 1976. Effects of off-road vehicle use on the hydrology and landscape of arid environments in central and southern California. U.S. Geological Survey Water-Resources Investigations Report #76-99. 45p.

Switalski, T. A. and A. Jones. 2012. Off-road Vehicle Best Management Practices for Forestlands: A Review of Scientific Literature and Guidance for Managers. Journal of Conservation Planning. Vol. 8 (2014). Pages 12 – 24.

USFWS, Nevada Fish and Wildlife Office. 2007. 12-Month Finding on a Petition to List the Sand Mountain Blue Butterfly (Euphilotes pallescens ssp. arenamontana) as Threatened or Endangered with Critical Habitat. Federal Register, Vol. 72, No. 84. See pages 24260-61. http://www.wildlandscpr.org/denial-petition-list-sand-mountain-blue-butt....

USDA Forest Service (USFS) 1994. Rio Grande National Forest Roads Analysis Process Report. See pages 76-77 and 118.

USDA Forest Service. (USFS) 1998. National Forest System Roads and Use. Available online at http://www.fs.fed.us/eng/road_mgt/roadsummary.pdf.

USDA Forest Service. (USFS) 2008. Tongass National Forest Amendment to the Land and Resource Management Plan Record of Decision and Final EIS. http://tongass-fpadjust.net/Documents/Record_of_Decision.pdf

Vollmer, A.T., B.G. Maza, P.A. Medica, F.B. Turner, and S.A. Bamberg. 1976. The impact of off-road vehicles on a desert ecosystem. Environmental Management 1(2):115-129.

Webb, R.H., Ragland, H.C., Godwin, W.H., and D. Jenkins. 1978. Environmental effects of soil property changes with off-road vehicle use. Environmental Management 2: 219-233.

Webb, R.H.. 1983. Compaction of desert soils by off-road vehicles. Pages 51-79 in: Webb, R.H. and Wilshire, H.G., editors, Environmental Effects of Off-Road Vehicles. Springer-Verlag, New York.

Welsh, M.J., L.H. MacDonald, and E. Brown, and Z. Libohova. 2006. Erosion and sediment delivery from unpaved roads and off-highway vehicles (OHV). Presented at AGU fall meeting. San Francisco, CA.

Wilshire, H.G., G.B. Bodman, D. Broberg, W.J. Kockelman, J. Major, H.E. Malde, C.T. Snyder, and R.C. Stebbins. 1977. Impacts and management of off-road vehicles. The Geological Society of America. Report of the Committee on Environment and Public Policy.

Wilshire, H.G., Nakata, J.K., Shipley, S., and K. Prestegaard. 1978. Impacts of vehicles on natural terrain at seven sites in the San Francisco Bay area. Environmental Geology 2: 295-319.

Wilshire, H.G. 1980. Human causes of accelerated wind erosion in California's deserts. Pages 415-433 in D.R. Coates and J.B. Vitek, editors, Thresholds in Geomorphology. George Allen & Unwin, Ltd., London.

Wilshire, H.G. 1992. The wheeled locusts. Wild Earth 2: 27-31.

Wisdom, M.J., R.S. Holthausen, B.C. Wales, C.D. Hargis, V.A. Saab, D.C. Lee, W.J. Hann, T.D. Rich, M.M. Rowland, W.J. Murphy, and M.R. Eames. 2000. Source habitats for terrestrial vertebrates of focus in the interior Columbia basin: Broad-scale trends and management implications. Volume 1 – Overview. Gen. Tech. Rep. PNW-GTR-485. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. http://www.fs.fed.us/pnw/pubs/gtr485/gtr485vl.pdf

Wisdom, M.J., H.K. Preisler, N.J. Cimon, and B.K. Johnson. 2004. Effects of off-road recreation on mule deer and elk. Transactions of the North American Wildlife and Natural Resource Conference 69.

Wisdom, M.J. 2007. Shift in Spatial Distribution of Elk Away from Trails Used by All-Terrain Vehicles. Report 1, May 2007, USDA Forest Service, Pacific Northwest Research Station, La Grande, OR.

Appendix 5

Annotated Bibliography: Old Growth, Carbon, and Mycorrhizal Networks

APPENDIX 5

Annotated Bibliography: Old Growth, Carbon, and Mycorrhizal Networks

Averill, Colin, "Mycorrhiza-mediated competition between plants and decomposers drives soil carbon storage," *Nature* 505: 543-546 (2014).

- AMF [arbuscular] systems have lower soil C:N ratios than those dominated by EMF [ectomycorrhizal] systems, indicating fundamentally different nutrient cycling regimes, resulting in more carbon sequestered in EMF forests.
- "Using global data sets, we show that soil in ecosystems dominated by EEM-associated [ectomycorrhizal and ericoid mycorrhizal fungi] plants contains 70% more carbon per unit nitrogen than soil in ecosystems dominated by AM-associated [arbuscular mycorrhizal fungi] plants. The effect of mycorrhizal type on soil carbon is independent of, and of far larger consequence than, the effects of net primary production, temperature, precipitation and soil clay content." At p. 543.

Beiler, Kevin J., Simard, Suzanne W., & Durall, Daniel M., "Topology of tree-mycorrhizal fungus interaction networks in xeric and mesic Douglas-fir forests," *Journal of Ecology* 103, pp. 616-628 (2015).

- "A mycorrhiza is a symbiotic association between a fungus and a plant root. Ectomycorrhizal fungi (EMF), a specific type of mycorrhizal fungi that envelops root tips but does not penetrate root cortical cells, provides trees with increased access to water and nutrients and protection from root pathogens in exchange for carbon from the tree. A mycorrhizal network (MN) refers to interconnections between plant roots and mycorrhizal fungal hyphae below-ground." At p. 617.
- "Studies have demonstrated that linkage into a MN with residual trees or shrubs can improve the survival and productivity of newly established seedlings. […] With or without the direct transfer of materials between plants, seedlings gain access to water and nutrients through EMF mycelia that are predominantly subsidized by mature trees." At p. 617.
- In this study, "large mature trees contributed more to network connectivity than smaller trees. […] The connectivity of the MNs suggests materials could be shuttled efficiently between numerous trees, including mature veterans and newly established trees, when those trees are colonized by the same EMF genets." At p. 622.
- "The highly interconnected, nested topology of these MNs suggest they are robust systems that would be resilient to random perturbations targeting participants indiscriminately, because most trees in the network would remain connected following a moderate loss of participants. On the contrary, the MNs could be susceptible to the loss of critical participants such as large hub trees or hyperlinking fungal genets. […] A loss of key nodes or links could have cascading effects throughout the system that ultimately lead to a reduction in MN stability. For example, if the largest trees were removed from a stand due to selective harvesting or insect attacks, the remaining trees may not adequately meet the carbon demands of EMF species forming large perennial genets[.]" At p. 624.
- "Large, mature trees acted as hubs in the network and tended to have higher node degrees compared to younger trees. […] Through their influence on MN connectivity, large hub trees could play a foundational role in the self-regeneration of complex stand structures in

these forests. The presence of large trees can influence the ambient temperature and moisture of local environments, modify local edaphic conditions (soil pH, nutrient status, etc.) and sustain rich assemblages of EMF species that provide a diverse inoculum source to regenerating seedlings. When seedlings become linked into a MN with veteran trees, they gain access to hydraulically lifted water and patchily distributed nutrients that would otherwise be limiting resources." At p. 625.

- "Large mature trees acted as network hubs with significantly higher node degree compared to smaller trees." At abstract.

Burrascano et al., "Commonality and variability in the structural attributes of moist temperate old-growth forests: A global review," *Forest Ecology and Management* 291: 458-479 (2013).

- "old-growth forests showed global commonalities in structure when compared to mature forests: significantly higher densities of large living trees, higher quadratic mean diameter, and higher amounts of live above-ground biomass and coarse woody debris." At abstract.
- "Our review showed old-growth forests to host significantly higher amounts of biomass than mature forests, stored both in LAB [living aboveground biomass] and in CWD [coarse woody debris] pools." At p. 470.
- "LLT [large living tree, >20 in dbh] density is directly related to CWD recruitment, particularly for the largest size classes, and contributes to the pool of long-lasting deadwood, as deadwood residence time is strongly influenced, together with wood density and decay resistance, by tree size at the time of death." (internal citations omitted) At p. 470.
- "The published data support a contention that some stand development processes, such as LLT, LAB, and CWD accumulation, have the potential to continue very late into stand development." At p. 475.

Depro, Brooks M. et al., "Public land, timber harvests, and climate mitigation: Quantifying carbon sequestration potential on U.S. public timberlands," Forest Ecology and Management 255: 1122-1134 (2008).

- "Our analysis found that a 'no timber harvest' scenario eliminating harvests on public lands would result in an annual increase of 17-29 million metric tonnes of carbon (MMTC) per year between 2010 and 2050—as much as a 43% increase over current sequestration levels on public timberlands and would offset up to 1.5% of total U.S. GHG emissions. In contrast, moving to a more intense harvesting policy similar to that which prevailed in the 1980s may result in annual carbon losses of 27-35 MMTC per year between 2010 and 2050. These losses would represent a significant decline (50-80%) in anticipated carbon sequestration associated with the existing timber harvest policies." At abstract.
- NOTE: This study assumes that soil carbon is unaffected [i.e., it didn't account for soil carbon]. At p. 1127. Nor did it account for losses in sequestration structure (robust mycorrhizal network structures). It also (incorrectly) assumed that sequestration would slow as forests aged.

Dickie et al., "Influences of established trees on mycorrhizas, nutrition, and growth of Quercus rubra seedlings," *Ecological Monographs* (2002).

- Red oak seedlings benefitted from the (ecto) mycorrhizal networks (MNs) of nearby chestnut oak stumps that were still alive, but not from being placed nearby dead oak stumps or the (arbuscular) MNs of maples. At abstract.

Dickie et al., "Physiological and phenological responses of oak seedlings to oak forest soil in the absence of trees," *Tree Physiology* 27: 133–140 (2007).

- Belowground influences of trees on conspecific seedlings may play a critical role in early seedling establishment.
- "Seedlings receiving large amounts of forest soil had higher initial mycorrhizal infection, increased foliar nitrogen concentration and greater second-and third-year leaf mass than other seedlings. Compared with control and LF [low forest soil] seedlings, HF [high forest soil] seedlings flushed leaves earlier, expanded leaves more rapidly, had larger leaves and higher photosynthetic rates." At p. 137.
- There was "an estimated 80% higher seasonal gross carbon gain in HF seedlings compared with control seedlings." At p. 138.
- "The treatment effect on mycorrhizal infection was transient: by year 3 there were no differences among treatments." … "Although transient, these effects may have an important ecological effect during a critical period in seedling establishment." At p. 138.
- NOTE: In this study, the soil was taken from the forest and put in an open field setting – *these seedlings were not plugging into intact, robust mycorrhizal networks*; rather, they were inoculated by soilborne spores and sclerotia. These were *Quercus ellipsoidalis* seedlings (northern pin oak – which is not the same species as pin oak).

Gorzelak, Monika A. et al. "Inter-plant communication through mycorrhizal networks mediates complex adaptive behaviour in plant communities," *AoB Plants* 7: 1-13 (2015).

- "underground 'tree talk' is a foundational process in the complex adaptive nature of forest ecosystems." At abstract.
- "MNs [mycorrhizal networks] influence the survival, growth, physiology, health, competitive ability and *behavior* of the plants and fungi linked in the network." At p. 1.
- "interplant resource and signal fluxes through MNs have the potential to alter plant behavior. These fluxes have been shown to include carbon, water, phosphorus, micronutrients, stress chemicals, and allelochecmicals, and can occur between plants of the same or different species." At p. 3 (internal citations omitted).
- "Colonization of established seedlings by MNs enables them to acquire sufficient soil nutrients for root and shoot growth and hence survival." At p. 3.
- "stress signals have been shown to transfer from injured to healthy plants through MNs even more rapidly than carbon, nutrients or water." At p. 4.
- "Plants that are connected via an MN can rapidly modify their behaviour in response to fungal colonization and interplant biochemical communication. Plant behavioral responses that have been measured thus far include rapid changes in mycorrhizal colonization, root growth, shoot growth, photosynthetic rate, foliar nutrition, foliar defence chemistry and defence response." At p. 4-5.
- "In the interior Douglas-fir forests of western North America, the transfer of carbon, nitrogen and water from older trees to regenerating seedlings through an MN has been associated with rapid increases in net photosynthetic rates, shoot water relations, and

shoot and root growth of the young seedlings. These responses were linked to improved seedling survival and productivity, and hence regenerative capacity of the forest." At p. 5.

- "Defence signals travelling through the MN clearly result in rapid behavioural responses of recipient plants, and this is evident in sudden changes in foliar defence chemistry and pest resistance." At p. 6.
- "In a recent study using stable-isotope probing, we found that MNs transmitted more carbon from older 'donor' Douglas-fir seedlings to the roots of younger kin 'receiver' seedlings than to stranger 'receiver' seedlings, suggesting a fitness advantage to genetically related neighbours." At p. 7.
- "Underground 'tree talk' is a foundational process in the complex adaptive nature of forest ecosystems." At p. 9.
- "Targeted loss of hub trees, however, can cross thresholds that destabilize ecosystems." At p. 9.

Hartmann, Martin et al., "Resistance and resilience of the forest soil microbiome to logging-associated compaction," *The ISME Journal* 8: 226-244 (2014).

- "Compaction significantly reduced abundance, increased diversity, and persistently altered the structure of the microbiota. Fungi were less resistant and resilient than bacteria[.] […] Compaction detrimentally affected ectomycorrhizal species[.] […] This study demonstrates that physical soil disturbance during logging induces profound and long-lasting changes in the soil microbiome and associated soil functions[.]" At abstract.
- "Soil compaction has been recognized as a major disturbance associated with forest management. Economically efficient harvesting requires the use of heavy machines, causing severe compaction of the soil particularly during wet conditions and along skid trails and landings. Alterations in soil porosity affect pore connectivity, water infiltration, air permeability, temperature, rooting space, nutrient flow and biological activity, often resulting in increased surface runoff, soil erosion, nutrient leaching and greenhouse gas emission. As a consequence, the soil system can suffer substantial, persistent and sometimes irreversible damage, which ultimately reduces forest productivity and ecosystem functionality. Given that the affected area can range between 10 and 40% of the total logged stand, the impact on the ecosystem can be substantial." At p. 226-227 (internal citations omitted).
- "With the recent advent of molecular tools, there is increasing evidence that effects of soil compaction on microbial structure and function are probably substantial and long lasting." At p. 227.
- "In the present study, using an array of cutting-edge molecular techniques, the results dismantle the notion that the forest soil microbiome is largely resistant or resilient to logging-induced compaction." At p. 239.
- "Fungi appeared to be more sensitive and less resilient to compaction when compared with bacteria. […] The fact that mycorrhizal species were almost exclusively reduced in compacted soils also suggests negative effects on plant hosts, mechanical disruption of existing mycorrhizal networks and limited network reformation owing to restricted hyphal penetration." At p. 240.
- "the profound changes in the fungal community suggest significant and persistent alterations with respect to plant-microbe interactions and nutrient cycling, and raise

concern regarding forest productivity, juvenile tree regeneration and long-term ecosystem functioning." At p. 240.

- "Soil compaction is a major problem inherently linked to economically efficient logging operations. Once a soil has been compacted, a return to the initial state can be very slow, and recovery from severe compaction might take centuries rather than decades. As the degree of disturbance depends on factors like harvesting equipment, operation condition and site characteristics, careful operational design can substantially mitigate the environmental impact." At p. 241.

Hartmann, Martin et al., "Significant and persistent impact of timber harvesting on soil microbial communities in Northern coniferous forests," *The ISME Journal* 6: 2199-2218 (2012).

- "More than a decade after harvesting, diversity and structure of soil bacterial and fungal communities remained significantly altered by harvesting disturbances." At abstract.
- "Economically efficient harvesting requires the use of heavy machines, causing severe compaction of the soil, especially during wet conditions and in soils with low initial bulk density. The soil systems can suffer substantial and persistent damage, which ultimately reduces plant growth, forest productivity and ecosystem functioning. Soil compaction reduces water infiltration rates, hydraulic conductivity, aeration and rooting space, often resulting in increased surface runoff, soil erosion, nutrient leaching and greenhouse gas emissions." At p. 2200.
- "We found that environmental changes associated with timber harvesting alter soil microbial communities over the long term. Effects of clear-cut harvesting *per se* far exceed any differences observed among harvested treatments with varied disturbance levels." At p. 2211.
- "For the first time, we present data from new high-resolution analyses that challenge the assumption of resilience and demonstrate that soil microbial communities remain strongly affected 15 years after harvesting." At p. 2211.
- "Fungi showed a much stronger response to harvesting than bacteria. Clear-cut harvesting increased fungal evenness and altered fungal community structure. […] It has been reported that clear-cut harvesting generally reduces fungal biomass [citing literature]. […] The increased fungal evenness in harvested stands may reflect the loss of functional organization of this community, and the reduction of most ectomycorrhizal fungi in harvested stands suggest a change in functional potential." At p. 2212.
- "Harvesting eliminates plant hosts and therefore the energy source of symbiotic organisms. […] Furthermore, soil compaction can disrupt mycorrhizal networks, and subsequent increases in bulk density may similarly impede hyphal penetration through the soil." At p. 2212.
- "Given that bulk density in the BC LTSP [British Columbia long term soil productivity] sites has recovered little in the 10-15 years because of soil compaction associated with harvesting, the long-term environmental consequences of compaction are likely significant. In fact, once a soil has been compacted, a return to the initial state might be very slow (von Wilpert and Schäffer, 2006) and recovery of a soil from severe compaction might take centuries rather than decades (Attiwill and Weston, 2008)." At p. 2214.

James, J., Harrison, R., "The Effect of Harvest on Forest Soil Carbon: A Meta-Analysis," *Forests* 7, 308 (2016).

- Forest ecosystems contain 1240 Pg C, which represents as much as 80% of aboveground terrestrial C and 70% of all soil organic C. The relative proportion of forest C found in soils varies among biomes, and amounts to roughly 60% in temperate forests. At p. 1.
- For Alfisols there are significant losses in the O horizon C pools (-12%), but no significant loss in the mineral soil. At p. 5.
- Ultisols lost significant soil C in response to harvesting (-24.7% overall), with the most substantial losses occurring in the O horizon (-66.0%) rather than in the mineral soil (-11.9%). At p. 5.
- Page 6 notes that no observations were made in very deep soil for hardwood forests.
- "Our results reveal that across many publications in the literature there is a significant loss of soil C in response to harvest (-11.2% overall, -14.4% for studies reporting C pools). At p. 9.
- The O horizon is typically a smaller pool of C than mineral soil horizons. Consequently, smaller absolute declines in O horizon C pools can lead to larger response ratios. At p. 9.
- "The overall estimates of change in very deep soil (60-100+ cm) [roughly 2-3 ft] shows substantial and significant loss of C (-17.7%). This estimate, however, only covers a small number of observations (21) […] and completely excludes hardwood forests." At p. 10.
- "Globally, the average maximum rooting depth for trees is ~7 m [21 ft], far outreaching even the deepest observations in this database. Harvesting disrupts the continued growth and turnover of roots extended deep into soil by mature trees, which in turn disturbs the steady state of C cycling in deep soil by changing environmental conditions (temperature, moisture) as well as the type and rate of C inputs. Furthermore, the flush of nitrate and dissolved organic matter that frequently follows harvest could prime the breakdown of older, subsurface C by providing a spike in nutrient availability and labile energy sources." At p. 11.
- "Neither the response of deep soil C to harvest nor the mechanisms for that change have been sufficiently resolved in the literature, and future work to address these questions are necessary." At p. 11.
- "The recovery period of soil C following harvest depends upon soil type and takes at least 60 years in many production forests." At p. 13.
- NOTE: the WNF's soils appear largely consist of Alfisols (Udalfs) and Ultisols (Udults).

Johnson et al., "Mycorrhizal associations and the spatial structure of an old-growth forest community," Oecologia 186: 195 (2018).

- Arbuscular mycorrhizal (AM) and Ectomycorrhizal (ECM) fungi examined in an old growth oak-hickory forest in southern Indiana.
- "AM fungi do not form external structures that prevent the pathogens from entering the root cells. In contrast, ECM fungi envelope root tips with a fungal mantle (sheath) that can serve as an effective barrier to pathogen entry. Consequently, AM roots may be more vulnerable to pathogen attack than ECM trees. This may contribute to apparent negative interactions of AM trees with their conspecifics, and positive or neutral interactions of ECM trees and their conspecifics. [The "pathogen protection" hypothesis]."

- ECM trees typically produce slow-decaying leaf litters with lower nutrient content relative to co-occurring AM trees, resulting in distinct biogeochemical syndromes or nutrient economies. Because ECM fungi possess the ability to mine nutrients from detritus, whereas AM fungi do not, ECM trees may be most competitive in their own soils, a process that would lead to positive feedbacks. [The "mycorrhizal mining" hypothesis]"
- "shared mycorrhizal types had sapling inhibition by trees at very short distances (~1 m), while opposing mycorrhizal associations (AM saplings with ECM trees and ECM saplings with AM trees) had significant inhibition at distances up to 13 m."
- "Overall, AM saplings tended to be inhibited near large individuals of either mycorrhizal type, while ECM saplings tended to be inhibited around AM trees, but clustered around ECM trees."
- "ECM saplings, but not AM saplings, tend to cluster around ECM species at relatively short distances. This supports the idea that alteration of nutrients by the ECM trees may be driving the spatial patterns or that shared ectomycorrhizal networks may subsidize saplings."
- "Our results suggest that species may perform poorly in areas dominated by species of alternative mycorrhizal associations and the mechanisms driving that pattern could prove important to understanding forest succession."

Klein et al., "Belowground carbon trade among tall trees in a temperate forest," SCIENCE 352:6283, pp. 342-344 (15 April 2016).

- Study found that the carbon assimilated by a 120-foot tall spruce was shared with neighboring beech, larch, and pine via ectomycorrhizal networks. At abstract.

Lichstein et al., "Biomass Chronosequences of United States Forests: Implications for Carbon Storage and Forest Management," in C. Wirth et al. (eds.), <u>Old-Growth Forests</u>, Ecological Studies 207 (2009).

- "In summary, our results suggest that substantial late-successional AGB [above ground biomass] declines are rare in US forests. In contrast, late-successional AGB increases are relatively common, particularly in the eastern US." At p. 333.
- "a substantial amount of additional carbon could probably be stored in US forests if large tracts of second growth were reserved from future harvest." At p. 335.
- "in most cases, AGB will stabilize or increase, rather than peak and decline, as succession proceeds." At p. 335.

Liebman et al., "Soil respiration in upper Great Lakes old-growth forest ecosystems," *BIOS* 88(3) 105-115 (2017).

- "declining C emissions from the soils of old-growth forests may contribute to unexpectedly high rates of forest C sequestration as forests age." At abstract.
- "Soil respiration is the rate of C emitted from microbial decomposition of soil organic matter and root respiration." At p. 106
- The study found that soil respiration (release of C) was lower in old growth forests than in younger forests. At p. 113.

McGarvey et al., "Carbon storage in old-growth forests of the Mid-Atlantic: toward better understanding the eastern forest carbon sink," Ecology 96(2): 311-317 (2015).

- "Total C density is 30% higher (154 Mg C/ha), and dead wood C density is 1800% higher (46 Mg C/ha) in the old-growth forests than in the surrounding younger forests (120 and 5 Mg C/ha, respectively)." At abstract.
- "Our results demonstrate the potential for dead wood to maintain the sink capacity of secondary forests for many decades to come." At abstract.
- NOTE: This study did NOT account for soil carbon storage.

McQuattie, Rebbeck, and Yaussy, "Effects of fire and thinning on growth, mycorrhizal colonization, and leaf anatomy of black oak and red maple seedlings," Proceedings, 14th Central Hardwood Forest Conference; 2004 March 16-19; Wooster, OH. Gen. Tech. Rep. NE-316. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station, pp. 200-208 (2004).

- NOTE: This study was cited in the 2006 FEIS, Appendix D-8-9.

Simard, Suzanne W. et al., "The role of mycorrhizas in forest soil stability with climate change," Chapter 15, Climate Change and Variability, pp. 275-302 (2010).

- Soils store one-third of the Earth's carbon. At p. 275.
- "Even though forests comprise only 30% of the terrestrial ecosystems, they store 86% of the above-ground carbon and 73% of the world's soil carbon. On average, forests store two-thirds of their carbon in soils." At p. 275.
- "Mycorrhizal fungi are obligate symbionts with all forest tree species, where they scavenge soil nutrients and water from the soil in exchange for photosynthate from the tree. Without their fungal symbionts, most trees cannot acquire enough soil resources to grow or reproduce; without the trees, the fungi have insufficient energy to carry out their life cycle. Because of this obligatory exchange, mycorrhizal fungi are considered the primary vectors for plant carbon to soils and, conversely, the primary vectors of soil nutrients to plants. The fungal partner plays a role in other essential services as well, such as increasing soil structure, protecting soil carbon against mineralization, and protecting tree roots against disease or drought. A single mycorrhizal fungus can also link different plants together, thus forming mycorrhizal networks. These networks have been shown to facilitate regeneration of new seedlings, alter species interactions, and change the dynamics of plant communities. As such, mycorrhizas are considered key players in the organization and stability of terrestrial ecosystems." At p. 277 (internal citations omitted).
- "Plants invest photosynthate carbon in mycorrhizas (instead of building their own roots) because the small and profuse hyphae have 60 times more absorptive area than fine roots." At p. 278.
- "Reductions in mycorrhizal richness, whether involving early or later successional fungi, reduces the complexity of mycorrhizal networks, which has corresponded with lower rates of nutrient transfer and survival of establishing seedlings in temperate forests." At p. 283.
- "seedling establishment success increased by four times where they had full access to the mycorrhizal network of older Douglas-fir trees. Access to the network not only improved seedling survival and physiology, but seedlings were colonized by a more complex

fungal community and received carbon, nitrogen and water transferred from the older trees." At p. 287.

- "Conservation of whole intact forests should be a global priority given the alarming trends in climate change and biodiversity. Where harvesting is necessary, however, retention of hub trees and their mycorrhizal networks should help maintain the strong carbon storage capacity of forests that is critical to the global carbon balance." At p. 290.
- "By contrast, large-scale clearcutting not only increases greenhouse gas emissions, it also removes critical hub trees, threatens biodiversity and could promote the decline of nearby forests." At p. 290 (internal citations omitted).
- "Mycorrhizal networks and hub trees are foundational to the organization of forests because they create favorable local conditions for tree establishment and growth. Therefore, conserving hub trees and mycorrhizal networks appears important to the conservation, regeneration, and restoration of forests." At p. 292.

Song, Yuan Yuan et al., "Defoliation of interior Douglas-fir elicits carbon transfer and stress signaling to ponderosa pine neighbors through ectomycorrhizal networks," *Scientific Reports* 5: 8495, pp. 1-9 (2015).

- "There is increasing evidence that mycorrhizal networks can transmit, for example, herbivore- or pathogen-induced defense signaling compounds to warn neighbors of pest infestations, kin recognition signaling compounds involving micronutrients to communicate genetic relationships of neighbors, toxins such as allelochemicals to convey negative interactions to competing neighbors, and essential resources such as carbon, nitrogen, phosphorus or water for altering physiology, survival or growth of conspecific or heterospecific neighbors. Mycorrhizal networks have also been shown to rapidly transmit phosphorus and nitrogen from dying plants to healthy conspecific neighbors, providing a conduit for legacy transference across generations." At p. 1.
- "With manual defoliation, the interior Douglas-fir exported carbon compounds to roots, a behavioral strategy known for helping trees survive subsequent defoliations." At p. 4.
- "Production of defense enzymes occurred in both donors and receivers 24 h after injury, suggesting stress signals were rapidly exported to the mycorrhizal network." At p. 8.
- "We found that mycorrhizal networks transferred physiologically significant levels of photosynthate-derived C and transmitted interspecific stress signals that elicited defense responses in ponderosa pine following manual and insect defoliation of interior Douglas-fir. These results show that mycorrhizal networks are mediators of interactions among trees of different species and defoliators, and therefore likely play a critical role in the defense response and recovery of forests from either abiotic damage or insect outbreaks. The direct pathway of carbon and stress signal transfer through mycorrhizal networks to interspecific plant targets may facilitate shifts in forest composition predicted with climate change." At p. 8.
- "Our research shows that mycorrhizal networks are positioned to play important roles in facilitating regeneration of migrant species that are better adapted to warmer climates and primed for resistance against insect attacks. These results point to the importance of conservation practices maintaining all of the parts and processes of these highly interconnected forest ecosystems to help them deal with new stresses brought by our changing climate." At p. 8.

Spake et al., "A meta-analysis of functional group responses to forest recovery outside of the tropics," *Conservation Biology* (2015).

- "We conducted a meta-analysis of 90 studies that measured differences in species richness for functional groups of fungi, lichens, and beetles between old-growth control and planted or secondary treatment forests in temperate, boreal, and Mediterranean regions. We identified functional-group-specific relationships in the response of species richness to stand age after forest disturbance. Ectomycorrhizal fungi averaged 90 years for recovery to old-growth values (between 45 years and unrecoverable at 95% prediction limits), and epiphytic lichens took 180 years to reach 90% of old-growth values (between 140 years and never for recovery to old-growth values at 95% prediction limits). […] The slow recovery by some functional groups essential to ecosystem functioning makes old-growth forest an effectively irreplaceable biodiversity resource that should be exempt from biodiversity offsetting initiatives." At abstract.
- 17 total studies examined ectomycorrhizal impacts. At p. 1698 (note that the 90 overall studies also covered other types of fungi, beetles, lichens, etc.).
- "For ectomycorrhizal fungi, a best estimate of recovery to undisturbed old-growth values of species richness was 90 years (between 45 years and unrecoverable at 95% prediction limits). The best estimate for lichens was 180 years to reach 90% of undisturbed forest values (between 140 years and never for full recovery). Saproxylic beetles had a best estimate of about 60 years to reach 90% of old-growth values (between 10 years and never for full recovery)." At p. 1698-99.
- "Lichen, ectomycorrhizal fungi, and saproxylic beetle richness was much lower in early successional or young planted forest than undisturbed old-growth forest. Recovery to old-growth values of species richness required 90 years for ectomycorrhizal fungi, 60 years for saproxylic beetles, and >100 years for lichens." At p. 1699.
- "The slow recovery of species richness for some functional groups essential to ecosystem functioning makes old-growth forest an effectively irreplaceable biodiversity resource that should be exempted from restoration offset initiatives." At p. 1701.

Spake et al., "Similar biodiversity of ectomycorrhizal fungi in set-aside plantations and ancient old-growth broadleaved forests," *Biological Conservation* 194: 71-79 (2016).

- Study took place in England's New Forest National Park.
- Examined 7 pairs of neighboring stands – each had an ancient stand (>1000 yr) paired with an "overmature" planted stand (ca. 180 yr). Oak dominated – Quercus robur (English oak) and petraea (sessile oak). At p. 72.
- "the diverse capacities amongst EMF species for mobilizing nutrients from soil mineral and organic matter insure a host tree against environmental stresses. At the ecosystem level, EMF are not only important for nutrient cycling, but high EMF diversity can facilitate resistance to disease and drought, and contribute to net primary productivity, mineral weathering and soil carbon storage." At p. 72 (internal citations omitted).
- This investigation found similar richness and composition of EMF in set-aside plantation and neighboring ancient stands. At p. 74.
- Many EMF species require long periods of stand continuity for colonization events to recover the richness to old-growth levels, consistent with strong dispersal limitation. At p. 74.

- Relatively recent evidence suggests that dispersal limitation is significant in EMF assemblages. At p.75.

Staeyert, L.T. and R.G. Knox, "Reconstructed historical land cover and biophysical parameters for studies of land-atmosphere interactions within the eastern United States," *Journal of Geophysical Research* 113 (2008).

- Estimating that 70% of the original eastern old growth remained in 1850, only 7% in 1920, and an insufficient amount to include as a land-use category in 1992. At p. 6.

Stephenson et al., "Rate of tree carbon accumulation increases continuously with tree size," *Nature* 507: 90–93 (06 March 2014).

- "Here we present a global analysis of 403 tropical and temperate tree species, showing that for most species mass growth rate increases continuously with tree size. Thus, large, old trees do not act simply as senescent carbon reservoirs but actively fix large amounts of carbon compared to smaller trees; at the extreme, a single big tree can add the same amount of carbon to the forest within a year as is contained in an entire mid-sized tree." At p. 90.
- "we conducted a global analysis in which we directly estimated mass growth rates from repeated measurements of 673,046 trees belonging to 403 tropical, subtropical and temperate tree species, spanning every forested continent. […] For all continents, aboveground tree mass growth rates (and, hence, rates of carbon gain) for most species increased continuously with tree mass (size). The rate of mass gain increased with tree mass in each model bin for 87% of species, and increased in the bin that included the largest trees for 97% of species[.] […] Even when we restricted our analysis to species achieving the largest sizes (maximum trunk diameter > 100 cm; 33% of species), 94% had increasing mass growth rates in the bin that included the largest trees." At p. 90.
- "our results are relevant to understanding and predicting forest feedbacks to the terrestrial carbon cycle and global climate system. […] The rapid growth of large trees indicates that, relative to their numbers, they could play a disproportionately important role in these feedbacks. For example, in our western USA old-growth forest plots, trees > 100 cm in diameter comprised 6% of trees, yet contributed 33% of the annual forest mass growth." At p. 92.

Wilhelm, Roland C. et al., "Biogeography and organic matter removal shape long-term effects of timber harvesting on forest soil microbial communities," *The ISME Journal* 11: 2552–2568 (2017).

- EM fungi's "overall decline was a major inter-ecozone effect of harvesting. In contrast, arbuscular mycorrhiza populations increased in harvested plots likely due to their common symbioses with successional plant cover[.]" At p. 12.

Appendix 6

Annotated Bibliography: White Oak in Southeast Ohio Forests

APPENDIX 6

Annotated Bibliography: White Oak in Southeast Ohio Forests

This annotated bibliography is organized in the following way. We have identified key topics related to the white oak's condition and sustainability. Under each, we provide a series of observations supported by the literature. The observations and cited literature are relevant to the following required categories in an assessment report.[1]

- *Terrestrial ecosystems (oak ecosystem)*
- *System drivers (disturbance regimes and stressors)*
- *Potential species of conservation concern (black bear, cerulean warbler, et al.)*
- *Scenic character (unique visual appeal of mature white oak)*
- *Potential need for additional designated areas (need mature, gap-driven interior forest)*

1. White oak (*Quercus alba*) is in serious decline in Ohio; unsustainable harvest is the most significant system driver of white oak's decline.

OBSERVATION – 1.A. – Conditions, Trends, Sustainability:
White oak (*Quercus alba*) is losing volume in Ohio, decreasing 7.3 percent from 2012 levels. Notably, white oak joins the insect-devastated white ash (-21.1%) as the only major tree species experiencing volume declines in the state. By contrast, northern red oak has seen a 9.5% volume increase since 2012.

> SUPPORTING LITERATURE:
> **Albright, Thomas A., "Forests of Ohio, 2017," Resource Update FS-171. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4 p. (2018).**

OBSERVATION – 1.B. – Conditions, Trends, Sustainability:
The decline in Ohio's white oak is driven by unsustainable timber harvest. White oak continues to be removed at rates exceeding net growth. In Ohio, white oak's growth to removal ratio (G:R) is 0.7:1. And, the present rate of unsustainable harvest is accelerating.

> SUPPORTING LITERATURE:
> *See* **Albright, Thomas A., "Forests of Ohio, 2016," Resource Update FS-139. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4 p., at 3 (2017)** (reporting white oak G:R at 0.8:1).

2. White oak's significant downward trend should be considered in the context of its historical dominance in southeast Ohio.

OBSERVATION – 2.A – Conditions, Trends, Sustainability:

[1] 36 C.F.R. § 219.6(b).

Recent scholarship shows that oak, generally, was a stronger component of southeast Ohio's canopies prior to European settlement than it is today.

SUPPORTING LITERATURE:
See **Deines et al., "Changes in Forest Composition in Ohio Between Euro-American Settlement and the Present,"** ***Am. Midl. Nat.,*** **176:247-271 (2016)** (Table S3, page 270: Presettlement forest composition of Gallia County = 59.4% "Oak"; Lawrence County = 57.0% "Oak"; Table S4, page 271: Modern era forest composition for Gallia County = 21.1% oak; Lawrence County = 36.5%).

OBSERVATION – 2.B. – Conditions, Trends, Sustainability:
White oak, specifically, dominated the Wayne National Forest's region prior to European settlement, accounting for 40% of witness trees in southeast Ohio.

SUPPORTING LITERATURE
See, e.g., **Abrams, Marc D., "Where Has All the White Oak Gone?,"** ***BioScience,*** **Volume 53, Issue 10, 1 October, Pages 927–939, at 927 (2003)** ("Before European settlement, oak was the dominant genus in the forests throughout much of what is now the eastern United States. Among the oaks, white oak (*Quercus alba*) reigned supreme."); **Dyer, James M., "Using witness trees to assess forest change in southeastern Ohio,"** ***Can. J. For. Res.*** **31: 1708-1718, at 1711 (2001)** ("The presettlement forests of southeastern Ohio were dominated by white oak, which accounted for 40.0% of all witness trees. White oak is still the most abundant species today, but it accounts for only 14.5% of trees [per 1991 FIA data]."); **Abrams, M.D., "History of eastern oak forests," in Keyser, et al., Managing Oak Forests in the Eastern United States, at 13 (2016)** ("Another casualty of the clearcut era [1870-1920] was white oak, one of the east's most dominant tree species, which declined in many eastern forests between the presettlement and present day. This decline is attributed to white oak not being as well adapted to intensive disturbance regimes compared to northern red oak and chestnut oak.").

3. Oaks, including *Quercus alba*, have species-specific management requirements.

OBSERVATION – 3.A. – Conditions, Trends, Sustainability:
An emerging trend in the best available oak management science is the acknowledgement that individual oak species have their own individual management needs and requirements. The 2006 Forest Plan and FEIS do not account for this important development in scientific understanding, and instead treat "oak" and "oak-hickory" as a uniform management category.

SUPPORTING LITERATURE:
See, e.g., **Keyser, et al., Managing Oak Forests in the Eastern United States, at 20 (2016)** ("Due to the sheer number of oak species found in the United States, a variety of management strategies are required because each species has individual requirements for proper management."); **Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? Growth and biomass,"** ***Canadian Journal of Forest Research*****, Vol. 41, pp. 2219-2230, at 2226 (2011)** ("Although it is well known that different oak species, even those found within

the eastern deciduous biome, differ in shade tolerance, drought resistance, productivity, and longevity (Burns and Honkala 1990), management recommendations to promote advance reproduction are often developed as though they are a single species." At p. 2226. "Forest management treatments should consider these [shade tolerance and seedling growth rate] differences among oak species. When these [northern red, white, and chestnut] oaks occur together in mixed stands, it will be difficult to develop a prescription that benefits each species' needs." At p. 2228); **Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? II. Gas exchange and chlorophyll responses,"** ***Canadian Journal of Forest Research*****, Vol. 42, pp. 1025-1037 (2012)** ("[W]hite oak appears to have the potential to maintain positive carbon gain under denser shade compared with either chestnut or northern red oak seedlings. White oak's physiological attributes as well as its slow growth and extended longevity (up to 600 years) support a survival strategy that is unique to that of other upland oak species." At p. 1035; "To target white oak seedling regeneration, we propose that light levels need not be increased above 18% of full sun; to target chestnut and northern red oaks, light levels need not be increased above 25% of full sun." At p. 1035); **Hutchinson et al., "Repeated prescribed fires alter gap-phase regeneration in mixed-oak forests,"** ***Can. J. For. Res.*** **42: 303-314, at 312 (2012)** ("Of the five common upland oaks in our region, white oak is the most shade tolerant and our findings suggest that white oak seedlings were able to persist in the burned stands prior to gap formation, despite relatively low-light conditions, and then exhibited significant height growth after gap formation."); **Abrams, Marc D., "Where Has All the White Oak Gone?,"** ***BioScience*****, Volume 53, Issue 10, 1 October, Pages 927–939, at 928 (2003)** ("[T]here is evidence of a dramatic decline in white oak forests from presettlement to the present day. In contrast, red oak (*Quercus rubra*) and chestnut oak (*Quercus prinus*), which were not nearly as important as white oak in the presettlement forest, increased significantly during and after the 19th century. […] It has been reported that white oak, which grows more slowly, did not recover from catastrophic disturbances as well as some other eastern oak species. […] Anthropogenic impacts during the late 19th and early 20th centuries were tantamount to a 'perfect storm' for most forests in the eastern United States. This period represented both the height and the tail end of the clear-cutting era and the catastrophic wildfires that followed, the state of the Smokey the Bear era of fire suppression, and the beginning and peak of the chestnut blight. In response, white oak has declined while other oaks have prospered.").

OBSERVATION – 3.B. – Conditions, Trends, Sustainability:

The slow growth rates, shade tolerance, and long lifespans of white oaks are not adequately accounted for in the 2006 Forest Plan and FEIS. These unique white oak characteristics are material to management considerations, and should therefore receive greater attention in the revised plan.

SUPPORTING LITERATURE:

Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? Growth and biomass," ***Canadian Journal of Forest Research*****, Vol. 41, pp. 2219-2230 (2011)** ("White oak seedlings were the slowest growers and demonstrated the most root-centered growth, with root to shoot ratios almost twice that of either chestnut or northern red oak seedlings. […] These differences need consideration when developing oak management prescriptions for specific oaks." At abstract. "Differences in seedling (shoot plus root) mass were quite dramatic with chestnut and northern red oak seedlings averaging 16.8 ± 0.4 g compared to white oak averaging 8.8 ± 0.4 g. This nearly twofold difference in seedling mass validates the slow-growth survival strategy of white oak. […] Forest management treatments should consider these differences among oak species. When these oaks occur together in mixed stands, it will be difficult to develop a prescription that benefits each species' needs." At p. 2228. "The slow-growing white oak may be able to persist longer in low-light conditions by developing a root system that will accumulate stored carbohydrates and be poised to respond to a light-creating disturbance. In stands with either a shelterwood cut or a final removal harvest, the slow-growing white oak would not persist but would instead be overtopped and outcompeted by faster growing neighbors. In stands with no immediate harvest planned (e.g., 10-20 years), multiple low-intensity burns over several years or herbicide application to the understory and midstory could be used to increase the competitive status of white oak regeneration by reducing the density of the sapling layer. The vigor and competitiveness of white oak regeneration would improve as it developed a larger root system in these relatively low-light environments. […] If regeneration of a white oak stand is the desired goal, then the implementation of a slower, more gradual approach to opening up the canopy may be necessary." At p. 2229); **Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? II. Gas exchange and chlorophyll responses,"** ***Canadian Journal of Forest Research*****, Vol. 42, pp. 1025-1037 (2012)** ("The white oak seedlings in the current study allocated about three times more carbon to root systems compared with either chestnut or northern red oak. […] White oak seedlings were able to maintain a positive carbon balance in dense shade." At p. 1032. White oak had the lowest respiration rates, and had maximum carbon exchange rates in 6% of full sun. At p. 1034. For all three species, "the light saturation point of photosynthesis occurred between 18% and 25% of full sun, although white oak grown at lower light levels displayed some plasticity. […] This suggests that the photosynthetic capacity is saturated with no additional benefits afforded to oaks. If light levels are higher, only faster-growing shade intolerant competitors such as red maple and black cherry, which display more plastic growth responses, would benefit." At p. 1035); **Burns & Honkala, <u>Silvics of North America. Vol. 2: Hardwoods</u>. USDA For. Serv., Agri. Handbk. 654, Washington, DC. pp. 605-613 (1990)** ("White oak (*Quercus alba*) is an outstanding tree among all trees[.]" At p. 605. "White oak can produce seeds prolifically, but good acorn crops are irregular and occur only every 4 to 10 years. […] The area seeded by individual trees is small and therefore widespread reproduction depends on adequate distribution of seedbearing trees. […] white oak seedlings established at the time of overstory removal normally grow too slowly to be of value in stand reproduction." At p. 608. Individual trees have been recorded at 600 years old. At p. 609. "White oak is generally classed as intermediate in tolerance to shade. It is most tolerant in youth and becomes less tolerant as the tree becomes larger. White oak seedlings, saplings, and even pole-size trees are nevertheless able to persist under a forest canopy for more than 90 years. […] White oak usually becomes dominant in the stand because of its ability to persist for long periods of time in the understory, its ability to respond well after release, and its great longevity." At p. 610); **McShea & Healy, <u>Oak Forest Ecosystems: Ecology and Management for Wildlife</u>, at p. 193 (2002)** (Because white oak acorns germinate in the fall, they are typically not dispersed long-distances by animal agents such as jays. Unlike red oaks, white oak reproduction generally remains in clumps near and around parent trees. This is evidenced in the greater clumping of white oak seedlings and adult trees, and in the greater shade tolerance of young white oaks.).

4. <u>White Oak responds poorly to aggressive harvest regimes; silvicultural (and commercial) clearcutting is a major driver of oak ecosystem decline.</u>

<u>OBSERVATION – 4.A. – Conditions, Trends, Sustainability:</u>
The unique characteristics and survival strategies of white oak – slow rate of growth, shade tolerance, poor stump sprouting ability at maturity, and exceptionally long lifespan – make it a poor competitor in aggressive even-age harvest regimes.

SUPPORTING LITERATURE:
See, e.g., **Abrams, M.D., "History of eastern oak forests," in Keyser, et al., <u>Managing Oak Forests in the Eastern United States</u>, at 13 (2016)** ("Another casualty of the clearcut era [1870-1920] was white oak, one of the east's most dominant tree species, which declined in many eastern forests between the presettlement and present day. This decline is attributed to white oak not being as well adapted to intensive disturbance regimes compared to northern red oak and chestnut oak."); **Swaim et al., "Overstory species response to clearcut harvest across environmental gradients in hardwood forests,"** ***Forest Ecology and Management*** **428: 66-80, at 71 (2018)** (Although all oak declined sharply after clearcut harvests in southern Indiana, white oak was especially hard hit in some locations: "In post-harvest stands, *Q. alba* nearly disappeared altogether on poor sites (steeper slopes and low pH)[.]"); **Hutchinson et al., "Repeated prescribed fires alter gap-phase regeneration in mixed-oak forests,"** ***Can. J. For. Res.*** **42: 303-314, at 312 (2012)** ("[T]he successful regeneration of white oak is often more difficult than that of other upland oaks, particularly in even-aged management systems, due to its slow juvenile growth rates."); **Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? Growth and biomass,"** ***Canadian Journal of Forest Research*****, Vol. 41, pp. 2219-2230, at 2229 (2011)** ("In stands with either a shelterwood cut or a final removal harvest, the slow-growing white oak would not persist but would instead be overtopped and outcompeted by faster growing neighbors. […] If regeneration of a white oak stand is the desired goal, then the implementation of a slower, more gradual approach to opening up the canopy may be necessary."); **Abrams, Marc D., "Where Has All the White Oak Gone?,"** ***BioScience*****, Volume 53, Issue 10, 1 October, Pages 927–939, at 928 (2003)** ("It has been reported that white oak, which grows more slowly, did not recover from catastrophic disturbances as well as some other eastern oak species. […] Anthropogenic impacts during the late 19th and early 20th centuries were tantamount to a 'perfect storm' for most forests in the eastern United States. This period represented both the height and the tail end of the clear-cutting era and the catastrophic wildfires that followed, the state of the Smokey the Bear era of fire suppression, and the beginning and peak of the chestnut blight. In response, white oak has declined while other oaks have prospered.");

Brose et al., "Prescribing Regeneration Treatments for Mixed Oak Forests in the Mid-Atlantic Region," U.S. Forest Service, General Technical Report NRS-33 (2008), *see* Table 3.2 (p. 25) (taken from Sander, Johnson, & Watt, "A Guide for Evaluating the Adequacy of Oak Advance Reproduction," U.S. Forest Service, General Technical Report NC-23 (1976)).

Table 3.2.—Expected percentage of oak stumps that will sprout after cutting

	D.b.h of parent tree (inches)			
Species	2 to 5	6 to 11	12 to 16	17+
Black oak	85	65	20	5
Chestnut oak	100	90	75	50
Northern red oak	100	60	45	30
Scarlet oak	100	85	50	20
White oak	80	50	15	0

OBSERVATION – 4.B. – Conditions, Trends, Sustainability:
Clearcutting is a major driver of oak ecosystem loss. Robust emerging data shows that silvicultural (and commercial) clearcutting consistently and dramatically accelerates the decline of oak ecosystems in the Central Hardwood Region.

SUPPORTING LITERATURE:
See, e.g., **Steiner et al., "A test of the delayed oak dominance hypothesis at mid-rotation in developing upland stands," *Forest Ecology and Management* 408: 1-8, at 2-3 (2018)** (examining 46 oak-dominated stands in Pennsylvania that were clearcut between 1968 and 1976: "Overall, oak declined from a pre-harvest average of 81% of BA to a 4th-decade average of 35%, red maple increased from 8% to 34%, and other species taken together increased from 11% to 31%. […] [These shifts] were strongest in the ApPl [Appalachian Plateau Province], where oak declined from 78% to 6% and red maple increased from 16% to 58%."); **Dey, Daniel C., "Sustaining Oak Forests in Eastern North America: Regeneration and Recruitment, the Pillars of Sustainability," *For. Sci.* 60(5): 926 –942, at 929 (2014)** ("Since the 1950s, it has been increasingly observed that clearcutting Eastern oak forests was resulting in stands being dominated by, in particular, yellow-poplar and red maple."); **Swaim et al., "Overstory species response to clearcut harvest across environmental gradients in hardwood forests," *Forest Ecology and Management* 428: 66-80, at 67, 73, and 78 (2018)** ("[Clearcutting] was frequently viewed as a panacea for regenerating *Quercus* species and was implemented across much of the eastern United States from the 1960s through the 1980s. Subsequent observations in post-harvest stands often found composition shifting away from *Quercus* domination towards a mix of hardwood species, raising concerns about the efficacy of clearcutting. […] Results from this long-term study illustrate a dramatic shift in species composition 23 years after clearcutting on the HNF. Following overstory removal, all stands experienced decreased importance of *Quercus* and *Carya* species and increased importance of other species including *A. rubrum*, *L. tulipifera*, *P. grandidentata*, and *P. serotina*. This corresponds with other reports of poor competition by *Quercus* species

following clearcut harvests in southern Indiana and elsewhere in the CHR [Central Hardwood Region]. […] If clearcut harvesting continued throughout the CHR, then it is likely that *Quercus* would continue to decrease in importance, and with each forest rotation there would be fewer and fewer *Quercus* stems until the genus is lost or relegated to the status of a minor associate in the new forest types. As the number of seed-bearing *Quercus* trees decrease in the overstory from one rotation from the next, the likelihood of abundant oak advance reproduction decreases. Therefore, relying on *Quercus* stump sprouts to perpetuate *Quercus* in new stands is a losing strategy in the long-term because not all large, older overstory *Quercus* are vigorous sprouters."); **Swaim et al. "Predicting the height growth of oak species (*Quercus*) reproduction over a 23-year period following clearcutting,"** ***Forest Ecology and Management*** **364: 101-112, at 101-102 and 108 (2016)** ("During the late 20th century, silvicultural clearcutting was used extensively across the hardwood forests of the eastern United States. A major goal of this management technique was to regenerate new stands of shade intolerant and mid-tolerant species, typically aspen and oak species, respectively. […]Subsequent research has shown that the past widespread use of silvicultural clearcutting failed to perpetuate oak dominance, especially on productive sites. […] Due to the lack of large oak advanced reproduction, clearcut stands in southern Indiana have shifted away from the oak-dominated forests that existed before harvest.").

5. White Oak recruits best via small gaps.

OBSERVATION – 5.A. – Conditions, Trends, Sustainability:
Recent best available science demonstrates that white oak establish well in small canopy gaps, and that, historically, white oak attained landscape dominance by recruiting in small canopy gaps (~ 1/20th an acre).

SUPPORTING LITERATURE:
Hutchinson et al., "Repeated prescribed fires alter gap-phase regeneration in mixed-oak forests," ***Can. J. For. Res.*** **42: 303-314 (2012)** (studying canopy gaps created by white oak mortality in Ohio's Vinton Furnace State Experimental Forest, and finding robust white oak regeneration in repeatedly burned small canopy gaps of 1/20th to 1/10th of an acre: "We found that larger white oak regeneration was abundant in moderate-sized canopy gaps (200-400 m^2) [1/20th to 1/10th of an acre] that had been burned repeatedly prior to gap formation. Although uneven-aged management is not typically used in oak forests, our results suggest that for white oak, the most shade tolerant of the upland oaks, the use of repeated burns prior to the creation of moderate-size canopy openings may be a feasible regeneration strategy. Periodic fires coupled with natural canopy openings of various sizes are thought to have sustained the presettlement-era dominance of white oak across much of the eastern United States." At p. 312. The percentage of full sunlight was significantly greater in burned gaps (18.7%) than in unburned gaps (7.3%). At p. 307. The burned stands had more large oak regeneration and also much lower levels of shade intolerant saplings and poles. At p. 310); **McEwan et al., "Fire and gap dynamics over 300 years in an old-growth temperate forest,"** ***Applied Vegetation Science*** **17: 312-322, at pp. 319-320 (2014)** (proposing that gap dynamics combined with fire drove centuries-long white and chestnut oak dominance on the Cumberland Plateau in

Kentucky); **Buchanan, Megan L. & Hart, Justin L., "Canopy disturbance history of old-growth *Quercus alba* sites in the eastern United States: Examination of long-term trends and broad-scale patterns," *Forest Ecology and Management* 267: 28-39 (2012)** (analyzing tree-ring series from 44 *Quercus alba* old-growth sites located throughout the species' distributional range, and finding that "70% of the [884] sampled *Q. alba* trees never experienced a large gap-scale disturbance" and instead recruited in small gaps. At p. 34. Of the 30% of white oaks (269 of 884) that did experience a "large gap-scale" release – which might roughly equate to a group opening or shelterwood treatment – only 144 (16% of 884) experienced the release within 50 years of establishing. At pp. 30, 34, and 37-38); **Rentch et al., "Spatial and temporal disturbance characteristics of oak-dominated old-growth stands in the central hardwood forest region," *For. Scie.* 49(5): 778-789 (2003)** (Examining spatial and temporal disturbance characteristics of five oak-dominated old-growth stands in the central hardwood region, and finding that most oaks recruited via small canopy openings less than or equal to 1/20th an acre in size: "Large (> 1000 m^2) [i.e., > 1/5th an acre] canopy gaps were identified; however, most oaks recruited via smaller (≤ 200 m^2) [i.e., ≤ 1/20th an acre] canopy disturbances involving two or more trees that occurred, on average, every 16 yr. These trees also reached overstory positions without being overtopped. However, in contrast to the even-aged structure resulting from stand-initiating events, these disturbances resulted in a spatially and temporally dispersed multicohort age structure. This disturbance regime is also consistent with conditions that are favorable to the establishment of shade-tolerant species […] Most silvicultural prescriptions for oak forests propose even-aged management. […] Yet, the variety of growth strategies exhibited by these old trees, and the age structures of these stands, suggest that persistent human use of fire, coupled with the frequent creation of canopy openings of various sizes, were integral components of the historic fire disturbance regimes of these forests, and the key to establishment and survival of a competitive oak understory, and eventual accession of oaks into the overstory." At p. 787); **Abrams, Marc D., "Where Has All the White Oak Gone?," *BioScience*, Volume 53, Issue 10, 1 October, Pages 927–939 (2003)** ("Some understory white oaks are nearly a century old. As this and many other old-growth white oak forests are uneven-aged, I believe that this species routinely recruited in small to moderate canopy gaps before European settlement, with adequate regeneration maintained through periodic burning." At p. 935. "Before European settlement, white oak grew successfully in uneven-aged forests. Periodic fires kept populations of fire-sensitive, later-successional species at a minimum and allowed adequate oak regeneration (including seedling sprouts) to persist. When a gap in the overstory was formed by natural disturbance or the death of an old tree, the understory white oaks, which could persist for up to a century, would respond by growing toward the canopy. […] Paleoecological and dendroecological evidence suggests that the process of fire and gap-phase regeneration in white oak forests went on for many hundreds and thousands of years." At p. 937).

OBSERVATION – 5.B. – Conditions, Trends, Sustainability:

In southeast Ohio, light levels of between 6 – 18% (achieved via prescribed fire alone or in combination with thinning treatments) have been shown to successfully establish and grow oak seedlings; light levels above 18% may favor oak competitors and thereby disfavor oak regeneration.

SUPPORTING LITERATURE:
Iverson, L. R., T. F. Hutchinson, M. P. Peters, and D. A. Yaussy, "Long-term response of oak-hickory regeneration to partial harvest and repeated fires: influence of light and moisture." ***Ecosphere*** **8(1) (2017)** (13-year longitudinal study over two areas in southeast Ohio. The study evaluated the influences of topography, moisture, burn intensity, thinning, and competition on regeneration response. "Based on this study, we recommend for topographically appropriate dry and intermediate sites, a partial harvest [i.e., thinning] followed by two or three dormant-season fires (depending on fire intensity) allowing roughly 6-18% light to penetrate the forest floor. This will promote oak-hickory into the advanced oak regeneration status." At abstract. "Mesic plots rarely attained greater numbers regardless of light levels, but wherever open sky was >6% on intermediate and dry plots, there were substantial gains in large oak-hickory seedlings through time."At p. 12. "Canopy openness in the range of 6—18% was sufficient to promote oak-hickory regeneration. Opening the canopy above that, for example, >24% open sky through high-intensity fire, though also resulting in abundant large oak-hickory seedlings, is not necessary." At p. 18. "light levels >6% open sky were frequently sufficient for successful oak-hickory advancement." At p. 19. "Our key findings and recommendations including the following: (3) increase canopy openness to between 6% and 18%—less light prevents oak-hickory growth while greater light levels may favor shade-intolerant competitors; […] (5) patience is required in restoring oak-hickory—long-term management strategies and investments are required[.]" At p. 20); **Hutchinson et al., "Repeated prescribed fires alter gap-phase regeneration in mixed-oak forests,"** ***Can. J. For. Res.*** **42: 303-314 (2012)** (studying canopy gaps created by white oak mortality in Ohio's Vinton Furnace State Experimental Forest, and finding robust white oak regeneration in repeatedly burned small canopy gaps of 1/20th to 1/10th of an acre. The percentage of full sunlight was significantly greater in burned gaps (18.7%) than in unburned gaps (7.3%). The burned gaps had more large oak regeneration and also much lower levels of shade intolerant saplings and poles.).

6. <u>The 2006 Forest Plan's treatment of silvicultural prescriptions for oak management should be updated and corrected to reflect best available science.</u>

<u>OBSERVATION – 6.A. – Conditions, Trends, Sustainability:</u>
The 2006 Forest Plan (at Appendix E-12 and E-21) concludes that uneven-age harvest methods are inferior to even-age methods for regenerating oak, including white oak (*Quercus alba*). These conclusions should be revised, because best available scientific information demonstrates that seedlings of the relatively shade tolerant white oak best establish and recruit in small gaps.

Regarding Single Tree Selection, the Forest Plan inaccurately states: "High levels of sun light are required for the survival and growth of advanced oak regeneration, and these light conditions cannot be achieved by the single tree selection method. (Fischer, 1979)" At p. E-12.

Regarding Group Selection, the Forest Plan inaccurately states: "This method of cutting would likely result in the oak component of the future stand to be […] less than the component created with even-aged treatments. One reason for the less effective oak regeneration is the large amount of edge in each group. The more mesic and shade-tolerant species would have an advantage along these shaded edges, while the oaks may thrive in the centers and northern edges of each group. Eventually, the amount of oak in the entire stand will decrease so that only the dry south slopes and ridgetops would be stocked with significant numbers of oaks." At p. E-21.

SUPPORTING LITERATURE:
See, e.g., Appendix Sections 3, 4, and 5 and supporting literature, above.

<u>OBSERVATION – 6.B. – Conditions, Trends, Sustainability:</u>
Shelterwood treatments generally fail to increase oak stocking density and distribution, and provide excessive light levels that favor competing species. Best available science holds that shelterwood treatments: (1) generally cannot correct for an initial lack of oak seedling numbers and spatial distribution (Steiner, et al. 2008), and (2) are not the best method for enhancing the size of oak seedlings (*see* Iverson, et al. 2017).

The above points are noteworthy because the 2006 Forest Plan incorrectly assumes that shelterwood treatments are the likely best option when oak seedlings are small, scarce, or absent: "When oak advanced reproduction is small, scarce, or absent, the shelterwood regeneration method will most likely produce the best results." 2006 Forest Plan Appendix E, at E-7 and 8.

SUPPORTING LITERATURE:
See, e.g., **Steiner et al., "Oak Regeneration Guidelines for the Central Appalachians,"** ***Northern Journal of Applied Forestry*** **25(1), at 11 (2008)** ("Although the growth of established oak seedlings can be expected to accelerate after a shelterwood cut (when combined with fencing, if necessary), it is less clear whether managers can depend on periodic acorn crops to increase oak seedling densities. ORSPA results indicate that, without a fortuitous acorn crop, less desirable species may benefit most from the improved growing conditions. In other words, experience shows that shelterwoods often fail to achieve the objective of enhancing oak regeneration. […] [S]helterwoods do little to supplement the oak regeneration cohort unless a heavy seed crop occurs within the 1st or (perhaps) 2nd year after harvest. […] [A] strong component of oak regeneration can not develop without an excellent acorn crop, which can be as infrequent as once in a decade. […] We recommend that shelterwoods be used only in stands in which 65% or more of sample milacre plots contain oak seedlings. Our long-term data set shows clearly that nonsprout regeneration of an oak component was always minimal in stands where this criterion was not met."); **Iverson, L. R., T. F. Hutchinson, M. P. Peters, and D. A. Yaussy, "Long-term response of oak-hickory regeneration to partial harvest and repeated fires: influence of light and moisture."** ***Ecosphere*** **8(1), at 20 (2017)** (recommending that managers use thinning and fire to "increase canopy openness to between 6% and 18%—less light prevents oak-hickory growth while greater light levels may favor shade-intolerant competitors").

OBSERVATION – 6.C. – Conditions, Trends, Sustainability:

The 2006 Forest Plan states that "clearcutting is the most effective method to regenerate [a] stand to species dominated by oak and hickory […] [when] there are adequate numbers of advanced oak seedlings over 4½ feet tall are vigorous and have well-developed root systems." 2006 Forest Plan Appendix E, at E-6-7. However, this statement contradicts best available scientific information relating to white oak management (*see* Appendix Sections 3, 4, 5, and supporting literature). And, the 2006 Plan does not recognize the severe scarcity of oak reproduction that characterizes the understories of oak-dominated stands in southeastern Ohio and the Central Hardwood Region, generally. Small oak seedlings are relatively rare, and competitive (large) oak seedlings and saplings are exceptionally rare. This severe scarcity means that clearcutting is inappropriate for oak regeneration purposes (let alone white oak regeneration purposes) on almost all sites, including dry and intermediate sites.

SUPPORTING LITERATURE:

See, e.g., **Iverson, L. R., T. F. Hutchinson, M. P. Peters, and D. A. Yaussy, "Long-term response of oak-hickory regeneration to partial harvest and repeated fires: influence of light and moisture."** ***Ecosphere*** **8(1), at 15 (2017)** (Finding only 2% of 237 understory plots in southeast Ohio oak-dominated stands were stocked with competitive oak seedlings, including only 3 of 130 plots on dry to intermediate sites); **Iverson et al., "Spatial modeling and inventories for prioritizing investment into oak-hickory restoration,"** ***Forest Ecology and Management*****, 424: 355-366, at 360-61 (2018)** (Finding that, even on the "Dry Oak" southeast Ohio landform type, only 25% of sample plots were considered "stocked" with oak seedlings, regardless of seedling size or competitive status; and, finding only 10% of plots on the intermediate "Dry-Mesic Mixed Oak Hardwood (DMMOH) forest landtype to be stocked, again, irrespective of seedling size. "For purposes of planning silvicultural interventions at the landscape scale, we developed an Oak Stocking Index (OSI) that emphasized whether or not plots were stocked with oak seedlings rather than their specific stage of development." At. P. 360. Given the exceptional rarity of large oak seedlings and saplings, <u>competitive</u> (large) oak understory stocking is likely far lower on these landscapes than the respective 25% and 10% size-neutral stocking reported.); **Paulus et al., "Structural and compositional shifts in forests undergoing mesophication in the Wayne National Forest, southeastern Ohio,"** ***Forest Ecology and Management*** **430: 413-420 (2018)** (stating with regards to plots sampled in the Wayne National Forest "the relative density of red maple (*Acer rubrum*) large saplings on dry ridges increased 25% [over 22 years], while zero oaks were recorded in the large sapling layer on dry ridges in 2016." At abstract. "While authors have repeatedly predicted oak regeneration to be more successful in areas of low moisture, this has only been demonstrated on truly xeric sites." At p. 418. "Our results support observations that oak regeneration is primarily restricted to dry sites, albeit in low densities, if present at all." At p. 419); **Dey et al., "An Ecologically Based Approach to Oak Silviculture: A Synthesis of 50 Years of Oak Ecosystem Research in North America,"** ***Revista Columbia Forestal Vol.*** **13 (2): 200-222, at 201 (2010)** ("Many oak stands have either few or no oak advance reproduction, and when present, it is small and noncompetitive."); **Dey, Daniel C., "Sustaining Oak Forests in Eastern North America: Regeneration and Recruitment, the Pillars of Sustainability,"** ***For. Sci.*** **60(5): 926 –942, at 931 (2014)** ("Commonly, the sizes of oak advance reproduction in mature forests are small, usually <20 cm tall and 4 mm in basal diameter and have low regeneration potential or are absent altogether, especially on the more productive sites.”).

<u>OBSERVATION – 6.D. – Conditions, Trends, Sustainability:</u>
Sufficient numbers of competitive (large) oak seedlings must be present prior to substantial overstory removal in order for oak regeneration to succeed. While this principle has been known for decades, recent studies further support and highlight the principle. Moreover, this principle is especially important and relevant, given the demonstrated low numbers and sparse distribution of competitive oak seedlings in the Wayne and the region.

SUPPORTING LITERATURE:
See e.g., **Dey, Daniel C., “Sustaining Oak Forests in Eastern North America: Regeneration and Recruitment, the Pillars of Sustainability,” *For. Sci.* 60(5): 926 – 942, at 931 (2014)** (“One thing is clear: in a wide range of oak ecosystems throughout eastern North America, sufficient numbers of large (e.g., > 12-mm basal diameter) oak advance reproduction are required to sustain oak stocking into the future. […] Reliance on oak stump sprouting to sustain current oak stocking is a failed strategy[.]”); **Dey et al., “An Ecologically Based Approach to Oak Silviculture: A Synthesis of 50 Years of Oak Ecosystem Research in North America,” *Revista Columbia Forestal Vol.* 13 (2): 200-222, at 208 (2010)** (“Oak germinants have relatively slow shoot growth even in full sunlight. They are easily suppressed by competing vegetation during stand reinitiation. This is why regenerating stands with abundant but small oak reproduction (< 10 mm basal diameter) that establishes after harvesting succeed to species other than oak.”); **Swaim et al. “Predicting the height growth of oak species (*Quercus*) reproduction over a 23-year period following clearcutting,” *Forest Ecology and Management* 364: 101-112, at 108 and 110-11 (2016)** (“Due to the lack of large oak advanced reproduction, clearcut stands in southern Indiana have shifted away from the oak-dominated forests that existed before harvest. In our study, most of the advance reproduction of oak species was <1.2 M tall prior to harvest. This pool of small seedlings remained the shortest of all reproduction present in year 6. […] The height growth winners in year 23 were the same stems that were winning in years 12 and 6. […] Initial height was the best predictor of future height growth in all species, further highlighting the poor competitive status of small oak reproduction.”); **Swaim, et al., “Overstory species response to clearcut harvest across environmental gradients in hardwood forests,” *Forest Ecology and Management* 428: 66-80, at 78 (2018)** (“In the current study, Quercus importance drastically decreased following clearcut harvests, likely due to a lack of large advance reproduction that would have competed better in the post-harvest environment.”); **Rebbeck, Joanne et. al., “Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? Growth and biomass,” *Canadian Journal of Forest Research,* Vol. 41, pp. 2219-2230, at 2219 (2011)** (“A continuing problem in the Appalachian region of eastern North America is the sustainability and regeneration of oak species within forests as overstory oaks are eliminated through natural mortality or harvesting. Typically, stand composition shifts to more shade-tolerant species such as red maple and American beech because of an inadequate number of competitive oak seedlings.”); **Sander, Johnson, and Watt, “A Guide for Evaluating the Adequacy of Oak Advance Reproduction,” USDA Forest**

Service General Technical Report NC-23, NCFES, at 4-5 (1976) (noting that oak advanced reproduction with a minimum height of 4.5 feet is the only class that will significantly contribute to future stand composition, and that “It is firmly established that the oak component of new stands following harvest cutting depends on size, number, and distribution of the oak advance reproduction.”).

Appendix 7

Conserving Black Bears in Southeast Ohio: A Synthesis of the Literature

Prepared by: Suzanne Prange, Wildlife Research Biologist

August 2018

Conserving Black Bears in Southeast Ohio: A Synthesis of the Literature

Prepared by: Suzanne Prange, Wildlife Research Biologist (CV attached)

August 2018

1) Specific ecological conditions necessary to ensure black bear population viability

Black bear (*Ursus americanus*) habitat must include three main resources: food, escape cover, and sufficient vegetation or trees for denning sites (Powell et al. 1997; Reynolds-Hogland et al. 2007). Black bears are dietary generalists that rely on varied and sometimes wide-spread food resources. Thus, they require multiple habitat types producing seasonal foods. Optimally, black bear habitat is forest interspersed with numerous openings or clearings. Disturbed habitats, such as recently logged or burned forests are important to black bears in the spring and summer for soft mast because they are areas of high berry production (Hellgren et al. 1991; Costello and Sage 1994). Conversely, in autumn non-managed and mature hardwood forests provide hard mast, such as beechnuts (*Fagus grandifolia*) and more importantly, acorns (*Quercus* spp.; Costello and Sage 1994). Therefore, habitat selection by black bears often varies seasonally and is strongly controlled by the presence of food (Fuller and Keith 1980; Hellgren et al. 1991; Schooley et al. 1994).

Good black bear habitat directly affects their nutritional condition. Nutritional condition may also influence fertility and survival (Noyce and Garshelis 1994). Specifically, nutritional status may affect age of primiparity (Eiler et al. 1989), litter interval (Rogers 1976; Eiler et al. 1989), litter size (Beecham 1980; Elowe and Dodge 1989), cub survival (Rogers 1976; Eiler et al. 1989), and yearling survival (Rogers 1976, 1987). Thus, habitats with adequate food sources are essential for effective bear management and bear population viability.

In addition to food resources, a well-developed, relatively impenetrable shrub layer for escape cover is also a critical part of black bear habitat (Pelton 2000). Riparian areas often provide more productive and diverse habitats, including escape cover, for black bears than other cover types (Hellgren et al. 1991; Lyons et al. 2003). Studies in the southeastern U.S. indicated that swamps and wetlands provided permeable travel corridors (Feckse et al. 2002; Larkin et al. 2004), escape cover (Pelton 2000), foraging habitat, and denning areas (Landers et al. 1979; Hellgren et al. 1991). Furthermore, black bears use riparian areas (e.g., lowland deciduous forests, rhododendron swamps; Alt et al. 1980) in human-dominated landscapes as escape cover, and possibly also for foraging cover and denning.

Exclusive of habitat for food and escape cover, denning habitat is vital for this hibernating mammal. Winter dens may be cavities in trees, rock crevices, brush piles, root excavations, underground burrows, caves, downed trees, or open-ground beds (Tietje and Ruff 1980; Wooding and Hardisky 1992; Hayes and Pelton 1994; Kasbohm et al. 1996). In Tennessee, preferred tree dens were 20–56 feet above ground in large diameter (average diameter at breast height [dbh] = 39 in) trees in mature hardwood stands. Eastern hemlock (*Tsuga canadensis*), oaks, and maples (*Acer* spp.) were the primary tree species used by black bears for denning (Pelton and Burghardt 1976). Den reuse from one year to the next is uncommon but bears often den in the same portion of their home range (Alt and Gruttaduria 1984; Rogers 1987).

Security is a significant factor affecting choice of den site, especially for females with cubs (Mack 1990). Parturition and early maternal care in black bears occur in dens, and lack of adequate den sites may result in litter loss or complete reproductive failure (Hamilton and Marchinton 1980; Alt 1984; Weaver and Pelton 1994). Black bears often abandon winter dens following disturbance (Goodrich and Berger 1994), and females may relocate their cubs. Thus, females require secluded areas for denning (Landers et al. 1979; Vander Heyden and Meslow 1999). Tree cavities are preferred maternal den sites (Wathen et al. 1986; Rogers 1987). Tree cavities should provide low vulnerability to predation and probability of human disturbance, as well as thermal protection.

In summary, black bears need a diversity of forest age/size classes across the landscape to meet their year-round requirements for food, water, escape cover, and den sites. Interspersion of different forest age/size classes and open areas across the forested landscape will result in high-quality black bear habitat. However, providing adequate annual food resources, while vital, is not the only requirement for a viable black bear population. Black bears need to feel secure, especially in areas near humans, and dense escape cover is critical. Finally, and perhaps most critical is adequate and safe hibernation sites, especially for females that are birthing cubs. Interior forest sites, away from disturbances, and having mature hollow trees with large dbh are optimal. Secure, thermally protected, and undisturbed winter birthing sites are key to the viability and growth of black bear populations.

2) Importance of interior and mature/old growth forest habitat to the viability of the black bear

The forest interior, away from the dangers of roads and humans, provides optimal habitat for black bears, as well as lowers the risk of mortality. In a camera study in Vermont, black bears were found to prefer interior sites, away from forest edges, and were photographed only in the more forested and less densely human populated eastern half of the study site (Moruzzi et al. 2002).

The importance of the interior in providing food and safety is increased when it is mature forest. Reynolds-Hogland et al. (2007) found that a model with the additive availability of hard mast and soft mast across the landscape predicted black bear survival and population growth rate. Conversely, the availability of young clearcuts predicted recruitment, but not population growth or survival. Thus, conservation efforts to maintain or increase population growth for the endangered black bears in the southern Appalachians should focus on maintaining the availability of both hard mast and soft mast. Older hardwood stands, which support high levels of hard mast and moderate levels of soft mast, should be maintained to sustain the population growth of black bears in the southern Appalachians. This objective may be achieved by increasing or maintaining the acreage of oak stands >70 years old, which can support high levels of hard mast and intermediate levels of soft mast (Reynolds-Hogland et al. 2006).

Simultaneously, the acreage of intermediate aged stands (10–25 years), which support very low levels of both hard mast and soft mast, should be minimized. Correlation analyses revealed that young clearcuts explained only 25% of the variability in berry plants across the landscape. Harvesting trees by clearcutting (i.e., removal of all trees within a stand) eliminates production of hard mast for 25–50 years, the time required for regenerating hardwoods to reach reproductive age in the southern Appalachians. Thus, changes in the availability of berry plants across the landscape is the result of succession, as intermediate-aged stands, with low soft mast availability (Noyce and Coy 1990; Reynolds-Hogland et al.

2006), age into older stands, where soft mast availability is at an intermediate level (Noyce and Coy 1990; Reynolds-Hogland et al. 2006).

Smith et al. (2016) considered a large, contiguous tracts of suitable habitat to be ≥300 km^2 for black bears, in concordance with Rogers and Allen (1987), who suggested a population with 30–40 adult females would require an area of 288–385 km^2. They speculated this would be the number of females in a minimum viable population of 50 black bears, based on the minimum population size accepted for grizzly bears (*Ursus arctos*) that would be genetically viable, at least in the short term. Smith et al. (2016) modelled suitable habitat for several large mammal species across the Midwest. They eliminated all pixel groups <500 km^2 for black bears to create maps of contiguous, suitable habitat. Suitable habitat for black bears had mean values of 3.3 persons/km^2 for human density, 0.1 km/km^2 roads, 39.1% forest, 40.9% grassland/shrubland, 4.7% agriculture, and 2.0% developed. In this simplified model, they did not specify forest age; however, its presence in the model was to provide cover and food. Forest food is primarily in the form of hard mast, signifying the importance of older, mast producing trees. Species habitat maps showed that contiguous suitable habitat existed only in the Appalachian region of Ohio and included the contiguous areas of the Wayne National Forest. Although black bears are habitat generalists, their ideal habitat consists of rugged terrain, dense understory vegetation, and food sources in the form of hard and soft mast; such habitat characteristics become more crucial when human populations expand into bear habitat (Pelton 2003).

3) Importance of oak as habitat and food source for the black bear

Oaks are a vital part of black bear habitat both as food and structure. In the southern Appalachian region, black bears prefer extensive, mature hardwood forests with late successional mast (acorn, hickory [*Carya* spp.], hazelnut [*Corylus* spp.]) trees and berry-producing (blueberry [*Vaccinium* spp.], huckleberry [*Gaylussacia* spp.], service berry [*Amelanchier* spp.]) shrubs (Landers et al. 1979). Structurally, mature oaks serve as an important denning resource. Oli et al. (1997) found that 77.8% of dens were in oaks with a mean dbh of 100.3 cm (39.5 in). The smallest oak to contain a den was 84 cm (33.1 in) dhb and the authors recommended management for trees with a minimum dbh of 84 cm to serve as den trees for black bears. Ryan and Vaughn (2004) examined maternal den use in the southern Appalachian region and found that 17 of 18 den trees were oaks. Dens were in large chestnut oaks and red oaks; mean dbh of chestnut oaks was 1.65 m (64.9 in) and of red oaks was 1.92 m (75.6 in).

The black bear is a generalist consumer, with a diet comprised generally of acorns, berries, grasses, insects, small rodents, birds, carrion, and foods from anthropogenic sources (Beeman and Pelton 1980). However, acorns in particular represent the primary, energy-rich source of food and hibernation reserves for black bears in the Appalachians during the dormant season (Beeman and Pelton 1980). Inman and Pelton (2002) measured caloric production by 19 species of vegetation used as food by black bears in the Great Smoky Mountains National Park to determine the significance of production by mast type, season, and species. Hard mast produced 74.5% of total calories available on the study area. Squawroot (*Conopholis americana*), a parasitic plant that grows on the roots of oaks, was the second most productive species on the study area, yielding almost 16% of available energy. The authors concluded that oaks were likely the single most influential genera affecting bear ecology in the southern

Appalachians, although squawroot was also a vital source of nutrients (Seibert and Pelton 1994). Squawroot grows on the roots of oaks and beeches, generally in older, less disturbed stands, and is another benefit derived from mature oak stands. Similarly indicative of mature oak stands, coarse downed woody debris is an important habitat component because black bears also rely on log-dwelling ants and other insects in many areas (Beeman and Pelton 1980, Bull et al. 2001)

Pelton (1989) reported that bears in the Appalachians respond to mast failure by undertaking long-range movements, or intensively using small areas of high acorn concentration. Long-range movements associated with oak mast failure may make bears more likely to cross roads and therefore more vulnerable to vehicle-related mortality. In addition, black bears are more likely to be attracted to human-related food sources and create nuisance situations during mast failures (Rogers 1976). In West Virginia, there was an increase in the number of nuisance complaints during mast failures and an increase in the number of bears destroyed on damage complaints (Ryan et al. 2007). The majority of non-hunting mortalities occurred between 15 August and 31 December, and this pattern was most pronounced during mast failures (Ryan et al. 2007).

Oak mast indices have been shown to be directly related to bear population growth rates (Clark et al. 2005). Hard mast failure may also negatively affect female age of reproductive maturity, litter size (Beecham 1980; Elowe and Dodge 1989), litter interval (Rogers 1976; Eiler et al. 1989), cub survival (Rogers 1976; Eiler et al. 1989), and yearling survival (Rogers 1976, 1987). Thus, population growth may subsequently fluctuate with success of mast crops (Beeman and Pelton 1980; Eagle and Pelton 1983; Eiler et al. 1989; McLean and Pelton 1994; Costello et al. 2003).

Noyce and Garshelis (2011) reported that state-wide food surveys indicated that oak trees, particularly bur (*Quercus macrocarpa*) and white oak (*Quercus alba*), were more abundant in the hardwood forests that were common south of their study area. Furthermore, they found that bears in their study area primarily migrated south and southwest, along the increasing food gradient. Bears and many species prefer white oak acorns to those of red oak, presumably because the lower tannin content of white oak acorns (Kirkpatrick and Pekins 2002). In a South Carolina study using a 15-year dataset of black bear abundance based on harvest, as well as a long-term mast dataset, black bear growth rates were influenced by mast abundance, although the relationship varied by oak type. The correlation was positive for white oaks and negative for red oaks. The authors speculated that white oaks were more important in bear diet than red oaks (Azad et al. 2017).

Because a threshold level of low fall mast availability may negatively affect the survival and reproduction of bears, effective habitat management for black bears in the southern Appalachians requires abundant oak stands that are mature and composed of both red and white oak species. Although white oak acorns may be preferred, red oaks are particularly valuable in years of white oak mast failure. Oaks and oak habitats are of great importance to bears in the southern Appalachians. Simply put, mature, mast-bearing oaks – especially white oaks – are the driving force behind black bear population dynamics and movements.

4) Threats to the American black bear in the Wayne National Forest region

In Ohio, habitat for the state-endangered black bear is limited to the Appalachian Plateau in the region of the Wayne National Forest. The preservation of suitable habitat in this region is vital to the recovery of this species. Suitable habitat consists of large tracts (≥300 km^2, Rogers and Allen 1987; Smith et al. 2016) of mature, mast-producing oaks, particularly white oaks (Azad et al. 2017), for fall hard mast. A thick understory or openings with shrubland should be available for summer soft mast. Although clear cuts initially provide soft mast, they become unproductive with time; intermediate-aged stands (10–25 years) support very low levels of both hard mast and soft mast (Reynolds-Hogland et al. 2006), and these areas should be minimized. Mature oaks with minimum dbh of 33 inches are required for maternal den sites (Oli et al. 1997). Thus, threats to habitat in this region include the loss of mature oaks, decline of white oaks, loss of large diameter trees, and increased area of clear cuts. Habitat threats can be avoided by increasing or maintaining the acreage of oak stands >70 years old, particularly white oaks, which can support high levels of hard mast and intermediate levels of soft mast, while simultaneously decreasing the area of intermediate growth stands (10-25 years) by avoiding new clear cuts (Reynolds-Hogland et al. 2006).

In addition to the loss of suitable habitat, the loss of contiguous habitat (i.e., fragmentation), and the development of an inhospitable matrix, such as agriculture or residential developments, surrounding fragments of suitable habitat is also a threat. The patchy distribution of resources in anthropogenically or naturally fragmented landscapes requires black bears to travel farther and thus to have larger home ranges than those inhabiting unfragmented natural habitats (Hellgren and Maehr 1992; Mitchell and Powell 2008). The increased travel needed to secure sufficient resources in fragmented landscapes also increases the risk of vehicular mortality and conflict with humans (Baruch-Mordo et al. 2008; McCown et al. 2009; Evans et al. 2014). Ditmer et al. (2018) found that black bear heartrates became elevated when 73−183 m away from roads prior to crossings. It follows that as habitats become more fragmented and more roads are crossed, stress to bears will increase, possibly negatively affecting bear health, as well as posing an increased risk of vehicle-related mortality.

Most bears avoid human development or use heavy cover to pass by or through it. Black bears use riparian areas (e.g., lowland deciduous forests, rhododendron swamps; Alt et al. 1980) in human-dominated landscapes as escape and foraging cover or for denning. According to Tri et al. (2016), black bears typically use rhododendron swamps adjacent to human development to move through the urban matrix. Bears may also occasionally use roads with low anthropogenic risk (Brody and Pelton 1989; Reynolds-Hogland and Mitchell 2007) as movement corridors, but roads typically hinder bears by introducing mortality risks (e.g., vehicle collisions) and fragmenting resources across the landscape (Reynolds-Hogland and Mitchell 2007; Waller et al. 2014). Anthropogenic mortality risk may especially influence resource selection of adult females with dependent young that are attempting to meet increased nutritional demands while avoiding vehicles (Wilton et al. 2014), hunters (Reynolds-Hogland and Mitchell 2007), and intraspecific predation (LeCount 1987; Garrison et al. 2007).

As residential and agricultural development expands, however, some bears have learned to utilize anthropogenic foods (e.g., garbage, fruit trees, birdfeeders) as food sources (Lewis et al. 2015; Kirby et al. 2016). Limited research suggests that black bears foraging on anthropogenic foods hibernate for shorter periods (Beckmann and Berger 2003; Baldwin and

Bender 2010), or even forgo hibernation altogether (Beckmann and Berger 2003), as their dependence on seasonal native foods declines.

In addition to human development, climate change is arguably the most significant factor altering habitat conditions for wildlife worldwide (Parmesan and Yohe 2003). These factors have transformed landscapes leading to changes in animal behaviour, distribution, population dynamics, and interspecific interactions (Selwood et al. 2015). The influence of land use and climate change are expected to be particularly pronounced in the hibernation of the black bear.

Like many other species, black bears hibernate in response to seasonal food shortages (Johnson and Pelton 1980; Schooley et al. 1994). Black bear hibernation is also correlated with various weather patterns, with individuals entering dens when temperatures decline and snow accumulates and exiting once temperatures increase and snow melts (Johnson and Pelton 1980; Schooley et al. 1994). Thus, changes in land use and climate may increase the active period for bears, which in turn may increase human-bear conflicts and subsequently bear mortality. Johnson et al. (2018) found that weather and food availability (both natural and human) additively determined black bear hibernation behavior, with warmer temperatures most strongly associated with denning chronology. Warmer temperatures reduced the duration of hibernation. Thus, future changes in climate and land use may further alter bear behavior and increase the length of their active season.

Pandey et al. (2018) used Maxent, an ecological niche modeling algorithm, to estimate the potential future distributions of an apex predator and mesopredator mammals in the boreal forest and tundra biomes of North America. They projected the climatic niche models of apex predators and mesopredators using future climate datasets based on three global circulation models and four greenhouse gas emission scenarios. Interestingly, the only apex predator that was predicted to increase its distribution under all greenhouse gas emission scenarios was the black bear. Thus, the future may witness increased black bear distributions and decreased black bear hibernation periods.

Increased black bear active periods will logically result in the need for additional food resources for black bears and potentially increase home range sizes. Mitigation of the effects of climate change on black bears will include the maintenance or creation of larger blocks of suitable habitat, with mature mast producing oaks, soft mast producing shrubs, and squawroot and food in downed woody debris characteristic of mature oak stands. Within these areas, fragmentation should be minimized, thus reducing the stress and increased mortality induced by road crossings. The creation of new roads should be minimized, and unneeded roads should be removed. Minimizing fragmentation will also minimize human contact that may occur in a fragmented landscape where bears must traverse human-dominated areas. Consequently, this will decrease nuisance behavior and associated black bear mortality.

5) Implication for forest management

Conservation of viable large carnivore populations, such as the black bears, and other mammalian species with large home ranges requires extensive blocks of habitat. Suitable habitat is mature mast-producing oaks (>70 years old) with a dense shrub layer or openings with shrubland (Reynolds-Hogland et al. 2006). Human influence, and thus fragmentation, in this habitat should be minimal to limit accidental mortality of these low-density and low birth-rate species, and because large carnivores are a perceived threat to humans and their domestic animals (Rudis and Tansey 1995). Thus, forest management should include the maintenance of large contiguous blocks of habitat. Blocks of ≥300 km^2 are necessary for a viable black bear population (Rogers and Allen 1987; Smith et al. 2016). It is important to note that this area represents contiguous, non-fragmented habitat; larger areas will be necessary if the area is fragmented by roads or human-dominated landscapes. The importance of such large contiguous blocks of forest will increase as climatic change increases black bear distribution and active periods.

Fragmenting large blocks of continuous forest results in larger bear home ranges as they are forced to move among patches of habitat (Karelus et al. 2016). Movement through human-dominated landscapes increases the chances of vehicle-related mortality and human-bear conflicts, which too often result in bear mortality. Furthermore, larger movement patterns result in increased energetic output and potentially poorer physical condition and reduced reproduction in females.

Habitat management should include mast enhancement and provision of key habitat components, such as foraging and denning cover (Hellgren and Vaughan 1994; Oli et al. 1997). The maintenance of large oaks (≥33 in) in the interior of forests are needed for safe and thermally protective maternal dens and reproductive success. Furthermore, areas of dense cover, especially near roads and human-dominated landscapes are necessary for escape cover. Because they provide spring and summer foods, wetlands should be preserved within the larger forested framework. Nutritional factors appear to be vital to black bear population growth and habitat improvement programs should be useful in the management of Ohio’s endangered black bears (Rogers 1976).

Bears require large areas of forested habitats with a dense shrub later or habitat interspersed with openings to achieve year-round dietary requirements. In Pennsylvania, male bears had an average home range size of 143 km^2, whereas females covered 41 km^2 (Alt et al. 1980). Forests dominated by oaks, especially white oaks, will allow for adequate fall foods during most years and will help to ensure positive black bear population growth rates. Management with the goal of maintaining or increasing population growth of black bears in the southern Appalachians should focus on maintaining the availability of both hard mast and soft mast. Older hardwood stands, which support high levels of hard mast and moderate levels of soft mast, should be maintained to sustain the population growth of black bears. This can be achieved by increasing or maintaining the acreage of oak stands >70 years old (Reynolds-Hogland et al. 2006) and minimizing the acreage of intermediate-aged stands (10–25 years), which support very low levels of both hard mast and soft mast. Although clearcutting (i.e., removal of all trees within a stand) results in the increased production of soft mast, it eliminates production of hard mast for 25–50 years, which is the time required for hardwoods to reach reproductive age in the southern Appalachians.

Overall, forest management to increase black bear populations should strive to provide bears adequate food, water, escape cover, and den sites within a contiguous, mature forest landscape. Habitat fragmentation, construction of roads, and development of spaces between seasonal food sources should be avoided.

LITERATURE CITED/ANNOTATED BIBLIOGRAPHY

Alt, G. L. 1984. Black bear cub mortality due to flooding of natal dens. Journal of Wildlife Management 48:1432–1434.

The author reports on cub mortality during flooding of maternal ground dens. Nineteen of 102 (18.6%) natal black bear dens flooded while in use between 1973 and 1983 resulting in the death of at least 15 of 286 (5.2%) cubs. Additional mortality was suspected, but not confirmed in at least nine other litters. Mortality of cubs in natal dens was a function of both den selection by the female and weather conditions prior to and during the denning period.

Alt, G. L., and J. M. Gruttadauria. 1984. Reuse of black bear dens in northeastern Pennsylvania. Journal of Wildlife Management 48:236–239.

The authors examined reuse of black bears dens and found a 4.8% overall rate of den reuse. Low rates of den reuse by black bears have also been reported for Arizona, Idaho, California, and Alberta. In these areas, availability of suitable den sites is probably not a limiting factor for black bear populations, although this may not be so in all areas. Over 50% den reuse occurred in Washington and Alaska.

Alt, G. L., G. J. Matula, Jr., F. W. Alt, and J. S. Lindzey. 1980. Dynamics of home range and movements of adult black bears in northeastern Pennsylvania bears: Their biology and management. A Selection of Papers from the Fourth International Conference on Bear Research and Management, Kalispell, Montana, USA, February 1977 (1980), 4:131–136.

The authors determined home range and movement patterns of 17 radiocollared adult black bears from approximately 2,000 radio locations obtained between January 1973 and December 1976 in northeastern Pennsylvania. Total home range size averaged 173 km^2 for males and 41 km^2 for females. Females traveling with offspring used larger areas than solitary females. Seasonal variation in home range and movement patterns was extensive. Maximum home range size and maximum daily movements of adult males and breeding females occurred during the June and July breeding season, whereas home range size and movements of females with cubs increased from spring through summer and peaked in September.

Azad, S., T. Wactor, and D. Jachowski. 2017. Relationship of acorn mast production to black bear population growth rates and human–bear interactions in northwestern South Carolina. Southeastern Naturalist 16:235–251.

A 15-year dataset of black bear abundance based on harvest and a long-term mast dataset from South Carolina were used. The authors determined the effects of acorn mast abundance on bear population growth rates and human-bear interactions. The results supported that black bear growth rates were influenced by mast abundance, although the relationship varied by oak type. The correlation was positive for white oaks and negative for red oaks. The authors speculated that the lower tannin content in white oaks made them more important to bear diet than red oaks. Furthermore, human-bear interactions were negatively related to mast abundance in the same year, indicating that bears may need to venture closer to humans when the acorn mast supply is low. This is another negative effect of low acorn mast abundance on black bear population growth and survival.

Baldwin R. A., and L. C. Bender. 2010. Development of equations predictive of size and condition for black bears in Rocky Mountain National Park, Colorado. American Midland Naturalist 164:44–51.

The authors assessed body condition of black bears in the Rocky Mountain National Park, Colorado, using body mass (BM), percent body fat (BF), and a body condition index (BCI) to: (1) develop a model predictive of BM for bears using morphometric measures, (2) compare three models that predict BM to provide information on the effect of elevation and more complex models on model accuracy, and (3) determine the relationship between BF and BCI. The best BM model included only girth and indicated that mass-morphology relationships were more consistent within specified elevation zones. Model complexity had little influence on model efficiency. A strong relationship between BF and BCI indicated that BCI scores could be accurately converted to estimates of BF. The predictive equation will be useful when BF cannot be directly estimated.

Baruch-Mordo, S., S. W. Breck, K. R. Wilson, D. M. Theobald. 2008. Spatiotemporal distribution of black bear–human conflicts in Colorado, USA. Journal of Wildlife Management 72:1853–1862.

The authors examined spatial and temporal distribution of bear-human conflicts in Colorado, related to three conflict types: agriculture operations, human development, and road kills. Bear-human conflicts exhibited spatial clustering by type, and areas of high clustering overlapped conflict types. Both human development and road-kill conflict clusters were high in areas of high-quality oak–shrub habitat in the central and southern portions of Colorado's Front Range region and near the city of Durango in southwestern Colorado. Bear-human conflicts varied by year and type but overall they increased during the 18 years. Conflicts were near equally distributed, but most were related to agriculture (32%), followed by road kills (27%) and human development (24%).

Beckmann, Jon P., and J. Berger. 2003. Rapid ecological and behavioural changes in carnivores: the responses of black bears (*Ursus americanus*) to altered food. Journal of Zoology 261:207–212.

The authors contrasted black bear behavior between individuals living in the urban-wildland interface ('experimental') and wildland ('control') settings at the interface of the Sierra Nevada range and the Great Basin Desert in the western United States. A temporal dimension was included by comparing data with those from the same population that lacked areas of human encroachment 10–15 years earlier. Specifically, they examined the effects of garbage on bear time budgets, patterns of activity, and den chronology. Individuals at the urban interface areas relative to wildland conspecifics were: (1) active for significantly fewer hours per day; (2) shifted their activities to nocturnal periods; (3) entered dens significantly later and remained in them for significantly fewer days.

Beecham, J. 1980. Some population characteristics of two black bear populations in Idaho. Bears: Their biology and management, A Selection of Papers from the Fourth International Conference on Bear Research and Management, Kalispell, Montana, USA, February 1977 (1980), 4:201–204.

The author studied two geographically discrete populations of black bears in Idaho during 1973–1976. The Council population, located in west-central Idaho, had a history of heavy hunting pressure, accessibility, and liberal hunting seasons. The Lowell population in north-central Idaho experienced relatively light hunting pressure, poor accessibility, and liberal hunting seasons. An analysis of the male and female age structures indicated that adult males were more susceptible to hunting than other segments of the population. Sex composition differed significantly between subadult and adult segments of the two populations, but not between populations. Mean litter size was 1.9 at Council and 1.7 at Lowell. Productivity (number of young produced per year) appeared to be density-independent and a function of habitat quality and the number of adult females in the population.

Beeman, L. E., and M. R. Pelton. 1980. Seasonal foods and feeding ecology of black bears in the Smoky Mountains. International Conference on Bear Research and Management 4:141–147.

The authors collected 75 stomachs and 1,025 scats from black bears in the Great Smoky Mountains National Park and vicinity for food content analysis. Grasses and the other herbaceous leaves and stems, squawroot, huckleberries, black cherry, acorns from oaks, blackberries, and blueberries composed 81 percent of the diet by volume. Eleven percent of the food consumed was animal matter, principally Coleoptera and Hymenoptera. Artificial food constituted 6 percent of the diet. The most critical season with regard to food availability was late fall because mast (nuts) is the only preferred natural food source available and mast failures occur frequently.

Bull, E. L., Torgersen, T. R., and Wertz, T. L. 2001. The importance of vegetation, insects, and neonate ungulates in black bear diet in northeastern Oregon. Northwest Science 75:244–253.

The authors examined fecal samples of black bear to determine diet in northeastern Oregon. Mean estimated relative volume of food items in 621 scats was 35% grasses, 24% insects, 16% fruit, 11% soil and wood, 10% animal remains, and 4% leaves and stems. During June, remains of mule deer and elk occurred in 44% of the scats in 1998 and in 25% in 1999. Between May and October, >40% of all scats collected in each month contained insects, and 98% of those scats collected in July contained insects, primarily ants and yellowjackets. Because most prey species were log-dwelling, management for coarse woody debris is important.

Brody A. J., and M. R. Pelton. 1989. Effects of roads on black bear movements in western North Carolina. Wildlife Society Bulletin 17:5–10.

The authors collected telemetry data from 17 black bears in Pisgah National Forest and determined road crossing frequency in relation to traffic volume and road density. Bears almost never crossed an interstate highway. Roads with low traffic volume were crossed relatively more frequently than roads with higher traffic volume. Road-crossing frequency was not affected by age or sex of bears, season, or sanctuary status of the home ranges. The road-crossing/road-density relationship was linear for all volumes of traffic, and thus bears did not restrict their movements in reaction to road density within established home ranges. Of particular interest, bears may react to increases in road density by shifting the locations of home ranges to areas with lower road densities.

Clark, J., F. T. Van Manen, and M. R. Pelton. 2005. Bait stations, hard mast, and black bear population growth in Great Smoky Mountains National Park. Journal of Wildlife Management 69:1633–1640.

This study used hard mast surveys to assess annual bear food availability. The objective was to determine if changes in bait station indices were related to bear population growth, and whether hard mast affected visitation rates to bait stations. Further, it evaluated whether mast from the previous year affected bear population growth rate (lambda) based on capture-recapture data. Oak mast indices were directly related to lambda, but there was no direct relationship between bear station visitation rates and lambda. The authors concluded that environmental factors can confound bear population growth rate estimates based on bear station visitation rates.

Costello, C. M., and R. W. Sage. 1994. Predicting black bear habitat selection from food abundance under three forest management systems. International Conference for Bear Research and Management 9:375–387.

The authors measured seasonal food abundance within 17 habitats in the central Adirondack Mountains of New York and used food abundance indices to predict habitat selection. Managed habitats provided the highest abundance of spring and summer foods. Non-managed and uneven-aged managed hardwood habitats provided the highest amounts of beechnuts, a primary fall food. Data from five adult female black bears showed that habitat selection was greatly influenced by food abundance. Seasonal shifts in habitat use were related to changes in food resources. Bears used habitats with high food abundance more than expected and habitats with low food abundance less than expected. Habitat diversity was beneficial. Management implications are discussed.

Costello, C. M., D. E. Jones, R. M. Inman, K. H. Inman, B. C. Thompson, and H. B. Quigley. 2003. Relationship of variable mast production to American black bear reproductive parameters in New Mexico. Ursus 14:1–16.

The authors examined the relationship between mast production to black bear reproductive parameters in two areas in New Mexico during 1993–2000. Mast production differed across years for each of the 10 species surveyed. Black bear reproductive characteristics were documented during 266 den investigations for 80 females ≥4 years old. On both study areas, acorn production by the two dominant oak species had the greatest influence on natality and recruitment. Natality among parous females decreased more than 60% following oak failure years, and recruitment decreased by more than 70% two years thereafter. The authors concluded that documenting annual mast production can be an effective index to subsequent black bear reproduction.

Ditmer,M. A., S. J. Rettler, J. R. Fieberg, P. A. Iaizzo, T. G. Laske, K. V. Noyce, D. L. Garshelis. 2018. American black bears perceive the risks of crossing roads. Behavioral Ecology. 29:667–675.

The authors deployed GPS collars in combination with cardiac biologgers on black bears in areas with differing road densities across Minnesota. They tested whether bears exhibited acute stress responses, as defined by significant increases in heart rate (HR), when crossing roads. Maximum HR between successive telemetry locations were an average of 13 bpm higher when bears crossed a road. They crossed a road an average of once a day. Stronger HR responses occurred when crossing high-traffic roads relative to low-traffic in half of the bear-year combinations sampled. Bears crossed high-traffic roads mainly at night, but low traffic roads during daylight. Bear HRs first became elevated when 73−183 m away from roadways.

Eagle, T. C., and M. R. Pelton. 1983. Seasonal nutrition of black bears in the Great Smoky Mountains National Park. International Conference on Bear Research and Management 5:94–101.

The authors sampled 86 composites of 646 scats collected at 2-week intervals during 1976 and 1977 and identified five seasonal patterns of food use by black bears in the Great Smoky Mountains National Park. Plant material composed 80% of the diet, and animal remains, mostly insects, were 12%. Major plant food items were identified. Crude protein and acid-detergent-fiber content of major food items were determined, and the nutritional value of each seasonal diet was evaluated. The early spring diet was of low nutritional value and bears lost weight during spring. The late spring, summer, and early fall diets were conducive to growth of bears because readily available energy and high-quality proteins were consumed. The late fall diet was high in available energy and led to rapid increase in weights of bears.

Eiler, J. H., W. G. Wathen, and M. R. Pelton. 1989. reproduction in black bears in the southern Appalachian Mountains. Journal of Wildlife Management 53:353–360.

This study addressed reproduction of black bears in the Great Smoky Mountains, Tennessee during 1972–82. The authors reported females were in estrus from 5 June to 12 September, and most breeding activity occurred from 24 June to 21 July. Females in ground dens had mean litter sizes of 2.6 cubs; mean litter size for females with yearlings in ground dens was 2.2. Most females gave birth for the first time at 4 or 5 years of age. Females usually gave birth every other year, but 8 of 23 females skipped years in between. The loss of entire litters was not common, although mortality also occurred within litters. The availability of hard mast during fall affected minimum reproductive age, productivity, and cub survival. Maximizing hard mast production and promoting secondary fall foods should enhance reproduction and survival of black bears in the southern Appalachian Mountains.

Elowe, K. D., and W. E. Dodge. 1989. Factors affecting black bear reproductive success and cub survival. Journal of Wildlife Management 53:962–968.

The authors present data from 18 adult female black bears bearing 62 cubs in 27 litters (31 M and 31 F) from an exploited population in western Massachusetts to provide information on black bear nutrition and population dynamics. Diet and nutritional analyses of food items indicated that nutritional condition of pregnant females affected reproductive success. Twenty-six of 28 females with access to high fat and carbohydrate mast diets produced cubs, but 10 of 10 females with low carbohydrate fall diets failed to produce cubs. Thirteen of 20 female cubs survived to adulthood. Eight of 21 male cubs survived until dispersal, but six of eight were shot by hunters while dispersing at age 2.5. Only two of 21 male cubs survived to adulthood. There was no evidence of competition for food or space. Fall mast availability influenced bear densities through the number of female cubs born.

Evans, M. J., J. E. Hawley, P. W. Rego, and T. A. G. Rittenhouse. 2014. Exurban land use facilitates human-black bear conflicts. Journal of Wildlife Management 78:1477–1485.

The authors applied a spatial modeling approach to identify landscape variables associated with the spatial intensity of human-black bear conflicts in Connecticut and predicted where conflicts were most likely to occur. Percent forest cover within 1 km^2 and the proportion of forest classified as edge habitat were the most important factors associated with the location of conflicts. They attributed the results to Connecticut's exurban landscape, typical of New England, in which housing and natural land cover are extensively interspersed.

Fecske, D. M., R. E. Barry, F. L. Precht, H. B. Quigley, S. L. Bittner, and T. W. Webster. 2002. Habitat use by female black bears in western Maryland. Southeastern Naturalist 1:77–92.

Maryland's black bears were legally protected in 1972. Since then, the population has grown and increasing bear-human conflicts created a need for information on bear management. Consequently, the authors determined macro-habitat characteristics of five adult radiocollared bears. Overall, bears selected mixed forest and wetlands, and habitat with high stream densities. Bears selected conifer stands throughout the year and residential areas during the spring-summer season. Variation in use of residential areas and habitat near streams appeared to be related to the availability of wetlands. Bears avoided primary highways, but not other road classes, although females traveling with cubs selected habitats with lower road densities. The authors suggested maintaining wetlands and mixed forest habitats, enhancing understory cover in maturing deciduous forests, increasing conifer stands in areas where management for mature forest is unrealistic, and constructing wildlife underpasses on highways.

Fuller, T. K., and L. B. Keith. 1980. Summer ranges, cover type use and denning of black bears near Fort McMurray, Alberta. Canadian Field-Naturalist 94:80–82.

The authors radiocollared black bears near Fort McMurray, Alberta during June-October 1976. Four females with cubs had an average range of 7.5 km. Spruce and open muskegs were avoided, whereas mixed aspen and jack pine were used more often than expected. Six bears denned; five dens were excavated on ground level and four were in stands of mixed aspen and birch.

Garrison, E.P., J.W. McCown, and M.K. Oli. 2007. Reproductive ecology and cub survival of Florida black bears. Journal of Wildlife Management 71:720–727.

The authors investigated reproductive ecology and cub survival of Florida black bears in the Ocala National Forest and the adjacent residential area of Lynne, Florida, 1999–2003. They documented production of 81 cubs from 39 litters. Average litter size was 2.08 ± 0.11 (SE) cubs and mean age of first reproduction was 3.25 ± 0.27 years. The inter-litter interval was 2.11 ± 0.11 years. The mean annual fecundity rate was 0.57 ± 0.06. Expandable radiocollars were used to monitor 41 cubs. The probability of cubs surviving to 9 months of age was 0.46 ± 0.09 and did not differ between cohorts or study locations. The greatest causes of cub mortality included infanticide and mortality caused directly or indirectly by collisions with vehicles. Cub survival rates were lower than those reported for most black bear populations.

Goodrich, J. M., and J. Berger. 1994. Winter recreation and hibernating black bears *Ursus americanus.* Biological Conservation 67:105–110.

The authors assessed the effects of winter activities on black bear denning ecology for three winters in the Sierra Nevada and Sweetwater Mountains in Nevada and California. Fourteen bears in the Sierra entered 31 dens earlier and were more selective in their choice of den sites than five Sweetwater bears using 10 dens. Bears at both sites abandoned dens and cubs in response to investigator disturbance, and all but one bear remained active after abandonment. High overlap between bear denning sites and potential winter recreation areas created a high potential for den abandonment because of human disturbance. Bear denning areas should be protected from human disturbance during winter.

Hamilton, R. J., and R. L. Marchinton. 1980. Denning and related activities of black bears in the coastal plain of North Carolina. International Conference on Bear Research and Management 4:121–126.

This study addressed black bear activities in southeastern North Carolina as determined by radiotelemetry, trapping success, track counts, seat collections, and hunter harvests from May 1974 to January 1977. All data indicated that bear activity decreased progressively in autumn. The only significant winter movement was by males. Four bears denned on the ground in dense Carolina bay vegetation. One adult female denned in a bald cypress with an entrance cavity approximately 25 m above the water. Post-denning movements gradually increased and reached a peak during breeding season in June and July.

Hayes, S. G., and M. R. Pelton. 1994. Habitat characteristics of female black bear dens in northwestern Arkansas. International Conference on Bear Research and Management 9:411–418.

This study included 29 radiocollared female black bears that were tracked to 48 den sites during winters 1988-89 and 1989-90 in the Ouachita and Ozark mountains of Arkansas to study den selection and habitat. Bears on both areas used rock cavity dens most often (66.6%), followed by excavations (12.5%), clearcuts (12.5%), open nests (4.2%), and tree cavities (4.2%). Black bears selected dens that were physically different, but functionally similar. Rock cavity dens occurred on steep slopes, within structurally secure cavities, far from external disturbances. Excavation and clearcut dens lacked permanent structure, but security was compensated by dense understory vegetation and increased horizontal cover.

Hellgren, E. C., and D. S. Maehr. 1992. Habitat fragmentation and black bears in the eastern United States. Proceeding of the Eastern Workshop on Black Bear Research and Management 11:154–165.

The authors discuss the effects of fragmentation by habitat loss and human disturbance on the American black bear. In addition to reductions in distribution, habitat, and population size, fragmentation has other biological effects, including effects on genetic diversity, demographics, range dynamics, and dispersal. Internal habitat fragmentation by roads is of particular interest to management of hunted black bear populations. The history of black bears in Florida is reviewed as a case study of bear populations in fragmented habitat. The authors discuss population and habitat considerations for the conservation of black bears in fragmented habitat, such as management to control mortality rates and using habitat projections in population models.

Hellgren, E.C., and M.R. Vaughan. 1994. Conservation and management of isolated black bear populations in the southeastern coastal plain of the United States. Proceedings of the Annual Conference of Southeastern Association of Fish and Wildlife Agencies 48:276–285.

The authors surveyed bear biologists in Canada, Mexico, and the U.S. and estimated the current range of black bears using four categories: primary range and secondary range (which together comprise total range), bear sighting locations outside range, and no bears reported. Primary and secondary ranges in 12 Canadian provinces and territories, 40 states in the U.S., and 6 states in Mexico totaled 10.5 million km^2, representing 65–75% of historical range. Total bear range in Canada was 6.9 million km^2, representing 95–100% of historical range. Total range in the U.S. was 3.5 million km^2, representing 45–60% of U.S. historical range. Respondents reported occasional sightings but no primary or secondary range in six U.S. states (IA, KS, NE, ND, OH, and SD), and bears were absent from the District of Columbia and four states (DE, HI, IL, and IN). Only primary range data were available in Mexico, consisting of approximately 99,000 km^2 across portions of six states (Chihuahua, Coahuila, Durango, Nuevo Leon, Sonora, and Tamaulipas). The expansion of primary range since the mid-1990s was confirmed in Virginia and North Carolina.

Hellgren E. C., M. R. Vaughan, and F. Stauffer. 1991. Macrohabitat use by black bears in a southeastern wetland. Journal of Wildlife Management 55:442–448.

This study was conducted to document habitat use by black bears in the Great Dismal Swamp of Virginia and North Carolina by radiotracking 24 female and 16 male bears. Females preferred pocosins and mesic areas and males preferred gum-cypress and maple-coniferous stands. Females preferred pocosins and disturbed areas during summer, mesic and gum-cypress habitats in early fall, and pocosins in late fall. Females used maple-dominated habitats less than their availability annually. Roads were preferred by females during all seasons except early fall, when females made excursions to feeding areas far from roads. The authors concluded that maintenance and enhancement of pocosins, mature gum, oak, and disturbed habitats would benefit black bears in southeastern wetlands by providing a wide variety of natural foods throughout the year.

Inman, R. M., and M. R. Pelton. 2002. Energetic production by soft and hard mast foods of American black bears in the Smoky Mountains. Ursus 13:57-68.

This study measured caloric production by 19 species of vegetation used as food by black bears in the Great Smoky Mountains National Park to determine the significance of production by mast type, season, and species. Hard mast produced 74.5% of total calories available on the study area, whereas soft mast produced 25.5%. *Quercus rubra* produced 65.7% of the calories, squawroot produced 15.8%, and huckleberries produced 5.1 %. Because of a white oak mast failure occurred, and white oaks produced only 5.1% of calories. The authors concluded that oaks were likely the single most influential genera affecting bear ecology in the southern Appalachians. However, availability of soft mast has a substantial effect on populations because of the timing of production, nutrients available, and its function as a surrogate during hard mast failure.

Johnson, K. G., and M. R. Pelton. 1980. Environmental relationships and the denning period of black bears in Tennessee. Journal of Mammalogy 61:653–660.

The authors determined the denning period of black bears in the Great Smoky Mountains National Park using motion-sensitive transmitter collars. Most (n = 14, 83%) collared bears entered dens between 25 December and 7 January. Emergence occurred between 25 March and 7 April, with the denning period averaging 90 days. Cumulative effects of increased precipitation and lower maximum and higher minimum temperatures provided a proximate stimulus to enter dens. Food supply also appeared to affect denning in a proximal manner because bears denned earlier in years with fair to poor mast yields than those with excellent mast yields. Emergence dates were less strongly correlated with environmental factors.

Johnson, H. E.. D. L. Lewis, T. L. Verzuh, C. F. Wallace, R. M. Much, L. K. Willmarth, and S. W. Breck. 2018. Human development and climate affect hibernation in a large carnivore with implications for human–carnivore conflicts. Journal of Applied Ecology 55:663–672.

The authors determined the influence of human development and weather on hibernation of black bears, a species whose behavior is strongly tied to food availability and weather conditions. They used GPS collar data from 131 den events of 51 adult female bears and determined the influence of natural food availability, anthropogenic food, and weather on the start, duration, and end of hibernation. They found that weather and food availability (both natural and human) additively determined black bear hibernation behavior, with warmer temperatures most strongly associated with denning chronology. Warmer temperatures reduced the duration of hibernation. Warmer temperatures and use of anthropogenic foods additively reduced black bear hibernation, suggesting that future changes in climate and land use may further alter bear behavior and increase the length of their active season. The authors concluded that longer active periods for bears will result in subsequent increases in human–bear conflicts and human-caused bear mortalities.

Karelus, D. L., J. W. McCown, B. K. Scheick, M. van de Kerk, and M. K. Oli. 2016. Home ranges and habitat selection by black bears in a newly colonized population in Florida. Southeastern Naturalist 15:346–364.

The authors sought to understanding how animals use space and resources in newly colonized, anthropogenically altered habitats. They collected GPS-location data for 16 individuals (6 females, 10 males) from the summer 2011 to summer 2013 to determine space and habitat use by a recently established black bear population. Home ranges were larger than those reported for black bears inhabiting the nearby contiguous forested habitat of Ocala National Forest, indicating that fragmentation influences home-range size. Bears strongly selected riparian forests and urban areas were avoided. Thus, this suggested that large carnivores that inhabit fragmented landscapes require more space than conspecifics in continuous habitats or those with better connectivity.

Kasbohm, J. W., M. R. Vaughan, and J. G. Kraus. 1996. Effects of gypsy moth infestation on black bear reproduction and survival. Journal of Wildlife Management 60:408–416.

This study tested the hypothesis that a gypsy moth infestation would adversely affect black bear reproduction and survival. The authors compared aspects of bear population dynamics between years of extensive gypsy moth defoliation and years immediately before the infestation (1982–84). Despite acorn failure, infestation had no detectable effect on bear reproduction or survival. Radiomarked females produced cubs by age 4, in alternate years, and none skipped an opportunity to reproduce. Five known primiparous mothers gave birth to at least 11 cubs and reared 10 of them to 1 year of age. Survival of all age/sex cohorts did not differ from pre-defoliation levels. The results demonstrated that variability in annual acorn crops do not solely explain fluctuations in bear reproduction and survival and indicated the importance of alternate fall food sources (i.e., soft mast) to bears.

Kirby, R., M.W. Alldredge, and J.N. Pauli. 2016. The diet of black bears tracks the human footprint across a rapidly developing landscape. Biological Conservation, 200, 51–59.

The authors explored the effects of landscape factors on black bear diet across the state of Colorado. They estimated assimilated diet using stable isotope analysis of tissues from harvested black bears to determine the contribution of human-derived foods to bear diets and how increasing reliance on human-derived foods increases the risk of conflict. They found that the 296 bears showed strong regional diet variability, and substantial use of human-derived foods in eastern Colorado. The age-sex class of the bear and housing density of its harvest location were the most influential predictors. Furthermore, foraging on subsidies increased the odds of being a nuisance bear. They concluded that although demographic differences play a role in the foraging ecology of bears, availability of subsidies with varying levels of human activity is a major driver in black bear diet throughout the western U.S.

Kirkpatrick, R. L., and P. D. Pekins. 2002. Nutrition value of acorns for wildlife. In: W.J. McShea and W.M. Healy, (Eds.), Oak forest ecosystems: Ecology and management for wildlife. pp. 173–181. Baltimore, Maryland: Johns Hopkins University Press.

This book summarizes the ways in which oaks are important components in many temperate forest ecosystems. It brings together knowledge from a diverse group of people who study oak forests and makes that information available to those interested in managing forests for wildlife. This chapter discusses the nutritional value of oaks to black bears, as well as other wildlife species in North American forests.

Landers, J. L., R. J. Hamilton, A. S. Johnson, and R. L. Marchinton. 1979. Foods and habitat of black bears in southeastern North Carolina. Journal of Wildlife Management. 43:143–153.

The authors determined foods and habitat use of black bears in the Coastal Plain of southeastern North Carolina from 732 fecal droppings and contents of 28 stomachs, and from radio monitoring 10 bears. Major habitat components were (1) a variety of habitats producing seasonal foods; (2) extensive, inaccessible areas (Carolina bays, hardwood swamps) for denning; and (3) escape cover for bears hunted with dogs (large swamps). Carolina bays contributed most natural foods (berries and succulent plants), except in spring when bears fed in swamps on arrow-arum leaves and in fall when they fed in swamps on black gum or on sand ridges on oak mast. Bears in this region need large areas with a variety of habitat types to meet annual food and cover requirements.

Larkin, J. L., D. S. Maehr, T. S. Hoctor, M. A. Orlando, and K. Whitney. 2004. Landscape linkages and conservation planning for the black bear in west-central Florida. Animal Conservation 7:23–34.

The authors worked with the Greater Chassahowitzka black bear population, which is the smallest documented in North America having fewer than 20 individuals. The authors identified potential landscape linkages between this isolated population and six others in Florida. Pathway lengths ranged from 60–194 km with varying potentials for facilitating black bear dispersal. Each pathway incorporated 35–88% conservation land and encountered at least 11 dispersal bottlenecks. All six pathways, however, passed through ≥95% core black bear habitat. Thus, the infrastructure for a conservation network is still largely intact. Immediate strategic planning and active conservation and restoration measures could provide long-term connectivity.

LeCount, A. L. 1987.Causes of black bear cub mortality. Bears: Their Biology and Management, A Selection of Papers from the Seventh International Conference on Bear Research and Management, Williamsburg, Virginia, USA, and Plitvice Lakes, Yugoslavia, February and March 1986 (1987), 7:75–82.

The author collared 23 black bear cubs in their winter den with motion-sensitive breakaway radiocollars from 1982 to 1985 in Arizona. Eleven (48%) died but cause of death was determined in only eight cases because of collar loss. Fifty percent of these deaths were the result of cannibalism by other bears. Other causes of mortality included other predation, disease, and hunting. The majority of cub deaths occurred within 60 days of den emergence; only one cub died of natural causes and lived beyond the end of the breeding season. Seven of 13 individual litters (54%) containing radio-collared cubs experienced mortality, and the entire litter died in six cases (86%).

Lewis, D. L., S. Baruch-Mordo, K. R. Wilson, S. W. Breck, J. S. Mao, and J. Broderick. 2015. Foraging ecology of black bears in urban environments: Guidance for human-bear conflict mitigation. Ecosphere 6(8):141.

The authors studied black bears in the urban area of Aspen, Colorado from 2007 to 2010 to quantify bear foraging on natural and anthropogenic resources and to model factors associated with anthropogenic feeding events. They collected fine-scale spatiotemporal data by tracking GPS-collared bears at 30-min intervals and backtracking to bear locations. They used discrete choice models to assess bear resource selection, modeling anthropogenic feeding (use) and five associated random (availability) locations as a function of attributes related to temporally changing natural (e.g., mast) and human (e.g., garbage) food resources, urban characteristics (e.g., housing density), and land cover characteristics (e.g., distance to riparian area). They backtracked to 2,675 locations used by 24 bears and classified 20% as foraging locations. They found that bears foraged on both natural and anthropogenic food sources in the urban environment, with 77% of feeding events being anthropogenic. They documented inter- and intra-annual foraging patterns in which bears foraged extensively in urban areas when natural food production was poor, then switched to natural food sources when available. Garbage was the main anthropogenic food source that bears used. Selection of foraging sites was not only influenced by presence of garbage but also by proximity to riparian habitat and presence of ripe anthropogenic fruit trees.

Lyons, A. L., W. L. Gaines, and C. Servheen. 2003. Black bear resource selection in the northeast Cascades, Washington. Biological Conservation 113: 55–62.

The authors examined resource selection of black bears in the northeast Cascades of Washington at two spatial scales. They compared habitats selected within home ranges to those available in the study area, and habitats selected for versus those available within home ranges. Similar habitats were selected at each spatial scale, with some differences. Black bears located home ranges within habitats that provided abundant food resources, such as riparian and deciduous forests, meadows, and shrub fields. Once established in a home range, black bears selected a mosaic of habitat types that provided security cover in proximity to food resources, such as riparian and deciduous forests, other forest types, and meadows.

Mack, J. A. 1990. Black bear dens in the Beartooth Face, southcentral Montana. International Conference on Bear Research and Management 8:273–277.

In this study, 33 black bear dens were located on the Beartooth Face of south-central Montana during the winters of 1984/85–1986/87. Mean slope and elevation of den sites did not differ between males and females. Most (61%) den sites were located on northerly (northeast, north, and northwest) aspects. Twenty and 18% of radiocollared bears abandoned den sites and relocated to new dens during 1985–1986 (N = 15) and 1986–1987 (N = 11), respectively. Security of dens appeared to be important, especially for females with cubs, and was related to bears denning at high elevations and on steep slopes away from disturbance.

McCown, J. W., P. Kubilis, T. H. Eason, and B. K. Scheick. 2009. Effect of traffic volume on American black bears in central Florida, USA. Ursus 20:39–46.

The authors reported that of black bears killed by vehicles in Florida from 1976 to 2003, 45% were from the population in central Florida centered in Ocala National Forest (ONF) and the adjacent community Lynne. More bears were killed along State Road 40 (SR-40), which bisects this population, than along any other road in the state. The authors analyzed the locations of 86 radiocollared bears (33 F:40 M in ONF and 13 F in Lynne) monitored May 1999–May 2003. Forty-eight bears crossed SR-40 a minimum of 388 times. ONF females were 2.9 times more likely than Lynne females to cross SR-40. ONF male bears were 4.3 times more likely to cross SR-40 than ONF females and 12.3 times more likely to cross than were Lynne females. The authors documented mortality of seven radiocollared bears by vehicles, four males in ONF and three females in Lynne.

McLean, P. K., and M. R. Pelton. 1990. Some demographic comparisons of wild and panhandler bears in the Smoky Mountains. Bears: Their Biology and Management A Selection of Papers from the Eighth International Conference on Bear Research and Management, Victoria, British Columbia, Canada, February 1989 (1990), 8:105–112.

The authors collected body measurements, sex, weight, age, and reproductive condition from 1,210 captures of wild and 492 captures of panhandler black bears trapped in the Smoky Mountains from 1968 to 1988. Gender was associated with the bear's status (panhandler: 60% male, wild: 54% male). Wild male bears were significantly older than panhandler bears. Male and female panhandlers were significantly heavier than their wild counterparts, and panhandler bears grew faster than wild bears. The number of lactating females was significantly associated with status; 56% of the panhandler and only 33% of the wild females were lactating. Panhandlers were more fertile and larger than wild bears likely reflecting the panhandlers' better access to and use of high-energy, human foods particularly during years of natural food shortage. These findings, as well as differences in demographic characteristics among wild bears within the Smoky Mountains, are further discussed as they relate to the nutritional qualities of the environment.

McLean P. K., and M. R. Pelton. 1994. Estimates of population density and growth of black bears in the Smoky Mountains. Bears: Their Biology and Management A Selection of Papers from the Ninth International Conference on Bear Research and Management, Missoula, Montana, February 23-28, 1992 (1994), 9:253–261.

The authors collected data from 1,239 black bears trapped in three areas of the Smoky Mountains in 1972-89 to estimate bear density. Bears were tagged, tattooed, and released, and the authors estimated densities of 0.09 to 0.35 bears/km^2. Year-to-year density estimates and the observed rate of growth (0–2%) indicated a stable to slightly increasing population. The predictions of the population model indicated the importance of hard mast to this population; in years of good mast, the numbers of bears increased and in years of poor or varying mast availability the population declined.

Mitchell, M. S., and R. A. Powell. 2008. Estimated home ranges can misrepresent habitat relationships on patchy landscapes. Ecological Modelling 216:409–414.

To evaluate potential for bias, the authors simulated home ranges based on optimal selection of resource-bearing patches across a series of simulated resource distributions varying in spatial continuity of resources. For unused patches, they included interstitial, unselected cells most likely to be traveled by an animal moving among selected patches. They compared characteristics of the simulated home ranges with and without interstitial patches to determine if estimates differed from actual characteristics of home ranges, depending on the patchiness of landscapes. The results showed that contiguous home range estimates could be misleading in terms of quality, size, resource content, and efficiency of home ranges, which was proportional to the spatial discontinuity of resource-bearing patches. They concluded that the potential bias of including unselected, largely unused patches in the estimates of home ranges could be high and inferences about the habitat relationships could be misleading.

Moruzzi. T. L., T. K. Fuller, R. M. DeGraaf, R. T. Brooks, and W. Li. 2002. Assessing remotely triggered cameras for surveying carnivore distribution. Wildlife Society Bulletin 30: 380–386.

This study assessed the utility of remotely triggered cameras to survey carnivores. They surveyed a 1,032-km^2 area of Vermont using 35-mm cameras connected to pressure plates at bait stations in an effort to photograph all carnivore species residing in the area and document species-specific habitat relationships. During June-October 1997–1998, camera stations were placed at >1 km intervals to determine the effects of forest cover type (deciduous vs. coniferous-dominated forest stands), distance from edge (<400 m or >500 m from agricultural and residential edges), and levels of human-related development (high or low). Photos of all expected species were obtained. Black bears preferred interior sites and were photographed only in the more forested and less densely populated eastern half of the study site.

Noyce, K.V., and P.L. Coy. 1990. Abundance and productivity of bear food species in different forest types of northcentral Minnesota. International Conference on Bear Research and Management 8:169–181.

The authors used visual ratings in conjunction with systematic sampling to characterize the areal coverage and productivity of 22 species of herbs and shrubs that produce food for bears in 11 common forest types in northcentral Minnesota. They made sample counts of berries and nuts to relate visual ratings to fruit biomass. Abundance of fruit-producing species was highest in regenerating (5–15-year-old) aspen stands, but total fruit production was highest in 8–20-year-old red pine plantations that contained interspersed openings of windrowed slash. Fruit yields were poorest under dense (>80% closed) canopies and in lowland forest types, but lowlands provided a different array of species from uplands.

Noyce, K. V., and D. L. Garshelis. 1994. Body size and blood characteristics as indicators of condition and reproductive performance in black bears. International Conference on Bear Research and Management 9:481–496.

In this study, the authors examined relationships between reproductive performance of female Minnesota black bears and potential indicators of nutritional condition during late hibernation. Litter size was influenced more by litter order (first or subsequent) than by maternal condition, except in very large females. Cub survival was affected only when mother's weight two months postpartum was <65 kg. No juvenile females (2–8 years old) weighing <41 kg in March produced their first cubs the following spring, but 57% of those above this threshold weight produced cubs. Life history parameters of black bears responded to declining nutrition in the following sequence: (1) litter size declines, then stabilizes across a broad range of maternal weights; (2) age of first reproduction increases; (3) juvenile survival decreases; (4) first-year cub survival decreases; and (5) litter frequency decreases.

Noyce, K. V., and D. L. Garshelis. 2011. Seasonal migrations of black bears (*Ursus americanus*): Causes and consequences. Behavioral Ecology and Sociobiology. 65:823–835.

The authors examined seasonal movements of 206 radiocollared bears in north-central Minnesota during 1981–1990. Late summer movements were common for both sexes and all ages but were variable from year-to-year in prevalence, timing, and destination. Bears typically left their summer home ranges in August and returned approximately 6 weeks later in September or October. Most traveled southward, where acorns were more plentiful. These facultative migrations were most common when rich resources were available outside home ranges. Bears were least apt to leave when foods were scarce in their home range, possibly sensing a risk of migrating during a widespread food failure. Among females, those whose body mass was close to a reproductive threshold were most prone to migrate. Migrating bears were less likely to be killed by hunters, suggesting that they were especially vigilant.

Oli, M. K., H. A. Jacobson, and B. D. Leopold. 1997. Denning ecology of black bears in the White River National Wildlife Refuge, Arkansas. Journal of Wildlife Management 61:700–706.

This study was conducted to improve the management of remnant bear populations in the lower Mississippi floodplain by understanding denning ecology. The authors monitored 23 radiocollared black bears for 33 den years from 1993 to 1995 in the White River National Wildlife Refuge, Arkansas to determine denning chronology and den requirements. They provide denning dates and lengths. More than 44% of the bears that denned (n = 27) used >1 den during a season, and one female used four dens. Most (90.2%, n = 51) dens were elevated tree cavities with a hollow opening on the top or middle of the main trunk. The species of tree most used (77.8%, n = 46) was overcup oak. Basal area of trees and number of stems differed among vegetation plots with and without den trees. For seasonally flooded habitats, the results suggested the need for maintenance or augmentation of trees with 84 cm dbh to increase the number of potential dens and to enhance the quality of den microhabitats.

Pandey, Ranjit, and M. Papeş. 2018. Changes in future potential distributions of apex predator and mesopredator mammals in North America. Regional Environmental Change 18:1223–1233.

The authors used Maxent, an ecological niche modeling algorithm, to estimate the potential future distributions of an apex predator and mesopredator mammals in the boreal forest and tundra biomes of North America. They projected the climatic niche models using future climate datasets based on three global circulation models and four greenhouse gas emission scenarios. Under future climate projections, the potential distributions of most of the predators studied increased by 2050 and 2070. The only apex predator that was predicted to increase its distribution under all greenhouse gas emission scenarios was the black bear. Predicted expansions of distribution ranges of most mesopredators and contractions of distribution ranges of apex predators included in this study may result in changes in species interactions in North American boreal forests and tundras in the future.

Parmesan, C., and G. Yohe. 2003. A globally coherent fingerprint of climate change impacts across natural systems. Nature 421:37–42.

The authors analyzed more than 1,700 species and show that recent biological trends match climate change predictions. Global meta-analyses documented significant range shifts averaging 6.1 km per decade towards the poles, and significant mean advancement of spring events by 2.3 days per decade. They defined a diagnostic fingerprint of temporal and spatial 'sign-switching' responses uniquely predicted by twentieth century climate trends. Among appropriate long-term, large scale, multi-species datasets, this diagnostic fingerprint was found for 279 species. They authors express very high confidence that climate change is already affecting living systems.

Pelton, M. R. 2000. Black bear. Pp. 389–408 in S. Demarais and P. R. Krausman (eds.). Ecology and management of large mammals in North America. Prentice Hall, Upper Saddle River, New Jersey.

The author presents an in-depth chapter reviewing the state of knowledge concerning the biology, ecology, and management of black bears in North America. Dr. Pelton is an expert on black bear ecology and this chapter provides important reference material on black bears.

Pelton, M.R. 2003. Black bear, *Ursus americanus*. Pp 547–555 in G.A. Feldhamer, B.C. Thompson, and J.A. Chapman (eds.). Wild mammals of North America. Second edition. John Hopkins University Press, Baltimore, Maryland.

This chapter provides comprehensive information on the distribution, physiology, ecology, and behavior of black bears. It summarizes research findings and the state of knowledge concerning the American black bear up to the date of its printing.

Pelton, M. R., and G. M. Burghardt. 1976. Black bears of the Smokies. Natural History 85:54–63.

The authors describe den use by black bears in the Great Smoky National Park. In Tennessee, preferred tree dens were 20–56 feet above ground in large diameter (average dbh = 39 in) trees in mature hardwood stands. Eastern hemlock (*Tsuga canadensis*), oaks, and maples were the primary tree species used by black bears for denning.

Powell R. A., J. W. Zimmerman, and D. E. Seaman. 1997. Ecology and behavior of North American black bears: Home ranges, habitat and social organization. Chapman and Hall, London, United Kingdom.

This book aims to address these issues by concentrating the authors' expertise and experience in studies of home ranges in general and focusing on their studies of the black bears of the Pisgah Forest, North Carolina, in particular. The authors provide an overview of black bears and methods for their study before discussing concepts of home range, developing predictive habitat quality models, addressing influences of food production on social organization, and exploring the mating behavior of male bears.

Reynolds-Hogland M. J., and M. S. Mitchell. 2007. Effects of roads on habitat quality for black bears in the southern Appalachian Mountains: A long-term study. Journal of Mammalogy 88: 1050–1061.

The authors tested the hypothesis that gravel roads had the largest negative effect on habitat quality for a population of American black bears in a protected area where vehicle collisions were rare. They also determined if road use by bears differed by sex or age and if annual variation in hard mast productivity affected the way bears used areas near roads. They used summer and fall home ranges for 118 black bears living in the Pisgah Bear Sanctuary in western North Carolina during 1981–2001, and estimated home-range scale (2nd-order) and within-home-range scale (3rd-order) selection for areas within 250, 500, 800, and 1,600 m of paved and gravel roads. All bears avoided areas near gravel roads more than paved roads during summer and fall for 2nd-order selection and during summer for 3rd-order selection. During fall, only adult females avoided areas near gravel roads more than paved roads for 3rd-order selection. The authors found a positive relationship between use of roads by adults and annual variability in hard mast productivity.

Reynolds-Hogland M. J., M. S. Mitchell, and R. A. Powell. 2006. Spatio-temporal availability of soft mast in clearcuts in the southern Appalachians. Forest Ecology and Management 237:103–114.

The authors tested a theoretical model of temporal availability of soft mast in clearcuts using empirical data on percent cover and berry production of *Gaylussacia, Vaccinium,* and *Rubus* spp. plants in 100 stands that were clearcut (0–122 years old) in the Southern Appalachian Mountains. They found that temporal dynamics explained berry production better than it predicted percent plant cover, whereas topographic variables influenced percent plant cover more than they influenced berry production. Berry production and percent plant cover were highest in 2–9-year-old stands. Percent plant cover was lowest in 10–69-year-old stands and intermediate in 70+-year-old stands. The methods they used to estimate the distribution of soft mast may be useful for modeling distributions of other resources.

Reynolds-Hogland, M. J., L. B. Pacifici, and M. S. Mitchell. 2007. Linking resources with demography to understand resource limitation for bears. Journal of Applied Ecology 44: 1166–1175.

The authors used long-term data on a population of black bears and evaluated competing hypotheses about whether availability of hard mast (acorns and nuts) or soft mast (fleshy fruits) limited bears in the southern Appalachians during 1981–2002. The effects of clearcutting on habitat quality were also evaluated. Annual survival, recruitment, and population growth rate were estimated using capture–recapture data from 101 females. The availability of hard mast, soft mast, and clearcuts was estimated with a GIS because each changed through time as a result of harvest and succession, and availabilities were used as covariates for each demographic parameter. The model with the additive availability of hard mast and soft mast across the landscape predicted survival and population growth rate. Availability of young clearcuts predicted recruitment, but not population growth or survival. The results indicated that older stands, which support high levels of hard mast and moderate levels of soft mast, should be maintained to sustain population growth of bears in the southern Appalachians. Simultaneously, the acreage of intermediate aged stands (10–25 years), which support very low levels of both hard mast and soft mast, should be minimized.

Rogers, L. L. 1976. Effects of mast and berry crop failures on survival, growth, and reproductive success of black bears. Transactions of the North American Wildlife and Natural Resources Conference 41:431–438.

In brief, 272 black bears were ear-tagged, and 105 were radio-tagged during the seven years of study. Instrumented bears were radio tracked to dens where they were weighed in autumn and spring, and the growth and survival of litters of radiocollared females were recorded. Data on food habits were obtained from analyses of 1,120 fecal droppings and from observations of foraging bears. The abundance of each bear food was assessed during the radio tracking. Annual fluctuations in food supply greatly influenced vital population characteristics. Nutritional factors appear to be vital to black bear population growth and habitat improvement programs should be useful in the management of black bears.

Rogers, L. L. 1987. Effects of food supply and kinship on social behavior, movements, and population growth of black bears in northeastern Minnesota. Wildlife Monographs 97: 1-72.

The author undertook an in-depth study of black bears ecology and behavior in northeastern Minnesota from 1969 through 1985 to determine (1) the annual cycle of foraging and social behavior, (2) changes in mother-offspring relationships from birth through maturity, (3) the influence of food availability on social behavior, movements, and population growth, and (4) important habitat components. The study area had relatively few fruit and mast species and a frost-free growing season of only 118 days. Crop failures were common and reduced the reproductive rate to less than half the biological potential. Females first reproduced at 4–8 years of age (average 6.3 years), depending upon food supply, and produced subsequent litters at 2–4-year intervals (average 2.28 years). Cub survival was 59–88%, depending on food supply in the year of conception and the year of birth. A larger area of unbroken habitat may be needed to maintain this population than would be needed where food is more reliable and abundant. Habitat management practices beneficial to bears in northeastern Minnesota were identified.

Rogers, L. L., and A. W. Allen. 1987. Habitat Suitability Index Models: Black Bear, Upper Great Lakes Region. U.S. Fish and Wildlife Service Biological Report 82, no.10.144

This document is part of the Habitat Suitability Index (HSI) model series, which provides habitat information useful for impact assessment and habitat management. Several types of habitat information are provided. The Habitat Use Information section is largely constrained to those data that can be used to derive quantitative relationships between key environmental variables and habitat suitability. This information provides the foundation for the HSI model and may be useful in the development of other models more appropriate to specific assessment or evaluation needs.

Rudis, V. A., and J. B. Tansey. 1995. Regional assessment of remote forests and black bear habitat from forest resource surveys. Journal of Wildlife Management 59:170–180.

In this study, a spatially explicit modeling approach was used based on a county-scaled remote forest assessment from 1984–1990 forest resource inventory data and a 1984 black bear range map for 12 southern states in the U.S. The authors used minimum suitable and optimal black bear habitat criteria, and georeferenced remote forest classification with the existing black bear range. Using the suitable habitat criterion, 97.2% of occupied and 9.7% of unoccupied range were classified. Using optimal habitat criteria, 69.8% of occupied and 60.1% of unoccupied range were classified. There was a lack of high-density (>34%) optimal habitat linkages among existing black bear populations, which could limit interpopulation gene flow. Unoccupied range with optimal habitat could be areas with repopulation potential.

Ryan, C. W., and M. R. Vaughn. 2004. Den characteristics of black bears in southwestern Virginia. Southeastern Naturalist 3:659–668.

This study assessed the den sites of reproductive female black bears. They monitored 31 bears for 39 bear winters in the southern Appalachians and 95% of the bears were confirmed to have denned. Bears denned in trees (41%), rock cavities (32%), excavations (14%), snags (8%), and ground nests (5%). Chestnut oak (*Quercus prinus*: n = 9), red oak (n = 8), and tulip-poplar (n = 1) were used as tree dens. Habitat characteristics did not differ between ground dens and tree dens.

Ryan, C. W., J. C. Pack, W. K. Igo, and A. Billings. 2007. Influence of mast production on black bear non-hunting mortalities in West Virginia. Ursus 18:46–53.

The authors used long-term mast data to study the relationship between mast conditions and non-hunting black bear mortalities by comparing combinations of hard and soft mast indices to black bear non-hunting mortalities in West Virginia, 1980–2004. Mast conditions were inversely related to non-hunting black bear mortalities. Oak and oak + hickory were the top competing models explaining non-hunting black bear mortalities. These data could be used to explain and predict the importance of hard mast conditions on non-hunting black bear mortalities.

Schooley, R. L., C. R. McLaughlin, G. J. Matula, Jr., and W. B. Krohn. 1994. Denning chronology of female black bears: Effects of food, weather, and reproduction. Journal of Mammalogy 75:466–477.

The authors studied factors affecting the chronology of denning by 104 female black bears from three areas in Maine 1982–1988. From 1986 to 1988, the authors found that patterns of habitat use reflected a behavioral response to beechnut crops failure; bears used hardwood forests more during autumn when nuts were abundant. Annual variation in den entry was not strongly associated with weather patterns during autumn. Where beech trees were less common in central Maine, den entry and habitat use varied less among years. The authors concluded that black bears generally remain active in autumn until a negative energy balance occurs; further, they hypothesized that pregnant females may den after they store adequate fat reserves for reproduction.

Seibert, SG, and MR Pelton. 1994. Nutrient content of squawroot, *Conopholis americana*, and its importance to southern Appalachian *Ursus americanus* (Carnivora, Ursidae). Brimleyana 21:151–156.

Squawroot is a preferred late spring and early summer food of black bears. It was collected from Pisgah National Forest, North Carolina, weekly from 25 April to 4 July 1987. Proximate analysis procedures were used to determine the nutrient content of the plant. Peak percentages were 13% crude protein (capsule), 31% crude fiber (capsule), 3% fat (capsule), and 77% nitrogen-free extract [NFE] (whole plant). Gross energy averaged 4.84 kcal/dry g. NFE levels were relatively high throughout the study and likely represent an important energy source for bears feeding on squawroot.

Selwood K. E., M. A. McGeoch, and R. MacNally. 2015. The effects of climate change and land-use change on demographic rates and population viability. Biological Reviews 90, 837–853.

The authors reviewed how demographic rates are affected by the major anthropogenic pressures, altered landscape conditions from human land, and climate change. They synthesized the results of 147 empirical studies and compared the relative effect size of climate and landscape condition on birth, death, immigration and emigration rates in plant and animal populations. Overall, climate variables had equally strong effects on demographic rates in plant and animal populations as altered landscape conditions. The combined pressures of land-use change and climate change may result in species declines and extinctions occurring faster than otherwise predicted, particularly if their effects are multiplicative.

Smith, J. B., C. K. Nielslen, and E. C. Hellgren. 2016. Suitable habitat for recolonizing large carnivores in the midwestern USA. Oryx 50:555–564.

The authors developed individual and combined models of suitable habitat for black bears, cougars, and wolves in 18 midwestern states, using geospatial data, expert-opinion surveys, and multi-criteria evaluation. Large, contiguous areas of suitable habitat comprised 35, 21, and 13% of the study region for wolves, bears, and cougars, respectively. Approximately 12% of the region was considered suitable for all three species. Arkansas, Minnesota, Texas and Wisconsin had the highest proportions (40%) of suitable habitat for black bears. Models performed well when validated with independent sets of carnivore locations. Contiguous areas of suitable habitat typically spanned multiple states, thus coordination across boundaries and among agencies will be vital to successful conservation. Their models highlight differences in habitat requirements and geographical distribution of potential habitat among these carnivores, and outline areas vital to their persistence in the Midwest.

Tietje, W. D., and R. L. Ruff. 1980. Denning behavior of black bears (*Ursus americanus*) in boreal forest of Alberta, Canada. Journal of Wildlife Management 44:858–870.

The authors determined denning chronology and behavior of black bears in east-central Alberta. Twenty-eight radiocollared bears were monitored spring–fall in 1975–1976 and 1976–1977. Adult males moved significantly longer movements to den sites than other cohorts. Bear dens usually were located on the periphery of summer ranges or beyond. Bears selected mixed stands of mature aspen and spruce, or mature spruce stands for den sites. Muskeg was avoided. All but two dens were excavated beneath ground level or under rootmasses of fallen trees. Delayed denning in 1975 was attributed to an abundance of blueberries that persisted into fall.

Tri, A. N., J. W. Edwards, M. P. Strager, J. T. Petty, C. W. Ryan, C. P. Carpenter, M. A. Ternent, and P. C. Carr. 2016. Habitat use by American black bears in the urban–wildland interface of the Mid-Atlantic, USA. Ursus 27:45–56.

This study was conducted to better understand characteristics of urban–wildland habitat characteristics of areas occupied by black bears. The authors used seven urban areas in New Jersey, Pennsylvania, and West Virginia and fit 77 black bears with GPS collars from 2010 to 2012. Generalized linear mixed models were fit with different combinations of variables including: study area, human impact (human density and housing density), habitat (distance to roads, patch size), land cover (deciduous forest, evergreen forest, mixed forest, shrubland, grassland, pasture, barren, open-, low-, medium-, and high-intensity development, woody wetlands, and herbaceous wetlands), topographic (elevation and slope), and other variables (year, period of day [night or day], age and sex of the individual bear). Black bears frequented forested slopes and riparian corridors in the urban–wildland interface. Additionally, they selected habitats similar to wildland bears (based on the literature). Sexes responded similarly. The authors concluded that managers could use the same management tools to reduce human–bear conflicts at the urban–wildland interface as in wildland areas.

Vander Heyden, M., and E. C. Meslow. 1999. Habitat selection by female black bears in the central Cascades of Oregon. Northwest Science 73:283–294.

The overall objective of this research was to define habitat characteristics that influence the autecology of female black bears in Oregon. The authors studied selection at both the home range and landscape scale by radio tracking 14 adult female black bears from June 1993 to December 1995 in the central Cascades of Oregon to determine home-range size and analyze habitat selection. Locations were classified into one of six habitat classes based on stand structure. Female black bears were associated with open-canopy sapling/pole and open canopy mature timber, selecting for a combination of foraging opportunities and escape cover. Additionally, black bears were negatively associated with roads and positively associated with streams.

Waller B. W., J. L. Belant, B. D. Leopold, D. L. Evans, B. W. Young, and S. L. Simek. 2014. Influence of landscape attributes on American black bear den-site selection in Mississippi. Mammal Study 39:115–119.

The authors predicted that black bears would choose den sites further from roads and habitat edges to avoid disturbance. Den selection suggested that bears chose den sites further from roads to reduce disturbance. Den selection is particularly important for pregnant females and disturbances to maternal dens can cause loss of litters. Therefore, for the conservation of black bears minimal construction of new roads in black bear habitat is recommended.

Wathen, W. G., K. G. Johnson, and M. R. Pelton. 1986. Characteristics of black bear dens in the southern Appalachian region. International Conference of Bear Research and Management 6:119–127.

In this study, the dens of radiocollared black bears were examined in the southern Appalachian Mountains from 1973 to 1982. Most dens were in tree cavities high above ground. Entrance height differed among tree species with high entrances in yellow poplars and low entrances in chestnut oak, red maple, and yellow birch. Den tree species differed with elevation, macrotopography, and microtopography. Chestnut oaks and northern red oaks comprised 10 of 15 tree dens in the exterior of the study area. Extensive use of these 2 species indicates the importance of incorporating site provisions into timber management plans in the Southern Appalachian region.

Weaver, K. M., and M. R. Pelton. 1994. Denning ecology of black bears in the Tensas River Basin of Louisiana. International Conference on Bear Research and Management 9:427–433.

The authors studied denning chronology, den use, and den characteristics of the Louisiana black bear (*U. a. luteolus*) in the remnant bottomland hardwood forests of the Tensas River Basin in northeastern Louisiana. They monitored 20 radiocollared bears (12 F, 8 M) for 30-den years during 1988–1989, 1989–1990, and 1990–1991. At least 45% (n = 13) of bears used >1 den site during a denning season. Some (34%, n = 10) bears displayed some winter activity, and an adult male did not den during 1 year of the study. Bears denned in elevated cavities in bald cypress (n = 17), overcup oak (n = 2) and sycamore (n = 1), ground nests (n = 17), and brushpiles (n = 7). Tree dens were used by 80% (n = 12) of all adult females and 68% (n = 15) of all adults. Bears denning in trees were less vulnerable to human disturbance than ground-denning bears. Forestry management practices should be directed toward conserving forested wetlands and den trees, maintaining thick cover for ground dens, and reforestation.

Wilton, C. M., J. L. Belant, and J. Beringer. 2014. Distribution of American black bear occurrences and human–bear incidents in Missouri. Ursus 25:53–60.

The authors used anecdotal occurrence data from 1989 to 2010 and forest cover to describe patterns of black bear re-colonization, human-bear incidents, and bear mortality reports in Missouri. Overall, 1,114 black bear occurrences (including 118 with dependent young) were reported, with 95% occurring within the Ozark Highlands ecological region. Human-bear incidents comprised 5% of total occurrences, with 86% involving bears eating anthropogenic foods. They found a positive correlation between the distribution of bear occurrences and nuisance problems. Twenty bear mortalities were reported, and 60% were caused by vehicle collisions. Black bear occurrences have been reported throughout most of Missouri’s forested areas. Occurrence data are often suspect, but the distribution of reliable reports supports the authors understanding of black bear ecology in Missouri.

Wooding, J. B., and T. S. Hardisky. 1992. Denning by black bears in northcentral Florida. Journal of Mammalogy 73:895–898.

The authors observed denning characteristics of black bears in northcentral Florida from 1983 to 1988 for 17 individuals (nine males, eight females). Fourteen den sites were found, with all being ground beds located in hardwood swamps or dense shrub thickets. Pregnant bears denned for periods similar to those reported for other areas of the southeastern United States. However, males and barren females denned for shorter periods than reported in other studies. The authors speculated that the availability of winter food in Florida has allowed bears to shorten the length of denning relative to that which occurs further north where winter food is unavailable.

SUZANNE PRANGE

CONTACT INFORMATION

Wildlife Research Biologist
7980 Long Run Road
Athens, Ohio 45701

Email: IngerSuzanne@protonmail.com

Phone: 740-590-3138 (Cell); 740-594-3971 (Home)

EDUCATION

University of South Alabama, Mobile, Alabama
B.S. Biology, July 1989, *Summa cum laude*

University of South Alabama, Mobile, Alabama
M.S. Biology, December 1992
Thesis: Population ecology of the southern flying squirrel (*Glaucomys volans*) in Alabama.

University of Missouri, Columbia, Missouri
Ph.D. Fisheries and Wildlife Biology, December 2000
Dissertation: Effects of urbanization on raccoon (*Procyon lotor*) population demographics, home range, and spatial distribution patterns.

TEACHING EXPERIENCE

Adjunct Assistant Professor. Ohio University, Biological Sciences, Athens, Ohio, May 2018 – present.
Serve on graduate student committees, mentor honor students, apply for grants, serve as co-PI in research, write manuscripts for academic publication, teach courses.

Adjunct Assistant Professor. Ohio State University, School of Environment and Natural Resources, Columbus, Ohio, November 2007 – present.
Serve on graduate student committees, and mentor honor students.

Adjunct Instructor. Hocking College
Department of Natural Resources, Nelsonville, Ohio, September 2010 – present
Wildlife Identification and Natural History (WLM-156)

Instructor. Colorado State University
Department of Fishery & Wildlife Biology, Fort Collins, Colorado, August 2002 – July 2003
Principles of Vertebrate Management (FW 360)
Conservation and Ecology of Large Mammals (FW 469)

Instructor. University of Missouri
Department of Fisheries & Wildlife Biology, Columbia, Missouri, January 2001 – May 2001
Ichthyology labs (F&W 311)

Instructor. University of Missouri
Department of Biological Sciences, Columbia, Missouri, January 2001 – May 2001
General Biology labs (BIO 10)

Graduate Teaching Assistant. University of Missouri
Department of Biological Sciences, Columbia, Missouri, August 2000 – December 2000
General Botany labs (BIO 12)

Graduate Teaching Fellow (Rucker Teaching Fellowship). University of Missouri
Department of Fisheries & Wildlife Biology, Columbia, Missouri, September 1993 – March 1995
Wildlife Research and Management Techniques (F&W 323)

Instructor. Faulkner University
Mobile, Alabama, May 1993 – September 1993
Environmental Science

Graduate Teaching Assistant. University of South Alabama
Department of Biology, Mobile, Alabama, September 1989 – August 1991
General Biology labs (BY 141)

RESEARCH/PROFESSIONAL EXPERIENCE

Adjunct Assistant Professor. Ohio University, Biological Sciences, Athens, Ohio, May 2018 – present.
Responsibilities: Serve on graduate student committees, mentor honor students, apply for grants, serve as co-PI in research, write manuscripts for academic publication, teach courses.

Wildlife Research Biologist. Ohio Division of Wildlife, Athens, Ohio, July 2006 – December 2017.
Responsibilities: Responsible for development and administration of new techniques to monitor wildlife populations, and monitoring endangered and threatened forest wildlife species, including black bears and bobcats.

Postdoctoral Research Associate/Visiting Scholar. Ohio State University, School of Environment and Natural Resources, Columbus, Ohio, and Max McGraw Wildlife Foundation, Dundee, Illinois, July 2003 – July 2006.
Responsibilities: Supervised graduate students and technicians, managed research projects related to carnivore ecology in the Chicago metropolitan area, evaluated new proximity detecting radiocollars, and conducted research to determine contact rates among members of a free-ranging raccoon population.

Fish & Wildlife Biologist. U.S. Fish & Wildlife Service, Phoenix, Arizona, June 2001 – July 2002.
Responsibilities: Conducted endangered and threatened species' activities, including recovery projects; candidate management; listing; cooperative state, federal, and private efforts; and section 7 consultations. Served as lead biologist for the ocelot and jaguarundi in Arizona.

Research Assistant. Missouri Department of Conservation, Columbia, Missouri, August 2000 – May 2001.
Responsibilities: Radio tracked river otters in conjunction with a study to determine cause-specific mortality and movement patterns in north-central Missouri.

Assistant Project Coordinator. International Association of Fish and Wildlife Agencies in cooperation with the Missouri Department of Conservation, Columbia, Missouri, May 1999 – August 2000.
Responsibilities: Assisted in the coordination of multi-state trap testing efforts to assess the performance of various types of devices used to trap furbearers, as well as the frequency and extent of trap-related injuries.

Graduate Research Assistant. Max McGraw Wildlife Foundation, Dundee, Illinois, April 1995 – December 1998.
Responsibilities: Conducted a research project to assess the demography and spatial distribution of raccoons along a rural-urban gradient in the Chicago metropolitan area.

Research Assistant. University of South Alabama, Department of Biology, Mobile, Alabama, May 1991 – August 1993.
Responsibilities: Assisted in extensive field surveys for colonies of the threatened gopher tortoise in Mobile and Baldwin counties, Alabama.

Graduate Research Assistant. University of South Alabama, Department of Biology, Mobile, Alabama, December 1990 – December 1992.
Responsibilities: Developed and conducted a mark-recapture project to determine population demographics of southern flying squirrels in Alabama.

Assistant Curator –Vertebrate Museum. University of South Alabama, Biology Department, Mobile, Alabama, June 1987 – June 1989.
Responsibilities: Prepared study skins of birds and mammals. Preserved reptiles and amphibians. Maintained and cared for the collection.

Undergraduate Research Assistant. University of South Alabama, Biology Department, Mobile, Alabama, June 1988 – September 1988.
Responsibilities: Conducted an experiment to determine the thermotolerance levels of freshwater grass shrimp.

PUBLICATIONS

Prange, S, C. Rose, C. Mollohan, A. Lecount. *In review*. Investigating uneven recovery of repatriated bobcats in a mined landscape. Journal of Mammalogy.

Rich, M., C. Thompson, S. Prange, and V.D. Popescu. 2018. Relative importance of habitat characteristics and interspecific interactions in determining terrestrial carnivore occurrence. Frontiers in Ecology and Evolution 6:78. doi: 10.3389/fevo.2018.00078.

Anderson, C., L. Gibbs, and S. Prange. 2015. Origin and genetic structure of a recovering bobcat (*Lynx rufus*) population. Canadian Journal of Zoology 93:889-899.

Rose, C., and S. Prange. 2015. Diet of the recovering Ohio bobcat (*Lynx rufus*) with a consideration of two sub-populations American Midland Naturalist 173:305-317.

Hirsch, B., S. Prange, S. Hauver, and S. Gehrt. 2014. Patterns of latrine use by raccoons (*Procyon lotor*) and implication for *Baylisascaris procyonis* transmission. Journal of Wildlife Diseases 50:243-249.

Hauver, S., B. Hirsch, S. Prange, J. Dubach, and S. Gehrt. 2013. Age, but not sex or genetic relatedness, shapes raccoon dominance patterns. Ethology 119:769-778.

Hirsch B.T., S. Prange, S.A. Hauver, and S.D. Gehrt. 2013. Raccoon Social Networks and the Potential for Disease Transmission. PLoS ONE 8(10): e75830. doi:10.1371/journal.pone.0075830

Slagle, K., R. Zajac, J. Bruskotter, R. Wilson, and S. Prange. 2013. Building Tolerance for Bears: A Communications Experiment. Journal of Wildlife Management 77:863–869.

Hirsch, B.T. S. Prange, S.A. Hauver, and S.D. Gehrt. 2013. Genetic relatedness does not predict raccoon social network structure. Animal Behaviour 85:463-470.

Zajac, R.M., J.T. Bruskotter, R.S. Wilson, and S. Prange. 2012. Learning to live with black bears: A psychological model of acceptance. Journal of Wildlife Management 76:1331–1340. DOI: 10.1002/jwmg.1398.

Prange, S., S.D. Gehrt, and S.A. Hauver. 2011. Frequency and duration of contacts among free-ranging raccoons: uncovering a hidden social system. Journal of Mammalogy. 92:1331–1342.

Shock, B.S., et al. 2011. The distribution and prevalence of *Cytauxzoon felis* in bobcats (*Lynx rufus*), the natural reservoir, and other wild felids, in thirteen states. Veterinary Parasitology 175:325–330

Hauver, S.A., S.D. Gehrt, S. Prange, and J. Dubach. 2010. Behavioral and genetic aspects of the raccoon mating system: evidence for promiscuity at high densities. Journal of Mammalogy. 91:749–757.

Hauver, S.A., S.D. Gehrt, and S. Prange. 2010. Maternal response to conspecific visits at natal dens in raccoons. American Midland Naturalist. 163:374–387.

Prange, S., and T.J. Prange. 2009. *Bassaricyon gabbii*. Mammalian Species 826:1-7.

Bozek, C.K., S. Prange, and S.D. Gehrt. 2007. The influence of anthropogenic resources on multi-scale habitat selection by raccoons. Urban Ecosystems 10:413-425.

Prange, S., and D.H. Nelson. 2007. Use of small-volume nest boxes by *Apis mellifera* (European honey bees) in Alabama. Southeastern Naturalist 6:370-375.

Prange, S., and S.D. Gehrt. 2007. Skunk response to a simulated increase in coyote activity. Journal of Mammalogy 88:1040-1049.

Gehrt, S.D., and S. Prange. 2007. Interference competition between coyotes and raccoons? A test of the Mesopredator Release Hypothesis. Behavioral Ecology 18:204-214.

Prange. S., T. Jordan, C. Hunter, and S.D. Gehrt. 2006. New radiocollars for the detection of proximity among individuals. Wildlife Society Bulletin 34:1333-1344.

Prange. S., and D.H. Nelson. 2006. Use of fungal rhizomorphs as nesting material by *Glaucomys volans* (southern flying squirrels). Southeastern Naturalist 5:355-360.

Prange. S., and S.D. Gehrt. 2004. Changes in mesopredator community structure in response to urbanization. Canadian Journal of Zoology 82:1804-1817.

Prange. S., S.D. Gehrt, and E.P. Wiggers. 2004. Influences of anthropogenic resources on raccoon movements and spatial distribution. Journal of Mammalogy 85:483-490.

Prange. S., S.D. Gehrt, and E.P. Wiggers. 2003. Demographic factors contributing to high raccoon densities in urban landscapes. Journal of Wildlife Management 67:324-333.

Gehrt, S.D., L.L. Hungerford, and S. Hatten. 2001. Drug effects on recaptures of raccoons. Wildlife Society Bulletin 29:833-837.

BOOK CHAPTERS

Beever, E., Prange, S., and DellaSala, D. Defining and interpreting ecological disturbances. *In* Disturbance ecology and biological diversity: scale, context, and nature (E. Beever, S. Prange, and D. DellaSala, eds.). CRC Press. In prep.

Prange, S., and Cavender, N. Slime molds to bobcats: A wildlife perspective of lessons and paradoxes from a recovering ecosystem following surface coal mining. *In* Disturbance ecology and biological diversity: scale, context, and nature (E. Beever, S. Prange, and D. DellaSala, eds.). CRC Press. In prep.

Prange, S., Beever, E., and DellaSala, D. Wildlife, vegetative, and abiotic response to ecological disturbance: lessons learned, research gaps. *In* Disturbance ecology and biological diversity: scale, context, and nature (E. Beever, S. Prange, and D. DellaSala, eds.). CRC Press. In prep.

Hadidian J., S. Prange, R. Rosatte, S. Riley, and S. Gehrt. 2010. Raccoon (*Procyon lotor*). Pp. 35-47 *in*: Urban Carnivores (S.D. Gehrt, S.P.D. Riley, and B.L. Cypher, eds.). Johns Hopkins University Press.

PRESENTATIONS

Rose, C., and S. Prange. 2013. Diet of the recovering Ohio bobcat with a consideration of two sub-populations. 20th Annual Conference, The Wildlife Society, Milwaukee, Wisconsin.

Prange, S., and C. Rose. 2013. Uncovering the mechanisms behind bobcat recovery in Ohio. 20th Annual Conference, The Wildlife Society, Milwaukee, Wisconsin.

Hirsch, B.T. S. Prange, S.A. Hauver, and S.D. Gehrt. 2012. Highly connected raccoon social networks and disease spread. 19th Annual Conference, The Wildlife Society.

Wilson, R.S., J.T. Bruskotter, R. Zajac, K. Slagle, and S. Prange. 2012. Carnivores as a hazard: The role of risk perception in predicting public acceptance. Fourth International Ecosummit, Columbus, Ohio.

Singh, D., Zajac, R., Bruskotter, J.T., and S. Prange. 2011. Social and Cognitive Predictors of the Acceptability of Black Bear Management. 17th International Symposium on Society and Resource Management. Madison: International Association for Society & Resource Management.

Zajac R., J.T. Bruskotter, R.S. Wilson, K. Slagle, and S. Prange. 2011. Carnivores as a hazard: The role of risk perception in predicting public acceptance. Society for Risk Analysis Annual Meeting. Charleston, South Carolina.

Frost, M., S. Johnston, R.A. Carreno, and S. Prange. 2011. Endoparasite survey in bobcats (*Lynx rufus rufus*) from Ohio. Parasitology Conference. Poster.

Zajac, R.M., J.T. Bruskotter, and S. Prange. 2011. Life and Death Decisions: How important is experience with bear problems to decisions about acceptability of lethal management? 20th Eastern Black Bear Workshop, Hendersonville, North Carolina. Poster.

Anderson, C., S. Prange, and L. Gibbs. 2011. Conservation genetic analyses of recovering bobcat populations in Ohio. Ohio Fish and Wildlife Management Association Conference, Columbus, Ohio.

Kugler, C.R., and S. Prange. 2011. Forest furbearer response to sound lures in southeastern Ohio. Ohio Fish and Wildlife Management Association Conference, Columbus, Ohio. Poster.

Anderson, C., S. Prange, and L. Gibbs. 2010. Conservation genetic analyses of recovering bobcat populations in Ohio. Midwest Fish & Wildlife Conference, Minneapolis, Minnesota.

Shock, B. C., S. M. Murphy, L. L. Patton, P. M. Shock, C. Olfenbuttel, J. Beringer, S. Prange, D. Fecske, M. Peek, V. F. Nettles, H. Brown, D. S. Peterson, and M. J. Yabsley. 2010. Geographic distribution and prevalence of (*Cytauxzoon felis*) in wild felids. Southeastern Society of Parasitologists Conference. Asheville, North Carolina.

Prange, S., Anderson, C., and H. L. Gibbs. 2009. The Ohio bobcat: Distribution, abundance, and genetic structure of a recovering population. Midwest Fish & Wildlife Conference. Springfield, Illinois. *Invited presentation*.

Shock, B. C., S. M. Murphy, L. L. Patton, P. M. Shock, C. Olfenbuttel, J. Beringer, S. Prange, D. Fecske, M. Peek, V. F. Nettles, H. Brown, D. S. Peterson, and M. J. Yabsley. 2009. Geographic distribution and prevalence of (*Cytauxzoon felis*) in wild felids. Southeastern Association of Fish and Wildlife Agencies Conference. Atlanta, Georgia.

Shanks, R. E., S. Prange, and R. A. Carreno. 2008. Endoparasites in bobcats (*Felis rufus*) from southern Ohio. Annual Midwestern Conference of Parasitologists. Urbana, Illinois.

Hauver, S. A., S. Prange, S. D. Gehrt, and J. Dubach. 2008. Does kinship explain variation of contact rates and den sharing of an urban raccoons? 45th Annual Animal Behavior Society Meeting, Snowbird, Utah.

Hauver, S. A., S. Prange, S. D. Gehrt, and J. Dubach. 2008. Does kinship explain variation of contact rates and den sharing of an urban carnivore, the raccoon? 88th Annual American Society of Mammalogists Meeting, Brookings, South Dakota.

Prange, S. 2008. Tracking the status of the black bear in Ohio. Wildlife Diversity Conference, Columbus, Ohio. *Invited presentation*.

Scott, D. and S. Prange. 2008. Ohio's endangered mammals: current status of snowshoe hares, black bears, and bobcats. Ohio Woodland, Water & Wildlife Conference, Mansfield, Ohio. *Invited presentation*.

Hungerford, L. S. Prange, and S. Gehrt. 2007. Rascals, recluses and R: Structure and transmission potential in raccoon contact networks. 2007 Conference of Research Workers in Animal Disease, Chicago, Illinois.

Hauver, S.A., S.D. Gehrt, S. Prange, and J. Dubach. 2007. Does genetic relatedness influence social interactions and contact rates of free-ranging raccoons? National Science Foundation, Ecology and Evolution of Infectious Disease PI Meeting, Albuquerque, New Mexico. (Poster)

Prange, S., and S.D. Gehrt. 2007. Uncovering a hidden social system: Quantifying contacts among free-ranging raccoons. National Science Foundation, Ecology and Evolution of Infectious Disease PI Meeting, Albuquerque, New Mexico. (Poster)

Gehrt, S.D., and S. Prange. 2007. Evaluating the mesopredator release hypothesis for structuring carnivore communities: Lack of effect of coyotes on raccoons and skunks. International Union of Game Biologists XXVIII Congress, Uppsala, Sweden.

Gehrt, S.D., and S. Prange. 2007. Uncovering a hidden social system: Patterns of contacts among free-ranging raccoons. International Union of Game Biologists XXVIII Congress, Uppsala, Sweden. (Poster)

Hauver, S.A., S.D. Gehrt, S. Prange, and J. Dubach. 2007. Using genetic relatedness to examine variation in social interactions of a nocturnal carnivore. 14th Annual Conference, The Wildlife Society, Tucson, Arizona.

Prange, S, and S.D. Gehrt. 2007. Frequency and duration of contacts among free-ranging raccoons: Uncovering a hidden social system. 14th Annual Conference, The Wildlife Society, Tucson, Arizona.

Hauver, S.A., S.D. Gehrt, S. Prange, and J. Dubach. 2007. Using genetic relatedness to examine variation in social interactions of a nocturnal carnivore. 87^{th} Annual American Society of Mammalogists Meeting, Albuquerque, New Mexico.

Prange, S, and S.D. Gehrt. 2007. Frequency and duration of contacts among free-ranging raccoons: Uncovering a hidden social system. 87^{th} Annual American Society of Mammalogists Meeting, Albuquerque, New Mexico.

Prange, S., and S.D. Gehrt. 2006. The urban raccoon: Conservation and conflict in a highly successful species. Urban Carnivores: Ecology, Behavior, Conflict, and Conservation Symposium, 13^{th} Annual Conference, The Wildlife Society, Anchorage, Alaska. *Invited presentation.*

Prange, S., and S.D. Gehrt. 2006. Individual patterns of latrine use by raccoons. 86^{th} Annual American Society of Mammalogists Meeting, Amherst, Massachusetts.

Prange, S., S.D. Gehrt, T. Jordan, C. Hunter, and L.L. Hungerford. 2005. Measuring contact rates for a nocturnal species with new radiocollars. Ecology of Infectious Diseases Meeting, National Science Foundation and National Institute of Health, Washington, D.C.

Prange, S., S.D. Gehrt, T. Jordan, and C. Hunter. 2005. Things that go bump in the night: Measuring contact rates for a nocturnal species with new radiocollars. 12^{th} Annual Conference, The Wildlife Society, Madison, Wisconsin.

Gehrt, S.D., S. Prange, and L.L. Hungerford. 2005. Modeling the dynamics of raccoon (*Procyon lotor*) rabies and estimating contact rates: An example of collaboration leading to new insights. XXVIIth Congress of the International Union of Game Biologists, Hanover, Germany. (Poster)

Prange, S., S.D. Gehrt, T. Jordan, and C. Hunter. 2005. Things that go bump in the night: Measuring contact rates for a nocturnal species with new radiocollars. 66th Midwest Fish and Wildlife Conference, Grand Rapids, Michigan.

Hauver, S.A., S.D. Gehrt, and S. Prange. 2005. Mother raccoon activity and extra-familial visits at natal dens. 66th Midwest Fish and Wildlife Conference, Grand Rapids, Michigan.

Graser, W.H., S.D. Gehrt, and S. Prange. 2005. Patterns of scent-station visitation by individual raccoons: Implications for predator surveys. 66th Midwest Fish and Wildlife Conference, Grand Rapids, Michigan.

Prange, S., and S.D. Gehrt. 2004. Skunk response to simulated coyote activity. 65th Midwest Fish and Wildlife Conference, Indianapolis, Indiana.

Prange, S., and S.D. Gehrt. 2004. Changes in mesopredator community structure in response to urbanization. 11th Annual Conference, The Wildlife Society, Calgary, Canada.

Gehrt, S.D., and S. Prange. 2004. Implications for the mesopredator release hypothesis: is there competition between coyotes and raccoons? 84th Annual American Society of Mammalogists Meeting, Arcata, California.

Prange, S., and S.D. Gehrt. 2004. Changes in mesopredator community structure in response to urbanization. 84th Annual American Society of Mammalogists Meeting, Arcata, California.

Prange, S., and S.D. Gehrt. 2004. Skunk response to simulated coyote activity. 22nd Midwest Furbearer Workshop. Utica, Illinois.

Gehrt, S.D., and S. Prange. 2003. Implications for the mesopredator release hypothesis: is there interference competition between coyotes and raccoons? 64th Midwest Fish and Wildlife Conference. Kansas City, Missouri.

Gehrt, S.D., L.L. Hungerford, and S. Hatten. 1998. Drug-specific effects on the recapture rates of raccoons. 5th Annual Conference, The Wildlife Society. Buffalo, New York.

Hatten, S., S.D. Gehrt, and E.P. Wiggers. 1997. Raccoon population demographics along an urban-rural gradient. 4th Annual Conference, The Wildlife Society. Snowmass, Colorado.

Hatten, S., S.D. Gehrt, and E.P.Wiggers. 1997. Effects of urbanization on raccoon population demographics. 58th Midwest Fish and Wildlife Conference. Milwaukee, Wisconsin.

Gehrt, S.D., L.L. Hungerford, and S. Hatten. 1997. Drug-specific effects on the recapture rates of raccoons. 58th Midwest Fish and Wildlife Conference. Milwaukee, Wisconsin.

Gehrt, S.D, L.L. Hungerford, and S. Hatten. 1997. Drug-specific effects on the recapture rates of raccoons. 77th Annual American Society of Mammalogists Meeting. Stillwater, Oklahoma.

Nelson, D.H., L.L. White, and S. Hatten. 1994. Population structure of the gopher tortoise (*Gopherus polyphemus*) in Mobile County, Alabama. 65th Annual Alabama Academy of Sciences Meeting.

Hatten, S., D.H. Nelson, and D. Biggs. 1993. Population ecology of the southern flying squirrel (*Glaucomys volans*) in Alabama. 64th Annual Alabama Academy of Sciences Meeting.

Nelson, D.H., L.L. White, and S. Hatten. 1993. Burrows of the gopher tortoise (*Gopherus polyphemus*) in Baldwin County, Alabama. 64th Annual Alabama Academy of Sciences Meeting.

Hatten, S. and D.H. Nelson. 1992. Nest box use by southern flying squirrels (*Glaucomys volans*) in Alabama. 63rd Annual Alabama Academy of Sciences Meeting.

Nelson, D.H., S. Hatten, L.L. White, and S. Carey. 1992. Distribution of the gopher tortoise (*Gopherus polyphemus*) in Mobile County, Alabama. 63rd Annual Alabama Academy of Sciences Meeting.

GRANTS

Modeling raccoon rabies in Cook County. Cook County Animal Control. $165,880, 12/01/04 – 11/30/06. Co-PI (PI: S.D. Gehrt, Ohio State University; Co-PI: Laura Hungerford, University of Maryland).

PROFESSIONAL DEVELOPMENT

Interagency Consultation for Endangered Species, National Conservation Training, 2001
Program MARK Workshop, Ohio State University, 2004
Information Theoretic Methods Short Course, Ohio State University, 2004
Design of Natural Resource Monitoring Surveys Short Course, Ohio State University, 2006
Occupancy Modeling Workshop, Ohio State University, 2007
Communicating Science Effectively Short Course, The Integration and Application Network, University of Maryland Center for Environmental Science, 2009
Chemical Immobilization of Animals Workshop, Safe-Capture International, 2010
Chemical Immobilization of Animals Workshop, Safe-Capture International, 2013

PROFESSIONAL SERVICE

Referee/Reviewer: Journal of Mammalogy, Wildlife Society Bulletin, Southeastern Naturalist, Southwestern Naturalist, Canadian Journal of Zoology, Wildlife Research, Human-Wildlife Conflicts, Urban Ecosystems, National Science Foundation Ecological Biology Proposals, Journal of Zoology, Check List, Journal of Wildlife Management, Journal of Veterinary

Medicine and Animal Health, Landscape and Urban Planning, Studies on Neotropical Fauna and Environment, Biological Conservation.

Editorships:
Editor, Disturbance ecology and biological diversity: scale, context, and nature, CRC Press, *in prep*.
Associate Editor, 2011 – 2015, *Journal of Mammalogy*
Guest Editor, *Northeastern Naturalist*
TWS Publication of the Year Committee, 2012, 2014, 2015
Editor, Cactus Communications, 2015 – present
Review Editor, *Frontiers in Ecology and Evolution*, February 2018 – present.

Professional Organizations, Working Groups, Committees:
American Society of Mammalogists, 1993 – present
The Wildlife Society, 1993 – present
Society for Conservation Biology, 2005 – present
TWS Urban Wildlife Working Group, 2003 – 2009
TWS Biodiversity Working Group, 2003 – present
TWS Wildlife and Habitat Restoration Working Group, 2008 – 2011
Midwest Furbearer Working Group, 2006 – 2016
Eastern Black Bear Study Group, 2007 – 2016
Mid-Appalachian Black Bear Study Group, 2007 – 2016
American Society of Mammalogists Conservation Committee, 2007 – 2012

Offices held:
Present Elect, Ohio Chapter of The Wildlife Society, 2007
President, Ohio Chapter of The Wildlife Society, 2007 – 2009
Past President, Ohio Chapter of The Wildlife Society, 2009 – 2011
Treasurer, TWS Biological Diversity Working Group, 2007 – 2011
Chair Elect, TWS Biological Diversity Working Group, 2012 – 2014
Chair, TWS Biological Diversity Working Group, 2014 – 2016
Past Chair, TWS Biological Diversity Working Group, 2016 – 2018
Board Member, Central Region Representative, TWS Wildlife and Habitat Restoration Working Group, 2009 – 2011
Board Member, Nominations Chair, TWS Wildlife and Habitat Restoration Working Group, 2010 – 2012
Treasurer, North Central Section of The Wildlife Society, 2009 – 2012
Secretary, Wild Felid Association, 2012 – 2015
North American Midwest Representative, Wild Felid Association, 2015 – present

HONORS, SCHOLARSHIPS & FELLOWSHIPS

Outstanding Senior in Biology, 1989
Blanch Dean Scholarship, 1990
Goethe Institute Scholarship for study in Austria, 1990
Rucker Teaching Fellowship, 1993 – 1995

Love Fellowship, 1995 – 1999
One the Spot Award, U.S. Fish & Wildlife Service, 2001& 2002
Full Member Sigma Xi, Scientific Research Society, 2006 – present

PROFESSIONAL REFERENCES

Dr. David Nelson
Professor Emeritus
University of South Alabama
5 Watch Tower
Spanish Fort, Alabama 36527
(251)460-6331
(251)626-0438 (cell)
dnelson@southalabama.edu

Dr. Viorel Popescu
Assistant Professor
Ohio University
Biological Sciences
Irvin Hall
Athens, Ohio 45701
(740)541-0105
popescu@ohio.edu

Cheryl Mollohan
Instructor (retired)
Hocking College
75743 Lemay Road
Albany, Ohio
(740)698-6761
(740)447-1207 (cell)
cherylandal@ohiohills.com

Appendix 8

CONSERVING CERULEAN WARBLER IN TEMPERATE FORESTS: A LITERATURE REVIEW

Prepared by: Amanda D. Rodewald, Ph.D., Garvin Professor and Senior Director of Conservation Science, Cornell Lab of Ornithology and Department of Natural Resources, Cornell University

August 2018

CONSERVING CERULEAN WARBLER IN TEMPERATE FORESTS: A LITERATURE REVIEW

Prepared by: Amanda D. Rodewald, Ph.D., Garvin Professor and Senior Director of Conservation Science, Cornell Lab of Ornithology and Department of Natural Resources, Cornell University
August 2018

The Cerulean Warbler is a migratory songbird that breeds in mature deciduous forests of eastern North America and winters in the Northern Andes of South America. Global populations of Cerulean Warblers have sharply declined since 1966, and the species is listed as a globally vulnerable species by the International Union for the Conservation of Nature, a species of national concern by the U.S. Fish and Wildlife Service, and a Continental Watch List species by Partners In Flight.

Ecological conditions necessary to support breeding Cerulean Warblers

Structural attributes associated with old and old-growth forests

Structurally-complex forests with heterogeneous, open canopies. During the breeding season, Cerulean Warblers are most closely associated with old, structurally complex forest stands (>80-100 years) that have features typical of old uneven-aged, steady-state forests (Bakermans and Rodewald 2009). Steady-state forests, which are typically >100 years old, are characterized by gap dynamics and natural disturbance processes that result in complex vertical strata and a heterogeneous canopy.

One of the hallmarks of high-quality habitat for Cerulean Warblers is a relatively open and heterogeneous forest canopy that often includes canopy gaps of ~40–100 m^2 in size and well-developed vertical strata (Roth and Islam 2007, Bakermans and Rodewald 2009, Hartman et al. 2009, Bakermans et al. 2012, Boves et al. 2013a, Kaminski and Kamal 2013). Canopy gaps of the size preferred by Ceruleans might be naturally expected to occur with natural disturbances including (but not limited to) treefalls in older forests with large trees and abundant grapevines, windstorms, icestorms, wildfire, or beaver activity.

Old-growth forests are widely considered to the habitat type historically used by Cerulean Warblers, but in today's forests age alone does not predict densities of Cerulean Warblers. Rather, the species requires specific old-forest features that are missing from many mature forests regenerated from stand-replacing disturbances, such as clearcutting. Within and near the Wayne National Forest in southeast Ohio, canopy openness and complex structure best explained variation in densities of Cerulean Warblers among mature forest stands (Bakermans and Rodewald 2009). Perkins and Wood (2014) reported that canopy gap densities were higher within core areas of territories, especially gaps that contained regenerating woody vegetation >12m tall and were surrounded by forest >24m in height.

Open canopies and heterogeneous forests, including well-developed understory and midstory layers, also are positively associated with nest placement and nest success (Bakermans and Rodewald 2009, Newell and Rodewald 2011, Bakermans et al. 2012). In fact, nest survival for a suite of mature forest birds (Bakermans and Rodewald 2009), including Cerulean Warbler, improved by 10.5% for every 1% increase in canopy openness within mature forests

(Bakermans et al. 2012). In southeast Ohio, nest sites had more open canopies as well as 24% more understory vegetation than random locations (Bakermans and Rodewald 2009). Although Ceruleans are a canopy species, both understory and midstory strata within mature forests are used by foraging females during incubation and brooding and by fledglings for cover from predators.

As a whole, the structural features required by Cerulean Warblers most often correspond to stocking levels between 60-70% (Wood et al. 2013), which can be present in old-growth forests, mature forests on steep slopes or dry sites, forests following natural disturbances (e.g., treefalls, windstorms, fire), and certain types of harvesting that retain substantial canopy. Observational and experimental studies have found that basal area of approximately 10-20 m^2/ha are associated with the highest densities of Cerulean Warblers (Newell and Rodewald 2012, Boves et al. 2013b, Wood et al. 2013, Sheehan et al. 2014). Interestingly, Boves et al. (2013a) found evidence that selection by males for structural habitat features varied among regions, such that males within the least forested landscapes favored features associated with closed-canopy forest whereas males in highly forested landscapes favored sites with canopy disturbance. Females, in contrast, consistently selected for large trees, well-developed understory, and lower basal area and midstory cover.

Tall and large trees. Cerulean Warblers are most likely to breed in forests with tall canopies, especially >24 m in height (Weakland and Wood 2005, Roth and Islam 2008, Perkins and Wood 2014) and large trees, usually >38 cm diameter-breast-height (dbh) (Oliarnyk and Robertson 1996, Roth and Islam 2008, Bakermans and Rodewald 2009, Hartman et al. 2009, Newell and Rodewald 2011, Nemes and Islam 2017). Nest trees in southeast Ohio were 32% larger than those randomly available (Bakermans and Rodewald 2009). Nest survival also improved with numbers of large trees (Newell and Rodewald 2011, Bakermans et al. 2012).

Grapevines. Grapevines are a common feature of old forests, particular those with heterogeneous and light-penetrating canopies. In southeast Ohio, grapevines are related to nest-site selection, nest construction, and nest survival (Bakermans and Rodewald, Newell and Rodewald 2011). Nest sites contained nearly 8x more grapevines than found in random locations (Bakermans and Rodewald 2009). Number of grapevines may promote nest survival by reducing the conspicuousness of female movements or concealing nests, though that has not been tested (Bakermans and Rodewald 2009).

Floristic composition

Cerulean Warblers exhibit strong preferences for specific forest types and tree species and actively avoid others. In the Appalachian Mountains they are strongly associated with oak-hickory forests, and white oak (*Quercus alba*) stands out as the most consistently preferred tree species (Newell and Rodewald 2011, Boves et al. 2013a, Newell et al. 2014, Wagner and Islam 2014, Barnes et al. 2016, Nemes and Islam 2017), followed by hickories (*Carya* spp.) in some locations (Gabbe et al. 2002, Newell and Rodewald 2011, Newell et al. 2014, Barnes et al. 2016). Dendroecology and witness tree studies indicate that white oak dominated many eastern forests prior to European Settlement, with the species ranking first in abundance in most Midwest and Central region forests (Abrams 2003). In southeastern Ohio, specifically, presettlement forests were estimated to be dominated by white oak (40%), hickory (14%), black oak (12%), and beech (8%), white oak has since declined to less than 15% (Dyer 2001).

Cerulean Warbler, along with many other forest wildlife species, rely heavily upon oak forests as habitat (Rodewald and Abrams 2002, Rodewald 2003).

Boves et al. (2013) also reported that across the Appalachians, Cerulean Warblers actively selected white oaks and, to a lesser degree and more variably across study sites, sugar maples (*Acer saccharum*) and cucumber trees (*Magnolia acuminate*). In contrast, territories and/or nest patches of Cerulean Warblers contained fewer chestnut oaks (*Quercus prinus*), red maples (*Acer rubrum*), and sugar maples than random points. One especially striking pattern in southeast Ohio was that Ceruleans strongly avoided foraging or placing nests in Northern red oak (*Quercus rubra*) (Newell and Rodewald 2011, Boves et al. 2013a, Newell et al. 2014), which also was negatively associated with nest survival (Newell and Rodewald 2011).

Tree species composition is likely important not only to provide structural features for nests, but also to support preferred insect prey given that Cerulean Warblers are highly selective foragers (Gabbe et al. 2002, Newell et al. 2014). Auer et al. (2016) reported that diets of Cerulean nestlings were comprised of 53-83% lepidopteran larvae, a group widely recognized to specialize on particular plant species. Tallamy and Shropshire (2009) found that oaks supported more lepidoptera species than any other native or introduced plants studied. Likewise, Newell et al. (2014) found that 69% of identifiable prey fed to nestlings were lepidopteran larvae or caterpillars.

Landscape composition and configuration

Topography. Unlike other parts of the breeding range in which the species regularly uses bottomland or riparian forest (Sallabanks et al. 2000, Thompson et al. 2012, Carpenter and Richter 2013, Carpenter and Wang 2018), Cerulean Warblers breeding in the Appalachian Mountains are most common in oak-hickory (*Quercus* and *Carya* spp) forests located on ridges and/or steep slopes (Wood et al. 2006, Roth and Islam 2008, Kaminski and Kamal 2013, Barnes et al. 2016, Nemes and Islam 2017). They most often select North, Northeast, or East-facing slopes, which tend to be mesic, and avoid drier Southwest aspects (Wood et al. 2006, Hartman et al. 2009, Bakermans and Rodewald 2009, Newell and Rodewald 2011, Kaminski and Kamal 2013, Barnes et al. 2016, Nemes and Islam 2017).

Landscape composition. Cerulean Warblers are strongly associated with forested landscapes (Weakland and Wood 2005, Buehler et al. 2008, Thompson et al. 2012, Wood et al. 2013, Becker et al. 2015, Carpenter and Wang 2018), with densities of 4.6 territories/10 ha in intact forest versus 0.7 territories/10 ha in fragmented forest in West Virginia (Weakland and Wood 2005). In southeast Ohio landscapes within or near the Wayne National Forest, densities of Cerulean Warblers tended to be lower in forest stands adjacent to regenerating clearcuts (1.3 birds/ha _0.6 SE) compared to those in forested landscapes (2.6 ± 1.3 SE), but differences were not statistically significant (Bakermans and Rodewald 2009).

In some regions, coal surface mining is an especially worrisome driver of landscape-scale habitat loss and fragmentation because of the high degree of overlap between areas suitable for coal mining and for breeding Ceruleans (Buehler et al. 2006). Cerulean Warblers and other forest interior songbirds responded negatively to relatively low thresholds of forest loss (~4%) due to mines (Becker et al. 2015). Although Wood et al. (2005, 2006) detected no avoidance of mine edges, Weakland and Wood (2005) found that territory density increased with distance to mine edge.

Patch size. Territory sizes of Cerulean Warblers are comparable to many songbirds at approximately 1 ha (Robbins et al. 2009, Oliarnyk and Robertson 1996), and they are generally considered to require large patches of forest for breeding (Thogmartin et al. 2004). Area sensitivity may stem from the fact that individuals may have home ranges (as opposed to territories defended for exclusive use) as large as 6 ha (Carptenter and Wang 2018) and have an affinity for nesting in clusters in close proximity to other breeding pairs (Roth and Islam 2007, Kaminski and Islam 2013).

There is no single patch size or unit area required for Cerulean Warblers because, as with many area-sensitive species, minimum patch size varies widely with forest cover and fragmentation in the landscape overall (Wood et al. 2013). Cerulean Warblers can indeed establish territories and breed in relatively small patches of forest (e.g., 10 ha) but only in landscapes that are heavily forested (Wood et al. 2013). In Ohio Hills, the species often require at least 25 ha forest stands, compared to orders of magnitude larger patches in very fragmented regions like the Mississippi Alluvial Valley or Mid-Atlantic Region (Wood et al. 2013 – bulletin). The key implication of variable area requirements is that as landscapes within and surrounding the Wayne National Forest become less forested – irrespective of the land use type – larger patches of mature forest will be required to support Cerulean Warblers. Thus, maintaining forested landscapes is one of the most important ways to ensure that forest stands will have potential to attract Cerulean Warblers.

Edges. Cerulean Warblers may be more sensitive to landscape composition and configuration (i.e., heavily forested landscapes) than edges per se. The presence of scattered regenerating clearcuts and other prominent edges within larger expanses of mature forest does not appear to affect occurrence or density (Wood et al. 2005, Wood et al. 2006, Bakermans and Rodewald 2009) or nesting success (Bakermans and Rodewald 2009, Bakermans et al. 2012). Although Weakland and Wood (2005) found no evidence that Ceruleans avoided internal edges, such as canopy gaps or small roads under partially-open canopies, they reported that territory densities increased with distance to mine edge.

Implications for forest management

Maintain or encourage heavily-forested landscapes. Managers should explicitly consider the landscape context of silvicultural treatments and management units to ensure that landscapes remain heavily forested and dominated by late seral stages. Management decisions that consider only stand-level factors and silvicultural prescriptions risk reducing the quality of habitat for Cerulean Warblers and exacerbating population declines. For example, though shelterwood harvests seem to improve habitat conditions for Ceruleans, they may not be beneficial if applied in a manner that reduces forest cover within landscapes to less than 60%, nor if overstory trees are eventually removed. Because most land in the WNF region is privately owned, public lands, including state and national forests, bear disproportionate responsibility for ensuring that landscapes remain heavily forested with significant cover in late-seral stages.

Allow forests to mature and naturally develop old-forest features. Given sufficient time to regenerate (usually >100 years, depending upon site conditions), many forests will develop the structural attributes required by Cerulean Warblers. Among the features that are expected to develop after forests reach steady-state, gap-dynamic phases are heterogeneous canopies, well-developed vertical strata, large diameter trees (>38 cm dbh), and grapevines – all of which promote high densities and successful reproduction of Cerulean Warblers. Although grapevines are often removed in forests because of perceived negative impacts on timber quality (e.g., damage to tree limbs, twisted or bent trunks, propensity to cause treefall), grapevines are both used in nest construction and were strongly related to density and nest survival of Cerulean Warblers (Bakermans and Rodewald 2009). These conditions might be achieved by extending rotation lengths or taking certain stands out of rotation entirely.

Retain white oaks whenever possible and promote oak-hickory forests. Forest management practices that promote oak-hickory forests are recommended to conserve Cerulean Warblers. In old forests subject to natural internal gap dynamics, oak may be able to recruit in understory gap environments (Abrams 2003). However, oaks are a disturbance-dependent and relatively shade-intolerant species that does not regenerate well under closed canopy conditions that instead favor maple and yellow poplar. The widespread oak decline in the eastern US, including Ohio, has been largely attributed to poor advanced regeneration due to altered disturbance regimes. Irrespective of the initial drivers of declines of white oak, recent FIA data suggest that harvesting rates in Ohio are unsustainable given continued recent declines (~7% since 2011), extremely poor recruitment, and Growth to Removal ratios of 0.8:1 (Albright 2017). Unless recruitment problems are addressed, continued harvesting of mature white oak trees is likely to exacerbate regional declines of the species.

Active management (e.g., harvesting, herbicide, and/or prescribed burning) may be required to ensure adequate regeneration. White oak has several traits, such as thick fire-resistant bark, deep rooting, and thick leaves, that confer an advantage over other tree species in the presence of fire and drought. In current conditions, white oaks are not as competitive and experience lower rates of regeneration.

Based on research at sites near the WNF, Iverson et al. (2008) reported that oak regeneration is most successful on dry or intermediate sites with at least 5000 oak and hickory seedlings/ha, where the canopy can be opened to 8.5–19% followed by at least two fires. Because their research showed that there was no appreciable oak and hickory regeneration developed on mesic sites – which are most preferred by Cerulean Warblers, managers may consider forgoing harvest in these locations. Within harvested stands, managers should make every effort to retain white oak trees and, as possible, avoid removing overstory oaks after shelterwood harvesting.

Removing understory vegetation also has been shown to significantly improve oak regeneration in mature forests. Lorimer et al. (1994) found that on undisturbed plots, more than 70% of planted oak seedlings died within 5 years compared to only 10% of those planted on sites with understory removal. Moreover, understory removal plots had 10-140x more natural oak seedlings after 5 years due to reduced competition with shade-tolerant species.

Because the success of efforts to regenerate oaks can vary widely among approaches and with site conditions, forest managers should take care that implementation carefully follows scientifically-vetted methods.

When appropriate, use silviculture to create suitable structural conditions. Habitat conditions associated with older forests are important habitat components for Cerulean Warblers, and these will require use of longer rotation ages (>100 years) or taking certain stands out of rotation altogether. Past legacies of even-aged management and other anthropogenic disturbances have resulted in even-aged and closed canopy forests that often lack the structural and floristic attributes needed to support Cerulean Warblers. Because densities of Cerulean Warblers often decline with increasing basal area of mature forests, i.e., very closed canopies (Bakermans and Rodewald 2009, Newell and Rodewald 2011, Bakermans et al. 2012), specific harvest prescriptions (e.g., single tree and group selection) and timber stand improvement practices (e.g., thinning and crop tree release) also may be able to create features typical of old, uneven-aged forests. In many cases, forest age or steep topography naturally create those features, but additional management may be required in some stands.

Research has shown that both even-aged and uneven-aged harvesting have the potential to benefit Cerulean Warblers, though responses to specific silvicultural practices vary among studies. Structural features required by Cerulean Warblers most often correspond to stocking levels between 60-70% (Wood et al. 2013) or residual basal area of approximately 10-20 m^2/ha (Newell and Rodewald 2012, Wood et al. 2013, Sheehan et al. 2014). Relative to unharvested forests, Cerulean densities have been reported to be higher in shelterwood harvests (roughly 14m^2 residual basal area, 45-55% canopy cover; Newell and Rodewald 2011, Newell and Rodewald 2012, Boves et al. 2013b, Kaminski and Islam 2013, Kellner et al. 2016), seed tree or clearcuts with residual tree harvests (roughly 6m^2 residual basal area, ~15-20% canopy cover; Boves et al. 2013b,), small-patch or group-select cuts (~0.4-2 ha; Register and Islam 2008, Kellner et al. 2016), and single-tree select/thinned stands (roughly 20m^2 residual basal area, 60-70% canopy cover; Register and Islam 2008, Boves et al. 2013b). Overall, the extent to which Ceruleans will respond positively to harvesting depends upon the number, size, and species of overstory trees that are retained. In cases where overstory trees are removed, as is typically done 5-10 years after initial harvest of shelterwoods for example, the sites would no longer be suitable for Cerulean Warblers.

Responses to harvesting may not be entirely generalizable across stands, however. For example, densities of Ceruleans were highly variable among shelterwood harvests in southeast Ohio and were anywhere from slightly less abundant to >200% more numerous compared to unharvested mature forests (Newell and Rodewald 2012), perhaps due to differences in slope or aspect among sites. The same study reported that patterns of settlement, site fidelity, and nest survival were equivalent between shelterwood and mature unharvested stands, suggesting that habitat quality did not decline in harvesting stands despite the disparate responses in density. A study in the Appalachians, including sites in southeast Ohio, found that density of Cerulean Warblers increased from 1-4 years after canopy disturbance from experimental silvicutural treatments, with males being in better condition on harvested versus unharvested control sites (Boves et al. 2013). Yet the same experiment showed no concomitant improvement in reproductive success; in fact, nest success was generally lower on treated than control plots.

Although the seemingly oppositional patterns for density and nest success might be interpreted to indicate that harvested stands are of lower quality, the pattern also could reflect density dependence – such that resources, and consequently nest success – declined at higher densities. Using data from the Cumberland Mountains of Tennessee, Boves et al. (2015) documented 1.7 to

2.2 more Cerulean territories on harvested (24-85% residual basal area, roughly equivalent to thinning, shelterwood, and seed tree prescriptions) than unharvested sites. Patterns of per capita productivity (i.e., young produced per breeding pair) showed the opposite pattern, such that productivity on unharvested sites was 60-172% greater than on harvested sites. Importantly, however, if one focused on population-level productivity (i.e., number of young produced per ha), the higher densities compensated for the lower nest survival such that more Ceruleans were produced in the shelterwood and seed-tree harvests compared to unharvested or thinned stands. Shelterwood harvests, in particular, produced 24%, 41%, and 125% more young birds/ha than on the heavy cut (15-20% residual canopy), unharvested, and thinned stands, respectively (Boves et al. 2015). Managers should thus carefully consider the tradeoffs associated with decisions that align with individual- (e.g., per capita measures like number of young produced per female) versus population-level (e.g., numbers of young produced per ha) measures of habitat quality. Here again, though, harvested stands will only be suitable for Cerulean Warblers as long as overstory trees are retained and not removed 5-10 years post-harvest, as is the typical silvicultural practice.

Given the variation in responses to harvesting, Wood et al. (2013) cautioned against harvesting to enhance habitat on sites with relatively high densities of Cerulean Warblers (>5 territories / 10 ha) due to the possibility of reducing reproductive success. Instead, harvesting is thought to be most appropriately applied to sites where densities are low and there is strong potential to attract additional pairs post-harvest. In cases where there is wide latitude in choice of harvest location, managers should avoid harvesting older forests with canopy gaps and/or those on northeast-facing slopes, because these tend to be most heavily used by Cerulean Warbler. Likewise, shelterwood harvests are best implemented in areas that lack steep slopes and/or have few canopy gaps, as they are more likely to create or improve habitat for Cerulean Warblers.

Threats to the Cerulean Warbler in the Wayne National Forest region

Based on the reviewed literature, the following are key threats to Cerulean Warblers breeding in the Wayne National Forest region:

Habitat loss and fragmentation. The Ohio Hills, the physiographic province, within which the Wayne National Forest occurs, has been largely forested since the early-to-mid 1900s following the widespread forest clearing and agriculture that reduced forest cover in the state to <10%. Almost no old-growth forest remains today. Landscape composition and configuration have been changing, sometimes rapidly, over recent decades. Drivers of landscape change are diverse and include urbanization, residential development, surface-mining, and increased harvesting of timber. For example, the liquidation of forestland owned by the private company Mead-Westvaco resulted in increased rates of timber harvesting as lands were sold to and cleared by many Timber Management Investment Organizations (TIMOs). Public agencies, including the Wayne National Forest and Ohio Division of Forestry, also have increased harvesting rates in recent years. Because most forest in the Appalachians and Ohio alike are privately owned, public forests play an especially important role in ensuring that landscapes remain forested.

Forest structural changes due to legacies from past disturbance and management. Despite decades of afforestation following more than a century of extensive forest loss, forests of eastern North America continue to bear a legacy from anthropogenic disturbance and lack the structural complexity and floristic diversity typical of presettlement forests with steady-state gap dynamics.

The lack of old forest characteristics, such as large trees, treefall or canopy gaps, and well-developed vertical strata, is thought to contribute to declines of Cerulean Warblers. Ensuring the persistence of Cerulean Warbler will likely involve both protecting old forests that currently support the species and actively managing mature forests (e.g., prescribed burns, understory treatments, thinning to open canopy – all described in previous sections) that lack structural or floristic attributes required by the bird.

Shifting floristic composition. Due to changes in disturbance regimes, forest management practices and – in some regions – overbrowsing by deer, the oak-hickory forests throughout the Appalachians are shifting floristically to shade-tolerant tree species, such as red maple. Poor regeneration and advanced recruitment of white oak, in particular, is a serious problem for the forest industry and threaten species that depend upon the ecosystem. Recent FIA data for Ohio indicate that white oak has experienced net volume loss and may currently be harvested at unsustainable rates (Growth to Removal ratio of 0.8:1), given extremely poor recruitment (Albright 2017). Forest management techniques that promote oaks and hickories, such as prescribed fire and certain mechanical/chemical disturbances, may be required on sites that are experiencing poor advanced regeneration of oaks. Caution is warranted, however, because white oaks do not sprout well from stumps after intensive harvesting or catastrophic disturbance. Until sufficient regeneration of white oak is achieved, continued harvest of mature trees will likely exacerbate declines in the state.

Table 1. Examples of literature providing evidence for specific ecological conditions.

Attribute	**Citations**
Ridges and/or steep slopes	Wood et al. 2006, Roth and Islam 2008, Kaminski and Kamal 2013, Barnes et al. 2016, Nemes and Islam 2017
North-, Northeast, or East-facing (i.e., mesic) slopes	Wood et al. 2006, Hartman et al. 2009, Bakermans and Rodewald 2009, Newell and Rodewald 2011, Kaminski and Kamal 2013, Barnes et al. 2016, Nemes and Islam 2017
Heavily-forested landscapes (>60% within 1-5 km)	Weakland and Wood 2005, Buehler et al. 2008, Thompson et al. 2012, Wood et al. 2013, Becker et al. 2015, Carpenter and Wang 2018
Canopy gaps; open or heterogeneous canopy	Bakermans and Rodewald 2009, Bakermans et al. 2012, Boves et al. 2013a, b, Kaminski and Kamal 2013, Perkins and Wood 2014
Basal area of 10-20 m^2/ha	Newell and Rodewald 2012, Wood et al. 2013, Sheehan et al. 2014
Large diameter trees (>40 cm dbh)	Oliarnyk and Robertson 1996, Roth and Islam 2008, Bakermans and Rodewald 2009, Hartman et al. 2009, Newell and Rodewald 2011, Nemes and Islam 2017
Tall forest canopy (>24 m)	Weakland and Wood 2005, Roth and Islam 2008, Perkins and Wood 2014
Complex vertical strata	Roth and Islam 2007, Hartman et al. 2009, Bakermans et al. 2012
White oak (*Quercus alba*)	Newell and Rodewald 2011, Boves et al. 2013a, Newell et al. 2014, Wagner and Islam 2014, Barnes et al. 2016, Nemes and Islam 2017

Grapevines	Bakermans and Rodewald 2009, Newell and Rodewald 2011
Hickory (*Carya* spp)	Gabbe et al. 2002, Newell and Rodewald 2011, Newell et al. 2014, Barnes et al. 2016

Literature Cited

Abrams, M.D. 2003. Where has all the white oak gone? Bioscience 53:927-939.

Albright, Thomas A. 2017. "Forests of Ohio, 2016," Resource Update FS-139, U.S. Department of Agriculture, Forest Service, NRS (2017), :https://www.fs.fed.us/nrs/pubs/ru/ru_fs139.pdf.

Auer, S. A., K. Islam, J. R. Wagner, K. S. Summerville, and K. W. Barnes. 2016. The Diet of Cerulean Warbler (Setophaga cerulea) Nestlings and Adult Nest Provisioning Behaviors in Southern Indiana. Wilson Journal of Ornithology **128**(3)**:**573-583.

Bakermans, M. H., and A. D. Rodewald. 2009. Think globally, manage locally: The importance of steady-state forest features for a declining songbird. Forest Ecology and Management **258**(3)**:**224-232.

Bakermans, M. H., A. D. Rodewald, and A. C. Vitz. 2012. Influence of forest structure on density and nest success of mature forest birds in managed landscapes. Journal of Wildlife Management **76**(6)**:**1225-1234.

Barnes, K. W., K. Islam, and S. A. Auer. 2016. Integrating LIDAR-derived canopy structure into cerulean warbler habitat models. Journal of Wildlife Management **80**(1)**:**101-116.

Becker, D. A., P. B. Wood, M. P. Strager, and C. Mazzarella. 2015. Impacts of mountaintop mining on terrestrial ecosystem integrity: identifying landscape thresholds for avian species in the central Appalachians, United States. Landscape Ecology **30**(2)**:**339-356.

Boves, T. J., D. A. Buehler, J. Sheehan, P. B. Wood, A. D. Rodewald, J. L. Larkin, P. D. Keyser, F. L. Newell, A. Evans, G. A. George, and T. B. Wigley. 2013a. Spatial Variation in Breeding Habitat Selection by Cerulean Warblers (Setophaga Cerulea) Throughout the Appalachian Mountains. Auk **130**(1)**:**46-59.

Boves, T. J., D. A. Buehler, J. Sheehan, P. B. Wood, A. D. Rodewald, J. L. Larkin, P. D. Keyser, F. L. Newell, G. A. George, M. H. Bakermans, A. Evans, T. A. Beachy, M. E. McDermott, K. A. Perkins, M. White, and T. B. Wigley. 2013b. Emulating Natural Disturbances for Declining Late-Successional Species: A Case Study of the Consequences for Cerulean Warblers (Setophaga cerulea). Plos One **8**(1)**:**e52107.

Boves, T. J., A. D. Rodewald, P. B. Wood, D. A. Buehler, J. L. Larkin, T. B. Wigley, and P. D. Keyser. 2015. Habitat Quality From Individual- and Population-Level Perspectives and Implications for Management. Wildlife Society Bulletin **39**(2)**:**443-447.

Buehler, D. A., M. J. Welton, and T. A. Beachy. 2006. Predicting cerulean warbler habitat use in the Cumberland Mountains of Tennessee. Journal of Wildlife Management **70**(6)**:**1763-1769.

Carpenter, J. P., and J. Richter. 2013. Current Distribution, Relative Abundance, and Landscape-Level Habitat Associations of the Cerulean Warbler (Setophaga cerulea) along the Lower Roanoke River in North Carolina. Southeastern Naturalist **12**(4)**:**723-737.

Carpenter, J. P., and Y. Wang. 2018. Diurnal space use and nocturnal roost-site selection by male Cerulean Warblers during the breeding season. Journal of Field Ornithology **89**(1)**:**47-63.

Dyer, J.M. 2001. Using witness trees to assess forest change in southeastern Ohio. Canadian Journal of Botany 31:1708-1718.

Gabbe, A., S. Robinson, and J. Brawn. 2002. Tree-species preferences of foraging insectivorous birds: Implications for floodplain forest restoration. Conservation Biology **16**(2)**:**462-470.

Hartman, P. J., D. S. Maehr, and J. L. Larkin. 2009. Habitat Selection by Cerulean Warblers in Eastern Kentucky. Wilson Journal of Ornithology **121**(3)**:**469-475.

Iverson, L.R., T.F. Hutchinson, A.M. Prasad. And M.P. Peters. 2008. Thinning, fire, and oak regeneration across a heterogeneous landscape in the eastern U.S.: 7-year results. Forest Ecology and Management 255:3035-3050.

Jones, J., R. DeBruyn, J. Barg, and R. Robertson. 2001. Assessing the effects of natural disturbance on a neotropical migrant songbird. Ecology **82**(9)**:**2628-2635.

Kaminski, K. J., and K. Islam. 2013. Effects of Forest Treatments on Abundance and Spatial Characteristics of Cerulean Warbler Territories. American Midland Naturalist **170**(1)**:**111-120.

Kellner, K. F., P. J. Ruhl, J. B. Dunning Jr., J. K. Riegel, and R. K. Swihart. 2016. Multi-scale responses of breeding birds to experimental forest management in Indiana, USA. Forest Ecology and Management **382:**64-75.

Lorimer, C.G., J.W. Chapman, and W.D. Lambert. 1994. Tall understory vegetation as a factor in the poor development of oak seedlings beneath mature stands. Journal of Ecology 82:227-237.

Nemes, C. E., and K. Islam. 2017. Breeding season microhabitat use by Cerulean Warbler (Setophaga cerulea) in an experimentally-managed forest. Forest Ecology and Management **387:**52-63.

Newell, F. L., and A. D. Rodewald. 2011. Role of topography, canopy structure, and floristics in nest-site selection and nesting success of canopy songbirds. Forest Ecology and Management 262(5):739-749.

Newell, F. L., T. Beachy, A. D. Rodewald, C. G. Rengifo, I. J. Ausprey, and P. G. Rodewald. 2014. Foraging behavior of Cerulean Warblers during the breeding and non-breeding seasons: evidence for the breeding currency hypothesis. Journal of Field Ornithology **85**(3)**:**310-320.

Newell, F. L., and A. D. Rodewald. 2012. Management for oak regeneration: Short-term effects on the bird community and suitability of shelterwood harvests for canopy songbirds. Journal of Wildlife Management **76**(4)**:**683-693.

Oliarnyk, C., and R. Robertson. 1996. Breeding behavior and reproductive success of Cerulean Warblers in southeastern Ontario. Wilson Bulletin **108**(4)**:**673-684 ER.

Perkins, K. A., and P. B. Wood. 2014. Selection of Forest Canopy Gaps by Male Cerulean Warblers in West Virginia. Wilson Journal of Ornithology **126**(2)**:**288-297.

Register, S. M., and K. Islam. 2008. Effects of silvicultural treatments on Cerulean Warbler (Dendroica cerulea) abundance in southern Indiana. Forest Ecology and Management **255**(8-9)**:**3502-3505.

Robbins, M. B., A. S. Nyari, M. Papes, and B. W. Benz. 2009. Song Rates, Mating Status, and Territory Size of Cerulean Warblers in Missouri Ozark Riparian Forest. Wilson Journal of Ornithology **121**(2)**:**283-289.

Rodewald, A. D. and M. A. Abrams. 2002. Floristics and avian community structure: implications for regional changes in eastern forest composition. Forest Science: 48: 267-272.

Rodewald, A. D. 2003. The decline of oak forests and implications for forest wildlife conservation. Natural Areas Journal 23:368-371.

Roth, K. L., and K. Islam. 2007. Do Cerulean warblers (Dendroica cerulea) exhibit clustered territoriality? American Midland Naturalist **157**(2)**:**345-355.

Roth, K. L., and K. Islam. 2008. Habitat selection and reproductive success of Cerulean Warblers in Indiana. Wilson Journal of Ornithology **120**(1)**:**105-110.

Sallabanks, R., J. Walters, and J. Collazo. 2000. Breeding bird abundance in bottomland hardwood forests: Habitat, edge, and patch size effects. Condor **102**(4)**:**748-758.

Sheehan, J., P. B. Wood, D. A. Buehler, P. D. Keyser, J. L. Larkin, A. D. Rodewald, T. B. Wigley, T. J. Boves, G. A. George, M. H. Bakermans, T. A. Beachy, A. Evans, M. E. McDermott, F. L. Newell, K. A. Perkins, and M. White. 2014. Avian response to timber harvesting applied experimentally to manage Cerulean Warbler breeding populations. Forest Ecology and Management **321:**5-18.

Thogmartin, W., J. Sauer, and M. Knutson. 2004. A hierarchical spatial model of avian abundance with application to Cerulean Warblers. Ecological Applications **14**(6)**:**1766-1779.

Thompson, Frank R.,,III, M. B. Robbins, and J. A. Fitzgerald. 2012. Landscape-Level Forest Cover is a Predictor of Cerulean Warbler Abundance. Wilson Journal of Ornithology **124**(4)**:**721-727.

Wagner, J. R., and K. Islam. 2014. Nest-site Selection and Breeding Ecology of the Cerulean Warbler in Southern Indiana. Northeastern Naturalist **21**(4)**:**515-528.

Weakland, C., and P. Wood. 2005. Cerulean Warbler (Dendroica cerulea) microhabitat and landscape-level habitat characteristics in southern West Virginia. Auk **122**(2)**:**497-508.

Wood, P., S. Bosworth, and R. Dettmers. 2006. Cerulean warbler abundance and occurrence relative to large-scale edge and habitat characteristics. Condor **108**(1)**:**154-165 ER.

Wood, P., J. Duguay, and J. Nichols. 2005. Cerulean warbler use of regenerated clearcut and two-age harvests. Wildlife Society Bulletin **33**(3)**:**851-858.

Wood, P.B., J. Sheehan, P. Keyser, D. Buehler, J. Larkin, A. Rodewald, S. Stoleson, T.B., Wigley, J. Mizel, T. Boves, G. George, M. Bakermans, T. Beachy, A. Evans, M. McDermott, F.

Newell, K. Perkins, and M. White. 2013. Management guidelines for enhancing Cerulean Warbler breeding habitat in Appalachian hardwood forests. American Bird Conservancy. The Plains, Virginia. 28 pp.

Annotated Bibliography (i.e., Published Abstracts) of Key Studies, with emphasis on those occurring within and near the Wayne National Forest

Bakermans, M. H., and A. D. Rodewald. 2009. Think globally, manage locally: The importance of steady-state forest features for a declining songbird. Forest Ecology and Management 258(3):224-232.

Changes in historical forest composition and structure may have cascading effects throughout the forest community. Perhaps nowhere is there a better example of current forests that carry a legacy from their past than in eastern North America. The Cerulean Warbler (*Setophaga cerulea*), a declining Neotropical migratory bird of high conservation concern, is one excellent example of a species that seems to be sensitive to both landscape configuration and subtle features of eastern forests of North America. We used the Cerulean Warbler as a model species to demonstrate how an appreciation of fine-scale structural attributes of forests may improve our ability to conserve late-successional forest species. To do this we evaluated the extent to which multiscale habitat features were associated with density, spatial distribution, and nesting success of Cerulean Warblers in 12 mature forest sites in southeast Ohio, 2004–2006. Results suggest that adjacency of regenerating clear-cuts did not influence density or nesting success of Cerulean Warblers in adjacent mature forest. Instead, variation in demographic parameters was best explained by local habitat features. Density and nesting success were positively associated with canopy openness, numbers of large-diameter trees, and number of grapevines—all of which are typical of heterogeneous steady-state phase forests. Thus, improved management for Cerulean Warblers may require creating features (e.g., large canopy gaps) that mimic old-growth forests. Although fragmentation and habitat loss remain important contributors to population declines of many mature forest species, our work provides evidence that subtle changes in forest structure, particularly to features associated with old forests, warrant additional attention from the conservation community.

Bakermans, M. H., A. D. Rodewald, and A. C. Vitz. 2012. Influence of forest structure on density and nest success of mature forest birds in managed landscapes. Journal of Wildlife Management 76(6):1225-1234.

Managing for forest wildlife requires attention not only to quantity but quality of forests within the landscape. We examined the extent to which local structural attributes and landscape context of forest stands explained variation in density and reproductive success of mature forest birds across 12 sites in southeast Ohio, USA, 2004–2006. Results suggest that several structural characteristics influenced bird– habitat relationships in our study. Densities of 3 songbird species (i.e., ovenbird [*Seiurus aurocapilla*], cerulean warbler [*Setophaga cerulea*], and scarlet tanager [*Piranga olivacea*]) were positively related to canopy openness, which is usually a function of canopy gaps. Habitat attributes described by ground litter, understory density, and canopy height were positively associated with densities of ground (i.e., worm-eating warbler [*Helmitheros vermivorum*]), or shrub nesting species (i.e., Kentucky and hooded warblers [*Geothlypis formosa* and *Setophaga citrina*], respectively). Furthermore, the number of small trees likely drove the positive relationship between density of wood thrush (*Hylocichla mustelina*), a subcanopy nester.

After accounting for temporal variability in daily nest survival rates, the odds of nest survival for all species increased 10.5% for every 1% increase in canopy openness and decreased 1.4% for each 5% increase in understory vegetation density. Habitat–nest survival relationships were not apparent at the level of the individual species. Our results suggest that structural attributes produced by increasing habitat heterogeneity may be necessary for conservation of forest bird communities.

Boves, T. J., D. A. Buehler, J. Sheehan, P. B. Wood, A. D. Rodewald, J. L. Larkin, P. D. Keyser, F. L. Newell, A. Evans, G. A. George, and T. B. Wigley. 2013. Spatial Variation in Breeding Habitat Selection by Cerulean Warblers (Setophaga cerulea) Throughout the Appalachian Mountains. Auk 130(1):46-59.

Studies of habitat selection are often of limited utility because they focus on small geographic areas, fail to examine behavior at multiple scales, or lack an assessment of the fitness consequences of habitat decisions. These limitations can hamper the identification of successful site-specific management strategies, which are urgently needed for severely declining species like Cerulean Warblers (*Setophaga cerulea*). We assessed how breeding habitat decisions made by Cerulean Warblers at multiple scales, and the subsequent effects of these decisions on nest survival, varied across the Appalachian Mountains. Selection for structural habitat features varied substantially among areas, particularly at the territory scale. Males within the least-forested landscapes selected microhabitat features that reflected more closed-canopy forest conditions, whereas males in highly forested landscapes favored features associated with canopy disturbance. Selection of nest-patch and nest-site attributes by females was more consistent across areas, with females selecting for increased tree size and understory cover and decreased basal area and midstory cover. Floristic preferences were similar across study areas: White Oak (*Quercus alba*), Cucumber-tree (*Magnolia acuminata*), and Sugar Maple (*Acer saccharum*) were preferred as nest trees, whereas red oak species (subgenus *Erythrobalanus*) and Red Maple (*A. rubrum*) were avoided. The habitat features that were related to nest survival also varied among study areas, and preferred features were negatively associated with nest survival at one area. Thus, our results indicate that large-scale spatial heterogeneity may influence local habitat-selection behavior and that it may be necessary to articulate site-specific management strategies for Cerulean Warblers.

Boves, T. J., D. A. Buehler, J. Sheehan, P. B. Wood, A. D. Rodewald, J. L. Larkin, P. D. Keyser, F. L. Newell, G. A. George, M. H. Bakermans, A. Evans, T. A. Beachy, M. E. McDermott, K. A. Perkins, M. White, and T. B. Wigley. 2013. Emulating Natural Disturbances for Declining Late-Successional Species: A Case Study of the Consequences for Cerulean Warblers (Setophaga cerulea). Plos One 8(1):e52107.

Forest cover in the eastern United States has increased over the past century and while some late-successional species have benefited from this process as expected, others have experienced population declines. These declines may be in part related to contemporary reductions in small-scale forest interior disturbances such as fire, windthrow, and treefalls. To mitigate the negative impacts of disturbance alteration and suppression on some late-successional species, strategies that emulate natural disturbance regimes are often advocated, but large-scale evaluations of these practices are rare. Here, we assessed the consequences of experimental disturbance (using partial timber harvest) on a severely declining late successional species, the cerulean warbler (*Setophaga cerulea*), across the core of its breeding range in the Appalachian Mountains. We measured numerical (density), physiological (body condition), and demographic (age structure and reproduction) responses to three levels of disturbance and explored the potential impacts of disturbance on source-sink dynamics. Breeding densities of warblers increased one to four years after all canopy disturbances (vs. controls) and males occupying territories on treatment plots were in better condition than those on control plots. However, these beneficial effects of disturbance did not correspond to improvements in reproduction; nest success was lower on all treatment plots than on control plots in the southern region and marginally lower on light disturbance plots in the northern region. Our data suggest that only habitats in the southern region acted as sources, and interior disturbances in this region have the potential to create ecological traps at a local scale, but sources when viewed at broader scales. Thus, cerulean warblers would likely benefit from management that strikes a landscape-level balance between emulating natural disturbances in order to attract individuals into areas where current structure is inappropriate, and limiting anthropogenic disturbance in forests that already possess appropriate structural attributes in order to maintain maximum productivity.

Newell, F. L., and A. D. Rodewald. 2011. Role of topography, canopy structure, and floristics in nest-site selection and nesting success of canopy songbirds. Forest Ecology and Management 262(5):739-749.

Although oaks (*Quercus* spp.) have historically dominated many forests in eastern North America, forest composition is changing due to anthropogenic impacts on disturbance regimes. Silvicultural practices, such as partial harvesting, are one component of management to promote oak regeneration. From 2007 to 2009 our research examined nest-site selection and nesting success for a guild of five canopy songbirds in upland mixed-oak forests in southeastern Ohio, USA. We monitored >700 nests across three state forests in both open canopy shelterwood stands harvested to approximately 50% stocking, and closed-canopy mature second-growth. Habitat attributes, including topography, canopy structure, and floristics, were measured at nest sites and random plots 6100 m from nests representing microhabitat available within the territory. Canopy songbirds selected specific topographic microclimates: Eastern Wood-pewees (*Contopus virens*) nested on xeric ridgetops, Blue-gray Gnatcachers (*Polioptila caerulea*) favored valleys, and Cerulean Warblers (*Setophaga cerulea*) preferred productive northeast-facing slopes. Nest sites differed among species in terms of concealment, nest support, topographic position on the slope, and basal area of trees >38 cm dbh. Four of the five focal species selected *Quercus* alba as the nest substrate more than twice as much as available, and three species avoided *Quercus rubra*. Daily survival rates of nests were negatively associated with basal area of red oak species (both *Quercus velutina* and *Q. rubra*) for several species individually and across the canopy-nesting guild. Additional factors related to success included time of season for Eastern Wood-pewees, nest age for Cerulean Warblers, and concealment and size of the support branch for Scarlet Tanagers (*Piranga olivacea*). In the long-term management for oak regeneration could benefit canopy songbirds, but our results indicate that white oaks, especially Q. alba, may be preferable to red oak species.

Newell, F. L., and A. D. Rodewald. 2012. Management for oak regeneration: Short-term effects on the bird community and suitability of shelterwood harvests for canopy songbirds. Journal of Wildlife Management 76(4):683-693.

Interest in regenerating oaks (*Quercus* spp.) has promoted use of partial harvesting techniques that create an open forest structure. From 2007 to 2009, we studied songbirds in mixed-oak forests in southeastern Ohio, comparing shelterwoods recently harvested to 50% stocking and closed-canopy mature second-growth. We surveyed birds using distance-based methods (56 line transects in 18 stands at 4 forests). We intensively investigated suitability of shelterwoods for canopy-nesting species by examining habitat preferences, as measured by settlement patterns, age distributions, and site fidelity; we also examined nesting success. Several midstory and ground-nesting species were 26–73% less abundant in shelterwood than unharvested stands, whereas shrub-nesting species increased >100% several years post-harvesting. Canopy nesting species were 31–98% more abundant in shelterwoods, but cerulean warbler (*Setophaga cerulea*) responses varied by forest. Patterns of settlement and site fidelity were generally similar among stands. Proportions of young males were actually greater for several species in shelterwood than unharvested stands, which may have been a consequence of young birds colonizing newly created (or improved) habitat. Even in our predominantly forested study system, nesting success (>700 nests) was low, ranging from 15% to 19% for yellow-throated vireos (*Vireo flavifrons*) and cerulean warblers, to 27–36% for scarlet tanagers, blue-gray gnatcatchers (*Polioptila caerulea*) and eastern wood-pewees (*Contopus virens*). However, nest survival did not differ between shelterwood and unharvested stands, possibly because numbers of avian predators did not change with harvesting. Despite increased numbers of brown-headed cowbirds (Molothrus ater) in shelterwoods, only 2% of canopy nests in which young could be identified were parasitized. Although these results suggest shelterwood harvests containing abundant overstory trees can provide short-term breeding habitat for canopy songbirds, long-term responses of birds to partial harvesting may differ from those documented here depending on different management options employed. Management for oak regeneration will typically remove all overstory trees later in the cutting cycle, initially resulting in loss of nesting substrates and hence breeding habitat for canopy songbirds.

Sheehan, J., P. B. Wood, D. A. Buehler, P. D. Keyser, J. L. Larkin, A. D. Rodewald, T. B. Wigley, T. J. Boves, G. A. George, M. H. Bakermans, T. A. Beachy, A. Evans, M. E. McDermott, F. L. Newell, K. A. Perkins, and M. White. 2014. Avian response to timber harvesting applied experimentally to manage Cerulean Warbler breeding populations. Forest Ecology and Management 321:5-18.

Timber harvesting has been proposed as a management tool to enhance breeding habitat for the Cerulean Warbler (*Setophaga cerulea*), a declining Neotropical–Nearctic migratory songbird that nests in the canopy of mature eastern deciduous forests. To evaluate how this single-species management focus might fit within an ecologically based management approach for multiple forest birds, we performed a manipulative experiment using four treatments (three intensities of timber harvests and an unharvested control) at each of seven study areas within the core Cerulean Warbler breeding range. We collected preharvest (one year) and post-harvest (four years) data on the territory density of Cerulean Warblers and six additional focal species, avian community relative abundance, and several key habitat variables. We evaluated the avian and habitat responses across the 3–32 m^2 /ha residual basal area (RBA) range of the treatments. Cerulean Warbler territory density peaked with medium RBA (16 $m^{2\,/}$ ha). In contrast, territory densities of the other focal species were negatively related to RBA (e.g., Hooded Warbler [*Setophaga citrina*]), were positively related to RBA (e.g., Ovenbird [Seiurus aurocapilla]), or were not sensitive to this measure (Scarlet Tanager [*Piranga olivacea*]). Some species (e.g., Hooded Warbler) increased with time post-treatment and were likely tied to a developing understory, whereas declines (e.g., Ovenbird) were immediate. Relative abundance responses of additional species were consistent with the territory density responses of the focal species. Across the RBA gradient, greatest separation in the avian community was between early successional forest species (e.g., Yellow-breasted Chat [*Icteria virens*]) and closed-canopy mature forest species (e.g., Ovenbird), with the Cerulean Warbler and other species located intermediate to these two extremes. Overall, our results suggest that harvests within 10–20 m^2 /ha RBA yield the largest increases in Cerulean Warblers, benefit additional disturbance-dependent species, and may retain closed-canopy species but at reduced levels. Harvests outside the optimum RBA range for Cerulean Warblers can support bird assemblages specifically associated with early or late (closed-canopy) successional stages.

Wood, P.B., J. Sheehan, P. Keyser, D. Buehler, J. Larkin, A. Rodewald, S. Stoleson, T.B., Wigley, J. Mizel, T. Boves, G. George, M. Bakermans, T. Beachy, A. Evans, M. McDermott, F. Newell, K. Perkins, and M. White. 2013. Management guidelines for enhancing Cerulean Warbler breeding habitat in Appalachian hardwood forests. American Bird Conservancy. The Plains, Virginia. 28 pp.

A scientific-based guide that summaries management practices and strategies that enhance habitat for Cerulean Warblers breeding in Appalachian hardwood forests.

Amanda D. Rodewald

Cornell Lab of Ornithology
Department of Natural Resources, Cornell University
159 Sapsucker Woods Road, Ithaca, N.Y. 14850
Email: arodewald@cornell.edu

EDUCATION

Ph.D. in Ecology, 2000. Pennsylvania State University, University Park, Pennsylvania.
M.S. in Zoology, 1995. University of Arkansas, Fayetteville, Arkansas.
B.S. in Wildlife Biology, 1992. University of Montana, Missoula, Montana.

PROFESSIONAL POSITIONS

Garvin Professor of Ornithology and Senior Director of Conservation Science, Cornell Lab of Ornithology and Department of Natural Resources, Cornell University. 2013 to present. (Garvin chair named in 2016)
Faculty Fellow, Atkinson Center for a Sustainable Future, Cornell University. 2013 to present.
Core Faculty, Latin American Studies Program. 2018 to present.
Affiliate Faculty, Cornell Institute for Public Affairs, 2018 to present.
Professor of Wildlife Ecology (2010-2013), Associate Professor (2006-2010), Assistant Professor (2000-2006). School of Environment and Natural Resources, The Ohio State University.
Visiting Scientist, Integrative Ecology, Estación Biológica de Doñana, CSIC, Sevilla, Spain. 2011-2012.
Graduate Research Associate, School of Forest Resources, Pennsylvania State University, 1996–2000.
Research Assistant, Montana Dept of Fish, Wildlife, and Parks, 1996 and 1995
Tropical Research Assistant, Manomet Observatory for Conservation Sciences, 1996.
Laboratory Assistant, Dept. of Entomology, University of Arkansas, 1995.
Graduate Assistant, Dept of Biological Sciences, University of Arkansas, 1993-95.
Biological Technician, Glacier National Park, Montana, 1992.

HONORS AND AWARDS

Honorary doctorate, Universidad Cientifica del Perú, 2018
Fellow, American Association for the Advancement of Science, 2017
International Research Fellow, Wall Institute for Advanced Studies, Univ. British Columbia. 2016-18
Public Voices Fellow, The Op-Ed Project, 2017
Partners in Flight Investigation Award, 2013
Avian Conservation and Science Award, Ohio Ornithological Society, 2012
Fellow, American Ornithologists Union, 2011
Fellow, CIC Academic Leadership Program, 2010-2011
Best Lessons Learned Award for Migratory Bird Conservation, Eco-Index & Rainforest Alliance, 2011
Distinguished Junior Faculty Research Award, Ohio Agricultural Research & Development Center, 2007
Elective Member, American Ornithologists' Union, 2006
Fellow, President's and Provost's Leadership Institute, OSU, 2006-2008
Best Lessons Learned Award for Migratory Bird Conservation, Eco-Index & Rainforest Alliance, 2009
Finalist, Magrath & Kellogg Foundation Engagement Award, OSU, 2007
Price Academic Advising Award, College of Food, Agricultural, & Environmental Sciences, OSU, 2004
Roger Latham Award, School of Forest Resources, PSU, 2000
Brian Horton Award, Ecology, PSU, 2000

Paul A. Stewart Research Award, Wilson Ornithological Society, 1999
Graduate Women in Science, Sigma Delta Epsilon Fellowship, 1998-99
Clare Boothe Luce Fellowship, Women in Science & Engineering Institute, PSU, 1997-99
Pinchot Scholar, School of Forest Resources, PSU, 1996-1999
National Park Service Productivity Award, 1993
Outstanding Senior Award, School of Forestry, UM, 1992
Scholarships: Watkins Research Scholarship, UM, 1991-92; Montana Board of Regents Scholarship, 1991-92; Ralph H. O'Brien Scholarship, 1989-90; New York Regents Scholarship, 1988-90

HIGHLIGHTS

- 18 years as a professor in Tier I Research Universities, where I:
    - led and integrated research, teaching and outreach/extension programs;
    - supervised (cumulatively) >150 staff, students, and post-doctoral researchers;
    - built a highly productive research program focused on ecology and sustainability science;
    - initiated and managed multi-year, multi-institution projects in North and South America;
    - developed and evaluated curricular and training programs in interdisciplinary departments;
    - taught 17 different course at the graduate and undergraduate levels;
    - served universities on campus-wide, college, and departmental task forces and committees;
    - designed and implemented outreach and extension programs at regional, national, and international levels
- Programmatic, financial, and administrative leadership as Director of the Conservation Science Program at the Cornell Lab of Ornithology to:
    - <u>discover and innovate</u> through interdisciplinary science that identifies the threats facing priority systems and species, the actions needed to ensure conservation, and the ways to work with people to achieve them;
    - <u>bring science to action</u>; by working at the interface of science and application and collaborating with decision-makers and practitioners, we help guide planning and policy, empower action, and provide leadership for strategic multi-partner initiatives, and
    - <u>build capacity</u> in science and conservation among students, scientists, and practitioners around the world.
- National leadership and service to Federal agencies that includes over a decade of service with the Science Advisory Board of the U.S. Environmental Protection Agency and chairing their controversial panel evaluating revisions to the regulatory definition of the “Waters of the US”.
- Extensive academic leadership and planning, such as on the Faculty Advisory Board of the Atkinson Center for a Sustainable Future and Steering Committee of the Ohio State University’s Senate.
- Strong record of publication for scientific and lay audiences, with 125 peer-reviewed scientific articles, 10 book chapters or edited volumes, 38 op-eds or popular articles, and 20 extension publications.
- Proven ability to raise funds (>$8 million in grants and contracts) and contribute to university development programs (e.g., major gifts, alumni events, capital campaigns).
- Demonstrated skills at translating science and engaging diverse audiences and stakeholders from public and private sectors on issues related to science, sustainability, environmental protection, conservation, and responsible business/finance.
- Media training and experience with interviews for articles, radio, television, and film.
- Successful history of cultivating and strengthening networks with partners in government agencies, non-profit organizations, foundations, and the private sector.

NATIONAL LEADERSHIP AND SERVICE

- **Scientific Review Board, National Socio-environmental Synthesis Center,** 2012-2016. SESYNC is an NSF-funded synthesis center focused on socio-environmental issues.
- **Advisory Committee for Monitoring Avian Productivity and Survival (MAPS)**, 2016 to present.
- **Founding member** of the Steering Committee for the Breeding Grounds program of the Canada Warbler International Conservation Initiative, 2015-2016.
- **Chartered Science Advisory Board of US Environmental Protection Agency**, 2009 to 2015. Advised the Agency on broad scientific matters in science, technology, social/economic issues, evaluates scientific and technical information as well as methodological and analytical approaches that support regulatory decisions, and provides guidance on development and application of strategic research programs in the Agency.
- **Avian Advisory Committee, Wildlife Habitat Council**, 2014. Provided guidance and recommendations on how corporate habitat improvement projects should be evaluated and certified by the Wildlife Habitat Council.
- **Chair, EPA Science Advisory Board review panel for EPA's draft report *Connectivity of Streams and Wetlands to Downstream Waters: A Review and Synthesis of the Scientific Evidence.*** 2013-2014. Reviewed the EPA's controversial draft report on The Waters of the US, that synthesizes the scientific literature regarding the biological, chemical, and hydrologic connectivity of waters and the effects that small streams, wetlands, and open waters have on downstream waters such as rivers, lakes, estuaries, and oceans. Reviewed the scientific basis of the proposed water rule at special request of Congress.
- **National Academies / National Research Council's Committee on Human and Environmental Exposure Science in the 21st Century**, 2010-2012. Developed a long-range vision for exposure science as well as an implementation strategy. Efforts included the development of a unifying conceptual framework for exposure science to advance the study and assessment of human and ecological contact with chemical, biological, and physical stressors in their environments.
- **Ecological Processes and Effects Committee of the Science Advisory Board**, **US Environmental Protection Agency**, 2006 to 2012. Provided independent advice to the EPA Administrator on issues related to EPA environmental programs, science, and research that aims to protect, sustain and restore the health of ecosystems.
- **Report on the Environment Review Panel of the Science Advisory Board, US Environmental Protection Agency**, 2009 to 2015. Provided advice on future development of the Agency's Report on the Environment.
- **Review Panel for National Science Foundation**, Ecology Program, 2007, 2009, 2012. Evaluated proposals submitted to Ecology program of Division of Environmental Biology of NSF.
- **Expert for US Environmental Protection Agency's Workshop on "Ecological Risk Assessment – An Evaluation of the State-of-the Practice",** 2006.
- **Geographic Information System Screening Tool (GISST) Review Panel of the Science Advisory Board**, US Environmental Protection Agency, 2005. Reviewed GISST, an environmental assessment tool that systematically evaluates single media and cumulative impacts for environmental and regulatory decisions in Region 6.
- **Critical Ecosystem Assessment Tool Review for the Science Advisory Board, US Environmental Protection Agency**, 2004. Reviewed a spatially explicit model (CrEAM) developed to assess the ecological significance of land areas across EPA Region5.

INSTITUTIONAL LEADERSHIP AND ADMINISTRATION

- **Senior Director of Conservation Science Program,** Cornell Lab of Ornithology (2013 to present)
  - Manage ~$1.5 million annual budget from grants, gifts, and contracts.

- Supervise 6-9 professional and academic staff and 6-8 graduate students.
- Developed a research portfolio with staff and students that included projects in 13 countries – Chile, Peru, Colombia, Panama, Costa Rica, Nicaragua, Honduras, Guatemala, Belize, Jamaica, Mexico, Canada, and the U.S.
- Conceived of and co-developed the Cornell Lab's Land Trust Initiative, which builds capacity in land trusts for strategic planning, monitoring, and conservation through workshops, publications, web-based resources, online interactive decision-support tool, and a small grant program.
- Initiated interdisciplinary research to innovate in collaborative and entrepreneurial approaches to sustainability, conservation finance, and environmentally-friendly business, such as developing market-based incentives for forest restoration and conservation in Latin America; collaborators include Johnson School of Business, Dyson School of Applied Economics, Cornell Institute for Public Affairs, and private sector. This includes co-organizing an international conference and roundtable on conservation finance in Vancouver (https://conservationfinance.pwias.ubc.ca/)
- Cultivated institutional partnerships with American Bird Conservancy, National Fish and Wildlife Foundation, Wildlife Conservation Society, and foundations.
- Developed competitive grant program to support conservation by land trusts.
- Engage frequently with conservation practitioners and environmental agencies and NGOs
- Write bi-monthly contributor column in The Hill, a leading US policy/news source for Capitol Hill as well as contribute op-eds to other news outlets.
- Interact regularly with media for interviews and commentaries (print, radio, film)
- Contribute to development activities by engaging with private donors and foundations.
- Coordinate the Conservation Associates program with the Cornell Institute for Public Affairs

- **Faculty Advisory Board,** Atkinson Center for a Sustainable Future, Cornell (2013 to present). Provided oversight, direction, and advice to Cornell's interdisciplinary sustainability center.
  - Provide faculty leadership for the development and launch of Cornell's partnership and grant program with The Nature Conservancy
- **Cornell Sustainability Task Force**, Cornell (2017-2018). Developed a strategy for Cornell University to be an international leader in sustainability science and application, emphasizing how to facilitate collaboration across campus and with external partners.
- **College of Agricultural & Life Sciences Structure Task Force**, Cornell (2016). Evaluated the organizational structure of the College and proposed ways to improve efficiency, capacity to pursue cutting-edge research, teaching, and extension efforts, and student experience.
- **Seminar Series Co-organizer,** Department of Natural Resources, Cornell (2015-2017).
- **Graduate Admissions Committee,** Department of Natural Resources, Cornell (2013-2016).
- **Environmental Science & Sustainability Internship Committee**, Cornell (2015)
- **Oversight Committee**, Cornell Center for Wildlife Conservation, Cornell (2013 to present)
- **Ad hoc tenure review committee chair,** College of Agricultural and Life Sciences, Cornell (2015).
- **Science Advisory Committee to Environmental Science Program Council**, OSU (2010-2011). Developed strategic plan to reorganize and integrate environmental sciences across colleges at Ohio State; reported to Provost and Deans.
- **Steering Committee of University Senate, Ohio State University** (2009-2011). Senate leadership committee that met monthly with Provost and academic leaders to identify and discuss key issues.
- **University Senate, Ohio State University** (2009-2011). Elected governance body comprised of faculty, staff, and students.
- **Advisory Committee for Ohio Sea Grant College Program, Stone Laboratory, the Center for Lake Erie Area Research (CLEAR), and the Great Lakes Aquatic Ecosystem Research Consortium (GLAERC)** (2010-2012). Developed strategic and tactical plans for research, education, and outreach efforts.

- **Advisory Board for Climate, Water, Carbon Program** at OSU (2008-2011). Appointed to administer and steer the multi-million dollar university targeted investment in excellence, especially regarding grant awards, research progress, and faculty hires.
- **Advisory Board for Raccoon Ecological Management Area** (OSU representative; 2008-2010). Board of appointed representatives from academic institutions, federal & state agencies, and non-profit organizations to oversee research and management on cooperatively managed natural area.
- **Environment & Natural Resources Graduate Studies Committee** (2001-2011). Responsible for administering graduate programs in School of Environment & Natural Resources, including matters regarding admission, fellowships and associateships, graduate curriculum, and program requirements.
- **Advisory Committee for Audubon Sanctuary**, Ohio State University Golf Course (2011). Tasked with providing advice on environmental sustainability and wildlife management on golf course. .
- **Affiliate Faculty of the John Glenn Institute of Public Service and Public Policy** (2006-present).
- **Search Committees**. Chair for search for Assistant Professor of Aquatic Ecology (2010); member, search committees for Assistant Professor in environmental decision-making (2006-07), SENR Director (2004-05), Assistant Professor of wildlife ecology (2002), and Assistant Professor in natural resources communication (2001).

LEADERSHIP AND SERVICE TO PROFESSIONAL SOCIETIES

- Editorial Board, *Scientific Reports*, a *Nature* Research Journal – Ecology and Evolutionary Biology section, 2018-2020.
- Elected member of Nominating Committee of the AAAS Section on Agriculture, Food, and Renewable Resources, 2015-2018.
- Special research topic co-editor, Frontiers in Ecology and Evolution: Behavioural and Ecological Consequences of Urban Life in Birds. 2016-2017. With Caroline Isaksson and Diego Gil.
- Editorial Board, *Issues in Ecology* (ESA), 2013 to present.
- Editorial Board, *Studies in Avian Biology*, 2010 to 2016.
- Member, Early Professionals Committee, American Ornithological Society 2013-14.
- Chair of Outreach and Education, Society for Ornithology Committee, 2011-2012.
- Council Member of The American Ornithologists' Union, 2008-2011.
- Associate Editor for the *International Journal of Forestry*, 2008-2011.
- Associate Editor for *The Auk, an International Journal of Ornithology,* 2006-2010.
- Associate Editor for *Journal of Wildlife Management*, 2004-2006.
- Member of Publication Awards Committee for The Wildlife Society, 2005-07.
- Member of Research Awards Committee of American Ornithologists' Union, 2005-07.
- Guest Editor for special issue, *Wildlife Society Bulletin*, 2004-2005.
- Guest Editor for *Conservation Biology*, Spring 2004
    - Grants for National Science Foundation - Ecology, Population Biology, & International Programs; US Fish and Wildlife Service; Great Lakes Protection Fund Program; US Forest Service. Northeast Research Station Research Charter; National Fish and Wildlife Foundation grants; Wayne National Forest Plan and Species Viability Evaluations; National Commission on Science for Sustainable Forestry, Sustainable forestry bio-indicators;
    - Reviewer for *Science*, *Nature*, *Ecology, Ecological Monographs*, *Ecological Applications, Landscape Ecology, Conservation Biology, Biological Conservation, Journal of Animal Ecology*, *Agroecosystems and Environment, Journal of Wildlife Management*, *Ecography, Journal of Tropical Ecology, Journal of Field Ornithology*, *Landscape and Urban*

Planning, Environmental Management, The Auk, Wilson Journal of Ornithology, Forest Science, Condor, Oikos, Naturwissenchaften, Ornis Fennica, Natural Areas Journal, American Midland Naturalist, Wildlife Research, Ohio Journal of Science, Journal of Applied Ecology, Forest Ecology and Management, Ardeola, Journal of Avian Biology, Frontiers in Ecology and Evolution

RESEARCH

As an ecologist, I study how global changes impact ecosystems across multiple spatiotemporal scales and levels of biological organization. My research touches on a variety of sub-disciplines, including conservation biology, community ecology, landscape ecology, population demography, behavioral ecology, ecological restoration, and sustainability science. My current work focuses on (1) population and community responses to changes in land use, climate, invasive species, and disturbance regimes, (2) socioecological dynamics and conservation in working landscapes, (3) eco-evolutionary dynamics in human-dominated and urbanizing systems, (4) sustainable management of temperate and tropical forests, (5) conservation planning and prioritization, and (6) innovative finance and market-based instruments to support conservation and alleviate poverty.

PUBLICATIONS:

Journal articles (*graduate student advisee, **post-doc, ***undergraduate student advisee)

126 Soto, G.E, P.M. Vergara, and A.D. Rodewald. *In press.* The fruit of competition: seed dispersal by Magellanic woodpeckers in the threatened Valdivian Rainforest. Ecology.

125 Isaksson, C., A.D. Rodewald, D. Gil. 2018. Behavioural and Ecological Consequences of Urban Life in Birds. Frontiers in Ecology and Evolution, section Behavioral and Evolutionary Biology. Volume 6, article 50. doi.org/10.3389/fevo.2018.00050

124 Swift*, R.S., A.D. Rodewald, N.R. Senner. 2018. Context-dependent costs and benefits of heterospecific associations. Behavioral Ecology 29(4): 974-983. doi:10.1093/beheco/ary042

123 Sevillano-Rios, C.S. *, A.D. Rodewald, and L.V. Morales. 2018. Ecología y conservación de las aves asociadas a Polylepis: ¿qué sabemos de ésta comunidad cada vez más vulnerable? Ecologia Austral 28:xxx.

122 Malpass, J.*, A.D. Rodewald, S.N. Matthews, L.J. Kearns*. 2018. Nest predators, but not nest survival, differ between adjacent urban habitats. Urban Ecosystems. doi.org/10.1007/s11252-017-0725-7

121 Hernández-Aguilera , J. N., M. I. Gómez , A.D. Rodewald, X. Rueda, C. Anunu, R. Bennett*, H.M. van Es. 2018. Quality as a driver of sustainable agricultural value chains: The case of the relationship coffee model. Business Strategy and the Environment 27:179-198. 10.1002/bse.2009

120 Rodewald, A.D. and P. Arcese. 2017. Reproductive contributions of cardinals are consistent with a hypothesis of relaxed selection in urban landscapes. Frontiers in Ecology and Evolution. Volume 5: article 77. DOI: 10.3389/fevo.2017.00077

119 Kearns, L. J.* and A.D. Rodewald. 2017. Does nest predator activity predict location and survival of songbird nests in urbanizing landscapes? Condor 119:745-760.

118 Schuster, R.**, A.D. Rodewald, T.G. Martin,, K.A. Wilson,. E.A. Law, M. Watts , H.P. Possingham & P. Arcese. 2017. Tax-shifting and incentives for biodiversity conservation on private lands. Conservation Letters. DOI: 10.1111/conl.12377

117 Swift, R.J.*, A.D. Rodewald, and N.R. Senner. 2017. Breeding habitat of a declining shorebird in a changing environment. Polar Biology. DOI 10.1007/s00300-017-2101-8

116 LaSorte, F., D.Fink, P.J. Blancher, A.D. Rodewald, V. Ruiz-Gutierrez, K.V. Rosenberg, W.M. Hochachka, P.H. Verburg, and S. Kelling. 2017. Global change and the distributional dynamics of migratory bird populations wintering in Central America. Global Change Biology. DOI: 10.1111/gcb.13794

115 Narango, D.* and A.D. Rodewald. 2017. Signal information of bird song changes in human-dominated landscapes. Urban Ecosystems. DOI 10.1007/s11252-017-0698-6

114 Sevillano-Rios, C.S. * and A.D. Rodewald. 2017. Avian community structure and habitat use of *Polylepis* forests along an elevation gradient. PeerJ 5:e3220; doi: 10.7717/peerj.3220

113 Bennett, R E. *, S. Barker Swarthout, J. S. Bolsinger, A.D. Rodewald, K. V. Rosenberg, and R. Rohrbaugh. 2017. Extreme genetic similarity does not predict non-breeding strategies in two closely related warblers. Journal of Field Ornithology.

112 Wood, E.M., S. B. Swarthout, W. M. Hochachka, R. W. Rohrbaugh, K. V. Rosenberg, and A.D. Rodewald. 2017. An improved survey methodology for monitoring population trends of the Golden-winged Warbler and other patchily distributed birds. Journal of Field Ornithology 88(4):387-398.

111 Vergara, P.M., L.O. Meneses, M. Saavedra, K. Norambuena, F.E. Diaz, A.D. Rodewald, A. Fierro, G.E. Soto*. 2017. Magellanic Woodpeckers in three national parks of central-southern Chile: habitat effects and population variation over the last two decades. Avian Conservation and Ecology 12(2) DOI: 10.5751/ACE-01106-120215

110 Swift*, R.J., A.D. Rodewald, and N.R. Senner. 2017. Environmental heterogeneity and biotic interactions as potential drivers of spatial patterning of shorebird nests. Landscape Ecology 32:1689-1703.

109 Soto, G.E.*, C.G. Pérez-Hernández, I.J. Hahn, A.D. Rodewald, P.M. Vergara. 2017. Tree senescence as a direct measure of habitat quality: linking red-edge vegetation indices to space use by Magellanic Woodpeckers. Remote Sensing of Environment 193:1-10. http://dx.doi.org/10.1016/j.rse.2017.02.018

108 Malpass, J.*, A.D. Rodewald, S.N. Matthews. 2017. Scale-dependent effects of anthropogenic foods on predators and prey. Condor 119:1-16.

107 Rodewald, A.D. 2016. Beyond biology: the political and legal implications of “conservation reliance.” Avian Conservation and Ecology 11 (2):13.

106 Colorado, G.J.Z.* and A.D. Rodewald. 2016. Patterns of mass change in wintering Neotropical-Nearctic migratory birds in shaded monocultures in the Andes. Agroforestry Systems. doi:10.1007/s10457-016-9989-9

105 Sullivan, BL, Phillips, T, Dayer, AA**, Wood, CL, Farnworth, A, Iliff, MJ, Davies, IJ, Wiggins, A, Fink, D, Hochachka, W, Rodewald, AD, Rosenberg, KV, Bonney, R, and Kelling, S. 2016. Using open access observational data for conservation action: a case study for birds. Biological Conservation. http://dx.doi.org/10.1016/j.biocon.2016.04.031

104 Wood, E. M.**, S. E. Barker, W. M. Hochachka, R. W. Rohrbaugh, K. V. Rosenberg, and A. D. Rodewald. 2016. Intermediate habitat associations by hybrids may facilitate genetic introgression in a songbird. Journal of Avian Biology. DOI: 10.1111/jav.00771

103 Rodewald, A.D. and P. Arcese. 2016. Direct and indirect interactions between landscape structure and invasive or overabundant species. Current Landscape Ecology Reports. DOI 10.1007/s40823-016-0004-y

102 Dayer, A.**, Rodewald, AD, Stedman, R., E. Cosbar***, and EM Wood**. 2016. Wildlife Conservation and Private Protected Areas: The Discrepancy between Land Trust Mission Statements and their Perceptions. Environmental Management 58:359-364.

101 Vergara, P.M., G.E. Soto*, D. Moreira-Arce, A.D. Rodewald, L.O. Menesese, and C.G. Perez-Hernandez. 2016. Foraging behavior in Magellanic Woodpeckers is consistent with a multi-scale assessment of tree quality. PLoS ONE 11(7):e0159096.

100 Narango, D.L.* and A.D. Rodewald. 2016. Urban-associated drivers of song variation along a rural-urban gradient. Behavioral Ecology 27:608-616.

99 Thieme, J.L.*, A.D. Rodewald, S.D. Gehrt, J. Brown, and C. Anchor. 2015. Linking grassland and early successional bird territory density to predator activity in urban parks. Natural Areas Journal 35:515-532.

98 Rodewald, A.D., R.P. Rohr, M.A. Fortuna, and J. Bascompte. 2015. Does removal of invasives restore ecological networks? An experimental approach. Biological Invasions 17:2139-2146. DOI 10.1007/s10530-015-0866-7

97 Colorado, G.J.Z.* and A.D. Rodewald. 2015. Multiscale influence of deforestation and habitat alteration on Neotropical-Nearctic migratory birds and mixed species flocks in the Andes. Biological Conservation 188:72-81.

96 Boves, T.J., A.D. Rodewald, P.B. Wood, D.A. Buehler, J.L. Larkin, T.B. Wigley, P.D. Keyser. 2015. Habitat quality from individual- and population-level perspectives and implications for management. Wildlife Society Bulletin 39:443-448.

95 Colorado, G. J. Z.* and A. D. Rodewald. 2015. Assembly patterns of mixed-species flocks in the Andes. Journal of Animal Ecology 84: 386-395.

94 LaSorte, F.A., D. Fink, W.M. Hochachka, J.L. Aycrigg, K.V. Rosenberg, A.D. Rodewald, N.E. Bruns, A. Farnsworth, B.L. Sullivan, C. Wood, and S. Kelling. 2015. Stewardship responsibilities on public lands and full life-cycle conservation of North American birds. Ecological Applications 25(1):39-51.

93 McDermott, M.*, A.D. Rodewald, S. N. Matthews. 2015. Managing tropical agroforestry for conservation of flocking birds. Agroforestry Systems. DOI: 10.1007/s10457-014-9777-3.

92 Malpass, J.*, A.D. Rodewald, and S. Matthews. 2015. Trees and shrubs do not promote activity of nest predators in residential yards. Landscape and Urban Planning 135:32-39

91 Padilla, B.J.* and A.D. Rodewald. 2014. Avian metapopulation dynamics in a fragmented urbanized landscape. Urban Ecosystems. Doi: 10.1007/s11252-014-0390-z

90 Newell, F.L.*, T.A. Beachy, A.D. Rodewald, C.G. Rengifo, I.J. Ausprey*, and P.G. Rodewald. 2014. Foraging behavior of Cerulean Warblers during the breeding and non-breeding seasons: evidence for the breeding currency hypothesis. Journal of Field Ornithology 85(3):310-320.

89 Rodewald, A.D., R.P. Rohr, M.A. Fortuna, and J. Bascompte. 2014. Community-level demographic consequences of anthropogenic disturbance: an ecological network approach. Journal of Animal Ecology. doi: 10.1111/1365-2656.12224

88 McDermott, M. E.* and A.D. Rodewald. 2014. Conservation value of silvopastures to Neotropical migrants in Andean forest flocks. Biological Conservation 175:140-147.

87 Rowse, L.M.*, A.D., Rodewald, S.M.P. Sullivan. 2014. Pathways and consequences of contaminant flux to Acadian flycatchers (*Empidonax virescens*) in urbanizing landscapes of Ohio, USA. Science of the Total Environment 485-486: 461-467.

86 LaSorte, F.A., D. Fink, W.M. Hochachka, A. Farnsworth, A.D. Rodewald, K.V. Rosenberg, B.L. Sullivan, C. Wood, and S. Kelling. 2014. The role of atmospheric conditions in the seasonal dynamics of North American migration flyways. Journal of Biogeography 41:1685-1696.

85 Newell, F.L.*, T.A. Beachy, A.D. Rodewald, C.G. Rengifo, I.J. Ausprey*, and P.G. Rodewald. 2014. Foraging behavior of migrant warblers in mixed-species flocks in Venezuelan shade coffee: interspecific differences, tree species selection, and effects of drought. Journal of Field Ornithology 85(2):134-151.

84 Sullivan, Aycrigg, Barry, Bonney, Bruns, Cooper, Dhondt, Dietrich, Farnsworth, Fink, Gerbracht, Gomes, Hochachka, Iliff, Lagoze, La Sorte, Merrifield, Phillips, Reynolds, Rodewald, Rosenberg, Trautmann, Wiggins, Winkler, Wong, Wood, Yu, Kelling. 2014. The eBird enterprise: an integrated approach to the development and application of citizen science. Biological Conservation 169:31-40.

83 Boves, T.J., D.A. Buehler, P.B. Wood, A.D. Rodewald, J.L. Larkin, P.D. Keyser, and T.B. Wigley. 2014. Multiple plumage traits convey information about age and within-age-class qualities of a canopy-dwelling songbird, the Cerulean Warbler. Auk 131:20-31.

82 Stoklosa, S.K.***, L.J. Kearns*, and A.D. Rodewald. 2014. Risky edges: temporal variation in brood parasitism of Northern Cardinals. Wilson Journal of Ornithology. 126:94-97.

81 Sheehan, J., P.B. Wood, D.A. Buehler, P.D. Keyser, J.L. Larkin, A.D. Rodewald, T.B. Wigley, T.J. Boves, G.A. George, M.H. Bakermans*, T.A. Beachy, A. Evans, M.E. McDermott*, F.L. Newell*, K.A. Perkins, and M. White. 2014. Avian response to timber harvesting applied experimentally to manage Cerulean Warbler breeding populations. Forest Ecology and Management. 321:5-18.

80 Lehnen, S. E.* and A. D. Rodewald. 2013. Daily and seasonal movements in a shrubland-obligate breeder in relation to mature forest edge habitat. Forest Ecology and Management 305:112-119.

79 Newell, F.L. *, T.J. Boves, D.A. Buehler, T.A. Beachy, P.B. Wood, A.D. Rodewald, J.L. Larkin, P.D. Keyser, G.A. George, J. Sheehan, J. Mizel, and A. Evans. 2013. Comparison of point counts and territory mapping for detecting effects of forest management on songbirds. Journal of Field Ornithology 84:270-286.

78 Rodewald, A.D., L.J. Kearns*, and D.P. Shustack*. 2013. Consequences of urbanizing landscapes to reproductive performance of birds in remnant forests. Biological Conservation 160:32-39.

77 Newell, F.L. *, A. Haiman, D. Narango*, J. Means, L.D. Leonhard, J. Philhower-Gillen, and A.D. Rodewald. 2013. Occurrence of polygyny and double brooding in the Eastern Wood-Pewee. Wilson Journal of Ornithology 125(2).

76 Boves, T.J., J. Sheehan, P.B. Wood, D.A. Buehler, P.D. Keyser, A.D. Rodewald, T.B. Wigley, J.L. Larkin, T.A. Beachy, M.H. Bakermans*, A. Evans, G.A. George, M.E. McDermott*, F.L. Newell*, K.A. Perkins, and M. White. 2013. Emulating natural disturbances for declining late-successional species: a case study of the consequences for Cerulean Warbler (*Setophaga cerula*). PLoS One 8(1): e52107.

75 Boves, T.J., D.A. Buehler, J. Sheehan, P.B. Wood, A.D. Rodewald, J.L. Larkin, P.D. Keyser, F.L. Newell, A. Evans, G.A. George, and T.B. Wigley. 2013. Spatial variation in habitat selection by Cerulean Warblers breeding throughout the Appalachian Mountains. Auk 130:46-59.

74 Vitz, A. C. * and A. D. Rodewald. 2013. Behavioral and demographic consequences of access to early-successional habitat by juvenile ovenbirds: an experimental approach. Auk 130:21-29.

73 Ausprey, I.J. * and A. D. Rodewald. 2013. Post-fledging dispersal timing and natal range size of two songbird species in an urbanizing landscape. Condor 115:102-114.

72 Kearns, L.J. * and A.D. Rodewald. 2013. Within-season use of public and private information on predation risk in nest-site selection. Journal of Ornithology 154:163-172.

71 Sridhar, H., S. Umesh, R.A. Askins, J. C. Canales Delgadillo, C.C. Chen, D.E. Ewert, E. Goodale, W.K. Gram, P.J. Hart, K.A. Hobson, S.W. Kotagama, J. Knowlton, T.M. Lee, C.A. Munn, S. Nimnuan, B.Z. Nizam, G. Peron, V.V. Robin, A.D. Rodewald, P.G. Rodewald, R.L. Thomson, P. Trivedi, S.L. Van Wilgenburg, K. Shanker. 2012. Positive relationships between association strength and phenotypic similarity characterize the assembly of mixed-species bird flocks worldwide. American Naturalist 180:777-790. (FEATURED IN *NATURE*)

70 Colorado, G.J. *, P.B. Hamel, A.D. Rodewald, and D. Mehlman. 2012. Advancing our understanding of the non-breeding distribution of Cerulean Warbler (*Setophaga cerulean*) in the Andes. Ornitologia Neotropical 23:307-315.

69 Larkin, J.L., P.B. Wood, T.J. Boves, J. Sheehan, D.A. Buehler, P.D. Keyser, A.D. Rodewald, T.A. Beachy, M.H. Bakermans*, A. Evans, G.A. George, M.E. McDermott*, F.L. Newell*, K.A. Perkins, M. White, and T.B. Wigley. 2012. Breeding season concerns and response to forest management: can forest management produce more breeding birds? Ornitologia Neotropical 23:283-287.

68 Smith, B.W., J. Botero, J.L. Larkin, A.D. Rodewald, P.B. Wood, P.N. Angel, and S.E. Eggerund. 2012. Integrating conservation management, species protection, and economic viability into sustainable land use practices for the Cerulean Warbler (*Setophaga cerulean*) in the Appalachian and Northern Andes mountains. Ornitologia Neotropical 23: 329-334.

67 Slager, D.L., M.E. McDermott*., and A.D. Rodewald. 2012. Kleptoparasitism of nesting material at a Red-faced Spinetail nest site. Wilson Journal of Ornithology 124:812-814.

66 Bakermans, M.H. *, A.D. Rodewald, and A.C. Vitz*. 2012. Influence of forest structure on density and nesting success of mature forest birds in managed landscapes. Journal of Wildlife Management 76:1225-1234.

65 Sullivan, M. and A.D. Rodewald. 2012. Ecological dimensions of aquatic-to-terrestrial contaminant fluxes: implications to science and society. Environmental Toxicology and Chemistry 6:1175-1183.

64 Rodewald, A. D. 2012. Evaluating factors that guide avian community response to urbanization. Pages 71-92 in *Urban Bird Ecology & Conservation* (C.A. Lepczyk and P.S. Warren, editors), Studies in Avian Biology No. 45.

63 Newell, F. L. * and A. D. Rodewald. 2012. Management for oak regeneration: Short-term effects on the bird community and suitability of shelterwood harvests for canopy songbirds. Journal of Wildlife Management 76:.683-693.

62 Vitz, A. C. * and A. D. Rodewald. 2012. Using stable isotopes to investigate the dietary trophic level of fledgling songbirds. Journal of Field Ornithology 83:73-84.

61 Rodewald, A. D. 2012. Spreading messages about invasives. Diversity and Distributions 18:97-99.

60 Bakermans, M.H. *, A.D. Rodewald, A.C. Vitz*, and C. Rengifo. 2012. Migratory bird use of shade coffee: the role of structural and floristic features. Agroforestry Systems 85:85-94. DOI: 10.1007/s10457-011-9389-0.

59 Dodd, L.E., M.J. Lacki, E.R. Brizke, D.A. Buehler, P.D. Keyser, J.L. Larkin, A.D. Rodewald, T.B. Wigley, P.B. Wood, and L.K. Rieske. 2012. Forest structure affects trophic linkages: how silvicultural disturbance impacts bats and their insect prey. Forest Ecology and Management 267:262-270.

58 Rodewald, A. D. and L. J. Kearns*. 2011. Shifts in dominant nest predators along a rural-to-urban landscape gradient. Condor 113:899-906.

57 Rodewald, A. D., D. P. Shustack*, and T. M. Jones***. 2011. Dynamic selective environments and evolutionary traps in human-dominated landscapes. Ecology 92:1781-1788.

56 Fullam-Seger, K.***, A. D. Rodewald, and J. Soha. 2011. Avian bioacoustics in urbanizing landscapes: relationships between urban noise and bird song. Bioacoustics 20(3):267-276

55 Newell, F. L. * and A. D. Rodewald. 2011. Role of topography, canopy structure, and floristics in nest-site selection and nesting success of canopy songbirds. Forest Ecology and Management 262:739-749.

54 Vitz, A. C. * and A. D. Rodewald. 2011. Survival in the thicket: Dense vegetation promotes survival of post-fledging songbirds. Condor 113:400-411.

53 Shustack, D.P. * and A.D. Rodewald. 2011. Nest predation reduces benefit to early clutch initiation in an urbanizing landscape. Journal of Avian Biology 42:204-209.

52 Rodewald, A. D., L. J. Kearns*, and D. P. Shustack*. 2011. Anthropogenic resources decouple predator-prey relationships. Ecological Applications 21:936-943.

51 Ausprey, I. * and A.D. Rodewald. 2011. Post-fledging survivorship and habitat selection across a rural-to-urban landscape gradient. Auk 128:293-302.

50 Shustack, D. P. * and A. D. Rodewald. 2010. A method for detecting undervalued resources with application to breeding birds. Ecological Applications 20:2047-2057.

49 Graves, B. M. *, A. D. Rodewald, and S. D. Hull. 2010. Influence of woody vegetation on grassland birds within reclaimed surface mines. Wilson Journal of Ornithology 122:646-654.

48 Shustack, D. P. * and A. D. Rodewald. 2010. Attenuated nesting season of the Acadian flycatcher (*Empidonax virescens*) in urban forests. The Auk 127:421-429.

47 Vitz, A. C. * and A. D. Rodewald. 2010. Fledgling songbird movements within and beyond the natal home range. The Auk 127:364-371.

46 Smith-Castro, J.R. * and A.D. Rodewald. 2010. Behavioral responses of nesting birds to human disturbance along recreational trails. Journal of Field of Ornithology 81:130-138.

45 Smith-Castro, J.R. * and A.D. Rodewald. 2010. Effects of recreational trails on northern cardinals (*Cardinalis cardinalis*) in forested urban parks. Natural Areas Journal 30(3):328-337.

44 Jones, T. M.***, A. D. Rodewald, and D. P. Shustack*. 2010. Variation in plumage coloration of Northern Cardinals in urbanizing landscapes. Wilson Journal of Ornithology 122:326-333.

43 Rodewald, A. D., D. P. Shustack*, and L. E. Hitchcock***. 2010. Exotic shrubs as ephemeral ecological traps for nesting birds. Biological Invasions 12:33-39.

42 Rodewald, A. D. 2009. Urban-associated habitat alteration promotes brood parasitism of Acadian Flycatcher. Journal of Field Ornithology 80:234-241.

41 Lehnen, S. E. * and A. D. Rodewald. 2009. Dispersal, inter-patch movements, and survival in a shrubland breeding bird community. Journal of Field Ornithology 80:242-252.

40 Bakermans, M. H. *, A. C. Vitz*, A. D Rodewald, and C. Rengifo. 2009. Migratory songbird use of shade coffee in the Venezuelan Andes with implications for conservation of cerulean warbler. Biological Conservation 142:2476-2483.

39 Lehnen, S. E. * and A. D. Rodewald. 2009. Investigating area-sensitivity in shrubland birds: responses to a patchy landscape. Forest Ecology and Management 257:2308-2316.

38 Bakermans, M. H. * and A. D Rodewald. 2009. Think globally, manage locally: the importance of steady state forest features for a declining songbird. Forest Ecology and Management 258:224-232.

37 Shustack, D. P. *, A. D. Rodewald, and T. A. Waite. 2009. Springtime in the city: exotic shrubs promote earlier green-up of urban forests. Biological Invasions 11: 1357-1371.

36 Shustack, D. P. * and A. D. Rodewald 2008. Understanding Demographic and Behavioral Mechanisms that Guide Responses of Neotropical Migratory Birds to Urbanization: a Simulation Approach. Avian Conservation and Ecology - Écologie et conservation des oiseaux 3 (2): 2. [online] URL: http://www.ace-eco.org/vol3/iss2/art2/

35 Marzluff, J. M. and A.D. Rodewald. 2008. Conserving Biodiversity in Urbanizing Areas: Nontraditional Views from a Bird's Perspective. Cities and the Environment 1(2): article 6. [http://escholarship.bc.edu/cate/vol1/iss2/6/]

34 Sundell-Turner, N. * and A.D. Rodewald. 2008. A comparison of landscape-based methods for conservation planning. Landscape and Urban Planning 86:219-225.

33 Dale, V. H., G. R. Biddinger, M. C. Newman, J. T. Oris, G. W. Suter, T. Thompson, T. M. Armitage, J. L. Meyer, R. M. Allen-King, G. A. Burton, P. M. Chapman, L. L. Conquest, I. J. Fernandez, W. G. Landis, L. L. Master, W. J. Mitsch, T. C. Mueller, C. F. Rabeni, A. D. Rodewald, J. G. Sanders, and I. L. van Heerden. 2008. Enhancing the ecological risk assessment process. Integrated Environmental Assessment and Management 4:306-313.

32 Colorado, G. *, P. Hamel, A. Rodewald, and W. Thogmartin. 2008. El groupo ceruleo: collaboration to assess nonbreeding range of Cerulean Warbler in South America. Ornitologia Neotropical 19: 521-529.

31 Rodewald, A. D. and D. P. Shustack*. 2008. Consumer resource-matching in urbanizing landscapes: are synanthropic species over-matching? Ecology.89: 515-521.

30 Rodewald, A. D. and D. P. Shustack*. 2008. Urban flight: understanding individual and population-level responses of Nearctic-Neotropical migratory birds to urbanization. Journal of Animal Ecology 77:83-91.

29 Rengifo, C., M.H. Bakermans*, R. Puente, A. Vitz*, A. D. Rodewald, and M. Zambrano. 2007. First record of the White-tipped Sicklebill (*Eutoxeres aquila aquila*: Trochilidae) from Venezuela. Wilson Journal of Ornithology 119: 292-295.

28 Vitz, A. C. * and A. D. Rodewald. 2007. Vegetative and fruit resources as determinants of habitat use by mature-forest birds during the post-breeding period. Auk 124:494-507.

27 Atchison, K. A. * and A. D. Rodewald. 2006. Do wintering birds prefer urban landscapes? Natural Areas Journal 26: 280-288.

26 Leston, L. F. V.* and A. D. Rodewald. 2006. Are urban forests ecological traps for understory birds? An examination using Northern Cardinals. Biological Conservation 131:566-574.

25 Bakermans, M. H. * and A. D. Rodewald. 2006. Habitat selection by the Acadian Flycatcher: a hierarchical approach. Auk 123:368-382.

24 Rodewald, A. D. and M. H. Bakermans*. 2006. What is the appropriate paradigm for riparian forest conservation? Biological Conservation 128:193-200.

23 Vitz, A. C. * and A. D. Rodewald. 2006. Can regenerating clearcuts benefit mature-forest birds? An examination of post-breeding ecology. Biological Conservation 127: 477-486

22 Rodewald, A. D. and A. C. Vitz. * 2005. Edge and area-sensitivity of shrubland birds. Journal of Wildlife Management 69:681-688.

21 Rodewald, P. G., M. J. Santiago*, and A. D. Rodewald. 2005. The role of midwestern golf courses in the conservation of red-headed woodpeckers. Wildlife Society Bulletin 33: 448-453.

20 Cristol, D. A. and A. D. Rodewald. 2005. Can golf courses play a role in bird conservation? Wildlife Society Bulletin 33: 407-410.

19 Borgmann, K. L. * and A. D. Rodewald. 2005. Forest restoration in urbanizing landscapes: interactions between land uses and an exotic shrub. Restoration Ecology 13:334-340.

18 Borgmann, K. L. * and A. D. Rodewald. 2004. Nest predation in urbanizing landscapes: the role of exotic shrubs. Ecological Applications 14: 1757–1765.

17 Rodewald, A. D., P. G. Rodewald, and M. J. Santiago*. 2004. Conservation of red-headed woodpeckers on Midwestern golf courses. USGA Turfgrass and Environmental Research Online. Vol 3, No. 15.

16 Rodewald, A. D. 2004. Nest-searching cues and studies of nest-site selection and nesting success. Journal of Field Ornithology 75:31-39.

15 Rodewald, A. D. 2003. The importance of land uses within the landscape matrix. Wildlife Society Bulletin 31:586-592.

14 Rodewald, A. D. 2003. The decline of oak forests and implications for forest wildlife conservation. Natural Areas Journal 23:368-371.

13 Rodewald, A. D. and P. G. Rodewald. 2003. Mixed-species bird flocks in primary and regenerating montane forests in Ecuador. Cotinga 19:51-54.

12 Rodewald, A. D. 2002. Nest predation in forested regions: landscape and edge effects. Journal of Wildlife Management 66:634-640.

11 Rodewald, A. D. and M. A. Abrams. 2002. Floristics and avian community structure: implications for regional changes in eastern forest composition. Forest Science: 48: 267-272.

10 Rodewald, A. D. 2002. Interagency collaboration on wildlife management issues: opportunities and constraints. Journal of Extension: 40(2). http://www.joe.org/joe/2002april/rb3.html.

9 Siepielski, A. M.***, A. D. Rodewald, and R. H. Yahner. 2001. Nest-site selection and nesting success of the Red-eyed Vireo in central Pennsylvania. Wilson Bulletin 113:302-307.

8 Rodewald, A. D. and R. H. Yahner. 2001. Influence of landscape composition on avian community structure and associated mechanisms. Ecology 82: 3493-3504.

7 Rodewald, A. D. and R. H. Yahner. 2001. Avian nesting success in forested landscapes: influence of landscape composition, stand and nest-patch microhabitat, and biotic interactions. Auk 118:1018-1028.

6 Rodewald, A. D. 2001. Delivery systems – is the "latest" technology the greatest? Journal of Extension 39(4). http://joe.org/joe/2001august/tt2.html.

5 Yahner, R. H., A. D. Rodewald, and S. C. Talbott. 2001. Edge-related nest predation associated with the retention of residual trees in harvested hardwood stands. Canadian Field Naturalist 115:82-87.

4 Rodewald, A. D. and R. H. Yahner. 2000. Influence of landscape composition and habitat structure on Ovenbird pairing success. Wilson Bulletin 112:238-242.

3 Rodewald, A. D. and R. H. Yahner. 2000. Bird communities associated with harvested hardwood stands containing residual trees. Journal of Wildlife Management 64:924-932.

2 Rodewald, A. D. and R. H. Yahner. 1999. Effects of a new forest-management practice and landscape composition on woodland salamander communities. Northeast Wildlife 54:45-54.

1 Rodewald, A. D. and S. A. Foster. 1998. Effects of gravidity on habitat use and antipredator behavior in threespine stickleback. Journal of Fish Biology 52:973-986.

Books

Isaksson, C., Rodewald, A. D., Gil, D., eds. 2018. Behavioural and Ecological Consequences of Urban Life in Birds. Lausanne: Frontiers Media. doi: 10.3389/978-2-88945-497-6

Morrison, M.L., A.D. Rodewald, G. Voelker, J. Prather, and M.R. Colón. 2018. Ornithology: Foundation, Critique, and Application. John Hopkins Press.

Committee on Human and Environmental Exposure Science in the 21st Century, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council. 2012. *Exposure Science in the 21st Century: A Vision and a Strategy*. Washington, DC: The National Academies Press.

Book chapters

Rodewald,A.D., M.L. Morrison, M.R. Colón, G. Voelker and J. Prather. 2018 What makes a bird. In Ornithology: Foundation, Critique, and Application. John Hopkins Press.

Arcese, P., A. Rodewald, R. Schuster, O. Venter, and J. Bennett. 2017. Partnerships for conservation. In: Reflections of Canada: Illuminating our Opportunities and Challenges at 150+ Years. Peter Wall Institute for Advanced Studies, University of British Columbia Press. Pages 166- 175.

Fitzpatrick, J.W. and A.D. Rodewald. 2016. Bird conservation. In: Handbook of Bird Biology. Cornell Lab of Ornithology.

Rodewald, A.D. 2016. Urban agriculture as habitat for wildlife. Sowing Seeds in the City: Municipal and Ecological Considerations (Brown, McIvor & Snyder, eds). Springer Press.

Rodewald, A.D. 2015. Demographic Consequences of Habitat. In: Habitats in Peril (M. Morrison and H. Matthewson, eds). John Hopkins Press.

Rodewald, A.D., and S. D. Gehrt. 2014. Wildlife Population Dynamics in Urban Landscapes. Pp. 117-147 In: Urban Wildlife Science: Theory and Practice (McCleery, R.A., C. Moorman, and N. Peterson, eds). Island Press.

Yahner, R. H., Mahan, C. G., and A. D. Rodewald. 2012. Forest wildlife management. In: Wildlife Techniques Manual, 7th edition (N. Silvy, ed), The Wildlife Society, Bethesda, MD.

Yahner, R. H., Mahan, C. G., and A. D. Rodewald. 2005. Forest wildlife management. In: Techniques for Wildlife Investigations and Management, 6th edition (C. E. Braun, ed), The Wildlife Society, Bethesda, MD.

Rodewald, A. D. and M. A. Abrams. 2002. Floristics and avian community structure: implications for regional changes in eastern forest composition. In: Forest Wildlife-Habitat Relationships: Population and Community Responses to Forest Management (S. DeStefano and R. G. Haight, eds), Society of American Foresters, Bethesda, MD.

Peer-reviewed proceedings

Rodewald, A. D. 2005. Interactions between exotic shrubs and breeding birds in riparian forests. Pages 43-48 *in* Proceedings of the Ohio Invasive Plant Research Conference, Ohio Agricultural Research and Development Center, Special Circular 196.

Rodewald, A. D. 2004. Landscape and local influences of forest management on Cerulean Warblers in Pennsylvania. Pages 472-477 *in* Proceedings of the 14th Central Hardwoods Conference. Forest Service Technical Report. NE-316. Newtown Square, PA: U.S. Department of Agriculture. Forest Service. Northeastern Research Station.

Larkin, J.L., P.B. Wood, T.J. Boves, J. Sheehan, D.A. Buehler, P.D. Keyser, A.D. Rodewald, T.A. Beachy, M.H. Bakermans, A. Evans, G.A. George, M.E. McDermott, F. L. Newell, K.A. Perkins, M. White, and T.B. Wigley. 2012. Breeding season concerns and response to forest management: Can forest management produce more breeding birds? Proceedings of the XIth Neotropical Ornithological Congress, Cusco, Peru.

Reviews and letters

Rodewald, A.D., P. Arcese, J. Sarra, and J. Tobin. 2018. eLetter: Paying to save biodiversity. Science. http://science.sciencemag.org/content/360/6388/486/tab-e-letters

Rodewald, A. D. 2004. Effects of habitat fragmentation on birds in western landscapes: contrasts with paradigms from the eastern United States by T.L. George and D.S. Dobkin, eds.: a review. The Auk 121:978-980.

Peer-reviewed manuscripts in revision or review

1. Bennett*, R.E., A.D. Rodewald, and K.V. Rosenberg. Failure to address sexual segregation leads to biased conservation recommendations for migratory landbirds. Conservation Letters.

2. Schuster, R.**, Wilson S., Rodewald, A. D., Arcese P., Fink, D., Auer, T., Bennett, J. R. Optimizing the conservation of migratory species over their annual cycle in the Western Hemisphere. Nature - Ecology & Evolution.

3. Lutter, S.H., A.A. Dayer, A.D. Rodewald, D.J. McNeil, and J.L. Larkin. Young forest management on private lands as a localized coupled human and natural system. Ecology and Society.

4. Sevillano-Rios, C.S. * and A.D. Rodewald. Seasonal patterns of the threatened *Polylepis* avian diversity along a high Andean elevation gradient. Ibis.

5. McNeil*, D.J., C.J. Fiss, A.D. Rodewald and J.L. Larkin. Facultative polygamy influences post-fledging movements in a brood-splitting passerine. Wilson Journal of Ornithology.

6. Fiss, C., D.J. McNeil*, F. Rodríguez, A.D., Rodewald, and J. Larkin. Hail-induced nest failure and adult mortality in a declining ground-nesting forest songbird. Journal of Field Ornithology.

7. Lees, A.C., K.V. Rosenberg, V. Ruiz-Gutierrez, S. Marsden, T. Schulenberg, and A.D. Rodewald. A roadmap to identifying and filling shortfalls in Neotropical Ornithology. Studies in Avian Biology.

8. McNeil, D.J.* , C. Fiss, V. Rohwer, A. Dhondt, A.D. Rodewald, K. Rosenberg, R. Bennett, J. Larkin. Rapid Pre-formative Molt in a Wood-warbler: An Overlooked Challenge During the Post-fledging Period. Journal of Avian Biology.

9. Vergara, P.M., G.E. Soto, A.D. Rodewald, M. Quiroz. Behavioral switching in Magellanic woodpeckers reveals perception of habitat quality at different spatial scales. Landscape Ecology.

10. Hernandez-Aguilera, J.N., J. Conrad, M. Gomez, and A.D. Rodewald. The economics and ecology of shade-grown coffee: A model to incentivize shade and bird conservation. Ecological Economics.

11. Arcese, P. and A.D. Rodewald. Predictors and consequences of earthworm invasion in a coastal archipelago. Biological Invasions.

Op-Eds and Commentaries

1. Rodewald, A.D. 2018. Lawmakers rally to keep Pruitt from transparently restricting science. The Hill. July 2.
2. Rodewald, A.D. and J.W. Fitzpatrick. 2018. Undermining protection for migratory birds. The Hill. April 16.
3. Rodewald, A.D. 2018. Infrastructure plan builds barriers to public engagement. The Hill. Feb 20
4. Rodewald, A.D. 2017. The value of biodiversity is unknown, but we must conserve it. The Hill. December 26.
5. Rodewald, A.D. and Fitzpatrick, J.W. 2017. Ryan Zinke wants to break many conservation efforts. The Hill. October 14.
6. Rodewald, A.D. 2017. Farm Bill pays high dividends for people and the environment. The Hill. August 10.
7. Rodewald, A.D. 2017. Trump plans for updated bridges but ignores the troubled waters below. The Hill. June 15.
8. Rodewald, A.D. 2017. The songbird-coffee connection. Scientific American. Guest blog: April 18. https://blogs.scientificamerican.com/guest-blog/the-coffee-songbird-connection/#

9. Garip, F. and A. D. Rodewald. 2017. Trump can't win on immigration if he scraps climate change funds – here's why. The Hill. April 12.
10. Rodewald, A.D. 2017. Protecting the environment is our best wall of defense. The Hill. Feb 7.
11. Rodewald, A.D. 2016. Dismantling EPA regulations hurts both health and economy. The Hill. Dec. 10.
12. Rodewald, A.D. 2016. Paris agreement is the catalyst for a clean global economy. The Hill. Oct 27.
13. Rodewald, A.D. 2016. Working across borders is essential for birds, but also people. The Hill. Aug. 26
14. Rodewald, A.D. 2016. Our National Forests weren't designed just for timber. The Hill. July 21.
15. Rodewald, A.D. 2016. Protecting the environment is critical for a stronger America. The Hill. May 2.
16. Rodewald, A.D. 2016. As we respond to Zika, don't forget about unintended consequences. The Hill. Feb 12.
17. Rodewald, A.D. 2015. UN conference is opportunity to renew climate change partnership with Canada. The Hill. Nov 24.
18. Rodewald, A.D. 2015. The cresting wave of migrants. The Hill. Sept 21.
19. Rodewald, A.D. 2015. The science and morality of climate change. The Hill. July 21.
20. Rodewald, A.D. 2015. Federal agencies turn to citizen scientists. The Hill. May 21.
21. Rodewald, A.D. 2015. Don't close the door on open science. The Hill. March 18.
22. Rodewald, A.D. 2015. National security and environmental security, two sides of the same coin. The Hill. Feb 18.
23. Rodewald, A.D. 2014. Gunnison sage-grouse listing is a confirmation of grassroots conservation. The Hill. Nov 18.
24. Rodewald, A.D. 2014. The Path to Zero. The Hill. Sept 10.
25. Rodewald, A.D. 2009. Guest column on wildlife habitat management on golf courses. Green Links, online publication of The Environmental Institute for Golf (www.eifg.org).

Bulletins & Manuals

Rodewald, A.D. 2013. Managing Ohio's forest birds: a guide for land managers. Ohio Bird Conservation Initiative, The Nature Conservancy, and Ohio Division of Wildlife. 33 pp.

Wood, P.B., J. Sheehan, P. Keyser, D. Buehler, J. Larkin, A. Rodewald, S. Stoleson, T.B., Wigley, J. Mizel, T. Boves, G. George, M. Bakermans, T. Beachy, A. Evans, M. McDermott, F. Newell, K. Perkins, and M. White. 2013. Management guidelines for enhancing Cerulean Warbler breeding habitat in Appalachian hardwood forests. American Bird Conservancy. The Plains, Virginia. 28 pp.

Rodewald, A. D. 2004. Wildlife habitat management on public open spaces. Ohio State University Extension Bulletin 915. 22 pgs.

Popular Articles

1. Rodewald, A.D. 2018. The Trump administration's new migratory bird policy undermines a century of conservation. The Conversation. https://theconversation.com/the-trump-administrations-new-migratory-bird-policy-undermines-a-century-of-conservation-95038
2. Rodewald, A.D. and K.V. Rosenberg. 2018. An amazing race: spring migration in the Americas. Living Bird.
3. Rodewald, A.D. 2017. Birds offer a connection to tens of millions of coffee drinkers. Coffee Talk Magazine. Volume: April 2017, No. 4: 28-32.

4. Rodewald, A.D. 2016. Beyond borders: Why we need global action to protect migratory birds. The Conversation. August 15. (http://theconversation.com/beyond-borders-why-we-need-global-action-to-protect-migratory-birds-62070)
5. Rodewald, A.D. 2016. The dilemma of conservation reliance: When a species needs help indefinitely. Living Bird. Spring Issue.
6. Rodewald, A.D. 2012. In the thick of it: how invasive and exotic shrubs affect breeding birds. Birding. January 44-51. (invited by Editor).
7. Bakermans, M. H. and A. D. Rodewald. 2010. Cerulean Warbler – Singing the Blues. Wild Ohio Magazine, Spring issue.
8. Bakermans, M.H. and A.D. Rodewald. 2007. A cup in the hand is worth two birds in a bush: coffee's role in conservation. Ohio Ornithological Society Newsletter.
9. Bakermans, M.H. and A.D. Rodewald. 2007. Cerulean Warbler and Ohio's Forests. Ohio Woodlands, Wildlife, and Watersheds Newsletter, Spring.
10. Rodewald, A. D. and M. H. Bakermans. 2004. The Cerulean Warbler – an Ohio treasure. The Ohio Woodland Journal 11(3):20-21.
11. Rodewald, A. D. 2003. Goodbye to oak? Consequences of changing forest composition to wildlife. Ohio Woodland Stewards Newsletter.
12. Rodewald, A. D. 2002. Woodland wildlife. Ohio Woodlands, Wildlife, and Watersheds Newsletter, Spring.
13. Rodewald, A. D. 2002. Strategies to minimize deer damage. The Ohio Woodland Journal 9(4):21.
14. Rodewald, A. D. 2001. Managing for woodland wildlife. Southeast Ohio Edition Bulletin, Southeastern Ohio Forestry Initiative.
15. Rodewald, A. D. 2001. Forest management for Ohio's woodland songbirds. Ohio Woodland Owners' Journal 8(4):14-16.

Extension Fact Sheets (18; peer-reviewed at Ohio State University)

Santiago, M. J. and A. D. Rodewald. 2004. The benefits of managing your property for wildlife.
Santiago, M. J. and A. D. Rodewald. 2004. Wildlife-friendly golf course management.
Santiago, M. J. and A. D. Rodewald. 2004. Dead trees as resources for wildlife.
Santiago, M. J. and A. D. Rodewald. 2004. Managing shelterbelts for wildlife.
Bakermans, M. H. and A. D. Rodewald. 2002. Wildlife management on farmlands.
Borgmann, K. L. and A. D. Rodewald. 2002. Butterfly gardens.
Borgmann, K. L. and A. D. Rodewald. 2002. Native landscaping for birds, bees, and butterflies.
Comer, G. L. and A. D. Rodewald. 2002. Controlling mole damage.
Rodewald, A. D. and M. C. Brittingham. 2001. Incorporating wildlife needs into forest management plans.
Rodewald, A. D. 2001. Backyard enhancement for wildlife.
Rodewald, A. D. 2001. Managing for forest songbirds.
Rodewald, A. D. 2001. Preventing and controlling deer damage.
Rodewald, A. D. 2001. Preventing and controlling blackbird damage.
Rodewald, A. D. 2001. Preventing and controlling woodpecker damage.
Rodewald, A. D. 2001. Nuisance Canada Geese: how to deal with the problem.
Rodewald, A. D. 2001. Preventing and managing raccoon problems.
Rodewald, A. D. 2001. Dealing with nuisance groundhogs.
Rodewald, A. D. 2001. Preventing and controlling coyote problems.

FUNDED GRANTS (>$8 Million)

Atkinson Center for a Sustainable Future, Cornell University. Stay or go? The role of environment in migration decisions in Mexico. Garip, Chatrchyan, Chau, Ortiz-Bobea, Rodewald, and Yúnez-Naude. $150,000. 2018-2019.

Packard Foundation. Coastal solutions fellowship program on coastal habitat and shorebird protection. $400,000. Rodewald and Ruiz-Gutierrez. 2018-2019.
Peter Wall Institute for Advanced Studies, University of British Columbia. Promise and peril: design and application of conservation finance models to biodiversity conservation, human well-being, and sustainability. $36,200. With Arcese and Sarra. 2017-2018.
Packard Foundation. Coastal Solutions: Fellowship program on coastal habitat and shorebird protection. Planning grant. $73,000. Rodewald and Ruiz-Gutierrez.
National Science Foundation. Collaborative Research Belmont Forum: Ecological calendars and climate adaptation in the Pamirs. Kassam, Wolfe, Ruelle, Rodewald, and Dunn. $100,000. 2016-2019.
National Resource Conservation Service (via Indiana University of Pennsylvania). Inventory and Monitoring of Relevant Wildlife Species Across Properties Enrolled in Nrcs Conservation Programs in Appalachian and Great Lakes Areas. $52,978. 2017-2018.
National Resource Conservation Service (via Indiana University of Pennsylvania). Range-Wide Monitoring of Private Lands Enrolled in Natural Resource Conservation Service Programs That Target Golden-Winged Warbler and American Woodcock. $97,602. 2015-2017.
American Bird Conservancy (via Indiana University of Pennsylvania). Migratory connectivity of wintering golden-winged warblers. $22,050. 2016-2017.
Atkinson Center for a Sustainable Future at Cornell University. Market-based instruments and incentives for sustainability and conservation in rural working landscapes of Latin America. Rodewald, Ruiz, Milstein, Gomez, DeGloria. 2016-2018. $150,000.
Natural Resources Conservation Service, USDA (via Indiana University of Pennsylvania). Range-Wide Monitoring of Private Lands Enrolled in Natural Resource Conservation Service Programs That Target Golden-Winged Warbler and American Woodcock. 2015-2018. $99,000.
U.S. Fish and Wildlife Service. Ecological segregation and sex-biased habitat selection in overwintering. Golden-winged and Blue-winged warblers. With Rosenberg and Bennett. 2015-2016. $20,000.
*Atkinson Center for a Sustainable Future at Cornell University.*Ecological calendars to anticipate climate change. Kassam, Dunn, Wolfe, Rodewald, Degaetano, Rudstam, & Ruelle. 2015-2017. $98,956.
Disney Foundation. Agroecosystems, communities, and conservation in Guatemala. Rodewald and Inigo. 2014-2015. $25,000.
Sarah K. de Coizart Charitable Trust. Amplifying the Conservation Impact of Land Trusts in the Northeast. Rohrbaugh, Rodewald, Dayer. 2013-2015, $100,000
National Science Foundation. Multitrophic consequences of novel plant assemblages in urban ecosystems. D. Tallamy, P. Marra, and A. Rodewald. 2013-2016. $450,000
Ohio Department of Natural Resources – Division of Wildlife. Ohio biodiversity conservation partnership – understanding landscape-scale responses of animal communities to urbanization, 2011-2013. $137,250.
U.S. Fish and Wildlife Service. Wintering Grounds Conservation Plan for Golden-winged Warblers With Rosenberg & Rodewald. 2013-2014. $94,000
Ohio Department of Natural Resources – Division of Wildlife. Ohio biodiversity conservation partnership – conserving birds in urbanizing landscapes. 2011-2013. $127,100.
Ohio Department of Natural Resources – Division of Wildlife. Ohio biodiversity conservation partnership – forest bird habitat management. 2011. $26,450.
U.S. Fish and Wildlife Service. Assessing the impact of free-ranging cats and food-provisioned cat colonies on the conservation value of protected areas to grassland birds. U.S. Fish and Wildlife Service. 2010-2013. $38,709. With Stan Gehrt.
National Science Foundation. Research Experience for Undergraduate (REU) Supplement for "Towards a mechanistic understanding of landscape-scale responses of animal communities to urbanization. 2010. $14,876.
U.S. Fish and Wildlife Service. Non-breeding ecology of Cerulean Warblers in shade-coffee plantations in the northern Andes. U.S. Fish and Wildlife Service. 2010-2014. $24,516.

National Science Foundation. Research Experience for Undergraduate (REU) Supplement for "Towards a mechanistic understanding of landscape-scale responses of animal communities to urbanization. 2009. $12,974.

National Council on Air and Stream Improvement. Cerulean Warbler conservation initiative 4. 2008-2010. Breeding ground forest management experiment, $108,000

National Council on Air and Stream Improvement. Non-breeding demography of Cerulean Warblers in Venezuela, 2008-2010. $ 30,000.

National Council on Air and Stream Improvement. Habitat model testing for the Cerulean Warbler in South America, 2008-2010, $21,000

Ohio Agricultural Research and Development Center (OARDC) and *The Ohio State University.* Social and ecological values of agroecosystems in the Venezuelan Andes. Office of International Affairs. 2008. $2,000.

U.S. Fish and Wildlife Service. Non-breeding ecology of Cerulean Warblers in shade-coffee plantations in Venezuela. U.S. Fish and Wildlife Service. 2008-2010. $17,796.

National Science Foundation. Research Experience for Undergraduate (REU) Supplement for "Towards a mechanistic understanding of landscape-scale responses of animal communities to urbanization. 2008. $6,551.

National Science Foundation. Linking watershed research and GK-12 education within an ecosystem context. R. Moore, V. Bouchard, C. Goebel, C. Hoy, L. Williams, A. Rodewald, D. Stinner, and P. Grewal. 2007-2012. $2,958,178.

National Science Foundation. Towards a mechanistic understanding of landscape-scale responses of animal communities to urbanization. 2007-2011. $421,300.

National Science Foundation. Research Experience for Undergraduate (REU) Supplement for "The role of the landscape matrix in structuring avian communities". 2007. $6,230.

Ohio Ornithological Society. Winter ecology of Cerulean Warblers in shade-coffee plantations in Venezuela, 2007. $1,500.

Cleveland Metroparks Zoo. Winter ecology of Cerulean Warblers in shade-coffee plantations in Venezuela, 2007. $1,500.

Ohio Department of Natural Resources – Division of Wildlife. Conserving birds in urbanizing landscapes: the importance of the post-fledging period. 2007-2012 $139,166.

Ohio Department of Natural Resources – Division of Wildlife. Towards a mechanistic understanding of landscape-scale responses of animal communities to urbanization. 2007-2012. $157,755.

National Council on Air and Stream Improvement. Cerulean Warbler conservation initiative 3. 2007-2008. $32,000.

U.S. Fish and Wildlife Service. Cooperative Cerulean Warbler forest management project. USFWS, 2005-2009, $53,310.

National Science Foundation. The role of the landscape matrix in structuring avian communities. 2004-2008. $125,000.

National Science Foundation. Research Experience for Undergraduate (REU) Supplement for "The role of the landscape matrix in structuring avian communities". 2005. $6,000.

National Science Foundation. Research Experience for Undergraduate (REU) Supplement for "The role of the landscape matrix in structuring avian communities". 2006. $6,245.

National Fish and Wildlife Foundation. Cooperative Cerulean Warbler forest management project; administered through National Council on Air and Stream Improvement, 2006-2010. $600,000 per year. B. Wigley, D. Buehler, P. Hamel, P. Keyser, J. Larkin, D. Maehr, A. Rodewald, K. Rosenberg, P. Bohall-Wood.

Ohio Department of Natural Resources – Division of Wildlife. Avian response to forest management for oak regeneration. 2006-2009. $163,634.

Ohio Department of Natural Resources – Division of Wildlife. Conservation of riparian forests in urbanizing landscapes. 2005-2007. $22,200.

Ohio Agricultural Research and Development Center (OARDC) and *The Ohio State University*. After the invasion: Developing a mechanistic understanding of ecological and human responses to exotic species to inform restoration decisions. 2005-2007. Ohio Agricultural Research and Development Center Competitive Grant Program, $100,000. A. Rodewald, V. Bouchard, M. Miriti, and J. Arvai.

U.S. Fish and Wildlife Service. Demography of Cerulean Warblers on breeding and wintering grounds, 2004-2006. Neotropical Migratory Bird Conservation Act Program. $57,204. A. D. Rodewald and M. H. Bakermans.

U.S. Fish and Wildlife Service. Conservation of Cerulean Warblers in the Ohio Hills. Nongame Bird Program, 2004-2006. $12,000.

Ohio Department of Natural Resources – Division of Wildlife. Conservation of Cerulean Warblers in the Ohio Hills. 2004-2006. $40,000.

The Nature Conservancy. Conservation of Cerulean Warblers in the Ohio Hills. 2004-2005. $8,713.

Ohio Department of Natural Resources – Division of Wildlife. Conservation of late-successional birds in managed forest landscapes. 2003-2008. $265,934

Ohio Department of Natural Resources – Division of Wildlife. Balancing the needs of early and late successional birds on public forestlands. 2003-2007, $185,106.

Ohio Department of Natural Resources – Division of Wildlife. Bird conservation in midwestern riparian forests: local and landscape influences on breeding birds. 2003-2005, $19,047.

American Association for the Advancement of Science. Edge effects in tropical montane forests: impacts on avian communities. 2003. $4,000.

U.S. Fish and Wildlife Service. Wildlife habitat enhancement on public open spaces. 2001-2003. National Conservation Training Center, $26,379.

Ohio Department of Natural Resources – Division of Wildlife. Monitoring and demographic modeling of grassland birds on strip mines, 2002-2007, $73,000.

National Fish and Wildlife Foundation – Wildlife Links. Assessment of Midwestern golf courses as breeding habitat for a declining bird species: the Red-headed Woodpecker. 2001-2004. $59,920. Funding through U.S. Golf Association. A. D. Rodewald and P. G. Rodewald.

Ohio Department of Natural Resources – Division of Wildlife. Minimum area and habitat requirements of scrub-successional birds: does landscape context matter? 2001-2004, $101,332.

Ohio Department of Natural Resources – Division of Wildlife. Suitability of riparian and upland forests as stopover habitat for migrating songbirds: a multi-scale approach. 2001, P. Rodewald and A. Rodewald. $5,000.

Ohio Agricultural Research and Development Center (OARDC) and *The Ohio State University*. A landscape approach to riparian forest buffer design: implications for wildlife conservation and policy. 2001, The C. William Swank Grant Program in Rural-Urban Policy. $8,000.

Ohio Agricultural Research and Development Center (OARDC) and *The Ohio State University*. A multi-scale analysis of landscape matrix effects on riparian forests: implications for wildlife conservation and buffer design. 2000-2002, OARDC Research Enhancement Competitive Seed Grants. $19,500.

INVITED RESEARCH SEMINARS

1. XI Congreso Peruano de Ornitología, Universidad Cientifica del Perú, Iquitos. 2018 ¿Cómo pueden funcionar los paisajes productivos para la conservación de las aves? Ponencia Magistral (Plenary).

2. Wall Institute for Advanced Studies – Conservation Finance Conference, University of British Columbia. 2018. Down in the dirt: Approaches to establish and track environmental outcomes of conservation finance projects.

3. Center of Excellence for Environmental Decisions, University of Queensland. 2017. Synergies & trade-offs in biodiversity conservation on private lands. With Peter Arcese.

4. Nuttall Ornithological Club, Harvard University. 2017. A bird's eye view of nature in the city.

5. Ecology & Conservation of Forest Biodiversity Seminar Series, Oregon State University. 2017. Altered species interactions and the role of anthropogenic inputs.

6. AVES seminar, Oregon State University. 2017. eBird as a tool for science and conservation.

7. Annual meeting of the American Ornithological Society and Society for Canadian Ornithologists, East Lansing, Michigan. 2017. Plenary address. The Anthropocene frontier: understanding ecological responses to urbanization.

8. Dumbarton Oaks, Harvard University. Mellon Initiative in Urban Landscape Studies. 2017. How a bird's eye view of the city teaches us about urban ecology.

9. Skidmore College, Department of Biology. 2017. A bird's eye view of the city: how our actions alter species interactions.

10. University of British Columbia, Institute for Resources, Environment, and Sustainability. 2017. Can working landscapes work for conservation?

11. Invited Inaugural Presentation. Colombian Ornithological Congress, Medellin, Colombia. 2016. A vista de aves de la naturaleza en la ciudad: Los sorprendentes formas en que nuestras acciones alteran las comunidades ecológicas.

12. Cornell Lab of Ornithology, Monday Night Seminar Series. 2016. Coffee, communities, and conservation: how your cup can make a difference.

13. Barkalow Distinguished Conservationist Lecture, College of Natural Resources, North Carolina State University. 2016. A bird's eye view of nature in the city: the surprising ways that our actions alter species interactions and shape ecological communities.

14. Ecology, Evolution, and Behavior Seminar Series, Virginia Tech. 2016. Altered species interactions in cities and the role of anthropogenic inputs.

15. Plenary for Trilateral Committee for Wildlife and Ecosystem Conservation and Management, Annual Meeting in Ottawa, Canada. 2016. Bringing vision to reality: the path forward for bird conservation in the Americas.

16. Department of Ecology, Evolution, and Biodiversity, University of British Columbia. 2015. Altered species interactions in cities and the role of anthropogenic inputs.

17. El Instituto de Ecología (INECOL), Xalapa, Mexico. 2015. Causes and consequences of altered species interactions in urbanizing landscapes.

18. Department of Wildlife Ecology and Conservation, University of Florida. 2015. Causes and consequences of altered species interactions in urbanizing landscapes.

19. Organismic and Evolutionary Biology Program Seminar Series, University of Massachusetts-Amherst. 2014. Altered species interactions in cities and the role of anthropogenic resources.

20. Department of Natural Resources Seminar Series, Cornell University. 2014. Altered species interactions in cities and the role of anthropogenic resources.

21. Programa de Ciencias Ambientales, Universidad de Ciencias Aplicadas y Ambientales, UDCA, Bogota, Colombia. 2014. Respuesta de la aves a la urbanización: mecanismos, demografícos y de comportamiento. (Invited and funded by the The Colombian Institute for Education Funding and Study Abroad; ICETEX)

22. Environmental Lecture Series, Ashland University. 2014. The intersection of coffee, communities, and conservation in Latin America.

23. Center for Ecology's Distinguished Speaker Series, Southern Illinois University. 2013. Altered species interactions in cities and the role of human inputs.

24. Department of Ecology and Evolutionary Biology, Cornell University. 2013. Anthropogenic inputs and consequences to bird-plant-predator interactions.

25. Distinguished Ecologist Lecture Series, School of Forest Resources and Environmental Sciences, Michigan Tech University. 2013. Anthropogenic inputs and consequences to bird-plant-predator interactions.

26. Program in Ecology, Evolution, and Conservation Biology, University of Illinois. 2013. Behavioral and population processes shaping bird communities in an urbanizing world.

27. Department of Natural Resources and Environment, University of Michigan. 2013. Behavioral and population processes shaping bird communities in an urbanizing world.

28. XXI Congreso Español y V Ibérico de Ornitología, 2012. Plenary: Demographic and behavioural drivers of avian responses to urbanization.

29. Center for Urban Environmental Research, University of Maryland, Baltimore. 2012. Linking pattern and process: behavioral and demographic drivers of avian responses to urbanization.

30. School of Environment and Natural Resources, The Ohio State University. 2012. High life in the city? Behavioral and population processes shaping avian conservation in an urbanizing world.

31. Integrative Ecology Group, Doñana Biological Station – CSIC, Sevilla, Spain. 2012. Demographic and behavioral drivers of avian responses to urbanization.

32. Department of Ecology, Evolution, and Conservation Biology, University of Nevada – Reno. 2011. Demographic and behavioral mechanisms that drive urban-associated changes in bird communities.

33. Department of Biology, Texas Tech University. 2011. Demographic and behavioral mechanisms that drive urban-associated changes in bird communities.

34. Department of Biological Sciences, Western Michigan University. 2011. Theodosia Hamilton Hadley Lecture in Ornithology - A bird's eye view of the city: Bird conservation in an urbanizing world.

35. Department of Biology, Case Western Reserve University, 2011. Understanding demographic and behavioral mechanisms that drive avian responses to urbanization.

36. Stone Laboratory, Ohio Sea Grant and Ohio State University, 2011. Bird conservation in an urbanizing world: are we winging it?

37. Department of Biological Sciences, Kansas State University, 2009. Understanding mechanisms that guide avian community responses to urbanization.

38. Universidad Nacional de Colombia, Medellin, Colombia, 2008. Mecanismos que determinan las respuestas de las aves a la urbanización.

39. Department of Natural Resources Conservation, University of Massachusetts – Amherst, 2008. Understanding mechanisms that guide avian community responses to urbanization.

40. Department of City and Regional Planning, The Ohio State University, 2008. Urban Flight: Understanding avian responses to urbanization.

41. Stone Laboratory Biological Field Station, The Ohio State University, 2007. A bird of two worlds: the challenge of conserving the Cerulean Warbler.

42. Department of Horticulture and Crop Science, The Ohio State University. 2006. Plant-mediated nest predation: can exotic plants thwart our efforts to conserve birds?

43. School of Natural Resources, University of Arizona. 2005. The importance of land uses within the landscape matrix: lessons from forested and fragmented landscapes. Invited as participant in series, "A Showcase of Promising Scientists in Natural Resources".

44. Department of Biological Sciences, University of Pittsburgh - Pymatuning Laboratory of Ecology. 2005. Conserving riparian forests in urbanizing landscapes.

45. Department of Natural Resources, Purdue University. 2005. The importance of shrubland habitat to early- and late-successional forest birds.

46. Ohio State University Research Foundation, The Ohio State University. 2005. Conserving Ohio's riparian forests: lessons from the birds.

47. Institute of Ecology, Department of the Sciences, The University of the Andes, Merida, Venezuela. 2005. La importancia de la matriz del paisaje para la avifauna del bosque.(The importance of the landscape matrix to forest bird communities).

48. Department of Zoology, Oklahoma State University. 2004. Avian community responses to an ever-changing landscape matrix.

49. Women in Science and Engineering (WISE) Institute, The Pennsylvania State University. 2004. How the WISE Institute helps to facilitate careers of women in science.

50. Department of Biological Sciences, University of Arkansas. 2003. The importance of the landscape matrix: lessons from forested and fragmented landscapes.

51. School of Natural Resources, The Ohio State University. 2003. The importance of land uses within the landscape matrix.

52. Department of Evolution, Ecology, and Organismal Biology, The Ohio State University. 2001. Influence of landscape composition on forest bird communities.

53. Annual Meeting of the Pennsylvania Society of Ornithology. 2001. Forested landscapes of Pennsylvania: the impacts of land uses on birds.

CONFERENCE ORGANIZATION:

Design and Application of Conservation Finance Models to Biodiversity, Conservation, Human Well-being and Sustainability, March 2018. University of British Columbia. ~110 attendees. With Peter Arcese.

Financing a Sustainable Future, Joseph & Rosalie Segal Centre, SFU Harbour Centre in downtown Vancouver. Event for finance community, investors, NGOs, and interested public. March 2018. ~70 attendees. With Peter Arcese.

ROUNDTABLE DISCUSSION:

Arcese, Rodewald, Sarra, and Tobin. 2018. Wall International Roundtable. Promise and Peril: Conservation Finance Models for Biodiversity Conservation, Well-Being and Sustainability. University of British Columbia. March 23-25.

Rodewald, A.D., P.P. Marra, K.L. Evans, L. Conole, and C.Suertegaray Fontana. 2010. Frontiers in urban ecology: moving from pattern to process. Organizers/Facilitators of a Roundtable Discussion Group at International Ornithological Congress, Brazil.

SCIENTIFIC PRESENTATIONS:

1. Sevillano-Rios, S. and AD Rodewald. 2018. Diversidad de especies de aves a lo largo de gradients de elevacion en el oeste de los Andes. XI Congreso Peruano de Ornitología, Iquitos.

2. Sevillano-Rios, S. and AD Rodewald. 2018. ¿Donde debemos enfocar los esfuerzos para la conservación de las aves asociadas a los bosques de Polylepis? XI Congreso Peruano de Ornitología, Iquitos.

3. Colorado Zuluaga G. and AD Rodewald. 2018. Patrones de cambio en condicion corporal e naves migratorias meotropicales en sistemas de sombrio en los Andes.. XI Congreso Peruano de Ornitología, Iquitos.

4. Swift, RJ, AD Rodewald, and NR Senner. 2017. Seasonal carryover effects in a long-distance migrant. Western Hemisphere Shorebird Group Meeting, Peru.

5. MacDonald, GJ, RJ Swift, and AD Rodewald. 2017. Influence of foraging substrate, mudflate type, and human disturbance on Hudsonian Godwit abundance on Isla Chiloé, Chile. Western Hemisphere Shorebird Group Meeting, Peru.

6. Colorado, G.J and AD Rodewald. 2017. Response of mixed-species flocks to habitat alteration and deforestation in the Andes. Ornithological Congress of the Americas. Puerto Iguazu, Argentina.

7. Bennett, R., AD Rodewald, and KV Rosenberg. 2017. Female-dominated non-breeding sites are low quality for male but not female Golden-winged Warblers. Meeting of the American Ornithological Society and Society for Canadian Ornithologists. East Lansing, Michigan.

8. Dossman, B., AD Rodewald, P Marra. 2017. Seasonal rainfall influences intra- and inter-seasonal variation in territoriality of a wintering migratory songbird. Meeting of the American Ornithological Society and Society for Canadian Ornithologists. East Lansing, Michigan.

9. McNeil, DJ, AD Rodewld, KE Johnson, JL Larkin. 2017. Monitoring reveals successful management of private- and public forestlands for nesting Golden-winged Warblers. Meeting of the American Ornithological Society and Society for Canadian Ornithologists. East Lansing, Michigan.

10. Soto, GE, AD Rodewald, PM Vergara, V Ojeda, and L. Chazarretad. 2017. Previously-used nesting cavities influence occurrence and territory size of Magellanic Woodpeckers. Meeting of the American Ornithological Society and Society for Canadian Ornithologists. East Lansing, Michigan.

11. Swift, R., AD Rodewald, NR Senner. 2017. Context-dependent protective nesting association in Hudsonian Godwits (Limosa haemastica). Meeting of the American Ornithological Society and Society for Canadian Ornithologists. East Lansing, Michigan.

12. Rodewald, AD, V. Ruiz-Gutierrez, F. LaSorte, and C. Wood. 2017. The dual roles of protected areas in conserving migratory birds and supporting communities. Invited symposium talk. International Congress of Conservation Biology. Cartagena, Colombia.

13. Arcese, P., E. Law, T. Martin, A.D. Rodewald, R. Schuster, K. Wilson, and H. Possingham. 2017. High complementarity in biodiversity, riparian, and carbon values: tax-shifting pays in three ways. International Congress of Conservation Biology. Cartagena, Colombia.

14. E. Law, R. Schuster, A. Rodewald, K. Wilson, and P. Arcese. 2017. Who will conserve? Understanding stakeholders to improve prioritization of private land conservation. International Congress of Conservation Biology. Cartagena, Colombia.

15. Rodewald, AD. 2016. Socioecological drivers of urban bird communities: trait and density-mediated consequences of human inputs. North American Ornithological Conference (NAOC) IV. Washington, DC. (invited for symposium)

16. Rodewald, AD. 2016. Causes & consequences of the urban phenotype. North American Ornithological Conference (NAOC) IV. Washington, DC.

17. Sevillano, C.S. and A.D. Rodewald. 2016. Diversity, Ecology, and Conservation of Bird Communities of Polylepis Woodlands in the Northern Andes of Peru. North American Ornithological Conference (NAOC) IV. Washington, DC.

18. Arcese, P., R. Schuster, E. Kleynhans, A.Rodewald, S. Wilson. 2016. Climate, land use and life history drivers of population growth and distribution and their application to conservation prioritization. North American Ornithological Conference (NAOC) IV. Washington, DC.

19. McNeil, D. J., A. D. Rodewald, C. J. Fiss and J. L. Larkin. 2016. From Touch-down to Take-off: Breeding Range Conservation for Golden-winged Warbler:. North American Ornithological Conference (NAOC) IV. Washington, DC.

20. Bennett, R., A.D. Rodewald, K. Rosenberg. 2016. Sexual segregation in overwintering Golden-winged Warblers (Vermivora chrysoptera) at multiple spatial scales. North American Ornithological Conference (NAOC) IV. Washington, DC.

21. Colorado, G. and AD Rodewald. 2016. Assembly patterns of mixed-species avian flocks in the Andes. North American Ornithological Conference (NAOC) IV. Washington, DC.

22. Dossman, B., C. Studds, P. Marra, A.D. Rodewald. 2016. Seasonal rainfall influences inter-and intra-seasonal territorial dynamics of a migratory bird. North American Ornithological Conference (NAOC) IV. Washington, DC.

23. Dossman, B., C. Studds, P. Marra, A.D. Rodewald. 2016. Assessing Plasticity in the Migratory Behavior of a Songbird Wintering in the Caribbean Using the Motus Wildlife Tracking System. North American Ornithological Conference (NAOC) IV. Washington, DC.

24. Gifford, G., A. Rodewald, W. Hochachka, V. Ruiz Gutierrez. 2016. Conservation value of tropical agroecosystems to migratory and resident birds in the Guatemalan HighlandsNorth American Ornithological Conference (NAOC) IV. Washington, DC.

25. Malpass, J. A. Rodewald, S. Matthews. 2016. Conserving our urban birds: Lessons from the OSU Yard Birds Project. North American Ornithological Conference (NAOC) IV. Washington, DC.

26. Swift, R., A.D. Rodewald, N. Senner. 2016. Do habitat and risk of predation explain spatial patterning of nests? North American Ornithological Conference (NAOC) IV. Washington, DC.

27. Soto, G.E., C.G. Pérez-Hernández, I.J. Hahn, A.D. Rodewald, P.M. Vergara. 2016. Tree senescence as a direct measure of habitat quality: linking red-edge vegetation indices to space use by Magellanic Woodpeckers. North American Ornithological Conference (NAOC) IV. Washington, DC.

28. Hernandez-Aguilera, J. N., M. I. Gómez, A. D. Rodewald, X. Rueda, C. Anunu, R. Bennett, R. R. Schindelbeck, H. M. van Es. 2016. Sustainable Supply Chains in high-quality coffee markets: The Relationship Coffee Model. International Sustainable Development Research Society Conference, Portugal.

29. Malpass, J.S., A.D. Rodewald. 2015. Effect of habitat and resource availability on avian nest survival in yards and adjacent forest parks. International Congress of Conservation Biology; Montpellier, France

30. McDermott, M., A.D. Rodewald, and S.Matthews. 2015. Functional traits and habitat use of Andean flocks in managed agroforestry landscapes. Neotropical Ornithological Congress, Brazil.

31. Malpass, J.S., A.D. Rodewald. 2015. Effect of anthropogenic food on predators and prey. Urban Wildlife Conference; Chicago, IL

32. Malpass, J.S., A.D. Rodewald and Kearns. 2015. Comparison of nest predator identity in forest parks and adjacent residential neighborhoods using video cameras. Ohio Fish and Wildlife Managers' Association; Columbus, OH

33. Swift, RJ, Senner, N. and AD Rodewald. 2015. Settlement Cues for Nest Placement in Hudsonian Godwits. Presentation at the Western Hemisphere Shorebird Group Meeting. Wallops Island, Virginia.

34. Malpass, J.S., A.D. Rodewald. 2014. Effects of anthropogenic subsidies on predator-prey interactions. The Wildlife Society; Winnipeg, Manitoba, Canada

35. Rodewald, A.D., RP Rohr, MA Fortuna, and J. Bascompte. 2014. Does removal of invasives restore ecological networks? An experimental approach. Annual Meeting of American Ornithologists' Union and Cooper Ornithological Society, Estes Park, CO.

36. Malpass, J.S., A.D. Rodewald, and S.N. Matthews. 2014. Effect of wildlife-friendly gardening on species interactions. Annual Meeting of Ohio Fish and Wildlife Management Association, Columbus, OH.

37. Malpass, J.S., and A.D. Rodewald. 2014. Nest survival of urban-adapted songbirds in residential yards and adjacent forest parks. Joint Meeting of American Ornithologists' Union, Cooper Ornithological Society, and Society of Canadian Ornithologists, Estes Park, CO.

38. McDermott, M.E., A.D. Rodewald, and S.N. Matthews. 2014. La contribución de sistemas agroforestales a la conservación de aves migratorias neotropicales. IV Congreso Colombiano de Zoología, Cartagena, Colombia.

39. McDermott, M.E., A.D. Rodewald, and S.N. Matthews. 2014. Conservation value of agroforestry for flocking Andean birds. Annual Meeting of the American Ornithologists' Union, Cooper Ornithological Society, and Society for Canadian Ornithology, Estes Park, CO.

40. McDermott, M.E., A.D. Rodewald, and S.N. Matthews. 2014. La contribución de sistemas agroforestales a la conservación de aves migratorias neotropicales. IV Reunión Ecuatoriana de Ornitología, Maldonado, Ecuador.

41. Malpass, J.S., A.D. Rodewald, and L.J. Kearns. 2014. Nest predator identity in forest parks and adjacent residential neighborhoods. Annual Meeting of The Wildlife Society, Pittsburgh, PA.

42. Malpass, J.S. and A.D. Rodewald. 2013. Effects of vegetation and food resources on activity patterns of nest predators. Annual Meeting of the Wildlife Society. Milwaukee, WI.

43. Malpass, J.S. and A.D. Rodewald. 2013. Influence of complex vegetation on activity of nest predators in residential yards. Meeting of the American Ornithologists' Union and Cooper Ornithological Society, Chicago, IL.

44. McDermott, M. and A.D. Rodewald. 2013. Conservation value of silvopasture and shade agroforestry to Andean forest birds. Meeting of the American Ornithologists' Union and Cooper Ornithological Society, Chicago, IL.

45. Rowse, L.M. and A.D. Rodewald. 2013. Reproductive consequences of mercury to Acadian Flycatchers in urbanizing landscapes of Ohio, USA. Meeting of the American Ornithologists' Union and Cooper Ornithological Society, Chicago, IL.

46. Rodewald, A.D. 2012. Demographic consequences of altered bird-plant networks in urbanizing landscapes. North American Ornithological Conference, Vancouver, BC, Canada.

47. McDermott, M. and A.D. Rodewald. 2012. Ecology of mixed-species flocks in shaded monocultures and silvopastures in the Colombian Andes. North American Ornithological Conference, Vancouver, BC, Canada.

48. Rowse, L. M. and A.D. Rodewald. 2012. Exposure of songbirds to heavy metal contaminants across an urban to rural landscape. North American Ornithological Conference, Vancouver, BC, Canada.

49. Malpass, J.S. and A.D. Rodewald. 2012. The influence of anthropogenic resources on nest predator activity and nest survival in suburban yards. North American Ornithological Conference, Vancouver, BC, Canada.

50. Thieme, J.L., A.D. Rodewald, and S. Gehrt. 2012. Linking grassland bird density to predator activity in urban parks. North American Ornithological Conference, Vancouver, BC, Canada.

51. Narango, D. and A.D. Rodewald. 2012. Variation in signal information within urban bird song. North American Ornithological Conference, Vancouver, BC, Canada.

52. Kearns, L.J. and A. D. Rodewald. 2012. Do patterns of nest predator activity predict nest locations and survival in urbanizing landscapes? North American Ornithological Conference, Vancouver, BC, Canada.

53. Boves, T., D. Buehler, P. Bohall Wood, A. Rodewald, J. Larkin, P. Keyser, and BT Wigley. 2012. Information content and habitat contingency of multiple plumage ornaments in a canopy-dewelling songbird, the Cerulean Warbler. North American Ornithological Conference, Vancouver, BC, Canada.

54. Kearns, L.J. and A.D. Rodewald. 2011. Incorporating predation risk into nesting decisions by an urban adapter and urban avoider. International Congress of Conservation Biology, New Zealand.

55. Larkin,J.L., P.B. Wood, T.J. Boves, J. Sheehan, D.A. Buehler, A.D. Rodewald, P.D. Keyser, T.A. Beachy, M.H. Bakermans, A. Evans, G.A. George, M.E. McDermott, F. L. Newell, K.A. Perkins, and M. White. 2011. Breeding Season Concerns and Response to Forest Management: Can forest management produce more breeding birds? Neotropical Ornithological Congress, Peru.

56. Colorado, C.J.,M. Bakermans, P. Caycedo, P. Ramoni-Perazzi, A. Rodewald, D. Mehlman, and P. Hamel. 2011. Hallazgos recientes en la ecología invernal de la reinita cerúlea (*Setophaga cerulea*) en los Andes: perspectivas, retos y oportunidades**.** Neotropical Ornithological Congress, Peru.

57. Botero,J., G. Medina, B. Smith, D. Buehler, J. Larkin, A. Rodewald, P.Wood. 2011. Integrating conservation management, species protection and economic viability into sustainable land use practices in the Andes and Appalachians. Neotropical Ornithological Congress, Peru.

58. Wood, P.B., T.J. Boves, J. Sheehan, D.A. Buehler, J.L. Larkin, A.D. Rodewald, P.D. Keyser, T.A. Beachy, M.H. Bakermans, A. Evans, G.A. George, M.E. McDermott, F. L. Newell, K.A. Perkins, and M. White, T.B. Wigley. 2011. Cerulean warbler and associated species responses to hardwood forest management. Annual Conference of The Wildlife Society. Hawaii.

59. Rodewald, A.D. 2011. Dynamic selective environments and evolutionary traps in human-dominated landscapes. 129th Stated Meeting of American Ornithologists' Union, Jacksonville, Florida.

60. Vitz, A.C. and A.D. Rodewald. 2011. Demographic and behavioral correlates of mature-forest bird use of successional habitat during the post-fledging period. 129^{th} Stated Meeting of American Ornithologists' Union, Jacksonville, Florida.

61. McDermott, M.E. and A.D. Rodewald. 2011. Mixed-species flocks in shaded monocultures and silvopasture in the Colombian Andes. 129^{th} Stated Meeting of American Ornithologists' Union, Jackonsville, Florida.

62. Shustack, D. P. and A.D. Rodewald. 2011. Interannual territory, mate, and nest site fidelity in Acadian Flycatcher. 129^{th} Stated Meeting of American Ornithologists' Union, Jackonsville, Florida.

63. Faaborg, J., D. King, and A.D. Rodewald. 2011. Use of early-successional vegetation by post-breeding birds: convenience or necessity? 129^{th} Stated Meeting of American Ornithologists' Union, Jackonsville, Florida.

64. Kearns, L. J. and A.D. Rodewald. 2011. Influence of prior fate and nest predator community on renesting decisions of multi-brooded forest songbirds. Joint Meeting of Cooper Ornithological Society/Wilson Ornithological Society/Association of Field Ornithologists in Kearney, Nebraska.

65. Thieme, J., A. D. Rodewald, and S. Gehrt. 2011. Behavioral and reproductive consequences of nest predator activity to grassland birds. Joint Meeting of Cooper Ornithological Society/Wilson Ornithological Society/Association of Field Ornithologists in Kearney, Nebraska.

66. Narango, D.L. and A.D. Rodewald. 2011. Bird song in the city: how are avian communication systems affected by urbanization? Joint Meeting of Cooper Ornithological Society/Wilson Ornithological Society/Association of Field Ornithologists in Kearney, Nebraska.

67. Boves, T. J., T.A. Beachy, P. Keyser, D.A. Buehler, P.B. Wood, J. Sheehan, J. Mizel, G. George, J.L. Larkin, A. Evans, M. White, A.D. Rodewald, M. Bakermans, F. Newell. 2011. Cerulean Warbler *Dendroica cerulea* response to forest management in the Appalachian Mountains. Joint Meeting of Cooper Ornithological Society/Wilson Ornithological Society/Association of Field Ornithologists in Kearney, Nebraska.

68. Sheehan, J., P.B. Wood, G. George, M. McDermott, J. Mizel, P. McElhone, K. Perkins, M. Shumar, D. Buehler, P. Keyser, T. Beachy, T. Boves, J. Larkin, A. Evans, M. White, A. Rodewald, M. Bakermans, F. Newell, and S. Stoleson. 2011. Avian community and species response to hardwood forest management for Cerulean Warblers. Joint Meeting of Cooper Ornithological Society/Wilson Ornithological Society/Association of Field Ornithologists in Kearney, Nebraska.

69. Newell, F.L., A.D. Rodewald, M.H. Bakermans, P.B. Wood, J. Sheehan, G.A. George, M.E. McDermott, P.M. McElhone, K.A. Perkins, M.B. Shumar, D.A. Buehler, P.D. Keyser, T.A. Beachy, T.J. Boves, J.L. Larkin, A. Evans, and M. White. A comparison of breeding density estimates from fixed-radius point counts, distance-sampling, and territory mapping for forest songbirds. Joint Meeting of Cooper Ornithological Society/Wilson Ornithological Society/Association of Field Ornithologists in Kearney, Nebraska.

70. Stoleson, S.H., J. Larkin, D. Buehler, P. Keyser, P. Hamel, A. Rodewald, and P.B. Wood. 2011. From Research to Management: Development of Best Management Practices for Cerulean Warbler. Joint Meeting of Cooper Ornithological Society/Wilson Ornithological Society/Association of Field Ornithologists in Kearney, Nebraska.

71. Rodewald, A. D., L. J. Kearns, and D. P. Shustack. 2010. Anthropogenic resources decouple predator-prey relationships. Annual Meeting of Ecological Society of America.

72. Rodewald, A. D. 2010. Understanding demographic and behavioral mechanisms that drive avian responses to urbanization. International Ornithological Congress, Brazil.

73. Colorado, G. and A. D. Rodewald. 2010. Effects of forest degradation and fragmentation on Neotropical-Nearctic migrants in the Andes. International Ornithological Congress, Brazil.

74. Colorado, G., P. Hamel, D. Mehlman, and A. D. Rodewald. 2010. Distribution and winter ecology of Cerulean Warbler in the Andes: new insights. International Ornithological Congress, Brazil.

75. Ausprey, I. and A. D. Rodewald. 2010. Are young birds city smart?: Survivorship and habitat selection of fledgling songbirds across an urban-to-rural landscape gradient. 24th International Congress for Conservation Biology.

76. Newell, F. and A. D. Rodewald. 2010. Shelterwood harvests provide suitable habitat for canopy-nesting songbirds. 24th International Congress for Conservation Biology.

77. Ausprey, I. and A. D. Rodewald. 2010. Post-fledging dispersal timing and natal home range size of two songbird species. Annual Meeting of Association of Field Ornithologists.

78. Newell, F. and A. D. Rodewald. 2010. Role of topography, canopy structure, and floristics in nest-site selection and nesting success of canopy songbirds. Annual Meeting of Association of Field Ornithologists.

79. Shustack, D. P. and A. D. Rodewald. 2010. Nest predation reduces benefits to early clutch initiation in an urbanizing landscape. Meeting of Wilson Ornithological Society.

80. Kearns, L. J. and A.D. Rodewald. 2010. Does prior experience influence nest-site selection of songbirds within a single season? Annual Meeting of American Ornithologists' Union.

81. Kearns, L. J. and A.D. Rodewald. 2009. Landscapes of risk for nesting songbirds: Does spatial variation in predator activity predict nest success? Annual Meeting of The Wildlife Society.

82. Rodewald, A.D., Kearns, L. J., and Shustack, D. P. 2009. Urbanization does not reduce nest success of forest birds. Annual Meeting of American Ornithologists' Union.

83. Boves, T., D. Buehler, T. Beachy, P. Wood, G. George, J. Sheehan, A. Rodewald, F. Newell, M. Bakermans, J. Larkin, and A. Evans. 2009. Effects of forest management on density and reproductive success of Cerulean Warblers in the Appalachian Mountains. Annual Meeting of American Ornithologists' Union.

84. Ausprey, I. and A.D. Rodewald. 2009. Post-fledging survivorship in an urbanizing landscape. Joint Meeting of Wilson Ornithological Society and Association of Field Ornithologists.

85. Newell, F.L. and A.D. Rodewald. 2009. A bird's eye view of forest canopy structure: how does canopy openness affect canopy-nesting species. Joint Meeting of Wilson Ornithological Society and Association of Field Ornithologists.

86. Kearns, L.J. and A.D. Rodewald. 2009. Associations between activity levels of nest predators and songbird nest placement in riparian forests. Joint Meeting of Wilson Ornithological Society and Association of Field Ornithologists.

87. Rodewald, A.D., Bakermans, M. H., Rengifo, C. 2008. Winter ecology and survival of Cerulean Warbler in coffee plantations in Venezuela. Congress on Conservation Planning for Migratory and Resident Birds of the Northern Andes, Colombia. [Invited]

88. Colorado, G., P.B. Hamel, D. Mehlman, and A. Rodewald. 2008. Distribution and ecology of Cerulean Warbler in the Andes: New insights. Congress on Conservation Planning for Migratory and Resident Birds of the Northern Andes, Colombia. [Invited]

89. Boves, T., T. Beachy, D. Buehler, J. Larkin, M. White, A. Evans, P. Wood, G. George, M. McDermott, P. McElhone, J. Sheehan, M. Shumar, A. Rodewald, F. Newell, and M. Bakermans. 2008. Effects of forest management on Cerulean Warblers in the Appalachian Mountains. Congress on Conservation Planning for Migratory and Resident Birds of the Northern Andes, Colombia. [Invited]

90. Kearns, L. J. and A. D. Rodewald. 2008. Exploring disconnects between avian nest predators and predation across an urban land use gradient. Midwest Fish and Wildlife Conference.

91. Ausprey, I. J. and A. D. Rodewald. 2008. Post-fledging survivorship across an urbanizing landscape. Midwest Fish and Wildlife Conference.

92. Rodewald, A.D. 2008. Exotic shrubs as ephemeral ecological traps for nesting birds. Meeting of the American Ornithologists' Union.

93. Bakermans, M. H. and A. D. Rodewald. 2008. Steady-state forest conditions and Cerulean Warblers. Meeting of the American Ornithologists' Union.

94. Shustack, D. P. and A. D. Rodewald. 2008. Are urban forests underutilized by migratory bird species? Meeting of the American Ornithologists' Union.

95. Kearns, L. J. and A. D. Rodewald. 2008. Nest predator communities in forest fragments across a rural-urban gradient. Meeting of the American Ornithologists' Union.

96. Lehnen, S. E. and A. D. Rodewald. 2008. Nest survival, settling patterns, and territory distribution in relation to edge habitat in a shrubland bird community. Meeting of the American Ornithologists' Union.

97. Colorado, G., P. Hamel, D. Melhman, and A. D. Rodewald. 2008. Ecology and distribution of Cerulean Warblers in the Northern Andes: new insights. Meeting of the American Ornithologists' Union.

98. Rodewald, A. D. 2008. Making way for birdies: avian conservation on golf courses. World Scientific Congress of Golf [Invited Symposium Presentation].

99. Shustack, D. P., A. D. Rodewald, and T. A. Waite. 2008. Advanced green-up in urban forests: compositional differences or intraspecific variation? Ohio Natural History Conference.

100. Rodewald, A. D., M. H. Bakermans, and T. Will. 2007. Connecting breeding and non-breeding seasons: Cerulean Warbler and El Grupo Cerúleo. Midwest Fish and Wildlife Conference. [Invited Symposium Presentation]

101. Graves, B., A. D. Rodewald, and S. Hull. 2007. Grassland bird conservation on reclaimed surface mines: evaluating the influence of vegetation structure on distribution, nest placement and nesting success. Midwest Fish and Wildlife Conference.

102. Rodewald, A. D. and D. P. Shustack. 2007. Urban flight: understanding individual and population-level responses of Nearctic-Neotropical migratory birds to urbanization. Meeting of the American Ornithologists' Union.

103. Bakermans, M. H. and A. D. Rodewald. 2007. Cerulean Warblers in Venezuelan shade coffee plantations and primary forests. Meeting of the American Ornithologists' Union.

104. Lehnen, S. E. and A. D. Rodewald. 2007. The importance of patch area to shrubland birds Meeting of the American Ornithologists' Union.

105. Smith, J.A. and A. D. Rodewald. 2007. Impacts of human recreational disturbance on nest success: Do trail users influence nest predation? Meeting of the American Ornithologists' Union.

106. Vitz, A. C. and A. D. Rodewald. 2007. Does Habitat Use Influence Survival of Post-fledging Mature-forest Birds? Meeting of the American Ornithologists' Union.

107. Seger, K., A. D. Rodewald, and J. Soha. 2007. Effects of urban noise on avian song. XXI International Bio-Acoustic Council International Congress, Italy. (Kerri Seger is an undergraduate honors student with me).

108. Rodewald, A. D. and D. P. Shustack. 2007. Urban flight: understanding individual and population-level responses of Nearctic-Neotropical migratory birds to urbanization. Meeting of The Wildlife Society.

109. Graves, B. and A. D. Rodewald. 2007. Effect of woody encroachment and vegetative structure on density and nest success of grassland birds on reclaimed surface-mined lands in eastern Ohio. Meeting of The Wildlife Society.

110. Shustack, D. P. and A. D. Rodewald. 2007. Why are there lower densities of migrant songbirds in urban forests? A modeling approach. Meeting of The Wildlife Society .

111. Shustack, D. P. and A. D. Rodewald. 2007. The urban heat island and vegetation phenology. Natural Areas Association Conference.

112. Smith, J. A. and A. D. Rodewald. 2007. Impacts of human recreational disturbance on nest success: Do trail users influence nest predation? Midwest Ecology and Evolution Conference.

113. Lehnen, S. E. and A. D. Rodewald. 2007. Patterns of habitat edge usage by shrubland songbirds in southeastern Ohio. Ohio Fish and Wildlife Conference.

114. Rodewald, A. D., A. C. Vitz, M. H. Bakermans, and S. E. Lehnen. 2006. Balancing needs of early- and late-successional birds in forested landscapes. Annual Meeting of Society of American Foresters. Pittsburgh, Pennsylvania.

115. Graves, B., A. D. Rodewald, and S. Hull. 2006. Nest survival analysis of grassland birds on reclaimed surface-mines in eastern Ohio. Midwest Fish and Wildlife Conference. (Best Student Poster Award)

116. Rodewald, A. D. 2006. Towards a mechanistic understanding of urban-associated changes in bird communities. North American Ornithological Conference, Veracruz, Mexico. (Invited symposium paper)

117. Shustack, D.P. and A. D. Rodewald. 2006. Reproductive timing of resident and migrant songbirds across an urban to rural gradient in central Ohio, USA. North American Ornithological Conference, Veracruz, Mexico.

118. Vitz, A. C. and A. D. Rodewald. 2006. Habitat use and survivorship of post-fledging mature-forest birds. North American Ornithological Conference, Veracruz, Mexico. (Honorable Mention for Best Student Paper).

119. Bakermans, M. H. and A. D. Rodewald. 2006. Population ecology of Cerulean Warblers on breeding and wintering grounds. North American Ornithological Conference, Veracruz, Mexico.

120. Lehnen, S. E. and A. D. Rodewald. 2006. Possible avoidance of transitional edge habitat by shrubland birds in southeastern Ohio. North American Ornithological Conference, Veracruz, Mexico.

121. Barker, S., K. V. Rosenberg, D. A. Buehler, P. B. Hammel, K. Islam, J. Jones, A. D. Rodewald, P. B. Wood. 2006. Cerulean Warbler population status, breeding habitats, and demographics. North American Ornithological Conference, Veracruz, Mexico. (Invited symposium paper)

122. Hamel, P., D. Mehlman, P. Ramoni-Perazzi, G. Colorado, T. Cuadros, J. Jones, S. Herzog, M. Moreno, M. Bakermans, M. Lentino, D. Diaz, P., Salaman, K. Girvan, A. Rodewald, D. Cisneros-Heredia. 2006. What do we know about non-breeding habitats of Cerulean Warblers? North American Ornithological Conference, Veracruz, Mexico. (Invited symposium paper)

123. Colorado, G., T. Cuadros, P. Hamel, D. Mehlman, M. Bakermans, A. Rodewald, P. Ramoni-Perazzi, J. Jones, D. Calderon, M. Moreno, and C. Rengifo. 2006. Habitat use by Cerulean Warbler (*Dendroica cerulea*) in agroecosystems in the Northern Andes. North American Ornithological Conference, Veracruz, Mexico. (Invited symposium paper)

124. Shustack, D. P. and A. D. Rodewald. 2006. Attenuated nesting seasons in urban forests: an overlooked consequence of urbanization? Ohio Fish and Wildlife Management Conference.

125. Bakermans, M. H. and A. D. Rodewald. 2005. Nest predation in forested landscapes: edge or landscape effects? Annual Meeting of The Wildlife Society.

126. King, D. I., A. D. Rodewald, R. Chandler, A. C. Vitz. 2005. Edge and area effects on shrubland birds. Annual Meeting of The Wildlife Society. [Part of Symposium that I co-organized]

127. Leston, L. and A. D. Rodewald. 2005. Are urban forests ecological traps for understory birds? Annual Meeting of The Wildlife Society.

128. Shustack, D.P. and A. D. Rodewald. 2005. Attenuated nesting seasons in urban forests: an overlooked consequence of urbanization? Annual Meeting of The Wildlife Society.

129. Vitz, A. C. and A. D. Rodewald. 2005. Post-fledging ecology of mature-forest birds. Annual Meeting of The Wildlife Society.

130. Leston, L. and A. D. Rodewald. 2005. Habitat selection by Northern Cardinals in urban and rural riparian forests. Annual Meeting of Wilson Ornithological Society and Association of Field Ornithologists.

131. Rodewald, A. D. and A. C. Vitz. 2005. Edge and area sensitivity of shrubland birds. Ohio Fish and Wildlife Management Conference.

132. Leston, L. and A. D. Rodewald. 2005. Habitat selection by Northern Cardinals in urban and rural riparian forests. Ohio Fish and Wildlife Management Conference.

133. Vitz, A. C. and A. D. Rodewald. 2005. Post-breeding ecology of mature forest birds. Ohio Fish and Wildlife Management Conference.

134. Bakermans, M. H. and A. D Rodewald. 2005. Multiscale habitat selection of Acadian Flycatchers. Ohio Fish and Wildlife Management Conference.

135. Rodewald, A. D. and A. C. Vitz. 2004. Edge and area sensitivity of shrubland birds. Midwest Fish and Wildlife Conference.

136. Leston, L. and A. D. Rodewald. 2004. Habitat selection by Northern Cardinals in urban and rural riparian forests. Midwest Fish and Wildlife Conference.

137. Rodewald, A. D. and A. C. Vitz. 2004. Edge and area sensitivity of shrubland birds. 122st Stated Meeting of the American Ornithologists' Union.

138. Leston, L. and A. D. Rodewald. 2004. Habitat selection by Northern Cardinals in urban and rural riparian forests. Annual Meeting of Wilson Ornithological Society and Association of Field Ornithologists.

139. Rodewald, A. D. 2003. Multiscale influences of landscape matrix composition on bird communities within forested landscapes. Annual Meeting of The Wildlife Society.

140. Vitz, A. C. and A. D. Rodewald. 2003. Post-breeding ecology of mature forest birds. 121st Stated Meeting of the American Ornithologists' Union.

141. Atchison, K. A. and A. D. Rodewald. 2003. Influence of landscape matrix, microclimate, and habitat on wintering birds in riparian forests. 121st Stated Meeting of the American Ornithologists' Union.

142. Santiago, M. J., A. D. Rodewald, and P. G. Rodewald. 2003. Suitability of golf courses as breeding habitat for Red-headed Woodpecker. 121st Stated Meeting of the American Ornithologists' Union.

143. Vitz, A. C. and A. D. Rodewald. 2003. Post-breeding use of regenerating clearcuts by mature forest birds. Cooper Ornithological Society Meeting.

144. Atchison, K. A. and A. D. Rodewald. 2003. Influence of landscape matrix, microclimate, and habitat on wintering birds in riparian forests. Annual Meetings of Wilson Ornithological Society and American Field Ornithologists.

145. Bakermans, M H. and A. D. Rodewald. 2003. Underlying mechanisms of landscape sensitivity in Acadian Flycatchers. Annual Meetings of Wilson Ornithological Society and American Field Ornithologists.

146. Vitz, A. C. and A. D. Rodewald. 2003. Post-breeding use of regenerating clearcuts by mature forest birds. Annual Meetings of Wilson Ornithological Society and American Field Ornithologists.

147. Atchison, K. A. and A. D. Rodewald. 2003. Influence of landscape matrix, microclimate, and habitat on wintering birds in riparian forests. Ohio Fish and Wildlife Management Conference.

148. Atchison, K. A. and A. D. Rodewald. 2002. Influence of landscape matrix, microclimate, and habitat on wintering birds in riparian forests. North American Ornithological Conference.

149. Bakermans, M. H. and A. D. Rodewald. 2002. Acadian Flycatchers in Midwestern riparian forests - local and landscape-level patterns. North American Ornithological Conference.

150. Borgmann, K. L. and A. D. Rodewald. 2002. Landscape-mediated invasion by exotic shrubs: effects on breeding birds. North American Ornithological Conference.

151. Borgmann, K. L. and A. D. Rodewald. 2002. Influence of landscape context on the amount of exotic shrub cover in riparian forests: implications for breeding birds. Annual Meetings of Wilson Ornithological Society and American Field Ornithologists. [received Best Student Paper Award]

152. Bakermans, M. J. and A. D. Rodewald. 2002. Local and landscape effects on Acadian Flycatchers in riparian forests. Annual Meetings of Wilson Ornithological Society and American Field Ornithologists.

153. Rodewald, A.D. 2001. Multiscale effects on avian nesting success in forested landscapes. Annual Meeting of The Wildlife Society.

154. Rodewald, A. D. 2001. Floristics and avian community structure: implications for regional changes in forest composition. 119th Stated Meeting of the American Ornithologists' Union and the Society of Canadian Ornithologists.

155. Rodewald, A. D. 2001. Avian nesting success in forested landscapes: local vs. landscape effects. 57th Northeast Fish and Wildlife Conference.

156. Rodewald, A. D. 2001. Floristics and avian community structure: implications for regional changes in forest composition. Ohio Fish and Wildlife Conference.

157. Rodewald, A. D. and R. H. Yahner. 2000. Avian nesting success in forested landscapes: the influence of landscape composition, local habitat, and biotic interactions. 118th Stated Meeting of the American Ornithologists' Union.

158. Rodewald, A. D. and R. H. Yahner. 1999. Influence of landscape composition on forest birds. Annual Meeting of The Wildlife Society.

159. Rodewald, A. D. and R. H. Yahner. 1999. Effects of landscape composition on forest birds and associated mechanisms. 117th Stated Meeting of the American Ornithologists' Union.

160. Rodewald, A. D. and R. H. Yahner. 1999. Effects of a new forest-management practice and landscape composition on woodland salamander communities. Joint Meeting of the American Society of Ichthyologists and Herpetologists, American Elasmobranch Society, Herpetologists' League, and Society for the Study of Amphibians and Reptiles.

161. Rodewald, A. D. and R. H. Yahner. 1998. Influence of adjacent habitat disturbance on forest birds. Annual Meeting of The Wildlife Society.

162. Rodewald, A. D. and R. H. Yahner. 1998. Influence of adjacent habitat disturbance on forest birds. North American Ornithological Conference.

163. Dumin, A. [Rodewald] 1994. Effects of gravidity on habitat use and antipredator behavior in threespine stickleback Conference on Ecological and Evolutionary Ethology of Fishes.

164. Dumin, A. [Rodewald]. 1994. Effects of gravidity on habitat use and antipredator behavior in threespine stickleback. Animal Behavior Society Meetings.

TEACHING

PHILOSOPHY:

I have been teaching at the university level since I first entered graduate school in 1993. Both my philosophy and approach continue to evolve as I develop as an educator. Over time, I have shifted my view from a teaching-focused to a learning-focused perspective. I understand that as an educator I must facilitate student learning by (1) using a variety of teaching techniques in order to engage students with different learning styles, (2) working actively and collaboratively with students both within and outside of the classroom, (3) instilling enthusiasm and the desire to learn in students through my own example, (4) creating a sense of community within the classroom that encourages open dialogue and learning, (5) promoting critical thinking and analysis through problem-solving and experiential learning activities, (6) stimulating self-discovery and reflection related to contemporary ecological and environmental issues, and (7) mentoring students in their professional aspirations.

COURSES TAUGHT:

Undergraduate courses

Introduction to Conservation Biology. NTRES/EEB 2670. Biological, ecological, evolutionary, and social science principles that guide the conservation of biological diversity. Overview of threats to biodiversity, sustainable use, habitat management, ecological restoration, reserve design, landscape ecology, consumptive and non-consumptive use, adaptive management, and species recovery.

Conservation with Communities. NTRES 4940. Integration of life sciences, social sciences, medical sciences, and the humanities to explore the concept of “One Health”, the idea that the health of the environment, animals and people are all inextricably linked. The course also serves as a preparatory course for a subset of students who will be selected for international field experiences in Indonesia and Africa to work with communities to conserve endangered rhinoceroses and great apes in partnership with Ujung Kulon National Park and the Jane Goodall Institute, respectively. A fall course will bring together the engaged learning students for a seminar course with mentors and peers. Team-taught course.

Principles of wildlife ecology and management. ENR 623. Biological, ecological, and sociological concepts that serve as the foundation of wildlife management.

Research in avian ecology. ENR H231. Introduction to the scientific process and research methods as commonly applied to avian ecology studies.
*Ecology and conservation of birds (*at OSU Stone Laboratory). ENR 230. Field-based course that introduces students to avian ecology and conservation. Heavy emphasis on field identification and individual research projects.
Introduction to the study of birds (at OSU Stone Laboratory). EEOB 126. Avian evolution, biology, ecology, and conservation; research techniques used in avian studies; and identification of birds.
Introduction to forestry, fisheries, and wildlife. ENR 319. Introduction to the ecological and sociopolitical principles guiding management of fish, wildlife, and forests. Team-taught course.
Ornithology (Penn State). Avian evolution, physiology, morphology, biology, ecology, and conservation.

Graduate courses

Controversial Conservation Topics Seminar. NTRES 6940. Discuss & debate the science and public discourse surrounding controversial conservation topics; explore feedbacks among science, policy, management, and public perceptions. The four topics are: status of global fisheries, ecosystem reference baselines, monetization of nature, and conservation triage. Team-taught course.
Drafting a conservation blueprint: approaches for regional conservation planning. ENR 899.06. Conservation planning within the context of ecological and sociopolitical complexity (with Dr. Deni Porej, The Nature Conservancy).
Applied ecology and environmental policy in urbanizing communities. ENR 899. Address ecological and sociopolitical underpinnings of urban environmental policy and planning through a combination of lectures, discussions, and group projects. Team-taught course with group projects.
Managing wildlife metapopulations. ENR 894. Applying metapopulation and landscape ecology theory to wildlife management (with Dr. Scott Hull, Ohio Div of Wildlife).
Readings in landscape ecology. ENR 894. Principles, methods, and applications of landscape ecology.
Advanced wildlife ecology. ENR 894. Concepts in population, community, and landscape ecology related to wildlife conservation and management.
Graduate research colloquium. ENR 897. Forum to present graduate research proposals.
Research in natural resources. ENR 800. Seminar to introduce new graduate students to research.
Sustaining natural resources in a world of six billion (Penn State). Natural resource management and agricultural sustainability with an ever-increasing human population. Team taught

Laboratories

Principles of Wildlife Management, PSU
Wildlife Population Dynamics, PSU
General Biology, UA
General Ecology, UA

Global Online Course

- Lecture for *Environmental Education: Trans-disciplinary Approaches to Addressing Wicked Problems* (http://www.globalee.net/). 3300 enrolled. Spring 2016.

First-year Experience Seminars

- Birds & Beans: How your consumer choices about coffee affect bird conservation. 2010.

Non-university short courses or workshops for K-12 students

- Neotropical migratory birds, COSI Electronic Experts broadcast to schools across Ohio, 2004-2006.
- Techniques in wildlife research, WISE (Women in Science and Engineering) Camp at The Wilds.
- Population ecology, "*Expanding Your Horizons*" Conference for 7th-9th grade girls.

- Research approaches in wildlife ecology, Nittany Science Camp for Girls.

Courses for Professionals and Managers

- Coinstructor for *Curso Internacional de Campo: Ecología de Aves Migratorias Neotropicales* in San Vicente de Chucurí, Santander – Colombia from October 2008.
- Coinstructor, *Wildlife habitat management on golf courses,* Invited full-day workshop at Annual Conference of Golf Course Superintendents Association of America (GCSAA), New Orleans, 2009.
- Coinstructor, *Wildlife habitat management on golf courses,* Invited full-day workshop at Annual Conference of Golf Course Superintendents Association of America (GCSAA), San Diego, 2010.

ADVISING:

Completed (18 MS, 8 PhD)

1. Kathi L. Borgmann, M.S. in Natural Resources. Fall 2002. Invasion of riparian forests by exotic shrubs: effects of landscape matrix and implications for breeding birds.
2. Marja H. Bakermans, M.S. in Natural Resources. Winter 2003. Hierarchical habitat selection in the Acadian Flycatcher: implications for conservation of riparian forests.
3. Kelly A. Atchison, M.S. in Environmental Science. Summer 2003. Community structure and behavior of wintering birds in riparian forests: relationships with landscape matrix, microclimate, and local habitat.
4. Andrew Vitz, M.S. in Natural Resources. Fall 2003. Habitat use of regenerating clearcuts by mature-forest birds during the post-breeding period.
5. Melissa J. Santiago, M.S. in Natural Resources. Winter 2004. Golf courses as habitat for an oak-savanna specialist: the Red-headed Woodpecker.
6. Lionel Leston, M.S. in Natural Resources. Summer 2005. Are urban riparian forests ecological traps for understory birds? Habitat selection by Northern Cardinals (Cardinalis cardinalis) in urbanizing landscapes.
7. Nancy Sundell-Turner, M.S. in Natural Resources. Fall 2006. Strategies to optimize conservation planning in urbanizing landscapes.
8. Bret Graves, M.S. in Natural Resources. Summer 2007. Grassland bird conservation on reclaimed surface mines: evaluating the influence of vegetation structure on distribution, nest placement, and nesting success.
9. Jennifer Smith-Castro, M.S. in Natural Resources. Winter 2008. Impacts of recreational trails on breeding birds in forested urban parks.
10. Marja Bakermans, Ph.D. in Natural Resources. Spring 2008. Demography and habitat use of Cerulean Warblers on breeding and wintering grounds.
11. Sarah Lehnen, Ph.D. in Natural Resources. Spring 2008. An evaluation of survivorship and habitat use of early-successional birds during the breeding season: implications for conservation.
12. Andrew Vitz, Ph.D. in Natural Resources. Spring 2008. Survivorship, habitat use, and movements for two species of mature forest birds during the post-fledging period.
13. Daniel P. Shustack, Ph.D. in Natural Resources. Summer 2008. Reproductive timing of passerines in urbanizing landscapes.
14. Felicity Newell, M.S. in Environment & Natural Resources. Spring 2010. A bird's eye view of the forest: how does canopy openness affect canopy songbirds?
15. Ian Ausprey, M.S. in Environment & Natural Resources. Spring 2010. Post-fledging ecology of two songbird species across a rural-to-urban landscape gradient.
16. Gabriel Colorado, Ph.D. in Environment & Natural Resources. Fall 2010. Ecology and conservation of Neotropical-Nearctic migratory birds and mixed-species flocks in the Andes.
17. Jennifer Thieme, M.S. in Environment & Natural Resources. Summer 2011. Behavioral and reproductive consequences of predator activity to grassland birds.

18. Benjamin Padilla, M.S. in Environment & Natural Resources. Avian metapopulations in an urbanizing landscape. Spring 2012.
19. Desiree Narango, M.S. in Environment & Natural Resources. Causes and consequences of urban-associated song variation: a study of vocal behavior in the Northern Cardinal (*Cardinalis cardinalis*) Spring 2012.
20. Laura Kearns, Ph.D. in Environment & Natural Resources. Avian responses to predator communities in fragmented, urbanizing landscapes. Spring 2012.
21. Linnea Rowse, M.S. in Environment & Natural Resources. Pathways and Consequences of Contaminant Flux to Acadian Flycatchers (*Empidonax virescens*) in Urbanizing Landscapes of Ohio, USA. Summer 2013.
22. Molly McDermott, Ph.D. in Environment & Natural Resources, Ohio State University. The Contribution of Agroforestry Systems to Bird Conservation in the Andes. Spring 2014.
23. Jennifer Malpass, Ph.D. in Environment & Natural Resources, Ohio State University. Effects of Food and Vegetation on Breeding Birds and Nest Predators in the Suburban Matrix. Fall 2015.
24. Gemara Gifford, M.S. in Natural Resources, Cornell University. Agroecosystems for communities and conservation: linking bird conservation and sustainable livelihoods in the Highlands of Guatemala. Fall 2015.
25. Rose Swift, M.S. in Natural Resources, Cornell University. Nest site selection in Hudsonian Godwits: effects of habitat and predation risk. Fall 2015.
26. Steven Sevillano. M.S. in Natural Resources, Cornell University. Diversity, ecology, and conservation of bird communities of *Polylepis* woodlands in the High Andes of Peru. Spring 2016.
27. Rose Swift, Ph.D. in Natural Resources, Cornell University. A world of decisions: how choices throughout the annual cycle affect survival, condition, and performance of a migratory shorebird. Spring 2018.

Current
1. Ruth Bennett, Ph.D. in Natural Resources, Cornell University
2. Stephen Sevillano, Ph.D. in Natural Resources, Cornell University
3. DJ McNeil, PhD. in Natural Resources, Cornell University
4. Bryant Dossman, PhD. in Natural Resources, Cornell University
5. Gerardo Soto, PhD. in Natural Resources, Cornell University
6. Anna Lello-Smith, Ph.D. in Natural Resources, Cornell University

- Advisor to undergraduate wildlife majors in School of Environment and Natural Resources at Ohio State (2000-2013) and in Environmental and Sustainability Sciences at Cornell (2013 to present).
- Advisor to Ohio State Chapter of Roots and Shoots, 2004-2006.
- Co-advisor to Student Chapter of The Wildlife Society, The Ohio State University, 2001-2004.

OUTREACH AND ENGAGEMENT

PHILOSOPHY:

Conservation has been practiced for decades, yet biodiversity continues to be lost at alarming rates. Our record of conservation accomplishment lags, in part because the best science is not always applied to the problems we face. We must close the gap between science and decision-making if we are to effectively address global challenges and get the best return on our conservation investments. As an ecologist and conservation biologist, I advocate for the use of science in planning, policy, and decision-making processes, and I seek ways to engage the various players in productive discourse to promote a shared understanding of issues, problems, and solutions. My approach is to work collaboratively with decision-makers, communities of practitioners, the private sector, and the public with the goals of bringing science into the decision-making process, developing approaches that are sensitive to both social and environmental needs, and achieving mutually beneficial outcomes.

REPRESENTATIVE OUTREACH ACTIVITIES:

(>175 outreach programs and/or presentations since 2000)

Selected film and radio:

- Radical collaborations. 2017. Cornell University. https://www.youtube.com/watch?v=CvwHtI_-2pI
- Conservation Science & Shade Coffee. 2017. Cornell Lab of Ornithology. https://www.youtube.com/watch?v=b9fZRPgl0tE
- Accelerating the speed of scientific discovery! 2016. Microsoft Education https://www.youtube.com/watch?v=OHilG8DjPCY&feature=youtu.be
- Shade-Grown Coffee Sustains Songbirds and People Alike. 2016. Cornell Lab of Ornithology. Two embedded short films at https://www.allaboutbirds.org/in-colombia-shade-grown-coffee-sustains-songbirds-and-people-alike/
    - Bird Research and Shade-grown Coffee
    - Economics of Sustainable Coffee
- Conserving migratory birds. Worldview. WBEZ Chicago radio. 2016. https://www.wbez.org/shows/worldview/survival-threats-faced-by-migratory-birds/a2b5b5bf-6a16-4867-bc0d-4f21f0069668
- Birds vs. Cats. How on Earth science show, KGNU radio Boulder/Denver. 2015. http://howonearthradio.org/?s=Rodewald
- Interviews with a wide variety of media outlets, including NPR, Washington Post, CBC, Science, USA TODAY, Reveal – Center for Investigative Reporting, Science Daily, Scientific American, National Geographic, Smithsonian Magazine, Science Times, Bloomberg News, Houston Chronicle, Columbus Dispatch, Plain Dealer, InsideClimate News, Deutsche Welle, Press Herald, Knoxville News Sentinel, Scienceline, Salon, Popular Science, Sierra Magazine,

Invited talks for general audiences:

- Conservation in Action panel at National Geographic's DC headquarters for the Year of the Bird. 2018. Other panelists included President of National Audubon Society, CEO of BirdLife International, and Chief Scientist for National Geographic. https://livestream.com/accounts/19771815/events/8040439
- Coffee, communities, and conservation: how your cup can make a difference. 2018. Presented to two Cornell Alumni Clubs in Sarasota and Naples, Florida
- In the thick of it: how invasive shrubs affect breeding birds. Cayuga Bird Club. 2017.
- Birds & beans: coffee's role in conservation. Ithaca Garden Club. 2017.
- Coffee, Communities, and Conservation. President's Circle event at New York City Center. 2017 (Cornell's premier fundraising event)
- Aves,Carreras Profesionales,y Conservación Workshop, NY. 2016. Café y aves: cómo el café puede contribuir a la conservación.
- BirdSleuth workshop for teachers, Jardin, Colombia. 2016. Café y aves: cómo el café puede contribuir a la conservación.
- Salish Sea Bird Symposium, 2015. *eBird as a conservation tool.*
- Lorain County High School Day at Ashland University, 2014. *Birds and beans: how your cup of coffee can make a difference.*
- Copper County Audubon Club, 2013. *A bird of two worlds: the challenge of conserving the Cerulean Warbler.*

- The Biggest Week in American Birding Festival, 2013. Evening Keynote: *Singing the blues: the plight of the Cerulean Warbler.*
- Kentucky Ornithological Society Spring Meeting, 2013. Keynote: *Singing the blues: the plight of the Cerulean Warbler.*
- Cornell Lab of Ornithology – Monday night seminar series, 2013. *A bird of two worlds: the challenge of conserving the Cerulean Warbler.*
- Holden Arboretum, Spring Scientist Series, 2011. *Fragmentation and the fate of forest interior birds: keeping a big picture perspective in a small-patch world.* (~75 attendees)
- Seventh-Annual Conservation Symposium at The Cleveland Museum of Natural History, 2010. *A bird's eye view of the city: Bird conservation in an urbanizing world.* (~200 attendees)
- Midwest Birding Symposium, 2009. S*inging the blues: the challenge of conserving the Cerulean Warbler*. (~300 attendees)
- Ohio Wildlife Diversity Conference, 2009. *Singing the blues: the plight of the Cerulean Warbler.* (~800 attendees)
- Black River Audubon Society, 2009. *A bird of two worlds: the challenge of conserving the Cerulean Warbler*.(~40 attendees)
- Columbus Natural History Society, 2008. *A bird of two worlds: the challenge of conserving the Cerulean Warbler.* (~50 attendees)
- Delaware Bird Club, 2006. *Conserving early and late successional birds in Ohio.* (~30 attendees)
- Ohio Bird Banding Association, 2006. *Balancing the needs of early and late successional birds.* (~40 attendees)
- Ohio Horticultural Society, *Wildlife-friendly gardening and landscaping.* 2005. (~30 attendees)
- Ohio Wildlife Diversity Conference, 2004. *Protecting Ohio's riparian forest wildlife.* (~500 attendees)
- Simply Living Conference, 2002 and 2001. *Go Wild: attracting birds, bees, and butterflies to your backyard.* (~100 attendees in 2002, 75 in 2001)

<u>Invited talks for regional or statewide bird conservation initiatives and efforts:</u>
- Ohio Biodiversity Conservation Partnership meeting, 2012. *Linking science and management to conserve Ohio's forest birds.* (~50 attendees)
- Ohio Ornithological Society Conservation Conference, 2007. *A bird of two worlds: the challenge of conserving the Cerulean Warbler*. (~150 attendees)
- Ohio Avian Ecology and Conservation Conference, 2007. *Towards a mechanistic understanding of urban-associated changes in bird communities.* (~200 attendees)
- Ohio Audubon Assembly, 2005. *Conserving Ohio's riparian forests: lessons from the birds.* (~200 attendees)
- Northeast Ohio Forest Bird Conservation Workshop (through Ohio BCI), 2005. *Challenges and opportunities for forest bird conservation in Northeast Ohio.* (~150 attendees)
- Ohio Bird Conservation Initiative Workshop, 2004. *Conserving Ohio's forest birds.* (~100 attendees)
- Ohio Avian Ecology and Conservation Conference, 2003. *Shrubland birds of Ohio.* (~150 attendees)
- Ohio Avian Ecology and Conservation Conference, 2001. *Influence of landscape composition, microhabitat, and biotic interactions on avian nesting success.* (~250 attendees)

<u>Invited talks for land managers and natural resource professionals:</u>
- Redamerica por las aves. Panel Virtual "Aves, Conservación y Políticas Publicas. 2018. *Café y aves: cómo el café puede contribuir a la conservación*

- Making better conservation decisions in British Columbia. Vancouver, BC. 2015. *Prioritizing conservation in the coastal Douglas fir zone: making strategic investments.*(Arcese, Schuster, &Rodewald).
- Conservation Connections Forum organized by Habitat Acquisition Trust of BC. Vancouver Island, BC. 2015. *Strategic conservation in dynamic & incentive-based systems.*
- Workshop for Cross-boundary planning for resilience & restoration of endangered oak savannah and coastal Douglas-fir forest ecosystems. Friday Harbor, WA. 2015. *eBird as a conservation tool.*
- Ohio Fish and Wildlife Presentation Series, 2014. *Managing forest birds. (*A webinar with ~40 attendees)
- Annual Meeting of Ohio Society of American Foresters, 2011. *Integrating management for oak regeneration and forest bird conservation.* (~100 attendees)
- Five Rivers Metropark Trails Symposium, 2011. *Impacts of trails on wildlife.* (~100 attendees)
- Annual Conference of Golf Course Superintendents Association of America (GCSAA), *Wildlife habitat management on golf courses,* Invited full-day workshop, San Diego, 2010. (~50 participants)
- Annual Conference of Golf Course Superintendents Association of America (GCSAA), *Wildlife habitat management on golf courses,* Invited full-day workshop, New Orleans, 2009. (~75 participants)
- Ecological Landscaping Conference, 2007. *Population and behavioral responses of birds to urbanization.* (~300 attendees)
- Midwest Deer and Turkey Biologists Meeting, 2007. *Balancing the needs of early- and late-successional species in forested landscapes.* (~75 attendees)
- Annual Meeting of Ohio Society of American Foresters, 2007. *An opportunity in disguise: can conservation of Cerulean Warblers help us to restore Appalachian oak forests?* (~100 attendees)
  - Annual Meeting of Ohio Society of American Foresters, 2006. *Silvicultural impacts on forest birds.* (~75 attendees)
  - Statewide conference for natural resource professionals and land managers, 2003. *Natural resource*
  - *management and wildlife habitat enhancement on public open spaces* (85 paid registrants; conference organizer and presenter).
  - Ohio Parks and Recreation Association, Annual Conference, 2003. *Developing and implementing wildlife habitat enhancement plans.* (workshop organizer and presenter; ~75 attendees).
  - Watershed Coalitions, 2002-2004. *Riparian forest wildlife*. Various locations in Ohio. (~30-50 attendees)
- Ohio Watershed Leaders Workshop, 2003. *Riparian forest wildlife.* (~35 attendees)
  - Ohio Department of Natural Resources Seminar Series, 2003. *Forest management and Ohio's wildlife.* 2003. (~25 attendees)
  - Ohio Department of Natural Resources – Division of Wildlife District Meetings, 2002-2003. *Managing for riparian forest birds.* (~30-60 attendees)
- Ohio Turfgrass Foundation Conference, 2002. *Creating wildlife habitats*. (~100 attendees)

<u>Invited talks for private forest landowners:</u>

- Eastern Ohio Forest Wildlife Conference, *Managing for forest songbirds.* 2001-2003. (~100 attendees)
- Ohio Woodland Stewards Program, *Incorporating wildlife needs into forest management plans* and *Wildlife habitat walk.* Various locations throughout Ohio, 2000-2004. (~25-50 attendees in each program)
- Ohio Woodland Stewards Program, 2003. *Exploring your forest.* (~100 attendees)

- Annual Meeting of the Ohio Woodland Owners' Association, *Forest fragmentation and Ohio's wildlife,* 2001. (~100 attendees)
- Woodland Owners Interest Groups (located throughout Ohio), *Incorporating wildlife needs into forest management plans and Managing forest wildlife,* 2001-2003. (~25-50 attendees per program)
- Capital Live, Alabama Forest Owners' Association, Inc. Live News Conference, *How do agricultural and silvicultural openings affect forest wildlife*? 2002.

Appendix 9

Ecosystem Representation on the Wayne National Forest. Methods and results.

Analyzed by The Wilderness Society, December 2018.

I. Methods and Analysis of Ecosystem Representation

We conducted an analysis of ecosystem representation in wilderness at the national- and forest-level scales to provide the best available scientific information for the ongoing wilderness evaluation and forest planning processes.

According to the U.S. Geological Survey (USGS), the contiguous United States contains 565 terrestrial, non-developed ecosystems. In this study, we analyzed representation of those ecosystems by comparing their areas in the NWPS with their areas on federal land at the national level in order to calculate a percent representation:

Equation 1: *(area of ecosystem in the NWPS/area of ecosystem on federal land)*100*[1]

We conducted these calculations at the finest scale for which consistent, spatially-explicit vegetative land-cover data is available: the 6th level of the National Vegetation Classification System (NVCS 2008).[2] That data is from the USGS Gap Analysis Program (GAP) national land-cover data version 2 at 30-meter resolution (USGS 2011).

We obtained spatial data of the NWPS from the University of Montana College of Forestry and Conservation's Wilderness Institute at wilderness.net, which maintains the most up-to-date spatial data on wilderness areas. To map federal land area, we used the U.S. Protected Areas Database (PAD-US) version 1.3 (USGS 2012), which includes geographic boundaries, land ownership, land management, management designation, parcel name, area, and protection category.[3]

---

[1] We used federal land, as opposed to all land, within the contiguous United States to better assess where ecosystems are under-represented on lands potentially available for wilderness designation.

[2] The NVCS classifications are as follows: 1) Class; 2) Subclass; 3) Formation; 4) Division; 5) Macrogroup; 6) Group (a.k.a. ecological system, to which we refer in this study as "ecosystem"); 7) Alliance; and 8) Association.

[3] The PAD-US is a national inventory of terrestrial and marine protected areas that are managed to preserve biological diversity and other natural, recreation, and cultural uses.

We overlaid the NWPS and all federal lands with land-cover data in a Geographic Information System (ArcGIS 10.4) to calculate and compare the total area of each ecosystem within the NWPS and federal land. We then calculated the percent of each ecosystem within the NWPS based on all area occurring on federal land (Equation 1, above).[4] This was part of a national assessment that we conducted (Dietz *et al.* 2015).

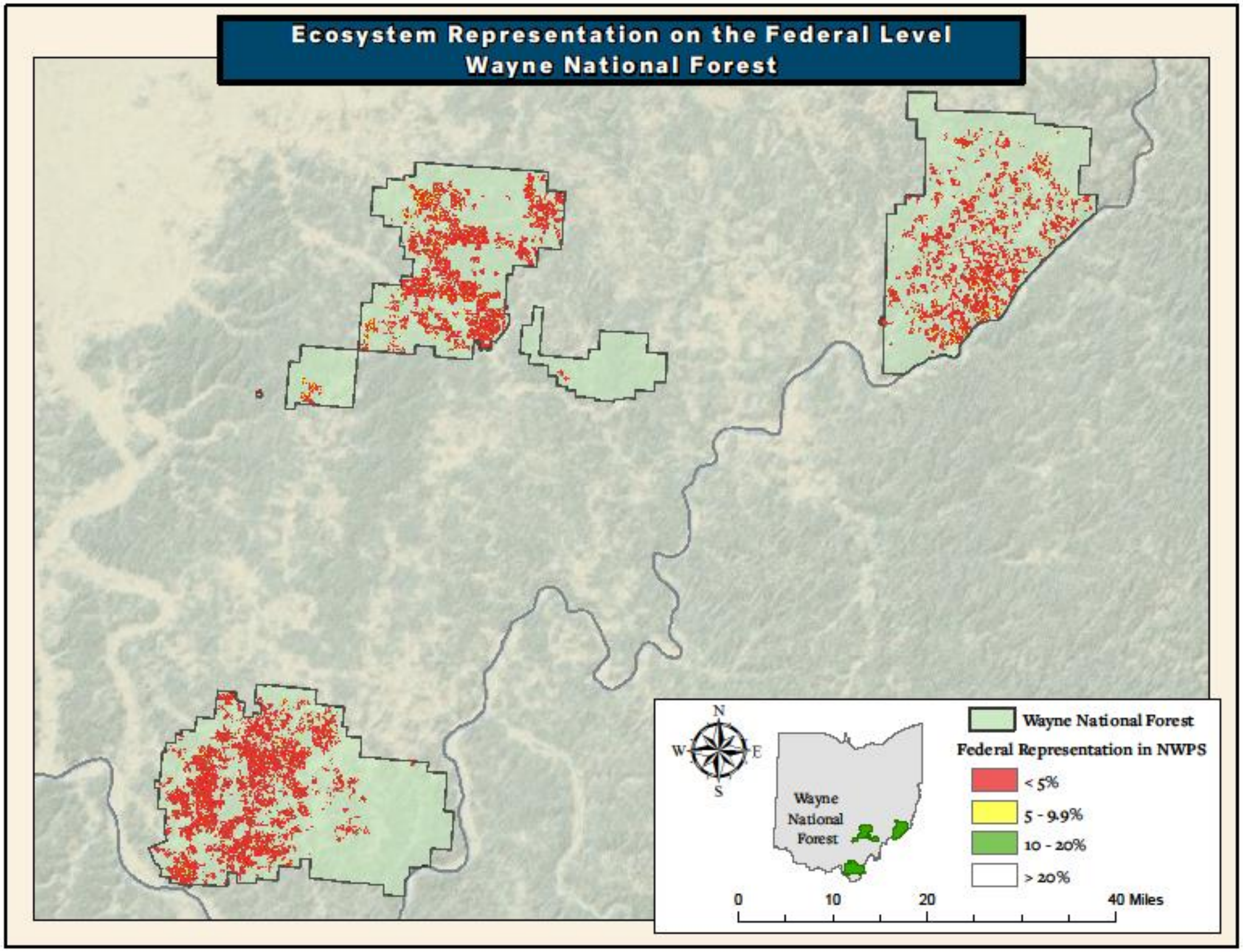
At the forest level, we extracted land-cover data and clipped it to the forest boundary. Next we classified representation for each ecosystem into four classes (<5%, 5-9.9%, 10-19.9%, ≥20%) and mapped them across the entire national forest. We considered ecosystems with <19.9% of their total area in the NWPS as inadequately represented.

[4] For example, when we say "boreal aspen-birch forest has 19% representation in NWPS," we mean that 19% of all federal land encompassing that ecosystem type is protected as wilderness in the NWPS.

II. Results

The representation of Wayne National Forest ecosystems in the National Wilderness Preservation System					
Ecosystem	**Acres in Federal Wilderness**	**Acres in Federal Lands**	**Acres on the Wayne National Forest**	**Representation in Wilderness at the Federal Scale**	**Representation Category**
Allegheny-Cumberland Dry Oak Forest and Woodland – Hardwood	9,075	484,074	96,408	1.9	0 – 5
Central Appalachian Pine-Oak Rocky Woodland	385	29,109	37	1.3	0 – 5
Central Interior and Appalachian Floodplain Systems	318	92,245	4,670	0.3	0 – 5
Central Interior and Appalachian Shrub-Herbaceous Wetland Systems	1,567	37,747	28	4.2	0 – 5
North-Central Interior Beech-Maple Forest	0	9,660	298	0.0	0 – 5
North-Central Interior Dry-Mesic Oak Forest and Woodland	36	28,543	30	0.1	0 – 5
North-Central Interior Wet Flatwoods	21	1,905	3	1.1	0 – 5
Northeastern Interior Dry-Mesic Oak Forest	3,264	115,779	16,986	2.8	0 – 5
South-Central Interior Mesophytic Forest	22,251	466,897	77,429	4.8	0 – 5
Appalachian Hemlock-Hardwood Forest	105,829	1,192,821	10,555	8.9	5 – 10
Central Interior and Appalachian Riparian Systems	733	7,916	644	9.3	5 – 10
Central Interior Highlands Calcareous Glade and Barrens	7,206	73,634	49	9.8	5 – 10
South-Central Interior Small Stream and Riparian	4,497	51,390	772	8.7	5 – 10
Allegheny-Cumberland Dry Oak Forest and Woodland - Pine Modifier	1,072	10,352	514	10.4	10 – 20
North-Central Interior and Appalachian Rich Swamp	6,378	59,250	60	10.8	10 – 20

Allegheny-Cumberland Dry Oak Forest and Woodland - Pine Modifier	1,072	10,352	514	10.4	10 – 20
North-Central Interior and Appalachian Rich Swamp	6,378	59,250	60	10.8	10 – 20
Cultivated Cropland	5,331	1,510,551	1,981	NA	NA
Developed, High Intensity	5,327	274,810	4,774	NA	NA
Developed, Low Intensity	13,198	507,836	828	NA	NA
Developed, Medium Intensity	2,680	125,721	88	NA	NA
Developed, Open Space	49,140	1,866,110	6,454	NA	NA
Disturbed, Non-specific	6,155	142,409	74	NA	NA
Harvested Forest - Grass/Forb Regeneration	19,897	485,950	3,105	NA	NA
Harvested Forest-Shrub Regeneration	22,759	1,617,522	2,217	NA	NA
Introduced Upland Vegetation - Perennial Grassland and Forbland	2,626	203,539	0	NA	NA
Introduced Upland Vegetation - Treed	558	3,072	5	NA	NA
Managed Tree Plantation	10,566	537,435	1,343	NA	NA
Recently burned grassland	32,037	225,105	34	NA	NA
Undifferentiated Barren Land	7,613	91,593	40	NA	NA
Evergreen Plantation or Managed Pine	18,740	1,172,959	3,069	NA	NA
Pasture/Hay	16,034	1,234,860	9,939	NA	NA
Quarries, Mines, Gravel Pits and Oil Wells	271	54,560	204	NA	NA
Ruderal forest	4,294	139,635	790	NA	NA
Open Water (Fresh)	431,518	3,121,934	721	NA	NA
Total	**818,828**	**16,046,526**	**244,725**		


Ecosystem Representation on the Federal Level
Wayne National Forest
N
W
E
S
Wayne
National
Forest
Wayne National Forest
Federal Representation in NWPS
< 5%
5 - 9.9%
10 - 20%
> 20%
0
10
20
40 Miles