Ruffed Grouse Society & American Woodcock Society

Response to Old Growth RFI (Fed. 87 Fed. Reg. 42493-42494, No. 2022-15185)

August 30, 2022

At the Ruffed Grouse Society & American Woodcock Society, we envision landscapes of diverse, functioning forest ecosystems that provide homes for wildlife and opportunities for people to experience them. Ruffed grouse and American woodcock are bellwethers of forest condition; they can only persist in healthy, diverse forests. These same forests clean the air, filter water, and support local communities. For over sixty years RGS & AWS has supported and advocated for sound, science-based forest and wildlife management.

We appreciate the opportunity to engage in the RFI and offer the following:

Secretary's Memorandum 1077-004 set course to optimize forests for all their values. We commend The Administration for recognizing forests as climate mitigation powerhouses while seeking balance among carbon, wildlife, watersheds, wood products, recreation, and planning efficiency. With stewardship and sound forest management, we can generate "*and*" answers to the challenges cited. It is not a matter of working lands *or* old growth, carbon stewardship *or* wildlife habitat, biodiversity *or* innovate forest product markets. We can accomplish the greatest good for the greatest number in the long run through pragmatic, sustainable forest management.

Shortly following the Secretary's Memo, this RFI focused our attention to one aspect of the memo – old growth. Old forests are one of many important successional stages. We believe that emphasizing old growth (and now adding mature forest) with a broad brush and without respect to forest type, and in a way that places priority over other forest types, may hinder the ability of the USFS to optimize carbon stewardship, resilience, and biodiversity. As the Forest Service moves forward as directed per Executive Order 14072, we offer the information herein to support stewardship of our National Forests, including active management and conservation where science supports their uses. We offer the following general insights:

● Humans are major ecological players and have been for thousands of years. Forest science and professional experience tell us that humans must continue to play an active role in stewarding many natural systems. That over half of the 134 million acres of agency-managed forest is under "protection from management" could limit USFS and BLM ability to respond to climate change and lead to loss of quality old growth and old forest conditions. Adding more acres under a broader umbrella of "mature" is concerning knowing what we know about ecosystem threats and active management approaches that can optimize carbon and climate resilience. Maintaining our ability to steward and manage forests is vitally important to navigate the climate crisis.

● Promoting forest diversity – a shifting mosaic of young, middle-aged, and old forest across landscapes is imperative. To do so, we must view forests as dynamic collections of equally important seral states, not just old growth, and everything else. Biodiversity is maximized when many forest ages are interspersed across landscapes. Again, sound management is essential.

● Carbon stewardship is optimized when forests with relatively high carbon storage (older forests) and forests with relatively high sequestration rates (young, actively growing forests) are interspersed across landscapes. A diverse portfolio of forest ages and structure provides resilient forests and an optimized carbon portfolio (Forest Service Research & Development).

● We understand the public pressures at play. Many of us serve on National Forest advisory councils and stakeholder groups as the debate over carbon takes center stage. A recent publication summarizes the issue relative to climate mitigation, carbon stewardship, and wildlife:

> "What happens when strategies to maximize carbon on the ground do not tidily align with disturbance-oriented strategies to promote habitat for imperiled wildlife species? Many managers are acutely aware of this question as public pressures mount to avoid any forest management that seemingly compromises carbon storage. Even within the growing body of literature that examines the relationship between carbon storage and wildlife habitat or biodiversity, the importance of maintaining heterogeneous habitat conditions is frequently obscured."
>
> "… applying the lens of climate adaptation uncovers apparent trade-offs between carbon and wildlife habitat and illuminates landscape-scale management paths that accommodate both goals, while achieving other co-benefits. In each, promoting habitat for imperiled species is incompatible with maximizing in situ tree carbon storage at the stand scale. But by pursuing a mosaic of habitat conditions at the landscape scale, we protect ecosystem adaptive capacity — and therefore carbon — in the face of change while accommodating a range of species' needs." (Littlefield and D'Amato 2022)

We support a definition framework, and resulting policy, that recognizes and facilitates forest management to optimize carbon stewardship, wildlife habitat, and all co-benefits.

● The framework basis already exists. The 2012 Planning Rule mandated an ecological reference model to evaluate ecological integrity. Natural Range of Variation (NRV) was built as a framework to meet this need. NRV establishes ecozone (i.e., forest type) specific ranges of forest seral classes based on the best available science of historic, pre-Euro-American forest conditions as a baseline. The NRV framework establishes spatial and temporal variation in those conditions based on natural disturbance, within a period of time and geographic area appropriate to a stated goal. A related concept, Historical Range of Variation (HRV), also incorporates historic human disturbance (i.e., Indigenous land-use) with ecological characteristics appropriate for a given management application.

Combined, the NRV and HRV frameworks provide a useful baseline for understanding old growth and mature forest characteristics *and* their variation across community types, site productivity, and geographic regions. Because NRV and HRV are adaptive to spatial and temporal variation, they can accommodate changes in forest composition over time whether from climate, disturbance events, or management. Further, NRV and HRV can capture this information for ALL seral stages, not just old growth and mature forest. NRV and HRV help establish ecozone-specific desired conditions for forest seral stages on National Forests to maintain ecological integrity, including for young, middle-aged, open, late-seral, and old-growth forest conditions. Establishing these desired conditions based on the best available science ensures that our forests have a balanced portfolio of seral classes, and that one condition is not managed at the expense of others. For example, managing for old-growth at the expense of young forests. NRV and HRV tell us that we need biologically significant levels of both.

Our understanding of historic conditions captured in NRV and HRV is imperfect, but NRV and HRV are durable frameworks that can be updated with new information and tailored to the numerous ecosystems and forest communities across Forest Service Regions. An assessment process can also integrate leading-edge guidance on carbon optimization that is being developed across academia and Forest Service Research & Development stations as we speak.

● NRV and HRV assessments are in use on many National Forests today to guide planning and management decisions. Improving this existing system, rather than starting over, will save thousands of staff hours, millions of dollars, and time. Time is not on our side, as urgent action is needed at landscape-scale to increase wildlife habitat diversity and reverse Species of Greatest Conservation Need declines before it's too late. As summarized in Littlefield and D'Amato (2022):

> "It is imperative to recognize that climate change itself is one of the most serious threats facing wildlife, and we do not have the luxury of unlimited time to devise the "perfect" balance of maximizing carbon storage and wildlife habitat across the landscape. Pursuing strategies that critically assess vulnerabilities and risks, explicitly acknowledge trade-offs, and prioritize ecological complexity and landscape heterogeneity may well be the best way to keep carbon out of the atmosphere while protecting wildlife and, in general, hedging our bets in an uncertain future."

● Beyond ecological, there are also many spiritual and cultural reasons that people value forests. However, determining spiritual values and incorporating them in sustainable forest management is a relatively new discipline. Systematic frameworks are few and most evidence is anecdotal. While some people are inspired by hiking in seemingly untouched old growth, others are equally moved by pursuit of game in young forest. Spiritual value might be considered in future policies and planning, but only after the major knowledge gaps are investigated and systematic frameworks developed. Additionally, forest managers' perspectives on spiritual values should be included, although they have been less studied than users' perspectives to date (Pater et al. 2021).

In response to the five specific questions included in the RFI, we offer the following:

1.) What criteria are needed for a universal definition framework that motivates mature and old-growth forest conservation and can be used for planning and adaptive management?

Beyond specific criteria for old-growth and mature forests, the universal definition framework for mature and old-growth forests should be grounded in the Natural Range of Variation (NRV) framework. As required under the 2012 Planning Rule, NRV contextualizes late and old growth forest conditions as part of the full habitat mosaic that's needed to maintain ecological integrity in specific ecological zones (Blankenship et al., 2021; USDA Forest Service, 2012). NRV helps inform desired conditions at the Forest Plan level to ensure that ecological integrity is maintained by ecological zone across a National Forest unit. Under this approach, late and old-growth forest seral stages are managed and maintained within their range of desired conditions established from NRV models. NRV ensures a balanced distribution of young, mid-open, mid-closed, late-open, late-closed, and old growth-open, old growth-closed forest conditions are maintained. Managing for one seral class (e.g., old growth forest) the expense of another seral class (e.g., young forest), would compromise ecological integrity.

Numerous National Forests are already appropriately using NRV to manage and conserve old-growth and mature forests along with other important seral stages and forest structural conditions. For example, as part of its proposed Forest Plan revision, the Nantahala and Pisgah National Forests uses NRV to quantifies the desired extent of old-growth and mature (late) seral stages as well as young and open seral stages and structures (Table 1, Figure 1).

Table 1: Modeled Natural Range of Variation Structural Classes by Ecozone for the Nantahala and Pisgah National Forests (USDA Forest Service, 2020).

Seral Class	Spruce Fir	Northern Hardwood	High Elevation Red Oak	Acidic Cove	Rich Cove	Mesic Oak	Dry Mesic Oak	Dry Oak	Pine Oak Heath	Shortleaf Pine Oak Heath	Alluvial Forest and Floodplain
Young	14-17%	5-7%	14-18%	4-5%	4-5%	4-6%	5-7%	9-22%	11-19%	8-13%	6-8%
Mid-closed	10-11%	17-23%	16-21%	27-32%	27-32%	12-15%	7-9%	2-7%	1-5%	1-4%	30-36%
Mid-open	2-4%	2-3%	11-14%	4-6%	4-6%	12-16%	13-17%	12-19%	34-42%	34-42%	9-14%
Late-closed	9-11%	11-14%	11-13%	9-11%	9-11%	8-10%	7-8%	1-3%	1-5%	1-4%	8-9%
Late-open	5-8%	2-3%	11-13%	1-2%	1-2%	5-7%	7-9%	6-9%	20-27%	22-26%	3-4%
Old growth-closed	36-45%	40-50%	6-10%	46-54%	46-54%	27-34%	22-28%	5-16%	1-3%	1-4%	22-30%
Old growth-open	12-16%	11-14%	18-26%	NA	NA	20-25%	28-33%	40-57%	11-26%	16-29%	9-13%

The NRV framework provides a floor and ceiling of the desired extent of seral classes to attain and maintain ecological integrity for a National Forest unit. For example, the Forest Plan for the Nantahala and Pisgah National Forests established Forest-wide targets of 6-9% young forests, 36-48% open forests, and 57-73% mature forests (including 43-56% old growth forests) as terrestrial wildlife habitat conditions across ecozones (USDA Forest Service, 2022b).

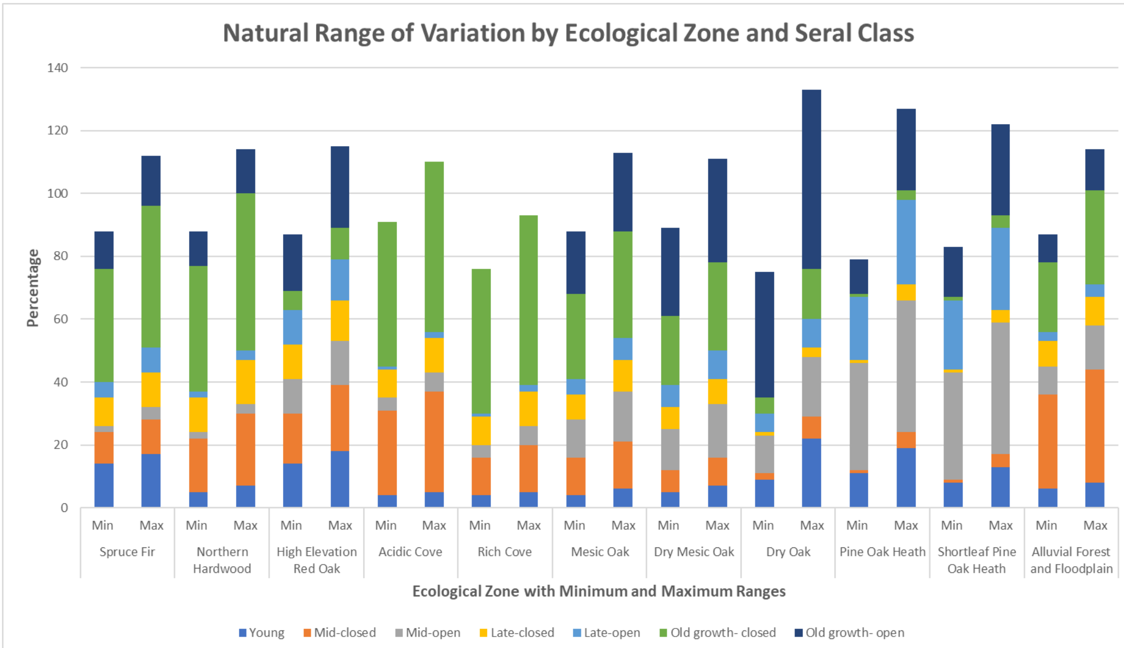

Figure 1: Modeled Natural Range of Variation from the Nantahala and Pisgah National Forests (USDA Forest Service, 2020)

A universal definition framework should consider that the extent of mature and old growth forests established by NRV varies spatially and temporally for a given National Forest unit. Just because ol d growth forests exist in a certain area today, does not mean they will in the future. Using NRV within the definition framework for old-growth and mature forests provides measurable, structural features and biophysical site conditions prepared by local experts and specific to forest types or ecological zones within regions (Spies, 1990).

In addition, forest stand dynamics should be regarded as the ecological context or basis for any universal definition framework of old-growth and mature forests (Franklin et al., 2002, 2007; Oliver, 1978, 1980). An appreciation for the science of forest stand dynamics leads to the understanding that old -growth conditions, while sometimes long lasting, are temporal. Old-growth conditions can be here today but gone tomorrow following a stand-replacing disturbance event. In the Oliver and Larson model, old-growth is one phase of stand development, including stand initiation, stem exclusion, and understory re-initiation. Franklin's model includes additional phases that capture structural changes as forests mature.

The universal definition framework should recognize that old-growth forests were, and are still, rare in regions and ecological zones that experience frequent stand-replacing disturbance events (Spies, 1990). This is especially true in fire-adapted ecosystems across the United States. In fact, there is evidence that the old-growth stage is rarely achieved because of the long time required to reach this stage and because major disturbances often disrupt the forest before this occurs (Oliver, 1980). As forests age, the probability of a stand-replacing disturbance event increases.

2.) What are the overarching old-growth and mature forest characteristics that belong in a definition framework?

Spies developed a framework that includes four ecological characteristics of old-growth forests, 1) development time, 2) patch size, 3) structure, and 4) stability. Multiple general definitions should be developed based on this framework that are ecozone or region-specific (Spies, 1990). This framework considers tree size, longevity, wood decay rate, tolerance of shade and fire, and disturbance frequency, as a starting point.

The fundamental stand dynamics definition of old-growth is an all-aged, late-successional forest dominated by an overstory that gradually dies and the understory slowly fills in to replace (Oliver, 1980). At the old-growth phase, the initial age cohort of trees that regenerated the stand are being replaced by multiples new age cohorts regenerating through small canopy gaps. Eventually, the initial pioneer cohort that establish the stand is replaced entirely by new age cohorts (Franklin et al., 2002).

The old-growth phase of stand development has also been characterized at containing a very high variety of living and dead tree structure, high vertical and horizontal spatial complexity, and very high structural complexity (Franklin et al., 2002).

Evidence suggests that temperate *old-growth* forests around the world exhibit higher densities of large living trees, higher quadratic mean diameters, higher amounts of live aboveground biomass, and higher amounts of coarse woody debris than *mature* forests (Burrascano et al., 2013). Evidence also suggests that old-growth forests share high structural complexity and spatial heterogeneity, including decurrent tree crowns, small canopy gaps (<.5 acres), generally closed-canopy conditions (at least for mesic forest types), dead wood, patchy understories, a dominance of shade tolerant trees, and all-aged or uneven-aged conditions (Lorimer, 1980; Runkle, 1981; Spies, 1990).

Patch size of an old-growth forest is important as it relates to the functional habitat it provides forest wildlife. For example, wood thrush are less likely to benefit from an old-growth patch that is less than 250 acres in size (Lambert et al., 2017).

Landscape context matters when evaluating where old-growth occurs and how it relates to other stand conditions at the landscape-scale. Where old-growth exists on the landscape, it is part of a spatially and temporally interconnected, ever-changing mosaic (Spies, 1990). The proximity and interspersion of seral classes is a key component of mature forest ecological integrity and habitat benefits. Wildlife species that depend on late-successional, within-stand structurally heterogeneous forests also utilize young forest habitat for parts of their life cycle (Lambert et al., 2017; Stoleson, 2013; Wood et al., 2013); and wildlife species that depend on young forests also utilize late-successional forests for part of their life cycle (Jones & Harper, 2004; Norman et al., 2004). Balanced proportions of young, middle-aged, open, mature, and old-growth forests at landscape-scales is what is best for all forest wildlife as part of a win-win-win solution.

3.) How can a definition reflect changes based on disturbance and variation in forest type/composition, climate, site productivity and geographic region?

As detailed herein, the definition framework should rely upon widely-supported data and modeling of the variation and extent of local ecological communities, including NRV, to guide Forest Plan components and to appropriately consider the roles of natural and human disturbances in shaping all forest seral classes, including mature and old-growth forests (Blankenship et al., 2021; USDA Forest Service, 2022a).

NRV and its related dataset Historic Range of Variation (HRV) incorporate historic anthropogenic disturbance, including frequent burning, swidden agriculture, clearing forest land for cultivation and settlement, old field abandonment, and grazing (Greenberg & Collins, 2016). Native Americans and early Euro-American settlers played an important role shaping what is often viewed as the "baseline" ecological condition. Our landscapes were historically heavily impacted by *natural* non-human disturbances and anthropogenic disturbances. Similarly, through the use of NRV and HRV, the universal definition framework should and will recognize the historic role of certain keystone wildlife species that are now extinct or extirpated that were drivers of forest disturbance, including eastern bison, elk, and passenger pigeons in the eastern United States (Greenberg & Collins, 2016).

At the stand-scale, old-growth forests exhibit a fine-scale shifting mosaic of smaller gaps (D'Amato & Orwig, 2008).

A definition should acknowledge that native biodiversity associated with old growth systems connected to disturbance regimes has evolved over time and persisted in juxtaposition to that disturbance. If natural disturbance systems become insufficient, this could impact long-term biodiversity (Newman, 2019).

4.) How can a definition be durable but also accommodate and reflect changes in climate and forest composition?

Adaptation and flexibility allowing managers to respond to current and unforeseen threats will be essential for wildlife, carbon optimization and forest resilience.

A definition should allow for frameworks that incorporate and rely upon adaptive management principles including assess, plan, implement, analyze, adapt and share (Open Standards for the Practice of Conservation, 2020). Further, a definition should consider long-term attributes like adaptive capacity and resilience, that can help provide guidance around changing conditions, threats, and vulnerabilities over time without being over-prescriptive (Gallopin, 2006).

5.) What, if any, forest characteristics should a definition exclude?

A universal definition of old-growth forests should exclude outdated ecological concepts such as "climax forests" or "steady state". These concepts often overlook competitive stand dynamics, shade tolerance, fire exclusion, climate change, and the impact of past land-use history on current stand processes. Similarly, the definition framework should not assume that "virgin forests" as synonymous with mature or old-growth forests. The best available science demonstrates that mature and old-growth forests are seral conditions, regardless of whether they were harvested in the past 100 years.

A definition framework should not assume that there are winners and losers when it relates to wildlife habitat on a landscape-level. It is the full suite of habitat diversity, that attains a biologically significant level of old, middle-aged and young forests, that forest wildlife depend on. NRV makes it clear that it is feasible to attain diverse forest structures and age classes. Forest wildlife traditionally considered "mature forest obligates" that utilize old-growth conditions have been shown to also rely on young forest conditions as a component on the landscape (Boves et al., 2013; Greenberg et al., 2018; Wood et al., 2013). For example, the 40-90 square feet per acre basal area that cerulean warbler depend upon can be provided by either old-growth conditions or shelterwood timber harvests, ideally a combination of both at landscape-scales (Wood et al., 2013). In fact, there is little evidence of forest wildlife species in the eastern United States that rely solely on old-growth forest conditions.

Lastly, a definition should not assume that passive forest management is the only viable pathway for restoring and maintaining old-growth structural conditions. Best available science demonstrates that even "mature forest obligate" wildlife, such as spotted owl, can benefit from certain active forest management practices and integration would likely improve long-term conservation, habitat conditions, and ultimately improve forest resilience (Stephans et al., 2019).

In conclusion, we recommend the approach to landscape-scale forest management planning articulated by Littlefield and D'Amato (2022), which mitigates the stand-level trade-offs between maximizing carbon storage versus wildlife habitat. "What happens when strategies to maximize carbon on the ground do not tidily align with disturbance-oriented strategies to promote habitat for imperiled wildlife species? Many managers are acutely aware of this question as public pressures mount to avoid any forest management that seemingly compromises carbon storage. Even within the growing body of literature that examines the relationship between carbon storage and wildlife habitat or biodiversity, the importance of maintaining heterogeneous habitat conditions is frequently obscured."

"… applying the lens of climate adaptation uncovers apparent trade-offs between carbon and wildlife habitat and illuminates landscape-scale management paths that accommodate both goals, while achieving other co-benefits. In each, promoting habitat for imperiled species is incompatible with maximizing in situ tree carbon storage at the stand scale. But by pursuing a mosaic of habitat conditions at the landscape scale, we protect ecosystem adaptive capacity—and therefore carbon—in the face of change while accommodating a range of species' needs."

We appreciate the opportunity to engage with the Forest Service on the Old Growth and Mature Forest RFI. We look forward to opportunities in the near future to engage on additional, equally important aspects of the Secretary's Memo (i.e., habitat connectivity, accelerating reforestation, creating and sustaining jobs in the forest products sector, forest resilience, imperiled wildlife, etc.).

Sincerely,

Benjamin C. Jones, Ph.D.
President & CEO, Ruffed Grouse Society & American Woodcock Society
benj@ruffedgrousesociety.org
(412) 522-0616.

Works Cited

Anders, A. D., Faaborg, J., & Thompson III, F. R. (1998). Postfledging dispersal, habitat use, and home-range size of juvenile Wood Thrushes. *The Auk*, *115*(2), 349-358.

Barton, A. & Keaton, W. (2018). Ecology and Recovery of Eastern Old Growth Forests. Ch. 6. Island Press.

Blankenship, K., Swaty, R., Hall, K. R., Hagen, S., Pohl, K., Shlisky Hunt, A., Patton, J., Frid, L., & Smith, J. (2021). Vegetation dynamics models: a comprehensive set for natural resource assessment and planning in the United States. Ecosphere, 12(4). https://doi.org/10.1002/ecs2.3484

Boves, T. J., Buehler, D. A., Sheehan, J., Wood, P. B., Rodewald, A. D., Larkin, J. L., Keyser, P. D., Newell, F. L., George, G. A., Bakermans, M. H., Evans, A., Beachy, T. A., McDermott, M. E., Perkins, K. A., White, M., & Wigley, T. B. (2013). Emulating Natural Disturbances for Declining Late-Successional Species: A Case Study of the Consequences for Cerulean Warblers (Setophaga cerulea). PLoS ONE, 8(1). https://doi.org/10.1371/journal.pone.0052107

Burrascano, S., Keeton, W. S., Sabatini, F. M., & Blasi, C. (2013). Commonality and variability in the structural attributes of moist temperate old-growth forests: A global review. Forest Ecology and Management, 291, 458–479. https://doi.org/10.1016/j.foreco.2012.11.020

D'Amato, A. W., & Orwig, D. A. (2008). Stand and landscape-level disturbance dynamics in old-growth forests in Western Massachusetts. Ecological Monographs, 78(4), 507–522. https://doi.org/10.1890/07-0593.1

Dey, D. C. (2014). Sustaining oak forests in eastern North America: regeneration and recruitment, the pillars of sustainability. *Forest Science*, *60*(5), 926-942.

Fiss, C.J., D. J. McNeil, A.D. Rodewald, J.E. Duchamp, and J.L. Larkin. 2020. Post-fledging Golden-winged Warblers require forests with multiple stand developmental stages. Condor https://doi.org/10.1093/condor/duaa052

Franklin, J. F., Mitchell, R. J., & Palik, B. J. (2007). Natural Disturbance and Stand Development Principles for Ecological Forestry, Gen. Tech. Rep. NRS-19, USDA Forest Service, Northern Research Station. 44.

Franklin, J. F., Spies, T. A., Pelt, R. Van, Carey, A. B., Thornburgh, D. A., Berg, D. R., Lindenmayer, D. B., Harmon, M. E., Keeton, W. S., Shaw, D. C., Bible, K., & Chen, J. (2002). Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. Forest Ecology and Management, 155(1–3), 399–423. https://doi.org/10.1016/S0378-1127(01)00575-8

Greenberg, C. H., & Collins, B. S. (2016). Natural Disturbances and Historic Range of Variation: Type, Frequency, Severity, and Post-disturbance Structure in Central Hardwood Forests USA. In Natural Disturbances and Historic Range of Variation (Vol. 32, Issue August). http://link.springer.com/10.1007/978-3-319-21527-3

Greenberg, C. H., Tomcho, J., Livings-Tomcho, A., Lanham, J. D., Waldrop, T. A., Simon, D., & Hagan, D. (2018). Long-term avian response to fire severity, repeated burning, and mechanical fuel reduction in upland hardwood forest. Forest Ecology and Management, 424(May), 367–377. https://doi.org/10.1016/j.foreco.2018.05.014

Hayward, G.D., T.T. Veblen, L.H. Suring, and B. Davis. 2012. Challenges in the application of historical range of variation to conservation and land management. Pp. 32-45 in: J.A. Wiens, G.D. Hayward, H.D. Safford, and C.M. Giffen, eds. Historical environmental variation in conservation and resource management. WileyBlackwell, Oxford, UK.

Jones, B. C., & Harper, C. A. (2004). Ruffed Grouse (Bonasa umbellus) Use of Stands Harvested via Alternative Regeneration Methods in the Southern Appalachians. Proceedings of the 15th Central Hardwood Forest Conference, 4563, 375–382.

Lambert, J. D., Leonardi, B., Winant, G., Harding, C., & Reitsma, L. (2017). Guidelines for managing Wood Thrush and Scarlet Tanager Habitat in the Northeast and Mid-Atlantic Regions. http://highbranchconservation.com/wp-content/uploads/2017/02/Guidelines-for-Managing-Wood-Thrush-and-Scarlet-Tanager-Habitat-in-the-Northeast-and-Mid-Atlantic-Regions-2017.pdf

Landres, P. B., P. Morgan, and F. J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications 9: 1179-1188.

Littlefield, C. E., & D'Amato, A. W. (2022). Identifying trade-offs and opportunities for forest carbon and wildlife using a climate change adaptation lens. Conservation Science and Practice, 4(4), e12631

Lorimer, C. G. (1980). Age Structure and Disturbance History of a Southern Appalachian Virgin Forest. Ecology, 61(5), 1169–1184.

Manley, P. N., G.E. Brogan, C. Cook, C., M.E. Flores, D.G. Fullmer, S. Husare, T.M. Jimerson, L.M. Lux, M.E. McCain, J.A. Rose, G. Schmitt, J.C. Schuyler, and M.J. Skinner. 1995. Sustaining ecosystems: a conceptual framework. Publication R5-EM-TP-001. USDA Forest Service, Pacific Southwest Region, San Francisco, CA.

McNitt, D. C., Alonso, R. S., Cherry, M. J., Fies, M. L., & Kelly, M. J. (2020). Influence of forest disturbance on bobcat resource selection in the central Appalachians. *Forest Ecology and Management*, *465*, 118066.

Morgan, P., G. H. Aplet, J. B. Haufler, H. C. Humphries, M. M. Moore, and W. D. Wilson. 1994. Historical range of variability: a useful tool for evaluating ecosystem change. Journal of Sustainabl e Forestry 2: 87-111.

Norman, G. W., Stauffer, D. F., Sole, J., Allen, T. J., Igo, W. K., Bittner, S., Edwards, J., Kirkpatrick, R. L., Giuliano, W. M., Tefft, B., Harper, C., Buehler, D., Figert, D., Seamster, M., & Swanson, D. (2004). Ruffed Grouse Ecology and Management in the Apalachian Region. Wildlife Restoration, August.

Oliver, C. D. (1978). The Development Of Northern Red Oak In Mixed Stands In Central New England. Yale University EliScholar.

Oliver, C. D. (1980). Forest development in North America following major disturbances. Forest Ecology and Management, 3(C), 153–168. https://doi.org/10.1016/0378-1127(80)90013-4

Pater, C.H., Elands, B.H.M., Verschuuren, B. 2021. Spirituality in Forest Management: A conceptual framework for empirical research. Journal for the Study of Religion, Nature, and Culture. http://doi.org/10.1558/jsrnc.41999

Raybuck, D. W., Larkin, J. L., Stoleson, S. H., & Boves, T. J. (2020). Radio-tracking reveals insight into survival and dynamic habitat selection of fledgling Cerulean Warblers. *The Condor*, *122*(1), duz063.

Runkle, J. R. (1981). Gap Regeneration in Some Old-Growth Forests of the Eastern United States. Ecology, 62(4), 1041–1051.

Schlossberg, S., King, D. I., Destefano, S., & Hartley, M. (2018). Effects of early-successional shrubland management on breeding wood thrush populations. *The Journal of Wildlife Management*, *82*(8), 1572-1581.

Shifley, S. R., Moser, W. K., Nowak, D. J., Miles, P. D., Butler, B. J., Aguilar, F. X., ... & Greenfield, E. J. (2014). Five anthropogenic factors that will radically alter forest conditions and management needs in the northern United States. *Forest Science*, *60*(5), 914-925.

Silver, E. J., D'Amato, A. W., Fraver, S., Palik, B. J., & Bradford, J. B. (2013). Structure and development of old-growth, unmanaged second-growth, and extended rotation Pinus resinosa forests in Minnesota, USA. Forest Ecology and Management, 291, 110–118. https://doi.org/10.1016/j.foreco.2012.11.033

Silvis, A.; Perry, R.W.; Ford, W.M. 2016. Relationships of three species of bats impacted by white-nose syndrome to forest condition and management. Gen. Tech. Rep. SRS–214. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 48 p.

Spies, T. A. (1990). Ecological Concepts and Diversity of Old-Growth Forests. The Journal of Ecology, 78(4), 1146. https://doi.org/10.2307/2260958

Stoleson, S. H. (2013). Condition Varies with Habitat Choice in Postbreeding Forest Birds. Auk, 130(3), 417–428. https://doi.org/10.1525/auk.2013.12214

USDA Forest Service. (2011) Monongahela National Forest Land and Resource Management Plan. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5330420.pdf

USDA Forest Service. (2012). National Forest System Land Management Planning Rule 36. In Federal Register (Vol. 77, Issue 68).

USDA Forest Service. (2020). Nantahala and Pisgah National Forests Proposed Land Management Plan (Issue January).

USDA Forest Service. (2022a). Nantahala and Pisgah National Forests Final Environmental Impact Statement for the Land Management Plan.

USDA Forest Service. (2022b). Nantahala and Pisgah National Forests Land Management Plan (Issue January).

Wiens, J.A., G.D. Hayward, H.D. Safford, and C.M. Giffen, eds. 2012. Historical environmental variation in conservation and resource management. Wiley-Blackwell, Oxford, UK.

Wilson, M. D., & Watts, B. D. (2008). Landscape configuration effects on distribution and abundance of Whip-poor-wills. *The Wilson Journal of Ornithology*, *120*(4), 778-783.

Wood, P., Sheehan, J., Keyser, P., Buehler, D., Larkin, J., Rodewald, A., Stoleson, S., Wigley, T. B., Mizel, J., Boves, T., George, G., Bakermans, M., Beachy, T., Evans, A., McDermott, M., Newell, F., Perkins, K., & White, M. (2013). Cerulean Warbler: Management Guidelines for Enhancing Breeding Habitat in Appalachian Hardwood Forests. American Bird Conservancy. The Plains, VA, USA. 28 pages.

Wright, D. W., Rittenhouse, C. D., Moran, K., Worthley, T. E., & Rittenhouse, T. A. (2021). Bat responses to silviculture treatments: Activity over 13 years of regeneration. *Forest Ecology and Management*, *494*, 119359.