Managing biological diversity in deciduous forests of southeastern Ohio

Report of the Biodiversity Working Group, Wayne National Forest management plan revision, Phase 1

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Contents (click on title to connect to each section)

Executive summary

Biological diversity is the defining feature of the Wayne National Forest (WNF). The WNF presents a distinctive combination of forest species, habitat types, and ecosystem processes falling in the Low Hills Belt of Braun's (1950) Mixed Mesophytic Forest Region. Lands in the WNF encompass the enormous biological diversity of the southeast Ohio region and, at the same time, support a variety of human activities. Because the state of Ohio has been both extensively and intensively impacted by humans, and supports a relatively high modern population density, the WNF, as the largest single tract under unified management, carries the primary burden of protecting diversity in the eastern half of the state. The WNF also supports a wide variety of other uses under the US Forest Service's signature theme of Multiple Use. Because, many of these uses are mutually incompatible, careful planning is required to provide the greatest public service and maintain the forest resource sustainably into the future. For this reason, the Wayne National Forest is embarking on its periodic revision of its guiding Management Plan.

As mandated by law, the revision process entails input from the general public and users of the forest. Biological diversity was identified as one of eight critical topic areas and interested parties were invited to participate in open meetings in September 2018. The purpose of these meetings and subsequent interactions was to aid the WNF in identifying areas of the previous (2006) Management Plan which needed revision. These areas are based on new information, new circumstances, or new emphasis in public or scientific discourse. This activity represents Phase I of the plan revision process. This document is one of the products of this process, representing four months of work by interested members of the public.

Biological diversity is not strictly comparable to activities considered in the seven other topic areas. Whereas most WNF activities serve a limited number of enthusiasts or investors, biological diversity serves the entire population of Ohio through its effect on climate, medicine, genetic resources, recreation, and ecosystem functioning. Biodiversity differs in scale from most other activities. For example, off-road-vehicle usage is a recreational activity that takes place only on established sited trails for that purpose, but biological diversity is located across the landscape and cannot be re-situated. Furthermore, biological diversity is irreplaceable on any human time scale. Thus, biological diversity must be the starting point for the planning process, and all other activities must be structured around it.

Our purpose is to protect and sustain biodiversity on the WNF by identifying critical management topics, to clearly articulate the management problem in each case, and to call attention to recent information relevant to the problem. The group is particularly well suited to this task. We include several forest scientists with research activity focused in southeast Ohio (often in the WNF itself), two environmental lawyers, active members of several environmental groups, and concerned citizens with a wide range of personal experience. Collectively, sixteen people have contributed to the writing of this report. Rachel Neuenfeldt and Dan Giannamore of the USFS provided background material when requested, often on very short notice.

By consensus the group chose four general areas of concern: Forest Health, Landscape Processes, Vegetation, and Wildlife, and four members volunteered to lead these groups (i.e., editors). Within each category, individual issues are addressed (see Table of Contents). In each issue we have used a standard format:

Issue of concern: *A brief statement of the management challenge.*
Best available science: *The most salient recent science.*
Condition of the WNF: *How the issue is currently addressed in the WNF.*
General remedies: *The general direction that management should take.*
Bibliography: *Peer-reviewed scientific literature supporting the issue*.

These issue-directed sections are not intended to review extensive and complex scientific topics, nor to provide detailed management plans. We merely seek to nominate topic areas that require attention and to provide sufficient explanation to develop the topic with links to the best available literature on the topic. Of the dozens of possible diversity issues, we have chosen to include nineteen that a) potentially pose major threats to forest diversity, and b) are within the power of WNF management to effectively address.

Although the identified issues cover a wide range of topics, a common theme ties them together: ***There is a lack of information about the location of high-value sites and a failure to monitor the broad-spectrum impacts of management efforts***. Absence of such information makes it very difficult to achieve forest management goals such as controlling white-tail deer browsing, evaluating the effectiveness of prescribed fire, and planning around historical biodiversity hotspots. There is a very real danger that without monitoring and mapping data, diversity will be destroyed by conflict with destructive land uses, however well intentioned.

However, we are both optimists and pragmatists. The WNF is a big place and most reasonable land uses can probably be accommodated. Biodiversity is very patchy within the WNF and most management and land use activities are spatially localized. With a good understanding of these spatial relationships, the managers can put together the puzzle pieces to sustain biological diversity while also satisfying other users. We look forward to contributing to this process in Phases II and III as the management plan is developed.

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Section 1. Forest Health

1a. Increase and response to non-native invasive species

Issue

A key driver of change is the invasion of ecosystems by alien species, many of which attain sufficiently high abundance to influence biodiversity. Most meta-analysis studies have in fact shown either a neutral or negative effect of alien species upon native species—at both the community and ecosystem levels (Vila et al. 2011). The main issue haunting land managers at this point is how to respond to such a large-scale problem. FIA data (2001-2008) revealed that two-thirds of all plots in R9 contained one or more non-native invasive species (Schulz and Gray 2012).

Best Available Science

Geographical variation in numbers of non-native species reflects landscape characteristics that drive non-native species invasions. For example, forest pest species are much more concentrated in the northeastern region (R-9) of the USA than in other parts of the country. This pattern most likely reflects the combined effects of propagule pressure (pest arrival), habitat invasibility (pest establishment), and invasion spread indicating the importance of anthropogenic movement in that spread (Liebhold et al. 2013).

Exotic insect pests and pathogens pose a serious and immediate threat to the forests of eastern North America. The litany of exotic introductions is long and includes historically well-known and more recent introductions (Lovett et. Al. 2006). Important pests and pathogens include well-known examples such as chestnut blight (*Cryphonectria parasitica*), Dutch elm disease (*Ophiostoma ulmi*), gypsy moth (*Lymantria dispar*), beech bark disease (*Neonectria* spp.), hemlock woolly adelgid (*Adelges tsugae*), dogwood anthracnose (*Discula destructiva*), and emerald ash borer (*Agrilus planipennis*). Top invasive plant species include such familiar species as Japanese honeysuckle (*Lonicera japonica*), garlic mustard (*Alliaria petiolata*), Japanese barberry (*Berberis thunbergerii*), Norwat maple (*Acer platanoides*), Kudzu (*Pueraria montana*), Japanese stltgrass (*Microstegium vimineum*), multiflora rose (*Rosa multiflora*), Tree-of-heaven (*Ailanthus altissima*), etc. The point of this list is not so much to single out or document the species, but to recognize that most of the eastern deciduous forest biome is literally under siege, and likely to change dramatically in the coming decades.

There is a growing shift among scientists and land managers on the philosophy of how to respond. The problem is too pervasive. A "fix" is highly improbable. The solution is not to saturate the environment with chemicals (see below), or try to pull or cut every herb and shrub—all of these methods are likely to result in failure. A much more targeted approach is needed, and is likely the only approach to succeed.

From a purely biological perspective, exotic invasive species and native species are not fundamentally different. The carbon capture strategy of a species is strongly associated with disturbance, with species from disturbed sites having traits that confer capacity for fast growth. Thus, differences between exotic invasives and natives may simply reflect differences in the environmental conditions of the sites where they occur rather than differences between exotic invasives and natives per se (Leishman et al. 2010). In fact, most invasive species are not shade tolerant and will disappear from a plant community on their own over the course of natural succession (Matlack and Schaub 2011). Thus, we need to begin consideration of plant community change and acceptance of these new species into an ecological world that is different than it was in Pre-Columbian times.

To paint the invasive species issue as a choice between the native environment and alien species, between preservation and human meddling, obscures the real issue. Ecosystems change over time with shifts in climate, nutrients inputs, rainfall patterns, and the relative abundance of species in the plant community. How should we manage the new system that contains species that existed prior to European settlement or since the last ice age, relative to new alien species that seem well adapted to the environment? Do the benefits of removing NNIS justify the economic and ecological costs (Kauffman and Kauffman 2012)?

Condition of the WNF

The WNF is currently inhabited by hundreds of invasive plant and animal species, some of which have established large populations. Some of those species develop large and persistent seed or spore banks (Redwood et al. 2018). USFS management practices on the WNF have been implicated in the spread of at least one invasive (*Microstegium vimineum*; Christen and Matlack 2006) and road maintenance is widely recognized as a problem contributing to spread of NNIS (Rauschert et al. 2017).

General Remedy

Ultimately, reducing the impacts of exotic pests and pathogens on eastern forests requires that we minimize new introductions through concerted national and international policy efforts aimed at eliminating the transfer of pests and diseases between countries (beyond the scope of a specific forest plan). However, individual national forests can play a strong role in reducing the local spread of pests and pathogens by demanding high standards of those conducting operations within their jurisdictional boundaries (logging, road work, right-of-way maintenance, etc.), as well as careful supervision of internal operations involving USFS vehicles that may move pests and pathogens throughout the landscape. Importantly, Huebener et al. (2018) note that by keeping forest cover above 85% when conducting logging operations (often thinning to promote oak regeneration) will result in a dramatic reduction in the most problematic NNIS.

Moreover, based upon shifting mind sets of scientists and managers, there is a growing trend towards thinking about invasive species differently. A large-scale control effort will be fruitless. Agencies should consider prioritization (triaging): 1. Target only small (i.e. newly-established), isolated populations rather than large, well-established populations, 2. Target shade tolerant species (most other NNIS will disappear naturally as the canopy closes), 3. Avoid disturbance (fire, harvesting, trail creation, road grading, etc.) near existing NNIS populations, 4. WNF staff should be required to report any observation of new species or new populations of existing NNIS to the staff botanist and wildlife specialist.

Forest managers must base NNIS management decisions on: (1) the urgency of control relative to the degree of threat posed to biodiversity, and (2) the likelihood of achieving a successful conservation outcome as a result of alien plant control (Downey et al. 2017).

Supporting Literature

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1b. Potential for overuse of herbicides for NNIS control

Issue

Are chemical herbicides, fungicides, and pesticides the best way to control NNIS? Biocides often have far reaching effects on non-target organisms and the residence time of pesticide residues in the environment can be long. A growing body of scientific literature suggests that the use of biocides in the environment by land managers should be minimized to the extent practical and reserved as a last-ditch effort to achieve specific conservation objectives where there is overwhelming evidence to suggest success.

Best Available Science

There is a very recent change in attitude among scientists and land managers as to when and how to control NNIS. Likewise, there is increased recognition that we are overusing chemical herbicides, fungicides, and pesticides—and this is coming with environmental consequences.

A good example is glyphosate (Round-Up™). This is generally considered by most land managers to be relatively benign. Historical data support this notion and the herbicide is used widely in agriculture for food production. However, there is a now growing list of not previously envisioned issues with glyphosate. Herbicide resistant weeds are increasing dramatically. More disturbingly, a study appeared relatively recently (Relyea 2012) that implicated glyphosate use as the cause of morphological and behavioral changes in vertebrates (salamanders and frogs)—even when applied at sub-agricultural dosage levels. Amphibians are widely seen as indicator species due to their sensitivity to environmental change. This literature is burgeoning in the last five years and is way beyond the scope of review here. Collectively, these discoveries suggest that the world's most widely applied herbicide may have much further-reaching effects than previously anticipated.

The study by Relyea (2102) set off a cascade of subsequent studies in the industrial and academic environment that is ongoing today and quite contentious (the legal, socio-political, economic, and ecological consequences are profound). Sviridov et al. (2014) provide a relatively recent, but now somewhat dated review, of the environmental risks associated with glyphosate. Their review cited a number of studies showing significant negative impacts of glyphosate-based herbicides on human embryonic development. They indicate that there is notable amount of data suggesting that glyphosate can accumulate in the arable soil layer, and through the roots it can get into leaves, berries, and fruit and finally to mammals via food chains (Sviridov et al. 2014).

Despite its relatively benign reputation, Roundup was among the most toxic herbicides and insecticides tested in a recent study (Mesnage et al. 2014). They found 8 formulations out of 9 were up to one thousand times more toxic than their active principles alone (the part that is usually tested). Their results fundamentally challenge the relevance of the acceptable daily intake for pesticides because this norm is calculated from the toxicity of the active principle *only*. Chronic tests on pesticides may not reflect relevant environmental exposures if only one ingredient of these mixtures is tested in isolation. Despite advances in control methods and native species establishment techniques, rates of successful transition from an invaded system to a native community can be extremely low. In short, one is fighting a losing battle. Research links restoration failure following invasive plant control to prolonged invader persistence and reinvasion, extremely dry conditions, and native propagule limitation (Kettenring and Adams 2011).

To be clear, the issues surrounding herbicide application presented here are not about Roundup per se (this was just used as an example). *Regardless of which herbicide is used, what transfer agent is employed, how the herbicide was dosed (at or below label recommendations), or how applied (i.e., foliar, basal barking, or even direct injection—Lewis and McCarthy 2008)—the peer-reviewed scientific literature is crystal clear—there is no loop hole for environmental integrity*. These chemicals do not exist naturally in the environment, they are easily transferred into the food chain, and many have long residence times in the environment.

General Remedy

Because restoration success is so low, because current best practices advocate the use of a strong triage approach, and because there is a rapidly increasing body of data to suggest health concerns (for all vertebrates, including humans) related to herbicide usage, USFS should begin a rapid de-escalation of the use of all herbicides, pesticides, and fungicides on the WNF. There may be no need to fight a losing battle—we need to envision a new "normal" as it pertains to vegetation in the landscape. Inevitably, some biocides will be needed for specific projects, but they should really be reserved for the small number of situations of conservation projects that are deemed both imperative and that have a high probability of success (e.g., saving a threatened or endangered species population).

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1c. Oak Regeneration Failure

Issue

There is widespread agreement that oak-dominated forests across the North American landscape are failing to regenerate. Alarms have been sounded in the literature to this effect dating back into the 1960s and widely recognized by the 1980s. Given the ecological and economic importance of these ecosystems, oak restoration has become a major management goal among state & federal agencies, as well as non-governmental organizations (Dey 2014).

“With European settlement, fire became more consistently frequent and ubiquitous on the Eastern landscape from about the 1850s to the 1930s, too frequent to permit pine or oak recruitment into the overstory. The dynamic interaction between humans and oak forests also changed when colonial populations grew, thus increasing the demand for building supplies and food. European immigrants brought the technology to quickly clear forests for agriculture land uses and to create a forest products industry. The origin of many of today's mature oak forests throughout the region is from forest disturbances operating during this period of dramatic cultural changes in the latter 19th and early 20th centuries” (Dey 2014). Thus, the current forest is not “natural” per se, but the by-product of heavy anthropogenic disturbance at the turn of the last century. That said, oak has always been a strong component of southern Ohio forests for hundreds of years (Dyer 2001, Deines et al. 2016)—the exact compositional balance though now is likely different than it was historically.

Best Available Science

Arthur et al. (2012) provided a comprehensive and reasoned synthesis on the role of fire in sustaining oak forests based on oak biology and ecology. They identified several stages of stand development and times in the life cycle of an oak when fire could benefit oak regeneration, and the equally important times that fire must be suppressed to permit oak recruitment into the overstory. Single fires have little long-term benefit to oak (Brose et al. 2013), but in mature forests that lack oak advance reproduction, multiple fires can be a benefit by reducing thick litter layers, controlling competing vegetation, reducing competitor seed banks, and increasing light at the forest floor by eliminating midstory saplings and understory woody competition. Brose et al. (2008) refer to this as “site preparation burning,” making the site ready for the next good acorn crop and promoting seedling establishment.

While there is growing acceptance of the use of prescribed fire to restore oak dominated ecosystems, the use of fire as a forest management tool has often preceded research-based evidence for its effectiveness in accomplishing specific silvicultural and ecological objectives, and may often have non-target impacts. Moreover, “there are a large number of ecological circumstances whereby fire may not be the most effective tool to regenerate oak” (Arthur et al. 2012).

There is also a tendency to use data from adjacent states to make inference about local or regional fire regimes. Results reviewed from published studies reveal that fire histories are all quite site specific. Therefore, managers focused on ecological restoration are best advised to construct a place-based history rather than rely solely on results from other studies to set restoration targets and monitor treatment success (Hart and Buchannon 2012). A fire history from an oak forest in Missouri is next to useless in assessing the fire history of a southern Ohio oak forest.

White oak (*Quercus alba*) is of special concern in the State of Ohio. Specifically, it has lost 7.3% of its volume across the landscape between 2012-2017 (Albright 2017)! By contrast, red oak (*Q. rubra*) has seen a 9.5% increase in volume across the same time period. The loss of white oak is only exceeded by ash species, which have been devastated by EAB, and declined by 21.1%. 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. Moreover, 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.

Condition of the WNF

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 (https://www.fs.fed.us/forestmanagement/products/ptsar/index.shtml). At the same time, from an oak ecosystem maintenance perspective, very few, if any, of the Wayne's stands are ready for overstory removal. *Competitive oak seedlings and saplings—which must be present in sufficient size, number, and spatial distribution prior to overstory removal—are virtually non-existent in the WNF and the region's understories*. Iverson et al. (2017) found that only 2% of stands are stocked with competitive oak. If oak ecosystem maintenance is desired, then at least 10 to 30 years of significant resource and management investment in these stands will be required prior to overstory removal. The WNF's current timber targets simply do not appear to be compatible with oak ecosystem maintenance.

General Remedy

Managers need to recognize that there is no such thing as "instant oak." Where harvest is a management strategy, successful oak ecosystem mitigation will generally require, prior to overstory removals, 10 to 30 years of active understory stewardship, significant resource investments, and robust plot-based stand monitoring (e.g., SILVAH:OAK; Iverson et al. 2017). Managers must also acknowledge that the region's oak species have unique management requirements, and that managing for a blanket, generic "oak" category will likely result in the decline and loss of individual species (Rebbeck et al. 2011).

Fire is being increasingly used in eastern forests, most commonly to promote oak regeneration. However, there is considerable disagreement in the scientific literature over when and where to use prescribed fire effectively (Brose et al. 2013)—it is simply not a silver bullet. Moreover, there are additional fire effects on the landscape that require consideration. From an ecological perspective, fire is an ecosystem process with numerous interconnected implications for plant successional dynamics, biodiversity, species invasions, soil nutrient availability, carbon sequestration, and water and air quality. As such, management objectives must be considered in concert with fire's many other roles and scales of implementation (Arthur et al. 2012).

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1d. “Hazard” Fuel Reduction and Prescribed Fire

Issue

Hazard fuel reduction projects are typically undertaken to reduce surface and ladder fuels, and in certain cases reduce stand density. The over-arching objective is to remove enough vegetation (living and dead) so that when wildfires do burn they don’t burn as hot or as fast, and are more easily managed. Typically, this is accomplished with some combination of mechanical treatment and/or prescribed fire (NPS 2018). The distribution and abundance of forest fuels in regional mixed oak and oak-hickory forests is well known (Graham and McCarthy 2006) under a variety of management regimes. Moreover*, there is virtually no evidence that fuels build up in most eastern deciduous forests, except under the most specific of circumstances. Thus, the use of prescribed fire to control hazardous fuel build-up is simply an oxymoron and should be deleted from USFS media outreach and forest plans in Region-9.*

Best Available Science

The best available science is pretty clear: in most of the eastern deciduous forest biome, there simply is NO buildup of fuels on the forest floor (certainly not in most mixed oak or oak-hickory stands). Based on first principles of forest ecology and nutrient recycling (Oliver and Larson 1996), productivity and decomposition are nearly balanced throughout most mesic hardwood ecosystems in eastern North America. Thus, except in the rarest of circumstances (defined by site and disturbance regime), is there any significant build-up of fuels on the forest floor. And we certainly do not have much in the way of ladder fuels (occasionally greenbrier) or crown fires.

Leaf litter and fine woody debris (1-hr and 10-hr fuels) decompose very rapidly on the forest floor. There is a complex interaction among species, size, and position relative to the soil surface and site climate. Most fine fuels with ground contact will decompose rapidly. Fuels rarely build up except in those rare situations where there may have been a catastrophic stand replacing natural wind event (such as a tornado or hurricane) resulting in large volumes of FWD and CWD on the forest floor. Large pieces of coarse woody debris, while somewhat recalcitrant in the system are actually not a hazardous fuel problem as they hold considerable moisture upon decomposition (Fasth et al. 2011).

General Remedy

Stop using “hazardous fuel reduction” as a justification for prescribed burning in mixed oak forests via public press releases and comments. *There is simply no scientific justification* for this in most of the eastern United States. USFS cannot take principles developed in western forests and apply them haphazardly to eastern forests. Frankly, it just looks foolish and results in a loss of credibility. There are many legitimate reasons to use prescribed fire as a management tool on the WNF, hazardous fuel reduction is NOT one of them.

Supporting Literature

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1e. Small Mammals, Deer, and Lyme Disease

Issue

Lyme disease is the most frequently reported vector-borne disease in the United States (CDC 2002) and other zoonotic diseases like STARI are rapidly increasing (CDC 2018) throughout Region-9. Lyme disease is most prevalent in northeastern and north-central regions where suburban and exurban development encroaches on deciduous forest ecosystems that support the pathogen, vector, and their vertebrate hosts (CDC 2006).

Ground-breaking empirical and modeling studies by Ostfeld et al. (2006) have shown a strong correlation between forest cover, management, and the transmission of vector-borne diseases to humans and other vertebrates.

Best Available Science

Ostfeld and others, in a series of papers, showed that there was a strong relationship between deer abundance and tick abundance. There was also a strong relationship between mouse & chipmunk abundance two years following a large acorn crop, resulting in dramatically increased Lyme disease transmission. In fact, masting events and temperatures in the summer prior, were the two best predictors of high Lyme disease. This clearly signals that forest management activities that influence masting and larger scale changes in climate will have significant impacts on the prevalence of Lyme disease and likely other zoonotic diseases (Ostfeld et al. 2006).

Recent reviews have strongly argued that disease control is among the ecosystem services yielded by biodiversity. Biodiversity protects human populations against infectious disease transmission (Wood and Lafferty 2013). Many studies are just now beginning to look at conservation actions based on the utilitarian services that biodiversity can provide for human society. Unfortunately, there is a strong positive correlation between forested land and disease transmission. The only effective means of environmental management ever deployed against Lyme disease has been active suppression of native vertebrate species or their habitat.

Condition of the WNF

Data are not collected on deer, small mammal populations, or Lyme disease on the WNF. However, hunting data suggest that deer are abundant, and casual observation confirms this assessment. Lyme and other tick-borne diseases have been reported in Ohio. It is reasonable to expect that they will appear in the WNF soon, if not already present (see also “White-tailed deer” in Section 4c.).

General Remedy

Begin providing disease incidence in GIS shape files. The science on this is relatively new, but all the data point to a need to be aware of the situation, understand the context and variables that come to bear, and manage accordingly.

Supporting Literature

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Section 2. Vegetation

2a. Use of fire and impacts on non-target vegetation.

Issue

Fire has been widely embraced as a management tool to promote oak regeneration, however managers are often unaware of the broader biological impacts of fire and apply it indiscriminately over large areas of forest. The practice is often justified in terms of its supposed historical role; however, few studies have been done in moist deciduous forest that is typical of the WNF.

Best available science

Most research on fire in temperate-deciduous forest has been located in dry forest and savanna communities in states west of Ohio and on the Atlantic and Gulf Coasts; its application in the WNF is questionable. Frequent fire does not appear to be the historical condition of moist deciduous forest (Matlack 2013; Feurdean et al. 2017), and most typical plant and animal species lack adaptations to survive fire.

In the small number of moist-deciduous forest studies, fire is commonly followed by increased frequency of grasses, light-requiring summer forbs, seed-banking species, and tree seedlings (Nuzzo et al. 1996; Hutchinson et al. 2005; Albrecht and McCarthy 2006; Glasgow & Matlack 2007*a*). Many non-commercial plant species have been observed to decline in frequency following fire (Nuzzo et al. 1996; Vandermast et al. 2004). Burn intensity and seasonality can have long-lasting (decades) effects on deciduous herb community composition (Dhar et al. 2018). Other studies show no effect of fire on herb or shrub cover or a site-specific effect in which fire appears to cause both increased and decreased herb cover (Franklin et al. 2003; Elliott & Vose 2010). Fire in deciduous forest is often followed by increased cover of nonnative species, suggesting that fire creates opportunities for invasion (e.g., Glasgow and Matlack 2007*b*; Mandle et al. 2011; Wagner and Fratterigo 2015).

In rare microsites such as dry oak-pine forests at high elevations (Matlack 2013) fire may promote native-species population growth and community diversity.

State of the WNF

Most plant species in the WNF are neither “fire tolerant” nor “fire adapted”. Nevertheless, prescribed burning is currently used over hundreds of hectares of the WNF, often by crews with little knowledge of forest biota; burning is planned over even larger areas. The specialized microsites which might have historically burned (xeric montane pine-oak forests; prairie fragments) are rare within the WNF, and have not been reliably mapped. Casual observation suggests that fire is encouraging soil erosion by removing organic layers (e.g. on the ridge west of Lake Vesuvius).

Yearly monitoring reports of existing ginseng populations in the WNF have documented evidence of inappropriate “controlled” burns in mesic ecosystems favored by many woodland native medicinal plants. Data and anecdotes can be found in the thirteen annual ginseng monitoring reports maintained and housed by the WNF, and include observations such as “*acres of maidenhair fern burned*”, “*fire jumping creek* *bottoms and burning both sides of the creek*”, “*scorched tops of vegetative ginseng*”, and “*downed logs on fire in creek bottoms*”.

General remedies

Management burning should be limited to areas specifically identified for promoting oak regeneration, as most plant species in the WNF are neither fire tolerant nor fire adapted. Soil condition and vegetation should be monitored regularly to ensure that the silvicultural goals are being met and non-commercial species are not affected. Controlled burns for oak regeneration must be well planned, effectively communicated to staff both full time and seasonal, and managed on the ground in order to confine fire to primary oak habitat only.

Supporting literature

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2b. Overharvesting of Special Forest Products

Issues

The current WNF Plan favors extraction over maintenance of mature, intact forest and maintenance of forest biodiversity. Under the 2006 forest plan, native medicinal plants are most likely declining in the WNF due to overharvesting from wild populations and loss of habitat (native medical plants rely on mature, intact forests). Mining, pipelines, oil and gas development, roads, driveways, ATV trails, climate change, clear cuts, etc. all contribute to habitat loss for these plants.

Best available science:

Native medicinal herbs are typically long-lived, perennial plants that grow in closed-canopy, mature deciduous forests. However, rising consumer demand and the multi-billion dollar non-timber forest products industry threatens these populations (Vaughan et al. 2013).

A recently published global assessment of the conservation status of Goldenseal (*Hydrastis canadensis*) has found that the species has declined by at least 30% over the last three generations, and is classified as Vulnerable to Extinction (Oliver and Leaman, 2018). In Ohio, almost half of documented goldenseal populations have become extinct (Mulligan and Gorchov, 2004). Goldenseal populations harvested in the fall appeared to recover faster than those harvested in the summer (Albrecht and McCarthy, 2006)

Long term studies also show ginseng populations are in decline. (McGraw, 2017). A population viability analysis for ginseng found that the maximum sustainable harvest rate, would be 5% every year. Or, if harvesting was reduced to just once every 5 years, then a maximum harvest rate of 30% would be sustainable (Nantel et al. 1996). This assumes healthy and large populations. The same study also found the minimum viable population size to be 172 individuals. In an effort to quantify actual harvesting of ginseng, McGraw et al. (2010) monitored 30 ginseng populations in the eastern US. Over a period of 5-11 years, 43% of the populations were harvested, and at least 10% of plants were removed. On an annual basis, 15% of the populations were harvested.

State of the WNF

Goal 6.3 in the WNF 2006 Forest Plan: *Provide opportunities for the collection and use of special forest products. Manage removal of special forest products and monitor this use to sustain viable populations and future yields*. Most of the guidelines under this goal involve timber harvests. However, there are three specific guidelines for "Special Forest Products"

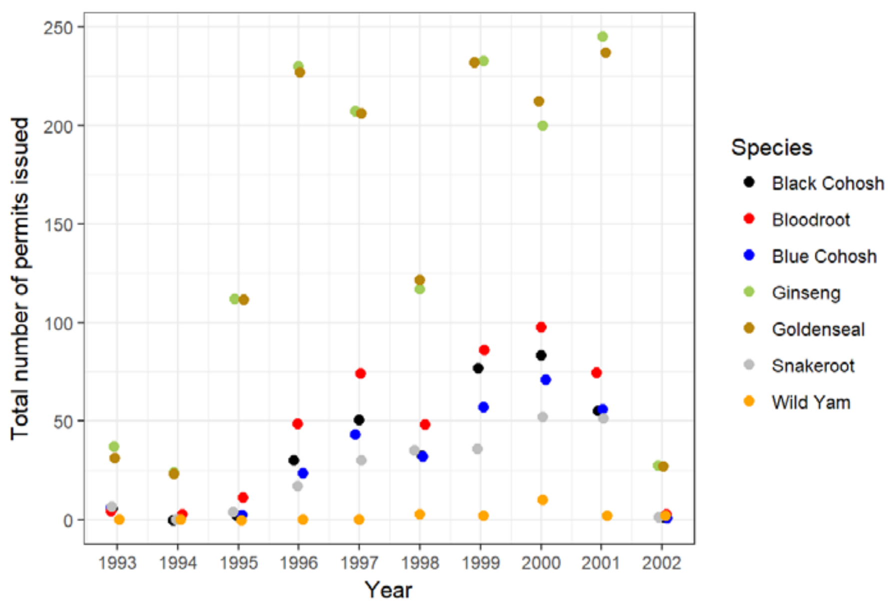
> SFW-VEG-18**:** Require a permit for all commercial collection of special forest products, and for collection of special forest products for personal use (i.e., medicinal plants, firewood). A permit is not required for personal use of berries, nuts, and pine cones.
>
> SFW-VEG-19**:** Prohibit collection of Federally listed or Regional Forester sensitive species.

SFW-VEG-20**:** Implement rotational area or Forest-wide closure orders to prevent over-harvesting of plants and allow stressed populations of plants to recover, when such populations are identified.

Based on the number of permits issued from 1993 – 2002, much of the WNF has been severely overharvested (see Figure below). This information is based solely on the number of permits issued. There is no information about the amount harvested with each permit.

Data collected by Dr. Matthew Albrecht.

Dr. Albrecht examined every plant collection permit issued from each of the three WNF units from 1993-2002. Shown here is the total from all three units. However, permit data was incomplete for the 1993, 1994, and 1998 harvesting season and thus this data is a conservative estimate (i.e., the number of permits issued in these years is likely higher than what is shown).



In addition, many permits failed to specifically indicate the approximate location targeted for plant harvesting and which species harvesters were intending to target for collection.

General remedies

- Cap the number of annual permits issued, and include a collection limit per permit (e.g., 20 pounds per permit).
- For permits issued, make it a condition that the harvester has to record and report to the WNF *which* population they harvested from as well as how much. Failure to report this information to the WNF will result in them not receiving future permits.
- Implement population monitoring and use this information to determine the cap and weight limit, for the annual permits issued.

Supporting literature

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2c. Reintroduction of American Chestnut

Issue

Scientists at The American Chestnut Foundation (TACF; https://www.acf.org/) have been engaged for thirty years in creating a blight resistant American chestnut hybrid for restoration purposes. TACF is rapidly approaching a product that is sufficient to begin this process. The United States Forest Service has signed an MOU that they will assist in restoring American chestnut to the forested landscape of the Appalachians (original range of the species). The forest management plan in the WNF will need to address when, where, and how this re-introduction would likely take place.

Best available science:

The American chestnut has been functionally extirpated from the eastern deciduous forest canopy for many years, following the instruction of the chestnut blight to the northeastern U.S. in 1904. The species still exists in many forests throughout its original range (Appalachian Mountains), primarily in the form of stump sprouts that grow and die back repeatedly after re-infection. Historical data from Ohio (witness trees) suggests that chestnut represented approximately 2-4% of the volume. As TACF continues to make progress in breeding a blight resistant chestnut through a backcross breeding program (where it is crossed with blight resistant Chinese chestnut) researchers have picked up the pace in trying to understand the ecology and silvics of this species. Jacobs (2007) published the first comprehensive review of the silvics and ecology of the species. Prior research by McCament and McCarthy (2005) demonstrated that the species does very well in disturbed habitats and is completely compatible with managed forest landscape subjected to thinning and prescribed fire (ostensibly for oak restoration). Through a series of projects, McCarthy and colleagues (McCarthy 2008, McCarthy et al. 2008, French et. al. 2014) have demonstrated that the species does exceptionally well on poor quality sites (rocky, poor soil nutrients) and may be useful in mine land reclamation, allowing both chestnut restoration and land reclamation to happen simultaneously. The species does not do well when planted on sites with poor drainage, high clay content, or where *Phytopthora* fungi is present in the soil.

State of the WNF

American Chestnut is not mentioned as part of the WNF 2006 Forest Plan.

General remedies

WNF needs to create a GIS map to identify optimal planting sites on the forest. This approach is currently being undertaken on the Daniel Boone NF in KY. Recent work has shown that that the mycorrhizae in the soil under recently harvested pine stands is often excellent for the promotion of chestnut survival and growth, and may represent an optimal planting site. Likewise, abandoned mine lands that can be treated with plowing or ripping of the soil are good candidate sites (McCarthy et al. 2010). Underplanting following thinning and prescribed fire has also shown to be an effective restoration strategy (McCament and McCarthy 2008). The process just requires careful planning and coordination of activities. Brian McCarthy (Ohio University) is currently the national Chair of the Board of Directors of TACF and is a good local contact to assist.

Supporting literature

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McCament, Corinne L, Brian C McCarthy. 2005. Two-year response of American chestnut (*Castanea dentata*) seedlings to shelterwood harvesting and fire in a mixed-oak forest ecosystem. Canadian Journal of Forest Research, 2005, 35:740-749, https://doi.org/10.1139

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McCarthy, B.C., J.M. Bauman, and C.H. Keiffer. 2008. Mine land reclamation strategies for the restoration of American chestnut. Ecological Restoration 26(4):292-294.

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2d. Management for future climate change

Issue

Over the past 30 years, increasing temperature and water availability has lengthened the growing season by 22 days in the Central Appalachians (Gaertner et al. 2019). Climate change projections for the Midwest show an additional increase in mean annual temperatures of 3.1 – 5.3 °C and a 10-15% increase in mean annual precipitation by the end of the century (Easterling et al., 2017; Vose et al., 2017). Climate change will also increase the uncertainly and variability in weather leading to more droughts, more flooding, and more extreme weather events (Wuebbles et al., 2017). There is nothing in the 2006 forest management plan that explicitly addresses these issues, both in terms of carbon mitigation or adaptive management.

Best available science

Forests sequester and store ~25% of anthropogenic carbon dioxide from the atmosphere. Achieving the Paris Climate Change Agreement will require an expansion of this global forest carbon sink (Harris et al. 2016). In the NE USA, timber harvest accounts for 85% of carbon emissions from forests, with insect damage the next most important factor at 9%. Although forests in the US remain a carbon sink, logging has reduced the potential of the US forest carbon sink by 35% (Harris et al. 2016). Changing our forest management practices has the potential to make a large difference nationally and globally. By eliminating timber harvest on public lands, it is estimated carbon sequestration would increase by up to 43%, which would offset up to 1.5% of total US greenhouse gas emissions by 2050 (Depro et al 2008).

Climate change, increasing drought frequency and intensity, and increasing risk of pest outbreaks will also contribute to changing species compositions and forest structure (e.g., Matthews et al. 2014; Clark et al. 2016). This will impact the provisioning of forest ecosystem goods and services (e.g., timber, non-timber products, soil retention, water storage and control, habitat and food provisioning for wildlife, etc.). Thus, climate-adaptive forest management is necessary to ensure sustainability and continued ecosystem health. Management that promotes diversity of species and diversity of functional traits are expected to have greater resilience and resistance to climate change and future disturbances (e.g., Elmqvist et al. 2003; Duveneck and Scheller 2016; Lucash et al. 2017). Simulation studies found that management strategies that used climate-suitable plantings had increased resistance and resilience under future climate change scenarios (Duveneck and Scheller 2016; Lucash et al. 2017). A study that examined different management practices in USDA experimental forests found the greatest functional diversity was in forests that had received no management, followed by those with shelterwood management (Curzon et al. 2017). Selection systems generally reduced functional diversity, due to the increase of shade tolerant species such as red and sugar maple, and beech (Curzon et al. 2017).

Finally, climate change refugia should be a part of a forest plan to protect biodiversity. Climate change refugia are areas that are relatively buffered against climate change, and can offer places for species to persist within a larger landscape that is no longer climatically suitable. These are typically places with high topographic, geomorphic and micro-climatic diversity (Morelli et al. 2016).

State of the WNF

Climate change is not mentioned in the 2006 Forest Plan (except for one note about monitoring for changing growing season lengths).

General remedies

- Carbon sequestration and the mitigation of national carbon emissions should be explicitly considered and valued, such that carbon sequestration is valued as much as timber extraction.
- Management should promote the identification, planting, and protection of climate-suitable species, and efforts to increase species and functional diversity.
- Areas in the WNF with high topographic and micro-climatic diversity should be protected.

Supporting literature

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2e. Carbon sequestration, soil effects, mycorrhizae impacts

Issue

Forest management needs to be more inclusive and consider not just the value of extraction (i.e., timber, minerals, medicinal plants), but also the value of ecosystem services such as carbon sequestration and storage, soil health, and mycorrhizal function. Managing for forest ecosystem goods AND services will best promote biodiversity.

Best available science

Healthy intact forests and soils are essential for sequestering and storing carbon. However, not all forests and not all soils are equal. Old growth forests have 30% higher above ground carbon compared to younger forests, and 1800% higher dead wood carbon (McGarvey et al. 2015). Soil respiration (i.e., the release of carbon from soils) was also found to be lower in old growth forests compared to younger stands (Liebman et al. 2017). A common misconception is that growth rate is highest in younger trees and declines as trees age, and thus carbon sequestration goals can be achieved with young forest stands. However, a recent global assessment of more than 400 tree species, found that growth rate increases continuously with size (Stephenson et al. 2014). Thus, old growth forests not only store more carbon but also sequester more carbon.

Soil carbon sequestration and storage are equally as important as above-ground carbon. The balance between above and below ground carbon is in part mediated by the soil microbiome. Most plants are associated with symbiotic mycorrhizal fungi, that aid in nutrient acquisition from the soil. Arbuscular mycorrhizal (AM) fungi are found in 80% of all vascular plants, including maples. Ectomycorrhizal mycorrhizal (EM) fungi are found primarily in temperate regions and include the beech and willow families (i.e., beech, oaks, poplar, etc.). Soils dominated by EM-associated plants, contained 70% more carbon per unit nitrogen than soils dominated by AM-associated plants (Averill et al. 2014).

Logging can impact the soil microbiota. The compaction associated with timber extraction was found to reduce the abundance and alter the structure of the soil microbiota (Hartmann et al. 2014). Fungi, in particular mycorrhizal species, were more sensitive to compaction compared with bacteria (Hartmann et al. 2014). In particular, the diversity of ectomycorrhizal (EM) fungi declined after logging and the removal of organic matter (Wilhelm et al. 2017). Maintaining a healthy and diverse mycorrhizal community is essential for forest health. For example, red oak seedlings benefited (i.e., increased N and P in shoots, more leaves and leaf area, taller, etc.) from being planted near chestnut oaks, due to the presence of the EM fungi in the soil and the increased proportion of infected root tips (Dickie et al. 2002).

State of the WNF

The word “carbon” is not found anywhere in the 2006 Forest Plan. Mycorrhizal impacts are also missing entirely from the 2006 plan. Soil effects are mentioned in various part of the 2006 plan. Soils are part of Watershed management (i.e., preventing soil erosion into water), and soil remediation due to past and ongoing land uses. Increasing soil productivity is also mentioned as a benefit of using fire. There are also rules for saving topsoil, as part of new mineral extraction projects. However, there is no language about soil carbon nor the soil microbiome.

General remedies

- Expand the management plan to include ecosystem services, such as carbon sequestration and soil microbiota diversity.
- The forest's carbon sequestration and storage potential can only be realized through the commitment to old growth recovery on a significant spatial scale.
- Older forests should be not be logged, as these are better suited for providing these ecosystem services.

Supporting literature

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Section 3. Landscape Processes

3a. Land use history

Issue

Biological diversity is patchy in forest ecosystems, and managers do not know where high-diversity patches are located within the WNF. Commonly used indicators such as tree size do not correspond closely to diversity. Use of indicator species (for example "Management Indicator Species") is no longer recommended. Ignorance of high-diversity patches is a problem because management risks destroying diversity by allowing conflicting land uses. Among the general public there is enormous pressure to protect "old growth" or "ancient" forest, although their location within the WNF is unknown.

Best available science

Most plant diversity is in the herb flora, not the relatively small number of tree species. Forest age is a strong predictor of plant species diversity in both eastern North America and western Europe (e.g., Peterken and Game 1984; McLachlan and Bazely 2001; Singleton et al. 2001,). After abandonment from human land use, it may take more than a century to re-assemble a naturally diverse forest plant community (Flinn and Marks, 2004; Verheyen et al., 2003a; Naaf and Kolk, 2015). Slow recovery of plant diversity appears to be caused by weak seed dispersal of many forest species (Matlack 1994; Brunet and Von Oheimb 1999; Matlack 2005) and by the very gradual development of forest structure which many species depend on (McKinney and Lockwood 1999; Flinn 2007). The important conclusion is that long-established stands contribute disproportionately to regional plant species diversity. Recent work in forests of Athens County (Holmes and Matlack 2017a,b; 2018; Monsted 2018) supports these conclusions and provides special insight specifically relevant to the WNF.

Condition of the WNF

The Wayne National Forest is a patchwork of stands of various ages following abandonment from agriculture in the early-mid 20th century. Recent work (Monsted 2018) shows that most forest in Athens, Vinton, and Meigs Counties was abandoned between 1940-1960, making it very young relative to the rates of species accumulation described above. Only 12% of modern forest (6% of the landscape) is more than 100 years old. Land was most often abandoned to forest on slopes and least often on flood plains, reflecting their respective agricultural value. Thus, most plant diversity in WNF is concentrated in a small area of long-established stands usually occurring on steep slopes. Most forest on the WNF is too young to support many forest species and will not achieve natural diversity for decades or centuries into the future.

General remedies

1. Old forest should be digitized into a GIS data layer from historical aerial photos, which are easily available for the WNF. This will provide essential information on the location of high-diversity patches.

2. Forested buffer zones must be established and retained around the old forest fragments identified from GIS to ensure biological integrity and to provide opportunity for forest species to spread out into surrounding forest. Previous work in deciduous forest (Matlack 1993, 1994) suggests buffers should be at least 50 m wide (100 m would be preferable).

3. Long-established stands and their respective buffers should be given the highest protection status, equivalent to the "wilderness area" designation in Western NF. **Future Old Forest** (FOF) is the most appropriate management category for identified old stands and their buffers (but not FOFM). The required protection level is **not** provided by Diverse Continuous Forest Management (DFC or DFCO) or Historic Forest Management (HF or HFO).

Because long-established stands and their buffers are a very small proportion of the WNF, such a high level of protection will not impede other uses. Indeed, identifying high diversity-value stands will facilitate other uses by clearly identifying the zones which must be avoided.

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3b. Mineral activities, including hydraulic fracturing

Issue

Biodiversity must be at the front of the planning process when considering extractive industry. At the moment the primary industrial activity in the WNF is recent and expanding extraction of natural gas by hydraulic fracturing ("fracking"). In addition to obvious negative effects at the well pad, fracking potentially affects biodiversity through landscape-structure effects distributed over a much larger area. A variety of supporting infrastructure including access roads, pipelines, holding ponds, pumping stations fragment the continuous forest (Drohan et al. 2012). Fracking also entails important questions about water quality, aquatic habitat, and erosion (Lutz and Grant 2016), but we are only focusing on its landscape effects here.

Best available science

The Marcellus shale region of central Pennsylvania gives a preview of the landscape alteration that can be expected in the WNF. Inspection in Google Earth shows a network of small roads leading to thousands of well pads (and see Lutz and Grant 2016). Unlike canopy removal by timber cutting, which is concentrated in small areas, fracking canopy removal is widely distributed across a region (Young et al. 2018). Individual pads generally range from 2.0 – 4.0 ha in size, but can be much larger (Davis and Robinson 2012). Well pads are generally located in level sites at high elevations (Meng 2014) with preference to wetland, agricultural land, and pasture reflecting real estate values and ease of access. Supporting roads and pipelines cause forest fragmentation, extending the biological impact over a much greater area than occupied by the well pads alone (Drohan et al. 2012; Racicot et al. 2014). Forest edge propagates out of proportion to the area directly lost to industrial sites. Access roads contribute to fragmentation, but pipeline construction causes the greatest landscape-scale impact by creating vast amounts of forest edge, reducing average forest stand size, and reducing interior forest (Slonecker et al. 2012; Racicot et al. 2014). Loss of interior forest may be 2-3× as much as total forest lost. Fracking operations create opportunities for invasion by nonnative species, either by providing disturbed habitat (Christen and Matlack 2009) or by creating corridors along which invasions can propagate. Fragmentation can be avoided by requiring that all gas lines be run along pre-existing roads. It is estimated that routing along roads would cost a trivial amount (< $0.02 per MCF of gas; Abrahams 2015). Substantial reduction in fragmentation and areal impact can be achieved by consolidating many wells in a few well pads (Klaiber et al. 2016).

State of the WNF

WNF has recently granted leases for wells, which will require construction of access roads and pipelines. At this point, the exact location of the well pads has not been determined. We predicct hundreds of ha of forest destroyed and tens of miles of access road and pipeline which will interfere with a variety of landscape-level processes. The 2006 plan has not evaluated the leasing of minerals for the effects of making private minerals outside the forest available and the cumulative effect of infrastructure build out. There has never been an EIS for these effects. Oil and gas leasing was not evaluated in the 2006 plan for the effects of horizontal drilling and fracking on the forest or the cumulative effects on health, socioeconomic sustainability, or climate issues. There is significant new information or circumstances as defined by 40 CFR 1502.9 requiring further environmental analysis (Legal Information Institute 2018).

General Remedy

Well pads must be sited away from areas of significant biodiversity value (for example, away from FOF and their buffer zones). To minimize fragmentation, pipelines must be routed along existing roads; new roads and pipeline corridors should not be constructed. Economic analysis based on modern drilling technology show that meeting these goals is possible at a trivial cost.

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3c. Mapping and Monitoring

Issue

Every aspect of biological diversity and the factors that influence it are patchy in space. For example, historical land use, fire, spread of invasive species, and outbreaks of disease occur in localized areas. These processes have legacy effects in the forest community which will inform management decisions in the future. Thus, it is essential to map critical events, past and present, and to monitor their influence on diversity afterwards. Management without maps or monitoring risks unintentionally destroying biological diversity.

Best available science

Several important processes identified in this document have strong spatial components and obvious legacy effects in the plant, animal, and soil communities. Fire causes fuel reduction and changes in species growth form and composition in Eastern forests (Dickinson 2006). A knowledge of previous fires improves the effectiveness of management burns. Monitoring non-commercial species is necessary to ensure that burns are achieving the desired biodiversity goals.

Invasive species expand populations from points of inoculation in a predictable way (Christen and Matlack 2009; Miller and Matlack 2010) and may persist unseen in the soil seedbank (Redwood et al. 2018). A knowledge of invasive populations, past and present, allows prediction of invasion propagation in the future. Historical land use imposes a pattern of stand structure and species composition on the modern forest (Flinn and Vellend 2005; Flinn and Marks 2004). Land use history is the best predictor of biological diversity in forests of southeastern Ohio (Holmes and Matlack 2018; Monsted 2018).

Monitoring and mapping are simple exercises using cheap, widely available technology. Presentation in GIS data layers allows easy reference to spatial data in planning future activities.

Condition of the WNF

Monitoring is stipulated in Ch. 4 of the WNF Forest Plan (2006, revised in 2016). Monitoring for federally listed T&E species is required through agreements with the US Fish and Wildlife Service. In practice, monitoring focuses on silvicultural outcomes and does not include non-commercial species nor aspects of the physical environment except where species are recognized as T&E. Some management activities on the Wayne are mapped by GPS and stored in GIS. Data layers include stand age (since last harvest), prescribed burns, and silvicultural treatment blocks. Spatial data are collected on invasive species but these data are project-specific and not comprehensive.

No data exist on long-term land use history, wildlife (including deer) distributions or abundance, or patterns of human activity. Several ginseng populations are monitored, but data are not comprehensive and only exist on paper. As a result, management decisions are made in ignorance of biodiversity and vegetation condition. Casual observation indicates that USFS staff members doing management activities in the forest often do not have information about vegetation condition, type, or disturbance history. Thus it appears that the data available are not being effectively used to guide management.

General remedy

Systematic monitoring should be extended to non-silvicultural species, including the herb and shrub community. Soil condition and wildlife distributions must be recorded. Land use should be documented by reference to historical aerial photos. Mapped data should be immediately entered into readily accessible GIS data layers, and used to guide management decisions. Information collected by other agencies should be stored in data layers and referenced appropriately.

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Section 4. Wildlife

4a. Reductions in Bat Populations

Issue

White-nose syndrome (WNS) has emerged as a threat since the 2006 Plan. It was first detected in Lawrence County in 2010-11, Athens and Jackson Counties in 2012-13, and Hocking County in 2013-14 (White Nose Syndrome 2018). Ohio's two largest bat hibernacula have had bat population declines of 91% and 99% (ODNR 2018a). The expansion of wind energy has also emerged as a threat to migratory bat species.

Best available science

While the WNS-affected species winter in caves and mines, they rely on forest habitat during their active seasons, and the species differ greatly in both their summer and winter ecology (J. Johnson, pers. Comm.). One recent study of northern long-eared bats (Thalken & Lacki, 2018) conducted in Mammoth Cave National Park found that for all ages and reproductive classes, spring roost tree selection characteristics (diameter of 31-33 cm, early decay class, 66-79% cover) were consistent with promotion of "energy savings and consistent with behaviors anticipated for bats vulnerable to WNS effects during winter hibernation because these bats are potentially compromised in health and physiologic condition upon emergence from hibernation in spring." Furthermore, "Pregnant and lactating females demonstrated a preference for roost trees in stands with lower basal areas and live tree densities than randomly selected snags" presumably to facilitate learning of foraging in offspring. Nonreproductive females also selected "more mature forests with higher canopy cover situated in more sheltered ravine bottoms," again, presumably to maximize torpor efficiency by minimizing daytime temperatures.

Similarly, research on tri-colored bat summer roost selection in Great Smoky Mountains National Park found that "Male tri-colored bats selected for roosts in forest stands with a lower density of stems and fewer conifers in the overstory, as well as taller and larger trees than were generally available. They also selected roosts that were closer to water and foraging resources, and were generally located at lower elevations" (Carpenter, 2017). Eastern small-footed bats in the Appalachian Ridge and Valley area of West Virginia used ground-level rock roosts in talus slopes close to vegetation (Johnson et al. 2011). Survival of WNS infection is higher in bats with better body condition at the start of hibernation (Johnson et al. 2014), highlighting the importance of maintaining high-quality foraging habitat.

The Forest Service was one of the partner organizations in the development of "A National Plan for Assisting States, Federal Agencies, and Tribes in Managing White-Nose Syndrome in Bats" (FWS 2011) and subsequent "Implementation Plan" (FWS 2014).

Wind turbine collisions have also emerged as a serious threat to bats since the 2006 plan, with over 500,000 estimated annual fatalities in the U.S. and Canada (Arnett & Baerwald 2013). In this region, particularly impacted species include silver-haired bat, eastern red bat and hoary bat (Thompson et al. 2017). Recently published population modeling projects that "the hoary bat population could decline by as much as 95% in the next 50 years" and could be at risk of extinction due to wind turbine mortality

(Frick et al. 2017). While wind turbine mortality is not a factor in the Forest Service's control within the planning area, ensuring that Wayne National Forest conditions support survival and recruitment is within the Forest's purview.

State of the WNF

The WNF's public-facing web information (Wayne National Forest 2018) on WNS is out of date, stating incorrectly that WNS has not yet been found in Ohio. The most recent dated information on the site is from 2010. All eleven of Ohio's bat species are found within the planning area; of these, six species are "cave-dwelling" hibernating bats that are most susceptible to WNS. Two of those species are state and federally listed (Indiana myotis -Endangered and northern long-eared bat-Threatened). The other four species are all have state "Species of Concern" Status (big brown bat, eastern small-footed bat, little brown bat and tri-colored bat) (Ohio DNR 2018b). Three additional "Species of Concern" (silver-haired bat, eastern red bat and hoary bat), have experienced high levels of mortality in collisions with wind turbines (Thompson et al. 2017).

General remedies

Based on this information, we recommend that: 1) the Forest assess whether it is fulfilling, to maximum extent possible, the action items in these plans, particularly "disease management," 2) fully consider the threat of WNS in its Species of Conservation Concern determinations for the WNF, 3) Prioritize the maintenance of spring and summer roost habitat in forest management decisions, by retaining large-diameter trees and snags, particularly those in ravines and close to water, and 4) Maintain and improve breeding and foraging habitat for migratory bats.

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4b. Bird and Insect Populations

Issue

It is critically important to federal obligations under the Migratory Bird Treaty Act that the WNF continue to provide habitat for migratory birds, particularly those trust species that rely on the Forest for breeding habitat. Each of the units of the Wayne National Forest is a state Important Bird Area as designated by "Audubon". The Athens Unit alone has recorded observations of 226 species, including many of the species of concern within our Bird Conservation Region, and fifteen species that U.S. Fish & Wildlife Service has designated "Species of National Conservation Concern" (U.S. Fish and Wildlife Service, 2008), which are emphasized here:

Best Available Science:

Bald eagle (*Haliaeetus leucocephalus*): Nonbreeding in the Wayne National Forest area, populations increasing (BCC due to former Endangered Species Act listed status). Protected under Bald and Golden Eagle Protection Act). This species is increasing its population through much of its range (Sauer et al., 2017).

Red-headed woodpecker *(Melanerpes erythrocephalus*): Year-round resident species with declining populations in many areas. In anthropogenically modified habitats in Ohio, associations included hard-mast trees, snags and dead limbs in live trees (Rodewald, Santiago, & Rodewald, 2005). Taller and larger-diameter snags are also associated with nest success (Hudson & Bollinger, 2013). Breeding Bird Survey (BBS) data indicate that the species is declining in Ohio at a rate of 0.92% per year from 2005-15 (Sauer et al., 2017). Interference competition from starlings may be a factor in the species' decline (Frei, Nocera, & Fyles, 2015). The species has a conservation status rank of 24 in the Ohio State Wildlife Action Plan.

Olive-sided flycatcher (*Contopus cooperi*): The Wayne NF provides migratory stopover habitat for this species, which has undergone a nationwide decline of 2.48% per year from 2005-2015 (Sauer et al., 2017).

Blue-winged warbler (*Vermivora cyanoptera*): Breed in thickets and forest-shrub ecotones. Ohio populations declined by 2.22% per year over 200-155 (Sauer et al., 2017). The species has a conservation status rank of 10 in the Ohio State Wildlife Action Plan.

Golden-winged warbler (*Vermivora chrysoptera*): According to the State Wildlife Action Plan, this species has likely been extirpated as a breeding species in Ohio, and has been recorded in Wayne NF during migration stopover only. Nearby breeding populations in the Appalachians are considered at risk for fragmentation and extirpation.

Prairie warbler (*Setophaga discolor*): Breeds in shrubby areas and early successional forests, and had declined at a rate of 4.16% per year over 2005-15 (Sauer et al., 2017). The species has a conservation status rank of 24 in the Ohio State Wildlife Action Plan.

Bay-breasted warbler (*Setophaga castanea*): The Wayne NF provides migratory stopover habitat for this species, which has undergone a nationwide decline of 1.74% per year from 2005-2015 (Sauer et al., 2017).

Cerulean warbler (*Setophaga cerulea*): A high-canopy insectivore, was listed in the 2006 forest plan as a Management Indicator Species for "open to semi-open mature misted oak forest with a heterogenous canopy layer." 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), the period mostly encompassed by the life of the most recent forest plan. The cerulean warbler is tied with Henslow's sparrow atop the Ohio State Wildlife Action Plan's conservation status rankings for avian species of greatest conservation need (SGCN).

Prothontary warbler (*Protonotaria citrea*): Our only cavity-nesting warbler, the prothonotary is an indicator species for bottomland hardwood forests and forested wetlands. Considered a "scarce" breeder in Ohio, it has a conservation status rank of 10 in the Ohio State Wildlife Action Plan.

Worm-eating warbler (*Helmitheros vermivorum*): Ground-nesting warbler found on forested slopes, worm-eating warbler was a Management Indicator Species for hardwood and pine-hardwood forest on hillsides with a dense understory and coarse woody debris. it has a conservation status rank of 10 in the Ohio State Wildlife Action Plan. Populations in Ohio have increased since 2005 (Sauer et al., 2017).

Kentucky warbler (*Geothlypis formosa*): Breeds in riparian corridors in hardwood forests with dense understory. The species has undergone a nationwide decline of 2.56% per year from 2005-2015 (Sauer et al., 2017). Under the Ohio State Wildlife Action Plan, Kentucky warbler is an unranked addition to SGCN "list because of research and management activities that need to be conducted under this Action Plan."

Canada warbler (*Cardellina canadensis*): The Wayne NF provides migratory stopover habitat for this species, which has undergone a nationwide decline of 1.26% per year from 2005-2015 (Sauer et al., 2017).

Henslow's sparrow (*Centronyx henslowii*): The Henslow's sparrow, which breeds in densely vegetated mesic grasslands, was a Management Indicator Species in the 2006 plan for grasslands on reclaimed mine sites. It has declined in Ohio at a rate of 4.08% per year from 2005-2015 (Sauer et al., 2017). It is tied with cerulean warbler atop the Ohio State Wildlife Action Plan's conservation status rankings for avian species of greatest conservation need (SGCN).

Dickcissel (*Spiza americana*): Ohio populations of this grassland species, following a long-term decline, have been increasing slightly (0.89% per year) over 2005-15 (Sauer et al., 2017). Under the Ohio State Wildlife Action Plan, dickcissel is an unranked addition to SGCN "list because of research and management activities that need to be conducted under this Action Plan."

Rusty blackbird (*Euphagus carolinus*): Winters in the Wayne NF, using bottomlands and wooded ponds and swamps. Species' long-term decline nationally has accelerated in the past decade, to 4.21% per year over 2005-15 (Sauer et al., 2017).

Insect and pollinator species: The *Natural Areas Journal* recently dedicated an entire issue [36(4); 2016] to pollination and pollinators. Of particular relevance to the Wayne NF is the one arguing that open forest conditions need to be maintained for pollinator presence: "The data thus far clearly show that bee and butterfly communities benefit (e.g. generally becoming more abundant and/or species rich) from open forest conditions regardless of forest type or geographic region." ......Despite the benefits of more open forests to most pollinator species interventions aimed at creating these conditions have the potential to negatively impact rare species with small scattered populations" (Hannula 2016). This article also contains a very extensive literature citation section.

Condition of the WNF

Bird and insert populations are not systematically monitored on the WNF.

General remedy

The Wayne NF should assess the status of these species, as well as other species identified as "Management Indicator Species" in the 2006 Plan: pileated woodpecker (mature to over-mature forest with snags and coarse woody debris), Louisiana waterthrush (riparian corridors along headwater streams), pine warbler (pine and pine-hardwood forest), ruffed grouse (mosaic of early- mid- and late-successional forest), yellow-breasted chat (early successional forest), and other Ohio SWAP SGCNs within the forest, and determine if there is a need for change in management in order to halt population declines and ensure that the Wayne NF is maintaining and restoring the ecosystem integrity of the habitats these species rely on, and maintaining a viable population of each species of conservation concern within the plan area.

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4c. White-tailed deer

Issue

White-tailed deer (*Odocoileus virginianus*) browse almost any forest plant species, causing a range of well-documented negative effects on native species abundance and diversity. Decades of white-tailed deer overpopulation have dramatically homogenized forests across much of the eastern United States (e.g., Carson et al. 2005; for a good review see Cote et al. 2004). Deer populations are close to a historical high in Ohio, a level vastly higher than any time before European settlement. The species is abundant in all parts of the WNF and casual observation shows severe impact on the flora in some areas. Deer numbers are controlled by recreational hunting, but in the last 10 years, there has been a decline in hunting pressure in Ohio followed by an increase in deer numbers (ODNR 2018). From these data we can infer an increase in browsing pressure.

Best available science

In addition to confirming the negative effects of deer in forest plant communities, recent research examines interactions of deer grazing with other factors influencing diversity and explores the prospects for diversity recovery. Most studies use a standard experimental design comparing fenced plots (no grazing) with open plots (deer-grazed).

Recent work suggests that recovery of forest communities from over-grazing is very slow. Only after 5 years of deer exclusion did density of native forest species begin to increase at sites in western Pennsylvania, and diversity had not recovered after 11 years (Pendergast et al. 2016). Over a period of 4 years after deer removal, changes in composition were not observed, although native species growth, flowering, and reproduction increased at a site in Illionis (Nuzzo et al. 2017). Recovery of species composition following over-grazing is slow, in part because extirpated species must be replaced from outside the site. For example, deer browsing decreased forest species abundance and richness in the seed bank at sites near Baltimore (Beauchamp et al. 2013), and caused a shift in composition to short-lived weedy species in central New York state (DiTommaso et al. 2014).

Grazing often affects herb species indirectly, expressed as changes in growth and reproduction rather than species composition (Beauvais et al 2017; Nuzzo et al. 2017). Recent work has explored complex interactions of grazing with soil, litter, and light. Grazing increased available light by favoring sapling recruitment and increased soil compaction and litter thickness in Michigan (Sabo et al. 2017) with corresponding effects on herb species composition. In combination with other stressors of native forest herbs, deer effects override effects of introduced earthworms, slug herbivory, introduced plant species, and nutrient alteration at sites in (Davalos et al. 2014).

In addition to grazing forest herbs, deer presence has a variety of other negative effects on forest diversity. Browsing significantly decreases native aboveground insect richness, abundance, and diversity (Chips et al. 2015). Grazing causes significant decreases in woody species abundance and richness, with oaks most strongly affected at Middle Atlantic sites (Bourg et al. 2017). Invasive species abundance is often higher in the presence of deer (Bourg et al. 2017).

In areas adjacent to forest, a large deer herd is potentially an economic and health hazard. Browsing by deer significantly reduces agricultural crop yields (e.g. soybeans) in Ohio (Bagley-Miller and Cady 2015). Populations of black-legged tick (*Ixodes scapularis*) have increased dramatically in Ohio in recent years (Wang et al. 2014) and several tick-borne diseases have been reported (Wang et al. 2014; Foley et al. 2018; see also section 1e above), probably facilitated by large deer populations.

Condition of the WNF

Data are not available for deer population size in the WNF. However, because deer are capable of traveling long distances and the WNF is mixed with privately own parcels, regional data are probably adequate to describe grazing pressure. County-level harvest data suggest substantial numbers in the WNF (ODNR 2018), and casual observation shows severe grazing impacts in some areas. In Ohio the number of female deer harvested is proportional to the amount of farmland in a county, the proportion of non-crop cover types, and the per capita deer permit sales (Karns et al. 2016). Thus, deer density is probably highest in sections of the WNF adjacent to agriculture.

Deer occupy day-to-day ranges of 100-200 ha, and locations of these areas do not change through the year, even when hunters move into an area (Marantz et al. 2016). This report is consistent earlier studies (e.g., Lesage et al. 2000) and with qualitative observations of patchy deer density in Athens County.

General Remedy

Deer numbers should be significantly reduced in areas determined to have high diversity value. Because deer have limited daily movement and high site fidelity, local reduction can be achieved consistent with the ODNR goal of maintaining high regional deer density.

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4d. Reptile and Amphibian Populations

Issue

The Wayne NF planning area potentially contains one Federal ESA candidate species, the Eastern hellbender (*Cryptobranchus alleganiensis alleganiensis*), which is also Endangered in Ohio. The planning area also potentially contains several state species of greatest conservation need: Eastern Cricket Frog (*Acris crepitans crepitans*), Blue-spotted Salamander (*Ambystoma laterale*), Green salamander (*Aneides aeneus*), Four-toed salamander (*Hemidactylium scutatum*), Midland mud salamander (*Pseudotriton montanus diastictus*), and Eastern spadefoot toad (*Scaphiopus holbrookii*). Several reptile species of conservation concern may also be in the planning area: Spotted turtle (*Clemmys guttata*), Timber rattlesnake (*Crotalus horridus*), Eastern hognose snake (*Heterodon platirhinos*), Northern rough greensnake (*Opheodrys aestivus aestivus*), Queensnake (*Regina septemvittata*), Little brown skink (*Scincella lateralis*), and Eastern box turtle (*Terrapene carolina carolina*).

Best available science

Globally, amphibians are facing an extinction crisis, with 32% of the world's nearly 6600 amphibian species threatened with extinction, 43% experiencing declines and another 22% with insufficient data (Stuart et al. 2004). Causes of amphibian death and reduced recruitment include pathogens, "atmospheric change, environmental pollutants, habitat modification and invasive species" (Hayes et al. 2010).

The pathogen *Batrachochytrium dendrobatidis*, known as Bd (a chytrid), is a pathogenic fungus that disrupts electrolyte transport across the skin (Voyles et al. 2009). It emerged in 1998 (Berger 1998) and has caused global declines in amphibian populations (Skerratt et al. 2007). It has been detected in 14 species of amphibians in Ohio (Ohio DNR undated), including hellbenders (Bales et al. 2015) but its status and impacts in southeastern Ohio are unclear.

A "meta-analysis of experimental studies that measured the effects of different chemical pollutants (nitrogenous and phosphorous compounds, pesticides, road de-icers, heavy metals, and other wastewater contaminants) at environmentally relevant concentrations" found that pollutants caused "a 14.3% decrease in survival, a 7.5% decrease in mass, and a 535% increase in abnormality frequency across all studies" (Egea-Serrano et al. 2012). Contaminants of particular concern to hellbenders in Ohio include fertilizer runoff, siltation from land-disturbing activities such as agriculture and logging, and acid mine drainage (Morris 2018). Impacts of hydraulic fracturing are currently under investigation; anecdotal evidence suggests that a massive die-off of aquatic species, including salamanders, in a West Virginia creek, may be linked to illegal discharge of hydraulic fracturing wastewater (Hopey 2009).

Forest management can also affect amphibians. Patches that had been clear-cut recently and eleven years previously were significantly less permeable to juvenile wood frogs than 20+ year-old and mature forests; meaning that "Forestry practices that involve canopy removal . . . may affect regional population viability by hindering successful dispersal" (Popescu and Hunter 2011).

General Remedy

The Wayne should assess the status of herpetofauna in the forest and develop plan components to ensure the conservation of these species, particularly those of federal and state conservation interest. We recommend the use of the USDA Natural Resource Conservation Service Soil Service Geographic Database, which is capable of identifying a greater number of potential wetland locations than the National Wetlands Inventory and thus should be used in surveying for amphibian populations (Bowen et al. 2009). Furthermore, trails may be used to effectively monitor salamanders with less disturbance to populations or sensitive habitat, requiring less time for researchers to cover a given transect length, allowing for larger areas to be covered (Milanovich et al. 2015).

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4e. Large vertebrates

Issue

Large terrestrial vertebrates, particularly carnivores, pose challenges to management and conservation because of their large space requirements, considerable magnitude of movements, and relatively little information available on their ecology. For carnivores, these issues are compounded by the potential for human-wildlife conflict, the fact that many species are currently trapped or hunted, and that their ranges overlap private and public lands. With some species stable on WNF (deer, red fox, raccoon, Virginia possum, skunk), increasing (coyote) and recovering (bobcat), declining (gray fox), or transient (black bear, fisher), one of the most pressing issue is coordination of management and conservation with private land owners.

Best available science

Large vertebrates are declining worldwide, and are at the focus of intense conservation actions (Ripple et al. 2014, Dirzo et al. 2014). Large and medium sized carnivore (mesocarnivore) dynamics is driven by the interaction between habitat and food availability, and intraguild interactions (i.e., interactions with other carnivores), such as competition and predation (Ritchie and Johnson 2009, Schuette et al. 2013, Lourenço et al. 2014, Rich et al. 2018). As such, investigating the potential for recovering carnivore populations in fragmented landscapes has focused on understanding the trophic relations between carnivores (Svenning et al. 2016), and the relative importance of habitat partitioning and interspecific competition (Levi and Wilmers 2012, Gompper et al. 2016). As apex predators, many carnivore species provide a top-down structuring of the entire mammalian community; the disappearance of top predators results in ‘mesopredator release’ (increase in abundance of mesocarnivores, such as foxes, raccoons or mustelids), and potential increases in large ungulate populations (Ritchie and Johnson 2009).

Many carnivore and ungulate populations are trapped or hunted, yet many management plans lack the scientific information needed for sustainable harvesting decisions (Artelle et al. 2018). As such, managing carnivore and ungulate populations must balance people’s values, economic interests, and social acceptance (Treves 2009, Chapron and Treves 2016).

Because of reforestation of vast areas of formerly mined or agricultural lands in the Midwest, several carnivore species are currently expanding their ranges in Ohio, and are (or have been) of state conservation concern. Bobcats (*Lynx rufus*) are recovering in Ohio (Anderson et al. 2015), while black bear (*Ursus americanus*) sightings are becoming more common, and four fisher (*Pekania pennanti*) sightings have been recorded in last several years. At the same time non-native, but naturalized coyote (*Canis latrans*) and red fox (*Vulpes vulpes*) have been part of the large vertebrate community in Midwest for >100 years and interacting (Theberge and Wedeles 1989, Gosselink et al. 2003).

Condition of the WNF

The WNF is extensively forested, which is conducive for the establishment and persistence of large vertebrate species. White-tailed deer (*Odocoileus virginianus*) is abundant on WNF and is managed through regulated hunting in agreement with Ohio DNR regulations. All carnivore species present on WNF are habitat generalists, thriving in the mosaic of different forest types and ages, interspersed with open habitat (agricultural, pasture). Recent studies in WNF, showed that six carnivore species (coyote, bobcat, red fox, gray fox, possum, and raccoon) co-occur and have positive or negative two-way interactions (Rich et al. 2018). The occurrence of many species is predicted by land cover types, especially forest, at several spatial scales. (Rich et al. 2018) also found that bobcats are breeding in WNF, that skunk were not common, and there is evidence that gray foxes are currently in a precipitous decline throughout Ohio. Conserving large vertebrates in WNF is challenged by the presence of a dense network of roads, which may result in high mortality for some species (deer, mesocarnivores). The mitigation structures along the Nelsonville Bypass (US 33) reduced deer-vehicle collisions.

General remedies

To protect large vertebrates inhabiting WNF and actively participate in the recovery of formerly extirpated species, we recommend:

1. Collection of more information on the ecology of carnivores and human-carnivore interactions, as well as on the impacts of current forest management actions on carnivore habitat selection
2. Establishment of a monitoring protocol for detecting trends on carnivore populations in SE Ohio in coordination with Ohio DNR Division of Wildlife and Division of Forestry, with a particular emphasis on gray foxes in the short term
3. Protection of old stands, especially of mast tree species; these stands are critical for providing black bears with food resources needed to start establishing an Ohio population. In addition, fishers and bobcats use large, old trees (live or snags) for denning, and retaining stands with such structures is critical for reproduction.
4. Documentation of road kill throughout WNF, as roads are the greatest source of mortality in unharvested carnivore populations, and can hinder population recovery through direct mortality and reduced gene flow.

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4f. Loss of Ruffed Grouse Habitat

Issue

Ruffed grouse abundance data collected on an annual basis in Ohio since 1972 demonstrate that a once relatively robust grouse population in Ohio, specifically within the Wayne National Forest, has been all but extirpated as indicated in the annual ruffed grouse drumming survey.

Best available science

Ruffed grouse thrive in young forested habitats containing high stem densities and a diverse shrub layer typically characteristic of recently disturbed forests. Life cycle needs change throughout the year, as such a mosaic of forested age classes with high stem densities offer superior protection from predators and provide breeding and brood rearing habitat (Gullion and Svboda 1972, Dessecker and McAuley 2001).

Roadside drumming counts conducted by OH Division of Wildlife and U.S. Forest Service personnel along 41 survey routes within 29 counties depict a severely declining ruffed grouse population, where in 1972 surveys indicated 38.0 drums per 100 survey stops and in 2017 data collected indicated 2.2 drums per 100 survey stops (Ohio Department of Natural Resources, 2017).

In addition, US Geological Survey Breeding Bird Survey data for Ohio (1966 – 2015) show a similar precipitous decline, 47% of the bird species that require shrub-dominated or young forest habitats for breeding are experiencing population declines, while only 26% of these species are increasing. Conversely, only 21% of the bird species that prefer mature forest habitats for breeding are experiencing population declines, while 48% of these species are increasing (U.S. Geological Survey, 2017).

The cause of these declines in populations of wildlife dependent on young forest habitats is largely due to the lack of age class diversity, specifically lacking representation from young forest age classes (0-20) on the landscape. U.S Forest Service Forest Inventory and Analysis data show that since 1991, Ohio has lost approximately 1 million acres of seedling/sapling habitats, a 50% reduction.

Condition of the WNF

Ruffed grouse has been all but extirpated in the WNF, largely due to significant loss of shrub-dominated and young forest habitats in the past several decades. Currently, .04% of the total forest area within the Wayne National Forest falls under the 0-10 year age class that is critical for ruffed grouse and other young forest dependent species (USDA Forest Service, 2018).

Management Strategy:

It is recommended that the Wayne National Forest continue to increase the amount of shrub-dominated and young forest habitats developed during numerous projects thru the implementation of shelterwood and/or even-aged silvicultural treatments in hardwood stands. Recent landscape-scale loss of these habitats can only be substantively addressed by initiating landscape-scale habitat development.

Increasing oak and hickory regeneration in areas where this cover type may be lost to stand conversion is key. Oak and hickory forests are aging and being lost at an alarming rate within the Wayne National Forest, as such wildlife species dependent on young forest habitat are declining due to the loss of suitable forage and cover. Where applicable in stands identified for commercial timber harvest, conducting even-aged timber harvest in blocks of 40 acres or larger is recommended, cuts of this size are less likely to succumb to deer browse and should see a higher rate of regeneration success.

Where applicable, shelterwood cuts may be another timber harvest strategy where most of the marketable timber is harvested and the best trees are left to provide seed and partial shading for regeneration. In this type of harvest, nearly the entire cut area provides ideal habitat for grouse and other young forest dependent species.

Additionally, utilizing prescribed fire or girdling to emulate natural fire disturbance on the landscape is also recommended. Fire disturbance was prevalent on the landscape prior to European settlement, restoring fire to the region will promote the establishment of native species to these stands, including fruit bearing shrubs and herbaceous ground cover beneficial to numerous wildlife species including ruffed grouse. <Note that the Editors and several Contributors disagree strongly with this assessment of the pre-European prevalence of fire in Southeast Ohio; see Section 2a, above. We fear that the management regime described here would cause extensive loss of biological diversity in the WNF.> The proposed actions are a positive step that will help to address the serious long-term population declines of wildlife species that require these habitats both on the Wayne and on surrounding landscapes while supporting the local economy.

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