

**Working Group on Ecological Forest Management,
Climate Protection, and Sustainable Economies**

**Wayne National Forest Assessment Phase Comments
January 28, 2019**

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1. Committee members brief bios

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Heather Cantino, Buckeye Environmental Network (formerly Buckeye Forest Council) board member since 2001; Athens County's Future Action Network (ACFAN, formerly Athens County Fracking Action Network) Steering Committee chair. M.Ed., Education; B.A. in General Studies, Radcliffe College, Harvard University. Heather has lived in Athens since 1981. acfanohio@gmail.com

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Connie Gadell-Newton is an attorney and community activist in Columbus Ohio, with a B.A. in Philosophy and Women's Studies from OSU and a J.D. from Penn State University. Gadell-Newton was the Green party candidate for Governor of Ohio in 2018. cgadellnewton@gmail.com

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Barbara Lund, B.S Cornell University, former Park Ranger, Naturalist, National Park Service, resides in Adams County, Ohio. copiesg@gmail.com

Loraine McCosker, MS, BSN, RN. Served on the Sierra Club Forests and Public Lands for 14 years with oversight on state and the Wayne National Forest. Currently works as educator at Ohio University in Environmental Studies. loraine.mccosker@gmail.com

James Matzorkis, B.A. Keep Wayne Wild, lives in NE Ohio.

Robert Morris, B.F.A, Lives on the border of the Wayne National Forest, Woodsfield, Monroe County.

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2. Cover letter: problems addressed and recommendations

Dear Planning Revision Team,

The citizen-led Ecological Forest Management, Climate Protection, and Sustainable Economies Working Group presents the following concerns, with references to peer-reviewed and other documents submitted separately by our members. We expect all submitted documents to be evaluated in your planning revision process. Some submissions are re-submissions of testimony, research, and analysis previously submitted by Buckeye Forest Council, Athens County Fracking Action Network, Heartwood, Sierra Club, and other groups as well as by professional biologists and concerned citizens on issues that have yet to be addressed by the Wayne in a NEPA-based evaluation of forest actions. This includes extensive, relevant and substantive arguments objecting to:

1. The highly flawed 2006 Wayne National Forest Plan, which was legally contested at the time by Heartwood, Buckeye Forest Council, and Sierra Club (press release attached),
2. USFS permission to the BLM to lease Wayne land for fracking without the USFS *ever* having conducted a NEPA-based evaluation of fracking, in spite of the current (2006) plan not having evaluated this new technology and its now apparent highly significant impacts on the forest, community, climate, regional air and water quality and public health,
3. Destructive timber sales, prescribed burns, and other mismanagement activities that conflict with USFS's congressional mandate to provide economic benefit to the American people and to take into consideration all potentially significant economic and environmental impacts, including long-term climate impacts, of Wayne Forest actions on the community surrounding the Wayne and on the well-being of the American people in its decision-making for any and all significant actions.

In addition to resubmitting previously submitted materials, we have submitted other relevant and up-to-date research addressing USFS's legal responsibility to protect ecosystems and ecosystem services of the highest value for present and future generations, addressing cumulative impacts of all significant actions to be authorized by the new Plan. We look forward to a complete evaluation of all relevant issues raised in the accompanying documents.

A. Problems Addressed:

1. The highly flawed 2006 Plan, which was challenged in a lawsuit by Heartwood et al. and heavily critiqued in the 2008 *Economic Analysis of the 2006 Wayne National Forest Plan*, commissioned by Heartwood, for the Plan's prioritization of logging, mining, oil and gas drilling, prescribed burning, and ORV use over provision of the much more valuable non-consumptive ecosystem services that are severely degraded by this prioritization.

As stated in the introduction to this 2008 analysis, "Under the management of the USDA Forest Service, the WNF has continued to be a sacrifice zone for extractive industries, including logging, strip mining, and oil and gas drilling. Its hills are scarred with clearcuts, crisscrossed with power lines, torn up by ORVs, and the water flowing through its creeks and rivers is tinted orange with mining waste. The WNF, managed for its highest values — water filtration and flow regulation, air purification, tourism, biodiversity and carbon sequestration — could become a great natural asset to the State of Ohio and to the nation. Yet, by implementing the 2006 WNF Plan, the Forest Service continues to degrade and diminish this natural asset. The 2006 WNF Plan has declared 161,752 acres—almost 70 percent of the WNF area—as suitable for timber production and proposes to log 18,441 acres over the next decade—not including salvage logging. In addition, the Forest Service plans to burn 46,215 acres for an unproven 'Oak regeneration' program and 21,904 acres to reduce questionable 'hazardous fuels' risks. Almost 11,000 acres of forestland may be sprayed with herbicides,

1,250 acres opened to surface coal mining, and 121 acres to oil and gas well development. We may see about 180 miles of new temporary and permanent roads.

“The sum of extractive and destructive activities proposed in the 2006 Forest Plan will lessen the attractiveness of the forest and will negatively impact tourism. The [proposed activities] will also diminish the capacity of the WNF to deliver ‘ecosystem services’ such as water purification performed by the natural filtration systems of the earth and carbon sequestration provided by the trees and other forest plants. These ecosystem services have a much higher value to society than the timber that is taken out.

“In addition, cutting timber, digging for minerals, drilling for natural gas, and building ORV trails costs more in purely financial terms than what the Forest Service receives in revenues from those activities. Consequently, they create a financial loss to the taxpayer. The Forest Service justifies this double–negative with supposed benefits of “ecosystem management,” “oil independence,” and “tourism niche marketing,” as well as benefits to the local economy. However, as our analysis shows, it is questionable whether the 2006 WNF’s Land and Resources Management Plan (LRMP) provides *any* net benefits to the public....” (2008 Economic Analysis intro) The 2006 Plan did not assess economic impacts or costs of such prioritization, including lost ecosystem service benefits to the regional economy.

2. The 2006 Plan did not address public health benefits of leaving the forest alone to provide critical ecosystem benefits or the public health *impacts* of its management activities, including water and air pollution from oil and gas extraction, ORV use, forest loss, burning, and NNIS chemical treatments and consequent public health

impacts. Neither did it assess climate impacts of Plan activities and *their* health and economic impacts.

Numerous research articles have been submitted, starting with Cantino Packet #1's *Human health impacts of ecosystem alteration*, Samuel S. Myers et al., PNAS, 11-19-13. 110 (47), 18753-18760, doi.org/10.1073/pnas.1218656110 and *Tick-borne disease risk in a forest food web*, R. S. Ostfeld et al., Ecology, 99,7, 2018, 1562–1573, which states, “**Infection prevalence of nymphal ticks ...was lowest in sites with continuous forest [within1 km buffer] that were occupied by a diverse assemblage of predators of small mammals** (Fig. 4; Appendix S1: Fig. S1), which document these impacts, which the Wayne must address in its new Planning process. It is understood that evaluating impacts of Wayne activities is challenging, given that, as the PNAS research authors state (p. 18757), "...many of the relationships we are interested in involve the loss of a protective service as opposed to the presence of a risk. Viewed through a burden of disease lens, the burden is, paradoxically, generated by the loss of a protection, not the presence of an exposure. As a result, we are concerned with calculating the 'disease averted' that is associated with a natural system in a particular state... As we expressed earlier, the burden of ecosystem alteration may be disproportionately experienced by future generations."

In spite of the difficulty of doing so, it is clear that impacts are significant, cumulative, and long-term, and therefore, as required by NEPA, that the Wayne Plan Revision team must evaluate and document how its planned activities will not exacerbate loss of protections and cause significant long-term burden on future generations. The latter research article by Ostfeld, et al. addresses the importance of forest cover in stemming the tick-borne Lyme disease, which is rapidly spreading into SE Ohio. The Wayne must evaluate, in all future logging, burning, and ORV decisions, the impact of such forest destruction and fragmentation activities on human health from Lyme disease and other impacts of its proposed activities.

3. The 2006 Plan did not adequately consider the public's concerns, including opposition to logging, expressed during the Plan development and approval process.

According to the May 2006 coalition press release announcing its administrative appeal of the Plan (attached in Cantino Packet #1), “During the draft stages of the forest plan, the overwhelming majority of written and oral comments requested either a cessation of all commercial logging or substantially reduced logging as compared to the old forest plan (1988). According to a poll conducted by Wright State University, over 60% of Ohioans are opposed to commercial logging on public forest lands...In addition to logging, the forest plan will increase road building, prescribed burning and oil and gas leasing. The Forest Service plans to log nearly 18,000 acres over the next ten to fifteen years, an area equivalent to 13,591 football fields. That area does not include part of the Wayne slated for permanent deforestation to make way for the Nelsonville bypass. The bypass will cross through 768 acres of the Wayne National Forest, the size of 582 football fields.” The Plan also ignored the overwhelming support, clearly spelled out in surveys referenced by the Wayne at the time, for protecting the Forest for its high value and widely valued low-impact recreation values and biodiversity.

4. The 2006 release thus also addresses another major flaw of the Plan, which ignores impacts of the Nelsonville Bypass:

“The impacts of the Nelsonville Bypass were only minimally included in the Forest Service's management plan analysis,’ said Loraine McCosker, Vice-Chair of the Ohio Chapter of the Sierra Club. ‘The Fish and Wildlife Service determination states that the bypass is ‘likely to adversely affect’ the Indiana bat, a federally listed endangered species. The Ohio Sierra Club is very disappointed with the approach taken by the Forest Service because the management plan should include the cumulative effects of all actions taken in the forest.’” (from Coalition p.r., 2006, attached in Cantino packet #1 of this planning process)

5. The Wayne has also refused to seriously consider subsequent documentation by the public of forest destruction and other negative impacts caused by Wayne timber sales and “habitat improvement projects” [sic], such as Pleasant Bear and Sunny Oaks; the Nelsonville Bypass, prescribed burns, ORV expansion, and granting permission to the BLM to conduct fracking lease sales in spite of no NEPA-based evaluation of HVHF, as previously documented in numerous comments, face-to-face meetings, petitions, and legal

actions (with many documents re-submitted during this assessment phase, such as in ACFAN/Cantino Packet #2, 8-20-18).

We expect the Wayne to fully consider all previously submitted documents, petitions, reports, citation, and expressions of our significant concerns, whether or not we have re-submitted them now.

B. Recommendations:

The next Plan must address the economic and human health impacts of extraction, burning, ORV trails and use, NNIS methods (most of which are required only because there is so much forest disturbance caused by Forest activities), and the economic and public health benefits of leaving the forest intact to provide true ecosystem services, including carbon sequestration, air and water purification, native forest habitat preservation, and low-impact recreation. Managers and planners for the Wayne National Forest's new plan must consider these issues in assessing activities to be included, which must reap a net benefit to the American people under USFS's Congressional mandate. Clearly any activity that has greater environmental costs than benefits cannot meet this standard and must be rejected.

From the 2008 *Economic Analysis of the Wayne 2006 Forest Plan*: “These recommendations are based on the findings of this report, and are derived from basic principles of economic reasoning, which demand the maximization of net public benefit. Simply put, net public benefit is maximized by preferring activities that generate a high net public benefit (= benefits minus costs) over those that create a lower net benefit. Net public benefit for any activity increases when costs of achieving that benefit go down, and decreases when costs go up. For this analysis, costs and benefits have both monetary and non-monetary components. Net public benefit cannot be maximized when activities that have a low net public benefit (or that generate a net public loss), are preferred over activities that have a high net public benefit (large benefit, low cost). Basically, our recommendations consist of pointing out activities

that are likely to generate the largest possible positive difference between costs and benefits.” The 2008 Analysis spells these out:

1. “The Forest Service activities that generate the highest (long and short-term) financial costs on the WNF—prescribed burns, logging, mining, and OHV use—are also the ones that generate the most pollution and that most diminish the capacity of the Forest to provide highly valued ecosystem services related to air, water, climate, recreation, and biodiversity. Therefore, by simply stopping logging, burning and mining, the Forest Service can at once cut short-term and long-term costs considerably (including future costs of mine reclamation, or costs of removing roadbeds that were constructed to facilitate logging), and provide much larger public benefits from ecosystem services.
2. “Stopping logging, mining and prescribed burning will give the forest the opportunity to heal from centuries of heavy abuse. With trees being allowed to grow beyond the age when it is economical to log them, second growth forest will, over 200 to 300 years, develop into old growth forests, in which early successional habitat is provided by natural disturbances, and the forest develops a fine grained structure of habitats at various stages of succession. Old growth forests have all but disappeared from the landscape, and facilitating its recovery will greatly enhance one of the most valuable of all ecosystem services, the provision of rare interior forest habitats that keep associated species from going extinct (currently valued at over \$900 per acre/per year).
3. To further enhance the potential of the WNF to provide highly valued ecosystem services, the Forest Service needs to put increased emphasis on mine reclamation, removal of roads and trails, on reclaiming and reforesting areas with highly compacted or eroded soils, repairing damaged stream banks, and restoring wetlands. Forested wetlands and riparian areas have the highest ecosystem values of all forest land, and should therefore receive priority with regard to any necessary restoration work. (Ecosystem services from general forest land are

currently valued at \$1,476 per acre/per year, from wetlands at \$11,568 per year, and riparian buffers at \$3,383 per year).

4. The costs of OHV to ecosystem services, including water quality, biodiversity, climate, and avoidance of NNIS must be assessed before OHV activity is considered in the new Plan, and commitment made to close and rehabilitate all illegal OHV trails and to enact an effective program for monitoring and enforcement of forest regulations related to OHV and the costs of this enforcement assessed. The negative effects of both legal and illegal OHV usage—air, water and noise pollution, damage to wildlife habitat and conflicts with other high value, low impact recreation activities—must be quantified and weighed against any monetary benefit now accruing from OHV use. The Wayne must evaluate and document why it is competing with private landowner provision of OHV trails and the costs of doing so.
5. Instead of expanding OHV trails, we recommend that the Forest Service focuses on facilitating more low-impact and widely valued uses, such as hiking, wildlife viewing, visits to historic/cultural sites, use of highly developed recreational sites, and swimming, kayaking, canoeing and regulated hunting, fishing, and foraging. This can be accomplished, for example, by offering more hiking trails that are not open to conflicting uses by horses or mountain bikes, and more opportunities for wildlife watching. We support the Forest Service identifying, protecting and developing recreational opportunities related to cultural and historic sites, which have already been identified by the Forest Service as a niche for the WNF.
6. We also support the Forest Service in consolidating forestland within the WNF proclamation area through purchases of land from willing sellers, and recommend that priority is given to high-value riparian areas, areas with wetlands, areas suitable for wetland restoration, and areas that could help expand and restore large, continuous blocks of interior forest.

7. In addition, we recommend that the Forest Service address ownership fragmentation through buying conservation easements from private land owners.
8. To increase the prospects of expanding habitat for rare and endangered forest species we recommend that the Forest Service partners with other public and private land-owners to create wildlife corridors that connect small remnants of still existing original forest with each other and with the emerging old growth forest.
9. We recommend that prescribed burns for treatment of hazardous fuels on the WNF not be used, since they are ineffective in protecting home sites, and the risk of wildland fires is low on the WNF. If and when abnormal, significantly higher fire risks do develop on the Wayne, appropriate risk reduction activities should be considered on a case-by-case basis.
10. We recommend that any future Forest Plans provide a rigorous, focused, and complete analysis of monetary and non-monetary costs and benefits associated with different activities (including detailed budget projections), inspired by the format developed in the 2008 Economic Analysis from which these recommendations largely come.
11. Future Forest Plans should include reports on the values of different ecosystem services and how they are affected by management activities. The values of different ecosystem services (per acre/per year) can be expected to change over time. Forest plans should keep up with new developments in ecosystem valuation. At some time, it may be appropriate for the Forest Service to conduct original studies on specific ecosystem services that may be of special importance for the WNF.
12. Instead of conducting benchmark analyses showing the largest possible timber output or OHV trail length, the Forest Service should develop benchmarks related to the highest benefits derived from the forest, for example the number and size of unfragmented interior forest blocks, the

consolidation of forest land, the development of high value/low impact recreation opportunities, the reintroduction of charismatic species, the restoration and rehabilitation of disturbed lands (including wetlands and riparian areas), the rehabilitation of illegal OHV trails, and the effective enforcement of regulations on Forest use.

13. There will be jobs and income for the Forest Service and local communities from the implementation of these recommendations, but they will be different jobs with new job descriptions. For example, the Forest Service would not need experts in timber management but instead would need to hire or contract with professionals trained in ecosystem restoration and re-introduction of rare species. People would be hired or contracted for monitoring trails and enforcing regulations. Experts in identifying, protecting and developing historic/cultural sites would be needed, and jobs and income opportunities would develop around expanding opportunities for high value/low impact recreation.
14. Currently, off-budget funds such as K-V and Salvage Sale Fund, and the Fee Demo Project, create incentives for Forest Service managers to continue logging, mining and offering high-impact recreation such as OHV use. We recommend that Congress remove such incentives. Instead, new incentives should be created for managers to give priority to forest and endangered species protection and to increasing capacity of the forest to provide highly valued ecosystem services, including different forms of low impact recreation.
15. We recommend that the Forest Service assemble a task force that includes low impact recreation groups, wilderness advocacy groups, and other interested parties and do a serious survey of areas on the WNF that might be designated Wilderness.” Full report with references and tables at heartwood.org/wp-content/uploads/2016/07/Wayne_Economic_Analysis-.pdf
16. Given the cultural, historical and economic value of non-timber forest products such as goldenseal, ginseng, bloodroot, blue cohosh and black cohosh as well as certain species of mushrooms and tree nuts, it would be economically beneficial to encourage and support owners of land

adjacent to the Wayne to develop as well as protect existing populations of these medicinal plants.

We submit the following scientific references and other documentation with accompanying comments and recommendations, all for due consideration in development of a new Forest Plan EIS.

3. Annotated Bibliography

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A. Climate and GHG emissions impacts of managed forests and forest clearing

1. Kim Naudts et al., *Europe's forest management did not mitigate climate warming*, *Science Magazine* Feb. 5, 2016 • 351(6273), 597-599, documents **significantly increased carbon emissions from managed forests in comparison to unmanaged forests**, noting, "Putting 417,000 km² of previously unmanaged forest into production is estimated to have released 3.5 Pg of carbon to the atmosphere, because the carbon stock in living biomass, coarse woody debris, litter, and soil was simulated to be, respectively, 24, 43, 8, and 6% lower in managed forests compared with unmanaged forests. Differences in standing biomass between managed and unmanaged forests explain 38% of the total simulated 2.7-Pg increase in atmospheric carbon due to wood extraction."

*Given these conclusions, that there are **significantly increased carbon emissions from managed forests in comparison to unmanaged forests**, it is critical that the Wayne assess all actions that may have significant ghg emission impacts, including all logging and "thinning;" OHV trails and use plans; prescribed burning; road, pipeline, wellpad and other infrastructure development; and other management activities or "uses" of the forest for their long-term and cumulative impacts on forest carbon.*

2. Alkama, R. and A. Cescatti, *Biophysical climate impacts of recent changes in global forest cover*, **Science**, Feb 5, 2016:351 (6273), pp. 600-604, DOI: 10.1126/science.aac8083:

"Results show that in all climate zones, **forest clearing produces a marked increase of mean annual maximum air surface temperatures**, slight changes in minimum temperatures, and an **overall increase of mean temperatures**, except at the northernmost latitudes." And "This analysis reveals that the **biophysical effects of changes in forest cover can substantially affect the local climate by altering the average temperature and, even more markedly, the maximum summer temperatures and the diurnal and annual variations.**"

The Plan must lay out how these impacts will be quantified and assessed before any Forest clearing is considered, including for pipelines, "oak regeneration," roads, trails, or infrastructure.

3. C. Petrenko and A. Friedland, *Mineral soil carbon pool responses to forest clearing in Northeastern hardwood forests*, *Bioenergy* (2014), doi: 10.1111/gcbb.12221:

The research documents the several-decades-long **decline of soil carbon following forest logging** and the difficulty of calculating C emissions from proposed Forest management activities.

The Plan must assess soil carbon loss from all activities proposed.

4. *Does replacing coal with wood lower CO₂ emissions? Dynamic lifecycle analysis of wood bioenergy*, John D Sterman et al., [Environmental Research Letters](#), **Vol 13 (1)**,

Jan. 18, 2018. Abstract: “Bioenergy is booming as nations seek to cut their greenhouse gas emissions. The European Union declared biofuels to be carbon-neutral, triggering a surge in wood use. But do biofuels actually reduce emissions? **A molecule of CO₂ emitted today has the same impact on radiative forcing whether it comes from coal or biomass.** Biofuels can only reduce atmospheric CO₂ over time through post-harvest increases in net primary production (NPP). The climate impact of biofuels therefore depends on CO₂ emissions from combustion of biofuels versus fossil fuels, the fate of the harvested land and dynamics of NPP. Here we develop a model for dynamic bioenergy lifecycle analysis. The model tracks carbon stocks and fluxes among the atmosphere, biomass, and soils, is extensible to multiple land types and regions, and runs in ≈ 1 s, enabling rapid, interactive policy design and sensitivity testing. We simulate substitution of wood for coal in power generation, estimating the parameters governing NPP and other fluxes using data for forests in the eastern US and using published estimates for supply chain emissions.

“Because combustion and processing efficiencies for wood are less than coal, the immediate impact of substituting wood for coal is an increase in atmospheric CO₂ relative to coal. **The payback time for this carbon debt ranges from 44–104 years after clearcut, depending on forest type—assuming the land remains forest.** Surprisingly, replanting hardwood forests with fast-growing pine plantations raises the CO₂ impact of wood because the equilibrium carbon density of plantations is lower than natural forests. Further, **projected growth in wood harvest for bioenergy would increase atmospheric CO₂ for at least a century because new carbon debt continuously exceeds NPP. Assuming biofuels are carbon neutral may worsen irreversible impacts of climate change before benefits accrue.** Instead, explicit dynamic models should be used to assess the climate impacts of biofuels.”

If any wood taken from the Wayne may be destined for use as biomass or biofuels, full accounting of lifecycle ghg emissions must be assessed in the new Plan.

B. Particulate air pollution: health and importance of forests

1. Nowak et al, *Tree and forest effects on air quality and human health in the United States*, Environmental Pollution 193 (2014) 119-129. **“The total amount of pollution removal in 2010 by trees and forests in the conterminous United States was 17.4 million t (range: 9.0 million t to 23.2 million t), with a human health value of \$6.8 billion (range: \$1.5 billion to \$13.0 billion) (Table 2).”**
2. *Ambient PM_{2.5} Reduces Global and Regional Life Expectancy*, Joshua S. Apte et al., Environ. Sci. Technol. Lett., DOI: 10.1021/acs.estlett.8b00360, Pub (web): August 22, 2018 pubs.acs.org/doi/pdfplus/10.1021/acs.estlett.8b00360: Exposure to ambient fine particulate matter (PM_{2.5}) air pollution is a major risk for premature death. Here, we systematically quantify the global impact of PM_{2.5} on life expectancy. Using data from the Global Burden of Disease project and actuarial standard life table methods, we estimate global and national decrements in life expectancy that can be attributed to ambient PM_{2.5} for 185 countries. In 2016, PM_{2.5} exposure reduced average global life expectancy at birth by ~1 year with reductions of ~1.2–1.9 years in polluted countries of Asia and Africa. If PM_{2.5} in all countries met the World Health Organization Air Quality Guideline (10 µg m⁻³), we estimate life expectancy could increase by a population-weighted median of 0.6 year (interquartile range of 0.2–1.0 year), a benefit of a magnitude similar to that of eradicating lung and breast cancer. Because background disease rates modulate the effect of air pollution on life expectancy, high age-specific rates of cardiovascular disease in many polluted low- and middle-income countries amplify the impact of PM_{2.5} on survival. **Our analysis adds to prior research by illustrating how mortality from air pollution substantially reduces human longevity.**

Given that the Wayne National Forest is in a region of highly compromised air quality, which is increasingly threatened by USFS and other permits for deep-shale drilling and high-volume horizontal fracturing and concomitant air pollution from associated infrastructure, including pipelines, compressor stations, and venting of waste before injection, the degradation of air quality caused by logging, burning, and further oil and gas extraction and infrastructure authorized by USFS must be assessed and quantified in terms of regional health impacts per NEPA.

C. Urgency of climate crisis and duty of government to act

1. David Splatt and Ian Dunlop, *What Lies Beneath: The Understatement of Existential Climate Risk* —

“Human-induced climate change is an existential risk to human civilization: an adverse outcome that will either annihilate intelligent life or permanently and drastically curtail its potential, unless carbon emissions are rapidly reduced. Special precautions that go well beyond conventional risk management practice are required if the increased likelihood of very large climate impacts — known as “fat tails” — are to be adequately dealt with. The potential consequences of these lower-probability, but higher-impact, events would be devastating for human societies.” Further, “Since 1992, short-term economic interest has trumped environmental and future human needs. The world today emits 50% more carbon dioxide (CO₂) from the consumption of energy than it did 25 years ago, and the global economy has more than doubled in size. The UNFCCC strives ‘to enable economic development to proceed in a sustainable manner’, but every year humanity’s ecological footprint becomes larger and less sustainable. Humanity now requires the biophysical capacity of 1.7 Earths annually as it rapidly chews up natural capital. **A fast, emergency-scale transition to a post-fossil fuel world is absolutely necessary to address climate change.**” And, “**The first duty of a government is to protect the people. A government derives its legitimacy and hence its authority from the people, and so has a fiduciary duty to act in accordance with the interests of all the people with integrity, fairness and accountability. This duty has a particular sharpness in the new era of disruption and existential risk that will manifest as a consequence of the global failure...**”

2. "Arctic's strongest sea ice breaks up for first time on record: Usually frozen waters open up twice this year in phenomenon scientists described as scary: The oldest and thickest sea ice in the Arctic has started to break up, opening waters north of Greenland that are normally frozen, even in summer. This phenomenon – which has never been recorded before – has occurred twice this year due to warm winds

and a [climate-change driven](#) heatwave in the northern hemisphere...”

theguardian.com/world/2018/aug/21/arctics-strongest-sea-ice-breaks-up-for-first-time-on-record

3. Petition to the United States Bureau Of Land Management, An Agency Of The Department Of Interior, on behalf of Wild Earth Guardians *Requesting a Programmatic Environmental Impact Statement Addressing the Bureau of Land Management’s Oil and Gas Leasing Program and Formal Adoption of the Council on Environmental Quality’s Guidance for Greenhouse Gas Emissions And Climate Change Impacts, Jan. 20, 2016*
wildearthguardians.org/site/DocServer/APA_Petition_BLM_WildEarth_Guardians_1_18_Final_.pdf This petition lays out arguments on the seriousness of the climate crisis in arguments for a programmatic EIS on the BLM oil and gas program.

While this petition specifically addresses the BLM and the need for a programmatic EIS on oil and gas leasing, its legal arguments, references, and science are of utmost relevance to the Wayne's upcoming new Plan development. The economic costs of oil and gas leasing of Wayne minerals far outweigh any benefits to the American public and must be assessed through an EIS, which has never been done, since the 2006 Forest Plan did not evaluate either climate or non-climate impacts of fracking on the human environment and there has been no subsequent USFS NEPA-based evaluation of fracking impacts by USFS.

*The rigor with which climate impacts of Wayne actions must be assessed applies both to oil and gas leasing consent decisions, i.e., making parcels available to lease for fracking, as well as to logging, ATV/OHV, and prescribed burning activities that may be proposed for the Wayne under a new Plan. Given the extreme climate breakdown now occurring and accelerating daily, **all activities considered in the new Plan, whether in the 2006 Plan or not**, must be assessed in an EIS-level analysis for short- and long-term climate impacts, including all downstream impacts as well as cumulative climate impacts. Potential effects of a proposed action must include quantified GHG emissions for all projected emissions (not just for CO2 but of course for methane as well, using the latest equivalences (88-108, not 25 or whatever other outdated equivalents the industry and Trump administration may still use), as well as impacts of climate change on potential impacts of the action.*

4. *Quantifying the implicit climate subsidy received by leading fossil fuel companies.*
C. Hope et al, Cambridge Judge Business School Working Paper No. 02/2015.
insight.jbs.cam.ac.uk/2015/measuring-fossil-fuel-hidden-costs/ The study assesses

the carbon emissions embedded in twenty fossil fuel companies' products by the "social cost of carbon," i.e., the net economic, health, and environmental cost of a ton of carbon dioxide. "For all companies and all years, the economic cost to society of their CO₂ emissions was greater than their after-tax profit, with the single exception of Exxon Mobil in 2008".

5. *Greenland ice sheet melt 'off the charts' compared with past four centuries*, Dec. 5, 2018, [sciencedaily.com/releases/2018/12/181205133942.htm](https://www.sciencedaily.com/releases/2018/12/181205133942.htm). "Surface melting across Greenland's mile-thick ice sheet began increasing in the mid-19th century and then ramped up dramatically during the 20th and early 21st centuries, showing no signs of abating, according to new research published Dec. 5, 2018, in the journal *Nature*. The study provides new evidence of the impacts of climate change on Arctic melting and global sea level rise. 'Melting of the Greenland Ice Sheet has gone into overdrive. As a result, Greenland melt is adding to sea level more than any time during the last three and a half centuries, if not thousands of years,' said Luke Trusel, a glaciologist at Rowan University's School of Earth & Environment and former post-doctoral scholar at Woods Hole Oceanographic Institution, and lead author of the study. 'And increasing melt began around the same time as we started altering the atmosphere in the mid-1800s.'

"From a historical perspective, today's melt rates are off the charts, and this study provides the evidence to prove this" said Sarah Das, a glaciologist at Woods Hole Oceanographic Institution (WHOI) and co-author of the study. "We found a fifty percent increase in total ice sheet meltwater runoff versus the start of the industrial era, and a thirty percent increase since the 20th century alone."

"Ice loss from Greenland is one of the key drivers of global sea level rise. Icebergs calving into the ocean from the edge of glaciers represent one component of water re-entering the ocean and rising sea levels. But more than half of the ice-sheet water entering the ocean comes from runoff from melted snow and glacial ice atop the ice sheet. The study suggests that if Greenland ice sheet melting continues at "unprecedented rates" -- which the researchers attribute to warmer summers -- it could accelerate the already fast pace of sea level rise.

"Rather than increasing steadily as climate warms, Greenland will melt increasingly more and more for every degree of warming. The melting and sea level rise we've observed already will be dwarfed by what may be expected in the future as climate continues to warm," said Trusel."

6. **Increasing likelihood of severe heat and drought occurring together worldwide:** Sarhadi et al., *Multidimensional risk in a non-stationary climate: Joint probability of increasingly severe warm and dry conditions*. *Science Advances*, Nov. 2018.

Abstract: “We present a framework for quantifying the spatial and temporal co-occurrence of climate stresses in a non-stationary climate. We find that, globally, anthropogenic climate forcing has doubled the joint probability of years that are both warm and dry in the same location (relative to the 1961–1990 baseline). In addition, the joint probability that key crop and pasture regions simultaneously experience severely warm conditions in conjunction with dry years has also increased, including high statistical confidence that human influence has increased the probability of previously unprecedented co-occurring combinations. Further, we find that ambitious emissions mitigation, such as that in the United Nations Paris Agreement, substantially curbs increases in the probability that extremely hot years co-occur with low precipitation simultaneously in multiple regions. Our methodology can be applied to other climate variables, providing critical insight for a number of sectors that are accustomed to deploying resources based on historical probabilities.

7. NEPA requires USFS and BLM to adequately consider climate impacts, *including downstream impacts*, of agency activities. Court cases provide precedence for USFS’s duty to consider cumulative impacts, including *consumption of oil and gas produced as a result of USFS actions*. As stated in the Memorandum Opinion And Order of the U.S. District Court for The District Of New Mexico decision in San Juan Citizens Alliance, et al, V. U.S. Bureau Of Land Management, U.S.F.S. et al, Case 1:16-cv-00376-MCA-JHR (Document 33 Filed 06/14/18, p. 24), “By regulation, indirect effects of an action are effects that ‘are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable.’ 40 C.F.R. § 1508.8(b). Accordingly, it is erroneous to fail to consider, at the earliest stage feasible, ‘the environmental consequences of the downstream combustion of the coal, oil, and gas resources potentially open to development’ under the proposed agency action. See, e.g., W. Org. of Res. Councils, 2018 WL 1475470, at *13. As such, the Court concludes that BLM’s failure to estimate the amount of greenhouse gas emissions which [sic] will result from consumption of the oil and gas produced as a result of development of wells on the leased areas was arbitrary. This error also requires that BLM reanalyze the potential impact of such greenhouse gases on climate change in light of the recalculated amount of emissions in order to comply with NEPA.” Order at westernlaw.org/wp-content/uploads/2016/05/2018.06.14-SFNF-Final-Opinion-and-Order.pdf.

The implications of the urgency of required action on climate and of USFS responsibility, based on the inherent obligation of a government to protect its people as well as USFS’s congressional mandate to provide net benefits to the American people and to abide by NEPA and the 2012 Planning Rule are significant for the Wayne planning process: Climate impacts of Wayne activities have global economic and public health implications and must be fully and meaningfully assessed. This has not been done in spite of the Wayne

giving consent to the BLM to lease for fracking, a dangerous and grievous abrogation of responsibility that must be addressed in this planning process.

D. Climate Change and the Wayne National Forest

The 2012 Planning Rule directs the Wayne NF to assess, among other things: “System drivers, including dominant ecological processes, disturbance regimes, and stressors, such as natural succession, wildland fire, invasive species, and climate change; and the ability of terrestrial and aquatic ecosystems on the plan area to adapt to change;” [36 CFR § 219.6(b)(3)].

The 2006 Forest Plan is virtually silent on the topic of climate change; understanding of and interest in the topic have increased substantially during the intervening years. Therefore the next forest plan for the Wayne NF should fully incorporate both climate change adaptation (adjustment in natural or human systems in response to actual or expected climatic effects, which moderates harm or exploits beneficial opportunities) as well as climate change mitigation (reducing greenhouse gas emissions, and removing greenhouse gases from the atmosphere). (IPCC 2015)

According to the 2018 National Climate Assessment, “Global average temperature has increased by about 1.8°F from 1901 to 2016, and observational evidence does not support any credible natural explanations for this amount of warming; instead, the evidence consistently points to human activities, especially emissions of greenhouse or heat-trapping gases, as the dominant cause” (Hayhoe et al., 2018). The region of the Wayne NF has to date experienced an observed temperature increase of about 1oF, and by mid-century temperatures are projected to increase by 2 to 3°F under a low emissions scenario (RCP 4.5) and 4 to 5°F under the higher emissions scenario (RCP8.5). The region has also experienced a 42% increase in the proportion of annual precipitation falling in heavy events. Projected impacts for the region of the Wayne NF include an increase of extreme high temperatures and severe storm events (Hayhoe et al., 2018).

Furthermore by mid-century southeast Ohio is projected to experience 30 to 50 more days per year with high temperatures above 90°F, and 20 to 30 fewer days with temperatures below 32°F (Vose et al., 2017). A 10 to 13% increase in 20-year return period for daily precipitation is also projected for the area (Easterling, et al., 2017). Vapor pressure deficit is projected to increase, leading to drier plants and soils.

The Forest Service has a long history of working on climate change, dating to its 2008 Strategic Framework and 2010 National Roadmap for Responding to Climate Change. *We recommend that the WNF fully utilize this wealth of expertise and background,*

including the following publications where Forest Service was a lead author or partner organization:

“Effects of Climatic Variability and Change on Forest Ecosystems: A Comprehensive Science Synthesis for the U.S. Forest Sector,”(Vose, Peterson, & Patel-Weynand, 2012)

“Changing Climate, Changing Forests: The Impacts of Climate Change on Forests in the Northeastern United States and Canada,” (Rustad et al., 2012)

“Responding to Climate Change in National Forests: A Guidebook for Developing Adaptation Options” (Peterson et al., 2011);

“Scanning the Conservation Horizon: A Guide to Climate Change Vulnerability Assessment” (Glick et al., 2011)

“Climate-Smart Conservation: Putting Adaptation Principles into Practice” (Stein et al., 2014)

“Central Hardwoods Ecosystem Vulnerability Assessment and Synthesis: A Report from the Central Hardwoods Climate Change Response Framework Project,” (Brandt et al., 2014)

“Forest Service Central Appalachians Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the Central Appalachians Climate Change Response Framework Project,” (Butler, et al., 2015)

“Forest Adaptation Resources: Climate Change Tools and Approaches for Land Managers,” 2nd edition (Swanston et al., 2016)

Climate Change Impacts to Wayne NF and its Habitats

The Forest Assessment should include a robust treatment of the various individual and interacting threats to the WNF’s habitats and species. The Wayne NF should undertake a vulnerability assessment of key species of plants and wildlife on the forest, utilizing standard tools and frameworks. This assessment can be informed by the Forest Service’s own Central Appalachians regional assessment, which covered the southern unglaciated Allegheny plateau (Butler et al. 2015). It found that the most vulnerable ecosystem types in the region are hemlock, dry calcareous and riparian forests.

The Wayne should build on this assessment to better understand the following climate-related stressors and drivers that are mentioned in the Regional Assessment and elsewhere (Swanston et al., 2018): climate-related stresses like drought stress, wildfire frequency and severity, acid deposition and carbon dioxide fertilization, altered nutrient cycling, changes in invasive species,

insect pests, and forest diseases, the effects of herbivory on young regeneration and interactions among these factors. In particular, the Wayne should assess the potential effects of ecological drought (Clark et al., 2016; Crausbay et al., 2017; Millar & Stephenson, 2015), the role of climate in mediating infestations of forest pests like emerald ash borer (DeSantis, et al., 2013) and hemlock wooly adelgid (Paradis, et al., 2008) and others (Weed, et al., 2013, Dukes et al. 2009), non-native flora (Fisichelli, et al., 2014, Lui et al. 2017), species range shifts and changes in composition (Jump, et al., 2009; Ma et al., 2016; Woodall et al. 2009, Iverson et al. 2008, Fei et al. 2017).

Climate Change Adaptation: Implications of Activities and Management on WNF

Maintaining biodiversity in the face of environmental change is key to maintaining ecosystem services and functioning (Oliver et al., 2015; Tilman, Isbell, & Cowles, 2014) and should be prioritized in forest planning. There is an extensive body of literature on development of climate change adaptation options, both in general (Stein, B.A. & P. Glick, 2014, Bierbaum et al. 2013), and targeted to forest management (Peterson et al., 2011, Janowiak et al., 2014, Millar et al. 2007, Littell et al. 2012, Keenan 2015).

The Wayne NF should plan to engage in climate change adaptation activities for species and habitats. A large suite of potential options has been catalogued (Heller & Zavaleta, 2009). Successful climate change adaptation will likely require a diversity of adaptation options and a mix of strategies to “resist climate impacts, enhance resilience or transition systems” (Ontl et al., 2018). This could include: identify and protect climate refugia (Michalak, et al., 2018; Morelli et al., 2016) and geophysical settings that are conducive to presence of rare species (Anderson & Ferree, 2010); identify movement corridors that will allow species to shift their ranges in response to climate changes (Carroll, et al., 2018; McGuire, et al., 2016); and identify actions to improve resilience to disturbance by ameliorating other threats (like invasive species, unsustainable harvest, etc.).

Climate change should also inform Species of Conservation Concern identification. Climate change is increasingly being considered in conservation

measures for species of concern, particularly through state wildlife action plans (Staudinger, et al., 2015).

Wayne NF Baseline Carbon Stocks

Baseline assessment of carbon stocks is a required element of the forest Assessment [36 CFR § 219.6(b)(4)]. There have been several efforts to assess carbon stocks in Ohio's forests since the 2006 forest plan. The Ohio Department of Natural Resources' 2010 Statewide Forest Assessment (Lytle, 2010) cites Forest Service data from 2008 (link non-functioning) in its statewide assessment of the carbon content of live trees (277 million short tons), dead trees (39 million short tons), understory plants (7 million short tons), leaf litter (41 million short tons) and soil (227 million short tons). A 2011 study indicated that Ohio's forests contain more than 597 million tons of carbon and that carbon stocks have increased substantially in recent years as forests have matured (Widmann et al. 2011), a fact which highlights the need for an updated assessment. Both studies agreed that the highest levels of forest biomass in the state were found in the planning region.

Climate change mitigation: Greenhouse Gas Implications of Activities and Management on WNF

Timber Harvest. Baseline assessment of carbon stocks forms the basis of a quantitative understanding of the WNF's potential to help mitigate climate change. As the need to reduce global greenhouse gas emissions to prevent catastrophic climate change has become more apparent (DeAngelo et al., 2017), recent research has generated considerable interest in carbon uptake and storage by photosynthetic systems, including forests. One recent study found that "conservation, restoration and improved land management actions" in natural ecosystems like forests, wetlands and grasslands, can provide over one-third of the CO₂ mitigation needed through 2030 (Griscom et al., 2017). Indeed, Article 5 of the Paris Climate Agreement, to which the United States remains a party until 2020 at the earliest, states that "(1) Parties should take action to conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases as referred to in Article 4, paragraph 1(d), of the Convention, including forests." A major synthesis of forests and carbon storage concluded that: "**Because forest carbon loss contributes to increasing climate risk and because climate change may impede regeneration following disturbance, avoiding deforestation and promoting regeneration after disturbance should receive high priority as policy considerations.**" Policies to encourage programs or projects that influence forest carbon sequestration and offset fossil fuel emissions should also consider major items such as leakage, the cyclical nature of forest growth and regrowth, and the extensive demand for and movement of

forest products globally, and other greenhouse gas effects, such as methane and nitrous oxide emissions, and recognize other environmental benefits of forests, such as biodiversity, nutrient management, and watershed protection. Activities that contribute to helping forests adapt to the effects of climate change and which also complement forest carbon storage strategies, would be prudent.” (Mckinley et al., 2011).

*Protection of remnant primary, intact forests, along with restoration and reforestation of degraded landscapes, is therefore an underutilized aspect of climate protection; however, due to perverse incentives and gaps in greenhouse gas reporting, “forest protection and restoration in the United States has been largely ignored as a climate imperative while accelerated logging [for biomass energy and wood products] is often proposed as a climate solution” (Moomaw & Smith 2017). Logging activities are, in fact, a major threat to the ability of forests to store carbon. **Carbon emissions attributable to harvest currently account for 85% of the annual forest carbon loss from U.S. forests (86% in Ohio), dwarfing that of losses from insects, fire, wind and drought combined** (Harris et al., 2016). It has further been calculated that wood products, which are sometimes touted as a form of carbon sequestration, provide long-term storage for only about 1% of the carbon that was originally stored in the living forest (Ingerson, 2011).*

The Wayne National Forest assessment should include a robust analysis of the Forest’s contribution to carbon sequestration and an assessment of the extent to which logging activities hinder that critically important ecosystem service.

Oil and Gas Drilling and Mining. Other working groups and interested parties providing input to the Wayne National Forest have extensively documented concerns about the impacts oil and gas drilling and mining, particularly hydraulic fracturing, to biodiversity, air and water quality, water supply, and local health. We incorporate by reference here those comments.

A recent analysis of federal lands energy development found that nationwide emissions from these fossil fuel developments are 1.52 billion tons CO₂eq per year, and must be reduced by at least 25% if the U.S. hopes to keep climate warming to 2°C or less (TWS 2018).

The USGS, in calculations, “Combining the fossil fuel extraction and combustion emissions with the ecosystems emissions and sequestration estimates provides an informative summary result that includes both anthropogenic emissions and sequestration by ecosystems on Federal lands,” found that Ohio’s federal lands (comprised mainly of the WNF), in 2014 were a net source of carbon sequestration, at a rate of 0.6 million

metric tons CO₂ eq. Concerningly, this figure represents a decline from previous years (the figure was 2.5 mmt CO₂ eq in 2011) (Merrill et al., 2018).

Given that further extraction of fossil fuels conflicts with the clear need to reduce greenhouse gas emissions, the Wayne should include the goal of climate protection in its assessment of the potential impacts of drilling and mining.

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Additional climate research that must be assessed by the Wayne planning team:

1. *Increasing carbon loss from soil due to climate warming and intensification of this loss by any proposed activities must be quantified. Specifically, the drying and warming of soil from burning, logging, forest fragmentation, and road building have significant climate and biotic implications that must be assessed, given climate, soil C loss, and drying projections. See Crowther et al., Quantifying global soil carbon losses in response to warming, Nature, Vol. 5 (40), Dec. 2016, doi:10.1038/nature20150, and Bond-Lamberty et al., Globally rising soil heterotrophic respiration over recent decades, Nature, Vol. 560, Aug. 2108, doi.org/10.1038/s41586-018-0358-x*
2. Thanks to OEC and The Wilderness Society for their comments on carbon sequestration and its importance for Wayne planning. Excerpts:

“Carbon sequestration and storage potential is highest when old growth forests are allowed to recover. This is because old growth forests in the eastern United States are superior to all other forest age classes for both

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

“Note that an analysis of U.S. public timberlands found that a “no timber harvest” scenario eliminating harvests on public lands would result in an annual increase of 17-29 million metric tonnes of carbon (MMTC) per year between 2010 and 2050—as much as a 43% increase over current sequestration levels on public timberlands and would offset up to 1.5% of total U.S. GHG emissions (Depro et al. 2008). In contrast, moving to a more intense harvesting policy similar to that which prevailed in the 1980s may result in annual carbon losses of 27-35 MMTC per year between 2010 and 2050.

“It should be noted that the estimates of Depro et al. are likely overly conservative because the study did not take soil carbon fluxes into consideration. This is significant because **soil carbon represents roughly 60% of forest carbon storage in temperate forests** (James and Harrison 2016). **And, harvesting substantially disrupts soil carbon storage, which results in significant carbon emissions.**

“In particular, a recent meta-analysis of existing literature demonstrates that harvesting results in significant carbon losses in the organic horizons of forest Alfisols (-12%) and Ultisols (-66%), as well as in the mineral soils of Ultisols (-11.9%) (James J, and Harrison, R 2016, *The Effect of Harvest on Forest Soil*

Carbon: A Meta-Analysis, Forests 7, 308). And, these soil carbon findings are themselves likely overly conservative: they do not account for carbon losses in soils deeper than approximately 14 inches, which is a recognized major gap in the scientific literature (James and Harrison 2016). **The recovery period of soil C following harvest depends upon soil type and takes at least 60 years in many production forests (James and Harrison 2016).**

The FS should consider the value of old forests in relation to their intact soils with highly developed and well-established mycorrhizal structure. These intact and structured soils are important for carbon storage and sequestration purposes, and for forest health and resiliency in the face of climate change.”

3. McGarvey et al. 2015: “Carbon storage in old-growth forests of the Mid-Atlantic: toward better understanding the eastern forest carbon sink,” *Ecology* 96(2): 311-317 (2015). From abstract: “Total C density is 30% higher (154 Mg C/ha), and dead wood C density is 1800% higher (46 Mg C/ha) in the old-growth forests than in the surrounding younger forests (120 and 5 Mg C/ha, respectively)...Our results demonstrate the potential for dead wood to maintain the sink capacity of secondary forests for many decades to come.” **Note:** This study did NOT account for soil carbon.
3. Liebman et al., “Soil respiration in upper Great Lakes old-growth forest ecosystems,” *BIOS* 88(3) 105-115 (2017). bioone.org/journals/bios/volume-88/issue-3/0005-3155-88.3.105/Research-Article--Soil-respiration-in-upper-Great-Lakes-old/10.1893/0005-3155-88.3.105.short. “...declining C emissions from the soils of old-growth forests may contribute to unexpectedly high rates of forest C sequestration as forests age.” The study found that soil respiration (release of C) was lower in old growth forests than in younger forests.
4. Stephenson et al. 2014, *Rate of tree carbon accumulation increases continuously with tree size*, *Nature* 501: 90-93 March 2014. [Nature](https://doi.org/10.1038/nature12914). 2014 Mar 6;507(7490):90-3. doi: 10.1038/nature12914: “Old trees actively fix large amounts of carbon compared to smaller trees....a single big tree can add the same amount of carbon to the forest within a year as is contained in an entire mid-sized tree. The apparent paradoxes of individual tree growth increasing with tree size despite declining leaf-level and stand-level productivity can be explained, respectively, by increases in a tree's total leaf area that outpace declines in productivity per unit of leaf area and, among other factors, age-related reductions in population density. Our results are relevant to understanding and predicting forest feedbacks to the terrestrial carbon cycle and global climate system...The rapid growth of large trees indicates that, relative to their numbers, they could play a disproportionately important role in these feedbacks.”

5. Lichstein et al., “Biomass Chronosequences of United States Forests: Implications for Carbon Storage and Forest Management,” in C. Wirth et al. (eds.), *Old-Growth Forests*, Ecological Studies 207 (2009). Excerpts: “In summary, our results suggest that substantial late-successional AGB [above ground biomass] declines are rare in US forests. In contrast, late-successional AGB increases are relatively common, particularly in the eastern US;” “a substantial amount of additional carbon could probably be stored in US forests if large tracts of second growth were reserved from future harvest;” “...in most cases, AGB will stabilize or increase, rather than peak and decline, as succession proceeds.”

6. Depro, Brooks M. et al., *Public land, timber harvests, and climate mitigation: Quantifying carbon sequestration potential on U.S. public timberlands*, *Forest Ecology and Management* 255: 1122-1134 (2008). From abstract: “Our analysis found that a ‘no timber harvest’ scenario eliminating harvests on public lands would result in an annual increase of 17-29 million metric tonnes of carbon (MMTC) per year between 2010 and 2050, as much as a 43% increase over current sequestration levels on public timberlands and would offset up to 1.5% of total U.S. GHG emissions. In contrast, moving to a more intense harvesting policy similar to that which prevailed in the 1980s may result in annual carbon losses of 27-35 MMTC per year between 2010 and 2050. These losses would represent a significant decline (50-80%) in anticipated carbon sequestration associated with the existing timber harvest policies.” NOTE: This study didn’t account for soil carbon nor for losses in sequestration structure (robust mycorrhizal network structures). It also (incorrectly) assumed that sequestration would slow as forests aged.

E. Impacts of fracking on communities— air and water pollution, including from explosions and fires, toxicity of chemicals, water consumption and waste production

The following research documents how fracking compromises human health, including reproduction and development, through a variety of channels -- ozone and chemicals (air pollution), compromised water sources, noise, disruption of rural quality of life, ground shaking, noxious smells and sights, light pollution, and fear, which can have synergistic impacts on health from all stages of the oil and gas extraction and production process. The Wayne must assess costs to public health, quality of life, individuals' and community economic health, as well as impacts on wildlife of noise, fragmentation,

chemical pollution, vehicle and other direct causes of mortality, and all other impacts from fracking. These research papers must be reviewed and taken into account if fracking or other polluting activities are to be considered by the Wayne for inclusion in its new Plan. Lifecycle impacts, including the impacts of water consumption and waste production and disposal, must be considered.

1. Evidence from frequently occurring well pad fires. Examples of visual and witness evidence provided by many commenters since 2011, including recent Cantino/ACFAN packet #4.
2. Eisenbarth wellpad fire, June 2014, in **Monroe County Ohio – The USEPA report** (Cantino/ACFAN pkt #4, 8-24-18) documented **fishkill of at least 70,000 fish and toxic chemicals released into tributary of Ohio River, upstream of drinking water supply of millions).**
3. Yan and Stoten, *Association of groundwater constituents with topography and distance to unconventional gas wells in NE PA*. *Science of the Total Environment* [Vol. 577](#), 15 Jan 2017, pp 195-207 (in Cantino-ACFAN packet #6, 8-23-18) **“We found certain meaningful associations of elevated levels of certain dissolved constituents (e.g., Ca, SO₄, Cl, and Fe) with topography and the distance to the nearest gas well. ...The associations indicate potential for further impact on groundwater quality...[T]his study adds more evidence that UGD can impact groundwater.”**
4. [DiGiulio DC](#)¹, [Jackson RB](#). *Impact to Underground Sources of Drinking Water and Domestic Wells from Production Well Stimulation and Completion Practices in the Pavillion, Wyoming, Field*, [Environ Sci Technol](#). 2016 Apr 19;50(8):4524-36. doi: 10.1021/acs.est.5b04970 (in Cantino/ACFAN packet #6, 8-23-18): “A comprehensive analysis of all publicly available data and reports was conducted to evaluate impact to Underground Sources of Drinking Water (USDWs) as a result of acid stimulation and hydraulic fracturing in the Pavillion, WY, Field. Although injection of stimulation fluids into USDWs in the Pavillion Field was documented by EPA, potential impact to USDWs at the depths of stimulation as a result of this activity was not previously evaluated. Concentrations of major ions in produced water samples outside expected levels in the Wind River Formation, leakoff of stimulation fluids into formation media, and likely loss of zonal isolation during stimulation at several production wells indicate that impact to USDWs has occurred.

“Detection of organic compounds used for well stimulation in samples from two monitoring wells installed by EPA, plus anomalies in major ion concentrations in water from one of these monitoring wells, provide additional evidence of impact to USDWs and indicate upward solute migration to depths of current groundwater use.”

5. Theo Colborn et al., 2011, Natural Gas Operations from a Public Health Perspective, *Human and Ecological Risk Assessment*. 17 (5): 1039–1056. [doi:10.1080/10807039.2011.605662](https://doi.org/10.1080/10807039.2011.605662). From abstract: “A list of 944 products containing 632 chemicals used during natural gas operations was compiled. Literature searches were conducted to determine potential health effects of the 353 chemicals identified by Chemical Abstract Service (CAS) numbers. More than 75% of the chemicals could affect the skin, eyes, and other sensory organs, and the respiratory and gastrointestinal systems. **Approximately 40–50% could affect the brain/nervous system, immune and cardiovascular systems, and the kidneys; 37% could affect the endocrine system; and 25% could cause cancer and mutations.**”

These results indicate that **many chemicals used during the fracturing and drilling stages of gas operations may have long-term health effects that are not immediately expressed. In addition, an example was provided of waste evaporation pit residuals that contained numerous chemicals on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Emergency Planning and Community Right-to-Know Act (EPCRA) lists of hazardous substances.** The discussion highlights the difficulty of developing effective water quality monitoring programs. To protect public health we recommend full disclosure of the contents of all products, extensive air and water monitoring, coordinated environmental/human health studies, and regulation of fracturing under the U.S. Safe Drinking Water Act.” **The study also documents the many routes and industrial stages by which these chemicals get into the environment and result in human and animal exposure.** Provided previously including most recently by Cantino/ACFAN in packet #9, 8-23-18.

6. Ellen Webb et al., **Developmental and reproductive effects of chemicals associated with unconventional oil and natural gas operations**, *Rev Environ Health* 2014; 29(4): 307–318. **Abstract:**

“Unconventional oil and gas (UOG) operations have the potential to increase air and water pollution in communities located near UOG operations. Every stage of UOG operation from well construction to extraction, operations, transportation, and distribution can lead to air and

water contamination. Hundreds of chemicals are associated with the process of unconventional oil and natural gas production. In this work, we review the scientific literature providing evidence that adult and early life exposure to chemicals associated with UOG operations can result in adverse reproductive health and developmental effects in humans. Volatile organic compounds (VOCs) [including benzene, toluene, ethyl benzene, and xylene (BTEX) and formaldehyde] and heavy metals (including arsenic, cadmium and lead) are just a few of the known contributors to reduced air and water quality that pose a threat to human developmental and reproductive health. The developing fetus is particularly sensitive to environmental factors, which include air and water pollution. Research shows that there are critical windows of vulnerability during prenatal and early postnatal development, during which chemical exposures can cause potentially permanent damage to the growing embryo and fetus. Many of the air and water pollutants found near UOG operation sites are recognized as being developmental and reproductive toxicants; therefore there is a compelling need to increase our knowledge of the potential health consequences for adults, infants, and children from these chemicals through rapid and thorough health research investigation.” Previously provided to Wayne managers, including in ACFAN/Cantino packet #10, 8-23-18.

7. G.P. Macey et al., *Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study*. **Environmental Health** 2014 13:82 doi.org/10.1186/1476-069X-13-82; Full report on the study: [Warning Signs: Toxic Air Pollution at Oil and Gas Development Sites](http://comingcleaninc.org/warning-signs) (comingcleaninc.org/warning-signs): “Results show a wide range of hazardous chemicals are present in the air at levels above federal health and safety standards. In some cases, monitors revealed concentrations of hazardous chemicals high enough to pose an immediate health threat to people.”(packet #11, 8-23-18)

New peer-reviewed research's data on water consumption and waste production projections in eastern and Appalachian Ohio, including the Muskingum River watershed, as well as a review of water contamination data, and discussion of water rights in Ohio and the region must be fully assessed in relation to impacts on downstream water consumers if fracking is going to be

considered as a potential action in the new Wayne Plan, which would require a full NEPA-based EIS that addresses the severe impacts to the community of such potential water rights abuse:

8. Robert C. Palmer, Damien Short, and Walter E. Ted Auch, *The Human Right to Water and Unconventional Energy*, Int. J. Environ. Res. Public Health 2018, 15, 1858; [mdpi.com/1660-4601/15/9/1858/htm](https://doi.org/10.3390/ijerph15091858), 8-28-18. (In Cantino packet #13, 8-28-18) Important issues addressed of utmost relevance to the Wayne include, for example, p. 18, ff of pdf:

"Traditionally, Appalachian West Virginia and Ohio laterals require 970–1080 gallons per lateral foot (GPLF) with demand growing at a rate of 11–22% per year ([Figure 5](#)). As an example of how much liquid—and potentially radioactive—waste is produced, we estimate that 11–12% of the freshwater used in the fracking process comes back to the surface as “brine” and must be disposed of in Class II Salt Water Disposal Injection Wells. Put another way an 85-million-gallon lateral would likely produce 9.8 million gallons of liquid waste, which is equivalent to the total amount of water in 15 Olympic sized swimming pools."

And (p. 23 of pdf): "Such data highlights a crucial problem, there is no supply-side price signal demanding the UOGD industry reduce or stabilize their water demand per unit of energy produced. **An additional issue concerns anecdotal evidence pointing towards the UOGD industry relying on highly fragile and ecologically critical 1st- and 2nd-order streams and reservoirs throughout Appalachia**, when their demand cannot be met by documented water withdrawals agreements with conservancy districts ([Fig 9](#)). At the present time, research points to a 22–25% gap in our understanding of where this industry’s water demand is coming from, thus leaving frontline communities and policy makers in the dark regarding how this known ‘unknown’ environmental externality will manifest in the coming years and decades."

And also on p. 23: "Resource demand in the UOGD industry is directly related to the global price of oil and gas, with water demand increasing exponentially as the price of oil and gas declines. This forces the industry to rely on resources known to generate a disproportionate return-on-investment (ROI) relative to the price paid for the

resources. As an example, the water demand inflection points we have documented in the Marcellus and Utica plays of southern Appalachia happened to coincide with a 50% decline in the global price of Brent crude and West Texas intermediate oil between Q1-2014 and the end of 2016."

... "The Pennsylvania Department of Environmental Protection disclosed details of **243 cases in which fracking companies were found by state regulators to have contaminated private drinking water wells in the last four years** [78]. In a much delayed survey of existing scientific literature on this topic (not a new data set), the U.S. Environmental Protection Agency found 'scientific evidence that hydraulic fracturing activities can impact drinking water resources under some circumstances. "The report identifies certain conditions under which impacts from hydraulic fracturing activities can be more frequent or severe:

- Water withdrawals for hydraulic fracturing in times or areas of low water availability, particularly in areas with limited or declining groundwater resources;
- Spills during the handling of hydraulic fracturing fluids and chemicals or produced water that result in large volumes or high concentrations of chemicals reaching groundwater resources;
- Injection of hydraulic fracturing fluids into wells with inadequate mechanical integrity, allowing gases or liquids to move to groundwater resources;
- Injection of hydraulic fracturing fluids directly into groundwater resources;
- Discharge of inadequately treated hydraulic fracturing wastewater to surface water; and
- Disposal or storage of hydraulic fracturing wastewater in unlined pits resulting in contamination of groundwater resources' [79].

Cumulatively, the scientific literature, NGO and other policy reports and the vital testimony of local people indicate the likely impairment of the right to water for residents living near fracking sites. Even so, from the data presented here, we can see that perhaps the major issue regarding water use is the shifting of the resource from society to industry and the demonstrable lack of supply-side price signal that would demand the

UOGD industry reduce or stabilize their water demand per unit of energy produced. Thus, in the U.S. context alone, there is considerable evidence that the human right to water is seriously undermined by the UOGD industry and, given its spread around the globe, this could soon become a global human rights issue.” (p. 24)

9. *Competition for shrinking window of low salinity groundwater*, Grant Ferguson et al. Environ Research Letters, Oct. 2018, DOI: 10.1088/1748-9326/aae6d8. iopscience.iop.org/article/10.1088/1748-9326/aae6d8 **Abstract:** “Groundwater resources are being stressed from the top down and bottom up. Declining water tables and near-surface contamination are driving groundwater users to construct deeper wells in many US aquifer systems. This has been a successful short-term mitigation measure where deep groundwater is fresh and free of contaminants. Nevertheless, vertical salinity profiles are not well-constrained at continental-scales. In many regions, oil and gas activities use pore spaces for energy production and waste disposal. *Here we quantify depths that aquifer systems transition from fresh-to-brackish and where oil and gas activities are widespread in sedimentary basins across the United States. Fresh-brackish transitions occur at relatively shallow depths of just a few hundred meters, particularly in eastern US basins.* We conclude that fresh groundwater is less abundant in several key US basins than previously thought; therefore drilling deeper wells to access fresh groundwater resources is not feasible extensively across the continent. Our findings illustrate that groundwater stores are being depleted not only by excessive withdrawals, but due to injection, and potentially contamination, from the oil and gas industry in areas of deep fresh and brackish groundwater.”
10. Relevant to the above issue is the proximity of oil and gas wells to private drinking water wells in Ohio and around the nation. Clearly neither Ohio law nor federal law assesses or protects private drinking water wells from contamination by fracking chemicals. S. Jasechko and D. Perrone, *Hydraulic fracturing near domestic groundwater wells*, Proc Natl Acad Sci. 2017 Dec 12; 114(50): 13138–13143, doi:[10.1073/pnas.1701682114. **Significance:** “Millions of Americans rely on self-supply groundwater wells for drinking water, but the number of these wells that are located near hydraulic fracturing operations is unknown. Here, we show that approximately half of all hydraulically fractured wells stimulated in 2014 exist within 2–3 km of one or more domestic (public and self-supply) groundwater wells. Our finding that many hydraulically fractured and domestic groundwater wells are co-located emphasizes that determining how frequently hydraulic fracturing activities impact groundwater quality is important to maintaining high quality water in many domestic wells. **ABSTRACT** Hydraulic fracturing operations are generating

considerable discussion about their potential to contaminate aquifers tapped by domestic groundwater wells. Groundwater wells located closer to hydraulically fractured wells are more likely to be exposed to contaminants derived from onsite spills and wellbore failures, should they occur. Nevertheless, the proximity of hydraulic fracturing operations to domestic groundwater wells is unknown. Here, we analyze the distance between domestic groundwater wells (public and self-supply) constructed between 2000 and 2014 and hydraulically fractured wells stimulated in 2014 in 14 states. We show that 37% of all recorded hydraulically fractured wells stimulated during 2014 exist within 2 km of at least one recently constructed (2000–2014) domestic groundwater well. Furthermore, we identify 11 counties where most (> 50%) recorded domestic groundwater wells exist within 2 km of one or more hydraulically fractured wells stimulated during 2014. Our findings suggest that understanding how frequently hydraulic fracturing operations impact groundwater quality is of widespread importance to drinking water safety in many areas where hydraulic fracturing is common. We also identify 236 counties where most recorded domestic groundwater wells exist within 2 km of one or more recorded oil and gas wells producing during 2014. Our analysis identifies hotspots where both conventional and unconventional oil and gas wells frequently exist near recorded domestic groundwater wells that may be targeted for further water-quality monitoring.

In Ohio, “*most (> 50%) hydraulically fractured wells stimulated in 2014 were within 2 km of one or more domestic groundwater wells in Ohio (89% of hydraulically fractured wells),...*”

11. Ingraffea, A.R.; et al. *Assessment and Risk Analysis of Casing and Cement Impairment in Oil and Gas Wells in Pennsylvania, 2000–2012*. Proc. Natl. Acad. Sci. USA 2014, 111, 10955–10960 (referenced in Auch 2018 paper above) on casing failure rates and water contamination in PA revealed: “*Statewide data show a sixfold higher incidence of cement and/or casing issues for shale gas wells relative to conventional wells.*”
[10.1073/pnas.1323422111](https://doi.org/10.1073/pnas.1323422111)

The implications of this research for the Wayne’s obligation to consider the costs to the community of its decision to lease land for fracking are profound. The new Plan must address these long-term and cumulative impacts on the human community surrounding the Wayne.

12. Research documenting the persistence of polyethylene glycol in spills of fracking fluids: [Molly C. McLaughlin](#) et al., *Spills of Hydraulic Fracturing Chemicals on Agricultural Topsoil: Biodegradation, Sorption, and Co-contaminant Interactions*, Environ. Sci. Technol., 2016, 50 (11), pp 6071–6078, DOI: 10.1021/acs.est.6b00240,

May 12, 2016. (Cantino packet #14, 8-28-18, also to Kathleen Atkinson before the first lease auctions of Wayne land). The study cites **838 hydraulic fracturing fluid spills in Colorado in 2014**, which do not include those claimed to be less than 5 barrels if on a wellpad or less than one barrel if off a wellpad.

13. *Characterization of the chemicals used in hydraulic fracturing fluids for wells located in the Marcellus Shale Play* Huan Chen and Kimberly E. Carter, **J of Environ Management** 200 (2017) 312-324, [dx.doi.org/10.1016/j.jenvman.2017.05.069](https://doi.org/10.1016/j.jenvman.2017.05.069) (re-submitted in Cantino packet #20). From the abstract: "...This paper investigated the chemicals introduced into the hydraulic fracturing fluids for completed wells located in PA and W. Virginia from data provided by the well operators. The results showed a total of 5071 wells, with average water volumes of 5,383,743 ± 2,789,077 gal (mean ± standard deviation). A total of 517 chemicals were introduced into the formulated hydraulic fracturing fluids. Of the 517 chemicals listed by the operators, 96 were inorganic compounds, 358 chemicals were organic species, and the remaining 63 cannot be identified. **Many toxic organics were used in the hydraulic fracturing fluids. Some of them are carcinogenic, including formaldehyde, naphthalene, and acrylamide. The degradation of alkylphenol ethoxylates would produce more toxic, persistent, and estrogenic intermediates. Acrylamide monomer as a primary degradation intermediate of polyacrylamides is carcinogenic...**"
14. *Fossil Fumes: A public health analysis of toxic air pollution from the oil and gas industry*. JUNE 2016, catf.us/resources/publications/view/221. **Abstract:** "As the United States works toward implementing ambitious climate goals, methane pollution from the oil and gas supply chain has received increased attention, and for good reason — methane is a greenhouse gas 87 times more potent than carbon dioxide in the near term, and the oil and gas industry is the largest U.S. source of methane pollution. But methane is just one harmful air pollutant from the oil and gas industry. This report sheds light on the health impacts of hazardous and toxic air pollutant that are often emitted from oil and gas sites alongside methane, including benzene, formaldehyde, and ethylbenzene. These hazardous toxic air pollutants harm the health of people living near oil and gas facilities such as oil and gas wells, compressor stations, and processing plants. This report presents estimates, based on recent analysis carried out by EPA, of the cancer risk and respiratory health risk to residents of every county in the United States that can be traced back to air toxics from the oil and gas industry. Specifically, the analysis here is based on EPA's most recent National Air Toxics Assessment (NATA) analysis updated to reflect the latest emissions data from EPA's National Emissions Inventory (NEI)....The NATA assessment only takes into account the health impacts related to toxic air emissions

from the oil and gas industry, i.e. it does not account for the health impacts from particulate matter and ozone related air emissions, and it does not account for the health impacts of water contamination caused by oil and gas development. As such, NATA is an underestimate of the full health impact of oil and gas operations.” The report documents the impacts of fracking on cancer risk. These impacts must be quantified and assessed if the Wayne plans to consider further leasing in its new Plan.

15. *Prenatal exposure to unconventional oil and gas operation chemical mixtures altered mammary gland development in adult female mice*, [SA Sapouckey](#), [C. Kassotis](#), [S. C Nagel](#), and L. Vandenberg, *Endocrinology* 159(3), March 2018, 1277–1289

“Female mice exposed to a mixture of 23 chemicals used in oil and gas fracking developed mammary lesions and enlarged tissues—suggesting the chemicals may leave breast tissues more prone to cancer, according to a new study. The study is the first to examine the potential impact of chemicals used in unconventional oil and gas extraction—such as hydraulic fracturing and directional drilling—on mammary glands and suggests that *low levels of the chemical cocktail commonly found near frack sites may spur abnormal development in women's breast tissue.*

"The mammary gland is a hormone-sensitive organ that is responsive to multiple endocrine inputs during development," the authors wrote in the study. It's the latest potential health impact linked to fracking chemicals, which have been associated with low birth weights, birth defects and reduced brain function in children. The findings are important as more than 17 million people in the U.S live within a mile of an oil or gas well. Hydraulic fractured wells now account for about half of U.S. oil, and two-thirds of the nation's natural gas, according to the U.S. Energy Information Administration. In addition, *health impacts were seen after exposure to levels of chemicals well within what is found near frack sites. The mixture was just a fraction of the more than 1,000 chemicals used during oil and gas fracking.*" (submitted in Cantino packet #15 8-28-18)

16. *Systematic review of the association between oil and natural gas extraction processes and human reproduction*. [Balise VD](#), [Kassotis CD](#), [Nagel SC et al](#). *Fertil Steril*. 2016 Sep 15;106(4):795-819. doi 10.1016/j.fertnstert.2016.07.1099. **Abstract:** This systematic review identified 45 original published research articles related to oil and gas extraction activities and human reproductive endpoints. Reproductive outcomes

were categorized as [1] birth outcomes associated with maternal exposure, [2] semen quality, fertility, and birth outcomes associated with adult paternal exposure, [3] reproductive cancers, and [4] disruption of human sex steroid hormone receptors.

“The results indicate there is moderate evidence for an increased risk of preterm birth, miscarriage, birth defects, decreased semen quality, and prostate cancer... There is ample evidence for disruption of the estrogen, androgen, and progesterone receptors by oil and gas chemicals, which provides a mechanistic rationale for how exposure to oil and gas activities may increase the health risks we have outlined. The results from this systematic review suggest there is a negative impact on human reproduction from exposure to oil and gas activities. Many of the 45 studies reviewed identified potential human health effects. *Most of these studies focused on conventional oil and gas activities. Few studies have been conducted to evaluate the impact of unconventional oil and gas operations on human health. The impact of UOG activities may be greater than that of conventional activity, given that unconventional activities employ many of the same approaches and use dozens of known endocrine-disrupting chemicals [EDC] in hydraulic fracturing.* (submitted in Cantino packet #15 8-28-18, emphasis added)

17. Akob, D.M, et al, *Wastewater Disposal from Unconventional Oil and Gas Development Degrades Stream Quality at a West Virginia Injection Facility*, Environ. Sci. Technol., 9 May 2016 DOI:10.1021/acs.est.6b00428. From the abstract: "In June 2014, waters collected downstream from the site had elevated specific conductance (416 CS/cm) and Na, Cl, Ba, Br, Sr and Li concentrations, compared to upstream, background waters (conductivity, 74 CS/cm). Elevated TDS, a marker of UOG wastewater, provided an early indication of impacts in the stream. Wastewater inputs are also evident by changes in stream water adjacent to the disposal facility. *Sediments downstream from the facility were enriched in Rad and had high bioavailable Fe(III) concentrations relative to upstream sediments. Microbial communities in downstream sediments had lower diversity and shifts in composition.* Although the hydrologic pathways were not able to be assessed, these data provide evidence demonstrating that activities at the disposal facility are impacting a nearby stream and altering the biogeochemistry of nearby ecosystems.” (submitted in Cantino packet #15 8-28-18)
18. And another study on the endocrine disrupting chemicals (EDC) found at this site at levels known to result in adverse health effects: Christopher D. Kassotis, S.C. Nagel, et

al. *Endocrine disrupting activities of surface water associated with a W.V. oil and gas industry wastewater disposal site* *Science of the Total Environment* ,557–558 (2016) 901–910 (submitted in Cantino packet #15 8-28-18) Research highlights:

- Oil and gas wastewater disposal may increase endocrine disrupting activity in water.
- Tested EDC activity in surface water near oil and gas wastewater injection site.
- **Water downstream had significantly more EDC activity than reference water upstream.**
- Downstream surface water antagonized five different nuclear hormone receptors.
- EDC activity downstream was above levels known to result in adverse health effects.

19. *Toward an Understanding of the Environ and Public Health Impacts of Unconventional Natural Gas Development: A Categorical Assessment of the Peer-Reviewed Scientific Literature, 2009-2015.* Jake Hays and Seth B. C. Shonkoff, **Plos One**, April 20, 2016 <http://dx.doi.org/10.1371/journal.pone.0154164> “**Abstract:** The body of science evaluating the potential impacts of unconventional natural gas development (UNGD) has grown significantly in recent years, although many data gaps remain. Still, a broad empirical understanding of the impacts is beginning to emerge amidst a swell of research. The present categorical assessment provides an overview of the peer-reviewed scientific literature from 2009–2015 as it relates to the potential impacts of UNGD on public health, water quality, and air quality. We have categorized all available original research during this time period in an attempt to understand the weight and direction of the scientific literature. Our results indicate that at least 685 papers have been published in peer-reviewed scientific journals that are relevant to assessing the impacts of UNGD. **84% of public health studies contain findings that indicate public health hazards, elevated risks, or adverse health outcomes; 69% of water quality studies contain findings that indicate potential, positive association, or actual incidence of water contamination; and 87% of air quality studies contain findings that indicate elevated air pollutant emissions and/or atmospheric concentrations.** This paper demonstrates that the weight of the findings in the scientific literature indicates hazards and elevated risks to human health as well as possible adverse health outcomes associated with UNGD. There are limitations to this type of assessment and it is only intended to provide a snapshot of the scientific knowledge based on the available literature. However, this work can be used to identify themes that lie in or across studies, to prioritize future research, and to provide an empirical foundation for policy decisions.” Submitted 9-3-18 and previously to K. Atkinson, 12/16, to K. Wadzinski (BLM) and T. Scardina, 4/16.

20. McKenzie et al., 2019: *Relationships between indicators of cardiovascular disease and intensity of oil and natural gas activity in Northeastern Colorado*. Environmental Research 170 (2019) 56–64 (doi.org/10.1016/j.envres.2018.12.004). “Background: Oil and natural gas (O&G) extraction emits pollutants that are associated with cardiovascular disease, the leading cause of mortality in the United States. **Objective:** We evaluated associations between intensity of O&G activity and cardiovascular disease indicators.” From the discussion: “In this population, we observed positive associations between the intensity of O&G activity **within 16 km** of a participant's homes and some indicators of cardiovascular disease.”

21. *Unconventional oil and gas development and risk of childhood leukemia: Assessing the evidence*, Elise G. Elliott et al., Science of the Total Environment 576 (2017) 138–147 dx.doi.org/10.1016/j.scitotenv.2016.10.072 **H i g h l i g h t s:**

- Concerns exist about carcinogenic effects of unconventional oil & gas development.
- We evaluated the carcinogenicity of 1177 water pollutants and 143 air pollutants.
- These chemicals included 55 known, probable, or possible human carcinogens.
- Specifically, 20 compounds had evidence of leukemia/lymphoma risk.
- Research on exposures to unconventional oil & gas development and cancer is needed.

From the abstract: “The objective of this analysis was to assess the evidence of carcinogenicity of water contaminants and air pollutants related to UO&G development. We obtained a list of 1177 chemicals in hydraulic fracturing fluids and wastewater from the U.S. Environmental Protection Agency and constructed a list of 143 UO&G-related air pollutants through a review of scientific papers published through 2015 using PubMed and ProQuest databases. We assessed carcinogenicity and evidence of increased risk for leukemia/lymphoma of these chemicals using International Agency for Research on Cancer (IARC) monographs. The majority of compounds (N 80%) were not evaluated by IARC and therefore could not be reviewed. Of the 111 potential water contaminants and 29 potential air pollutants evaluated by IARC (119 unique compounds), 49 water and 20 air pollutants were known, probable, or possible human carcinogens (55 unique compounds). A total of 17 water and 11 air pollutants (20 unique compounds) had evidence of increased risk for leukemia/lymphoma, including benzene, 1,3-butadiene, cadmium, diesel exhaust, and several polycyclic aromatic hydrocarbons.”

22. Ellen Webb, Jake Hays, L Dyrzka, B Rodriguez, C Cox, K Huffling and S Bushkin-Bedient, *Potential hazards of air pollutant emissions from unconventional oil and natural gas operations on the respiratory health of children and infants*, **Rev Environ Health** 2016; aop; DOI 10.1515/reveh-2014-0070. Submitted in Cantino packet #24 8-30-18 and to K Atkinson 12-8-16. **Abstract:** Research on air pollutant emissions associated with unconventional oil and gas (UOG) development has grown significantly in recent years. Empirical investigations have focused on the identification and

measurement of oil and gas air pollutants [e.g. volatile organic compounds (VOCs), particulate matter (PM), methane] and the influence of UOG on local and regional ambient air quality (e.g. tropospheric ozone). While more studies to better characterize spatial and temporal trends in exposure among children and newborns near UOG sites are needed, existing research suggests that exposure to air pollutants emitted during lifecycle operations can potentially lead to adverse respiratory outcomes in this population. Children are known to be at a greater risk from exposure to air pollutants, which can impair lung function and neurodevelopment, or exacerbate existing conditions, such as asthma, because the respiratory system is particularly vulnerable during development in- utero, the postnatal period, and early childhood. In this article, we review the literature relevant to respiratory risks of UOG on infants and children. Existing epidemiology studies document the impact of air pollutant exposure on children in other contexts and suggest impacts near UOG. Research is sparse on long-term health risks associated with frequent acute exposures – especially in children – hence our interpretation of these findings may be conservative. Many data gaps remain, but existing data support precautionary measures to protect the health of infants and children.”

23. McKenzie LM, et al. (2017) *Childhood hematologic cancer and residential proximity to oil and gas development*. PLoS ONE 12(2): e0170423. doi:10.1371/journal.pone.0170423 (submitted to Wayne Planning Team in Cantino packet #16, 8-28-18):

"...In this registry based case control study, *we found that children aged 5–24 years diagnosed with acute lymphocytic leukemia (ALL) were 3–4 times as likely to live in areas with active oil and gas wells as were children diagnosed with nonhematologic cancers*, and the association between ALL and residential density of oil and gas wells increased monotonically from the lowest to highest IDW¹ well count categories after adjusting for age, race, gender, socioeconomic status, and elevation. Further adjustment for year of cancer diagnosis resulted in a slightly larger association in children aged 5–24 years...One possible environmental risk factor for childhood ALL that is associated with oil and gas development is exposure to **benzene** and other petroleum hydrocarbons. Ambient air benzene levels in Colorado areas with active oil and gas development ranged from 0.03–22 parts per

¹ inverse distance weighted (IDW) oil and gas well counts within a 16.1-kilometer radius of residence at cancer diagnosis for each year in a 10 year latency period to estimate density of oil and gas development.

² Rural setback requirements are 50' for residences from frackpads. Waste disposal facilities, from which

billion by volume (ppbv). Median benzene concentrations ranged from 0.212–0.757 ppbv, which are greater than the EPA risk-based screening level (RBSL) of 0.102 ppbv for benzene in residential air [18, 20, 47–50]. Benzene concentrations in groundwater samples collected at oil and gas development sites in northeastern Colorado associated with surface spills range from less than 1–12,000 parts per billion (ppb), with a median of 1.5 ppb [16], which is greater than EPA’s RBSL of 0.45 ppb for benzene in tap water [50]. It is important to note that EPA’s RBSLs for benzene are based on cancer concerns. Benzene is a well established cause of acute myeloid *leukemia in adults* [51]. Studies of benzene exposures and acute leukemias in children are limited and less conclusive. An ecological study in Texas reported that census tracts with the highest benzene levels (1.6 ppbv) had elevated rates of childhood ALL [11]. A case-control study in France reported that children aged 0–14 years living in a home adjoining to a gas station or repair garage were at increased odds of ALL [10]. Another case-control study in California reported elevated odds of ALL in children aged 0–5 years exposed to ambient levels of benzene and xylenes in the their third trimester of pregnancy [8]. ..."

24. *Health Hazards To Fetuses, Infants, And Young Children in Heavily-Fracked Areas Of Pennsylvania* Joseph J. Mangano MPH MBA, Radiation and Public Health Project, June 2015 for The Pittsburgh Foundation Pittsburgh PA. “Major findings include:
1. The rise in infant mortality in heavily-fracked counties was 13.9% greater than in other PA counties
 2. The rise in perinatal mortality in heavily-fracked counties was 23.6% >
 3. The rise in low-weight births in heavily-fracked counties was 3.4% >
 4. The rise in prematurity (gestation <32 weeks) in heavily-fracked counties was 12.4% greater
 5. The rise in cancer incidence age 0-4 in heavily-fracked counties was 35.1% greater.”
25. *Hydraulic fracturing and infant health: New evidence from Pennsylvania*. Janet Currie et al, Science Advances 13 Dec 2017: 3(120, e1603021, DOI: 10.1126/sciadv.1603021. (Submitted to Wayne Planning Team in Cantino packet #16, 8-28-18): "...To evaluate the potential health impacts of fracking, we analyzed records of more than 1.1 million births in Pennsylvania from 2004 to 2013, comparing infants born to living at different

distances from active fracking sites and those born both before and after fracking was initiated at each site. We adjusted for fixed maternal determinants of infant health by comparing siblings who were and were not exposed to fracking sites in utero.

“We found evidence for negative health effects of in utero exposure to fracking sites within 3 km of a mother’s residence, *with the largest health impacts seen for in utero exposure within 1 km of fracking sites*. Negative health impacts include a *greater incidence of low-birth weight babies as well as significant declines in average birth weight and in several other measures of infant health*. There is little evidence for these health effects at distances beyond 3 km, suggesting that health impacts of fracking are highly local. Informal estimates suggest that about 29,000 of the nearly 4 million annual U.S. births occur within 1 km of an active fracking site and that these births therefore may be at higher risk of poor birth outcomes.”

26. **Unconventional Natural Gas Dev and Birth Outcomes in PA, USA**, J.A. Casey et al., *Epidemiology*, 2015. Submitted to Wayne in Cantino Packet #27, Aug. 30, 2018 and to K Atkinson, 12-8-16. “**Results:** in adjusted models, there was an association between unconventional natural gas development activity and preterm birth that increased across quartiles, with a fourth quartile odds ratio of 1.4 (95% confidence interval = 1.0, 1.9). there were no associations of activity with apgar score, small for gestational age birth, or term birth weight (after adjustment for year). in a posthoc analysis, there was an association with physician-recorded high-risk pregnancy identified from the problem list (fourth vs. first quartile, 1.3 [95% confidence interval = 1.1, 1.7]). **Conclusion:** Prenatal residential exposure to unconventional natural gas development activity was associated with two pregnancy outcomes, adding to evidence that unconventional natural gas development may impact health.”
27. Rabinowitz PM et al. 2015. *Proximity to natural gas wells and reported health status: results of a household survey in Washington Co, PA*. **Environ Health Perspect** 123:21-26. Submitted in Cantino packet #29, 8-30-18. <http://dx.doi.org/10.1289/ehp.1307732/> Results: “The number of reported health symptoms per person was higher among residents living < 1 km (mean ± SD, 3.27 ± 3.72) compared with > 2 km from the nearest gas well (mean ± SD, 1.60 ± 2.14; p = 0.0002). In a model that adjusted for age, sex, household education, smoking, awareness of environmental risk, work type, and animals in house, reported skin conditions were more common in households < 1 km compared with > 2 km from the nearest gas well (odds ratio = 4.1; 95% CI: 1.4, 12.3; p = 0.01). Upper respiratory symptoms were also more frequently reported in persons

living in households < 1 km from gas wells (39%) compared with households 1–2 km or > 2 km from the nearest well (31 and 18%, respectively) (p = 0.004).”

28. Sara G. Rasmussen et al. *Assoc Between Unconventional Natural Gas Devel in the Marcellus Shale and Asthma Exacerbations*. **JAMA Intern Med.**, July 18, 2016 doi:10.1001/jamainternmed.2016.2436. Submitted in Cantino packet #26, 8-30-18 and previously to K Atkinson, 12-7-16 with request for a response, which was never forthcoming. From the research: “Question: Is there an association between unconventional natural gas development (UNGD) and asthma exacerbations?
Findings: In this nested case-control study of 35,508 patients with asthma, those in the highest quartile of residential UNGD activity had significantly higher odds of 3 types of asthma exacerbations (new oral corticosteroid medication orders, emergency department visits, and hospitalizations) than those in the lowest quartile. Meaning: **UNGD activity near patient residences was associated with increased odds of mild, moderate, and severe asthma exacerbations.**”
29. M. Haley et al., *Adequacy of Current State Setbacks for Directional High-Volume Hydraulic Fracturing in the Marcellus, Barnett, and Niobrara Shale Plays*. *Envir Health Perspec* 124 (9) Sept 2016, ehp.niehs.nih.gov/doi/pdf/10.1289/ehp.1510547: “There is an increasing awareness of the multiple potential pathways leading to human health risks from hydraulic fracturing. ... We attempted to determine whether legal setback distances between well-pad sites and the public are adequate in three shale plays. We reviewed geography, current statutes and regulations, evacuations, thermal modeling, air pollution studies, and vapor cloud modeling within the Marcellus, Barnett, and Niobrara Shale Plays. **The evidence suggests that presently utilized setbacks may leave the public vulnerable to explosions, radiant heat, toxic gas clouds, and air pollution from hydraulic fracturing activities.** Our results suggest that setbacks may not be sufficient to reduce potential threats to human health in areas where hydraulic fracturing occurs. It is more likely that a combination of reasonable setbacks with controls for other sources of pollution associated with the process will be required.” (emphasis added, submitted in Cantino packet #16)
30. McKenzie LM et al., *Ambient Nonmethane Hydrocarbon Levels Along Colorado's Northern Front Range: Acute and Chronic Health Risks*. *Environ Sci Technol*. 2018 Apr 17;52(8):4514-4525. doi: 10.1021/acs.est.7b05983. Abstract: “Oil and gas (O&G) facilities emit air pollutants that are potentially a major health risk for nearby populations. We characterized prenatal through adult health risks for acute (1 h) and chronic (30 year) residential inhalation exposure scenarios to nonmethane hydrocarbons (NMHCs) for these populations. We used ambient air sample results to estimate and compare risks for four residential scenarios. We found that air pollutant concentrations

increased with proximity to an O&G facility, as did health risks. Acute hazard indices for neurological (18), hematological (15), and developmental (15) health effects indicate that populations living within 152 m of an O&G facility could experience these health effects from inhalation exposures to benzene and alkanes. Lifetime excess cancer risks exceeded 1 in a million for all scenarios. **The cancer risk estimate of 8.3 per 10,000 for populations living within 152 m of an O&G facility exceeded the United States Environmental Protection Agency's 1 in 10,000 upper threshold [which used to be 1 in 100,000]. These findings indicate that state and federal regulatory policies may not be protective of health for populations residing near O&G facilities.** Health risk assessment results can be used for informing policies and studies aimed at reducing and understanding health effects associated with air pollutants emitted from O&G facilities.”

Excerpts from the report: “**Note:** Colorado mandated regulatory exclusion zones around residential structures in which the drilling of O&G wells is discouraged are referred to as setback distances. Colorado setback distances were historically as short as 150 feet (46 m) and are currently at 500 feet (152 m). Additionally, setback distances of 1000 feet (305 m) apply to high occupancy buildings serving 50 or more people (e.g., schools and hospitals) as well as operating child care centers for 5 or more children. While the setback distances are intended to protect the general public’s safety and welfare from environmental and nuisance impacts resulting from O&G development, they are not intended to address potential human health impacts associated with O&G development air emissions. Air pollution is one of the major potential health risks for populations living near O&G sites. O&G sites directly emit nonmethane hydrocarbons (NMHCs) into the air, and several studies have identified O&G facilities as major contributors to ambient NMHC levels along the CNFR. Some of these NMHCs such as benzene, toluene, ethylbenzene, and xylenes (BTEX) are defined as hazardous air pollutants. Because of higher atmospheric stability at night, nighttime emissions do not disperse as much as during the daytime, and average nighttime benzene levels are approximately twice daytime levels. ... Recent Colorado studies observed that infants with congenital heart defects and children diagnosed with leukemia are more likely to live in the densest areas of O&G wells. Studies in Pennsylvania and Texas have observed associations between proximity to O&G wells and fetal death, low birthweight, preterm birth, asthma, fatigue, migraines, and chronic rhinosinusitis. ... One important shortcoming of previous risk assessments is that they did not consider shortterm and repeated nighttime peak exposures. They did not explicitly address childhood exposures or incorporate findings from the most recent studies on health effects associated with ambient benzene exposure. Additionally, data sets supporting most of the previous risk assessments were not sufficient for assessment of short-term exposures to air pollution O&G facilities or the variance in health risks with differing setback distances from O&G facilities.”

“... We assessed acute and chronic health risks from air pollution associated with O&G

operations using data collected in close proximity to O&G facilities and realistic residential scenarios tied to regulatory setback distances and literature reference points. This approach allowed us to incorporate proximity, spatial variability, and temporally relevant sampling durations into our exposure scenarios. The consistent application of exposure and toxicity parameters for all four scenarios allows for the comparison of hazards and risks between the scenarios. We found increasing (1) hematological and developmental His [hazard indices] and (2) cumulative lifetime excess cancer risks with decreasing distance to the nearest O&G facility. These results are consistent with findings from observational epidemiological studies that indicate an increased likelihood of adverse birth outcomes and childhood acute lymphocytic leukemia with increasing proximity to O&G wells... For the 1-min samples (Figure 3), mean ambient BTEX and total alkane concentrations increased as the distance of the sample collection from the nearest O&G facility decreased ($p < 0.001$). The mean ambient benzene, toluene, ethylbenzene, total xylene and total alkane concentrations from the 1-min samples collected within 152 m of the nearest O&G facility were 41, 34, 35, 32, and 86 times higher, respectively, than the mean from 1-min samples collected further than 1600 m from the nearest O&G facility... All cumulative lifetime excess cancer risks exceeded USEPA's de minimus benchmark of 1 in a million⁵⁸ with benzene representing more than 95% of the total risk estimate for all scenarios. The cumulative lifetime excess cancer risk increased with decreasing distance to the nearest O&G facility. For residents living within 152 m of an O&G facility, the risk exceeded the USEPA upper bound risk level of 1 in 10 000⁵⁶ with an overall risk of 8.3 per 10 000... These lifetime excess cancer risk estimates are 10–100 times greater than those reported in previous risk assessments in O&G development areas that used USEPA guidance. This is partly because the OEHHA inhalation benzene CPF (0.1 (mg/kg-day)⁻¹) is 4 times higher than USEPA's benzene slope factor (0.027 (mg/kg-day)⁻¹). The OEHHA approach addresses methodological shortcomings in the derivation of USEPA's current slope factor, which was calculated with a linear extrapolation model that assumes excess risk is proportional to the lifetime average exposure, is the same for all ages, and does not explicitly address the impact of episodic exposure peaks. OEHHA's inhalation CPF was calculated using a weighted cumulative exposure/relative risk procedure that assumes with continuous exposure, age-specific cancer incidence continues to increase as a power function of the elapsed time since the initial exposure.³⁵ Additionally, OEHHA includes prenatal exposures in the calculation of lifetime excess cancer risk based on recent studies indicating increased susceptibility to benzene in early life. Even using USEPA's current slope factor, which would reduce the lifetime excess cancer risk from benzene for residents living within 152 m of an O&G facility to 2.2 in 10 000, our results remain above USEPA's 1 in 10 000 upper bound for remedial action."

31. [Environmental Health Project's Setback Distances, Public Health and Shale Gas Development factsheet](#) (submitted 8-30-18). Note guidance to establish a setback distance minimum of 1 ¼ miles (6600 feet or 2 km) from gas processing plants and large compressor complexes whose emissions exceed 1000 grams/hour. Also: “Establish a setback distance minimum of 1¼ miles (6600 feet or 2 km) for schools/daycares, hospitals, nursing homes, and other high-occupancy buildings that house vulnerable populations and/or are difficult to evacuate.” Examples cited that support increased setbacks include:
- “Negative birth outcomes from 0.6-1.8 miles of shale gas development including low birth weight (5.8 lbs and less), and higher rates of small-for-gestational-age (SGA).
 - Babies born to mothers living less than a mile from wells were 25 percent more likely to weigh less than 5.8 pounds at birth.
 - Increase in number of babies born with congenital heart disease and possibly neural tube defects is related to both the number of wells in the vicinity and the distance from them to the mother’s homes.
 - Worsening asthma symptoms are linked to nearness of shale gas facilities.
 - Self-reported symptoms, including headaches, fatigue, upper and lower respiratory complaints, skin rashes, and mental health concerns (anxiety and depression) are seen up to 5 miles from well pads.
 - Health symptoms reported by residents, such as headaches and wheezing, were more frequent the closer the resident lived to wells....”

32. *The Human Health Implications of Oil and Natural Gas Development*, [Anne C. Epstein](#). *Advances in Chemical Pollution, Envir Management and Protection Vol. 1*, 2017, pp 113-145, Ch 5. doi.org/10.1016/bs.apmp.2017.08.002 **Abstract:**

“**Shale** energy extraction activities in residential areas have the potential to adversely affect human health. *The oil and gas sector is the largest industrial source of volatile organic compounds, which are dangerous because they include hazardous **air pollutants**, such as the **carcinogen benzene**; and because they are precursors to **ozone**, which is also hazardous to health.* Leaks from a small number of high-emitting sources account for a large percentage of these emissions. Furthermore, recent studies from several shale basins suggest that benzene emissions from oil and natural gas activities are significantly greater than accounted for in state inventories. Benzene may reach dangerous levels within legal residential distances in very close proximity to individual facilities, and sometimes at

the regional level as well. Recent studies of ozone indicate that *oil and natural gas activities are responsible for a significant percentage of regional ozone levels in densely drilled shale basins, with potential health impacts on millions of people. A study of well blowouts revealed that the average evacuation radius due to a major blowout is 0.8 miles and displaces 49 families. Additionally, six epidemiologic public health studies demonstrated that people who live in close proximity to multiple oil and gas wells in densely developed shale basins have experienced an increased incidence of childhood leukemia, asthma attacks, congenital heart defects, low birth weight, and preterm birth compared to people who live with no production wells nearby. Collectively, these data indicate that dense shale development, as currently practiced, may pose a risk to human health.*”
Submitted to Planning Team in Cantino packet #16

33. *Health symptoms in residents living near shale gas activity: A retrospective record review from the Environmental Health Project.* Beth Weinberger et al. Preventive Medicine Reports Vol 8, Dec 2017, 112-115 doi.org/10.1016/j.pmedr.2017.09.002.

Abstract: Increasing evidence demonstrates an association between health symptoms and exposure to unconventional natural gas development (UNGD). The purpose of this study is to describe the health of adults in communities with intense UNGD who presented for evaluation of symptoms. Records of 135 structured health assessments conducted between Feb 2012 and Oct 2015 were reviewed retrospectively. Publicly available data were used to determine proximity to gas wells. Analysis was restricted to records of adults who lived within 1 km of a well in Pennsylvania and denied employment in the gas industry (n = 51). Symptoms in each record were reviewed by a physician. Symptoms that could be explained by pre-existing or concurrent conditions or social history and those that began or worsened prior to exposure were excluded. Exposure was calculated using date of well drilling within 1 km. The number of symptoms/participant ranged from 0 to 19 (mean = 6.2; SD = 5.1). Symptoms most commonly reported were: sleep disruption, headache, throat irritation, stress or anxiety, cough, shortness of breath, sinus problems, fatigue, nausea, and wheezing. These results are consistent with findings of prior studies using self-report without physician review. In

comparison, our results are strengthened by the collection of health data by a healthcare provider, critical review of symptoms for possible alternative causes, and confirmation of timing of exposure to unconventional natural gas well relative to symptom onset or exacerbation. Our findings confirm earlier studies and add to the growing body of evidence of the association between symptoms and exposure to UNGD. Submitted in Cantino pkt #18, 8-18

34. *Dangerous and Close: Fracking Puts the Nation's Most Vulnerable People at Risk*, Elizabeth Ridlington, Frontier Group, Rachel Richardson, Environment America Research & Policy Center, Kyle Ferrar, FracTracker Alliance, Fall 2016. See this previously submitted report for findings and detailed data on proximity of vulnerable Ohioans to fracking infrastructure and implications. As documented in this report, thousands of our most vulnerable residents live, play, receive health services or study very close to fracked wells.

The following three papers (submitted in Cantino Packet #19, 8-29-18) address noise and its synergistic effects with air pollution and fear, including impacts from nearby o&g operations, and their impacts on health, psychological well-being, and cognition. Their conclusions must be taken into account as the Wayne weighs the longterm and cumulative effects of activities considered under the new Plan.

35. *Public health implic of environ noise associated with unconventional oil and gas dev.* Jake Hays et al. *Sci of the Total Environment* 580 (2017) 448–456
doi.org/10.1016/j.scitotenv.2016.11.118 **Abstract:** Modern oil and gas development frequently occurs in close proximity to human populations and increased levels of ambient noise have been documented throughout some phases of development. Numerous studies have evaluated air and water quality degradation and human exposure pathways, but few have evaluated potential health risks and impacts from environmental noise exposure. We reviewed the scientific literature on environmental noise exposure to determine the potential concerns, if any, that noise from oil and gas development activities present to public health. Data on noise levels associated with oil and gas development are limited, but measurements can be evaluated amidst the large body of epidemiology assessing the non-auditory effects of environmental noise exposure and established public health guidelines for community noise. There are a large number of noise dependent and subjective factors that make the determination of a dose response relationship between noise and health outcomes difficult. However, *the literature indicates that oil and gas activities produce noise at levels that may increase*

the risk of adverse health outcomes, including annoyance [i.e., stress], sleep disturbance, and cardiovascular disease...”

Excerpts from the report: “Noise, or unwanted sound, is a biological stressor and potential public health hazard in a variety of contexts. Exposure to noise modifies the function of human organs and systems (Münzel et al., 2014) and can be a contributing factor to the development and aggravation of health conditions related to stress (e.g., high blood pressure) (Dratva et al., 2012). Numerous large-scale epidemiological studies have identified associations between environmental noise exposure and adverse health outcomes, such as cardiovascular disease (Babisch et al., 2013), diabetes (Sørensen et al., 2013), adiposity (Christensen et al., 2015), birth outcomes (Gehring et al., 2014), cognitive impairment in children (Lercher et al., 2002), depression (Orban et al., 2015), and sleep disturbance (Hume et al., 2012). Health outcomes due to environmental noise exposure may also carry *economic* consequences due to the size of populations exposed to hazardous levels of noise (Swinburn et al., 2015)....

"In a report prepared for the West Virginia Department of Environmental Protection, McCawley (2013) monitored noise levels associated with various stages of natural gas development from 2 to 4 sampling sites located 190.5 m (625 ft) from the center of five different well pads. McCawley (2013) provided actual monitoring results from a number of different sites and for a variety of stages in the development process, including site preparation, drilling, hydraulic fracturing, and truck traffic. Analysis of these data yields the percent of time particular noise levels were exceeded in minutes (Table 3 and Table 4). **In all cases, for the five major operations the study surveyed, noise levels exceeded 55 dBA for N24 h**, though not necessarily continuously. ...

There are a number of health damaging air pollutants associated with UOGD that have been measured in high concentrations, including volatile organic compounds (VOCs), aromatic hydrocarbons, particulate matter (PM), and ground level ozone (Helmig et al., 2014; Oltmans et al., 2014; Pétron et al., 2014). Some of these pollutants have been shown to increase risk factors associated with heart disease and other adverse health outcomes. Numerous epidemiological studies have observed exposure to noise and air pollution simultaneously, since both often accompany transportation sources (e.g., busy roadways). It can be difficult to link one or the other to increased cardiovascular risks, and correlated exposures may lead to confounding in some epidemiological studies. It is not entirely clear from the available body of science whether air pollution is independent, additive, or synergistic to impacts from noise exposure. Several papers have also acknowledged that light pollution resulting from nighttime UOGD operations may constitute an additional stressor and potential health hazard (Ferrar et al., 2013; Perry, 2013; Witter et al., 2013). Evidence suggests that light at night may impact health by disrupting normal circadian rhythms and altering melatonin and other hormone releases (Chepesiuk, 2009; Pauley, 2004). There has also been some

epidemiological links of light at night to breast cancer (Hurley et al., 2014) and obesity (McFadden et al., 2014), although the research is still preliminary.

“...4.4. UOGD public health literature: There is an emerging body of epidemiology that suggests an association between UOGD and adverse health outcomes (Hays and Shonkoff, 2016). In a study using over 95,000 inpatient records from three counties in northeast Pennsylvania, Jemielita et al. (2015) noted an association between density of unconventional natural gas wells and increased inpatient prevalence rates for a number of medical categories, including cardiology and neurology. The authors hypothesized that this association could be due in part to **potential toxicant exposure and stress responses** (Jemielita et al., 2015), the latter of which may bear particular relevance to noise exposure. Several other studies have found associations between UOGD and some adverse birth outcomes (Casey et al., 2015; McKenzie et al., 2014; Stacy et al., 2015), *which have also been associated with noise exposure*. In light of these findings and our understanding of noise as a potential health risk factor for stress and adverse cardiovascular outcomes, additional research on noise levels and noise exposure associated with UOGD is warranted.”

36. *Noise and health in vulnerable groups: A review.* van Kamp I, Davies H. Noise Health. 2013;15:153-9:

“...In the Night noise guidelines, [18] for example, it has been suggested that night time exposure levels above 40 dB more severely affect vulnerable groups...Effects of noise in schoolchildren are the best documented. The available evidence shows that children are less vulnerable for annoyance than adults, but more **vulnerable for cognitive effects of noise**. They are not per se more vulnerable as a group, but more at risk because of less-developed coping strategies, and they are in a sensitive developmental period. This is indicative of a life phase effect rather than an age effect. Children seem to be less vulnerable for awakenings due to noise but more vulnerable for **physiological effects** during sleep and related motility. There is some evidence that annoyance from both road- and air traffic noise predicts **asthma** prevalence in children (both self-reported and diagnosed). Evidence does not indicate that the elderly are more vulnerable to noise in terms of annoyance and sleep disturbance. Age-specific comparisons rather show an inverted U-shaped relation and indicate that both young and older people are less at risk as far as annoyance and disturbance are concerned. But, *possibly, the elderly are more vulnerable regarding cardiovascular effects, and this may be a combined effect of air pollution and noise...*” *The review also discusses other vulnerable populations and confounding factors for negative impacts of noise.*

37. Benjamin D. Blair et al. *Residential noise from nearby oil and gas well construction and drilling*, **J of Exposure Sci & Envir Epidemiology**, May 2018
nature.com/articles/s41370-018-0039-8 **Abstract:** “Public concern about oil and gas

(O&G) operations in residential areas is substantial. Noise from construction and drilling to O&G operations may be greater than other phases of O&G operations; yet the impacts of audible and low frequency noise during these operations are not extensively explored nor the effects on health well understood. This study documents the noise levels at a multi-well O&G well pad during construction and drilling in a residential area in Colorado. A-weighted (dBA) and C-weighted (dBC) noise measurements were collected at four locations during development over a 3-month period. The maximum 1-min equivalent continuous sound levels over a 1-month period were 60.2 dBA and 80.0 dBC. Overall, 41.1% of daytime and 23.6% of nighttime dBA 1-min equivalent continuous noise measurements were found to exceed 50 dBA, and 97.5% of daytime and 98.3% of nighttime measurements were found to exceed 60 dBC. Noise levels exceeding 50 dBA or 60 dBC may cause annoyance and be detrimental to health; thus, these noise levels have the potential to impact health and noise levels and associated health effects warrant further investigation."

38. *Fracking, the Environment, and Health*, McDermott-Levy, Ruth PhD, RN al., **Amer J of Nursing** June 2013, 113 (6), 45–51 doi: 10.1097/01.NAJ.0000431272.83277.f4
39. *The Burden of Hypertension in an Oil- and Gas-Polluted Environment: A Comparative Cross-Sectional Study*, M.C. Ezejimofor, et al., *American Journal of Hypertension* 29(8) August 2016 doi:10.1093/ajh/hpw009 "...participants living in oil-polluted areas were almost 5 times as likely to have developed hypertension compared to participants in unpolluted areas."
40. *Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates*. Jemielita T, et al. (2015) **PLoS ONE** 10(7) doi:10.1371/journal.pone.0131093. Cantino packet #21, also submitted Dec. 2016 to USFS Regional Forester K. Atkinson). From abstract: "Over the past ten years, unconventional gas and oil drilling has markedly expanded in the U.S.. Despite substantial increases in well drilling, the health consequences of UGOD toxicant exposure remain unclear. This study examines an association between wells and healthcare use by zip code from 2007 to 2011 in PA. Inpatient discharge databases from the PA Healthcare Cost Containment Council were correlated with active wells by zip code in three counties in Pennsylvania... **Cardiology inpatient prevalence rates were significantly associated with number of wells per zip code and wells per km²...while neurology inpatient prevalence rates were significantly associated with wells per km²...** Furthermore, evidence also supported an **association between well density and inpatient prevalence rates** for the medical categories of **dermatology, neurology, oncology, and urology...**"

41. David R. Brown, C Lewis & B. Weinberger (2015) *Human exposure to unconventional natural gas development: A public health demonstration of periodic high exposure to chemical mixtures in ambient air*, **J of Environ Science and Health, Part A** 50:5, 460-472, DOI: 10.1080/10934529.2015.992663. Submitted in Cantino packet #23, 8-30-18 and to Forester Kathleen Atkinson, Dec. 2016). From the abstract: “Directional drilling and hydraulic fracturing of shale gas and oil bring industrial activity into close proximity to residences, schools, daycare centers and places where people spend their time. Multiple gas production sources can be sited near residences. Health care providers evaluating patient health need to know the chemicals present, the emissions from different sites and the intensity and frequency of the exposures. This research describes a hypothetical case study designed to provide a basic model that demonstrates the direct effect of weather on exposure patterns of particulate matter smaller than 2.5 microns (PM2.5) and volatile organic chemicals (VOCs). Because emissions from unconventional natural gas development (UNGD) sites are variable, a short-term exposure profile is proposed that determines 6-hour assessments of emissions estimates, a time scale needed to assist physicians in the evaluation of individual exposures. “The hypothetical case is based on observed conditions in shale gas development in Washington County, Pennsylvania, and on estimated emissions from facilities during gas development and production. An air exposure screening model was applied to determine the ambient concentration of VOCs and PM2.5 at different 6-hour periods of the day and night. Hourly wind speed, wind direction and cloud cover data from Pittsburgh International Airport were used to calculate the expected exposures. Fourteen months of daily observations were modeled. Higher than yearly average source terms were used to predict health impacts at periods when emissions are high. The frequency and intensity of exposures to PM2.5 and VOCs at a residence surrounded by three UNGD facilities was determined. The findings show that peak PM2.5 and VOC exposures occurred 83 times over the course of 14 months of well development. Among the stages of well development, the drilling, flaring and finishing, and gas production stages produced higher intensity exposures than the hydraulic fracturing stage. Over one year, compressor station emissions created 118 peak exposure levels and a gas processing plant produced 99 peak exposures over one year. The screening model identified the periods during the day and the specific weather conditions when the highest potential exposures would occur. The periodicity of occurrence of extreme exposures is similar to the episodic nature of the health complaints reported in Washington County and in the literature. This study demonstrates the need to determine the aggregate quantitative impact on health when multiple facilities are placed near residences, schools, daycare centers and other locations where people are present. It shows that understanding the influence

of air stability and wind direction is essential to exposure assessment at the residential level.”

42. *The Rush to Drill for Natural Gas: A Public Health Cautionary Tale*, M. L. Finkel, & A. Law, *Am J Public Health*. 2011 May; 101(5): 784–785.
ncbi.nlm.nih.gov/pmc/articles/PMC3076392/. 5-year update: Finkel and Law Editorial, *Am J Public Health*, Oct 2016, Vol 106(10) doi: 10.2105/AJPH.2016.303398. Submitted by H Cantino to Wayne, 12-7-16 and 8-30-18.

These important reviews must be quantified and their public health costs assessed and made public if fracking is to be considered as an activity in the next Wayne Plan.

The following four citations, a few of many peer-reviewed and governmental reports on radioactivity hazards of fracked gas products and waste, must be assessed, per NEPA, in relation to the longterm costs to the public and the environment of Wayne activities.

43. *Understanding the Radioactive Ingrowth and Decay of Naturally Occurring Radioactive Materials in the Environment: An Analysis of Produced Fluids from the Marcellus Shale*, Andrew W. Nelson et al., **Env Health Perspectives**, 2015 [dx.doi.org/10.1289/ehp.1408855](https://doi.org/10.1289/ehp.1408855). Submitted in Cantino packet #29, 8-30-18. From the paper: “We investigated the contribution to radioactivity concentrations from naturally occurring radioactive materials (NORM), including uranium, thorium, actinium, radium, lead, bismuth, and polonium isotopes, to the total radioactivity of hydraulic fracturing wastes.... We observed that radium decay products were initially absent from produced fluids due to differences in solubility. However, in systems closed to the release of gaseous radon, our model predicted that decay products will begin to ingrow immediately and (under these closed-system conditions) can contribute to an increase in the total radioactivity for more than 100 years.
Conclusions: Accurate predictions of radioactivity concentrations are critical for estimating doses to potentially exposed individuals and the surrounding environment. These predictions must include an understanding of the geochemistry, decay properties, and ingrowth kinetics of radium and its decay product radionuclides.”
44. **Radioactivity in frack waste is not adequately assessed:** *Understanding the radioactive ingrowth and decay of naturally occurring radioactive materials in the environment: an analysis of produced fluids from the Marcellus Shale*. Nelson AW et

al. 2015. **Envir Health Perspec** 123:689–696; [dx.doi.org/10.1289/ehp.1408855](https://doi.org/10.1289/ehp.1408855):
“...We found that estimates of total radioactivity in produced fluids based on Ra isotopes alone can underestimate the total radioactivity present due to the ingrowth of Ra decay-product radionuclides, a process that we demonstrate can be modeled using radioactive ingrowth equations (Bateman 1910). This model predicts that when produced fluids are sealed to the release of radon gas, the total radioactivity concentration of produced fluid can increase by a factor greater than five within the first 15 days following extraction due to the ingrowth of Ra decay products...Previous reports that described the radioactivity concentration in flowback, produced fluids, and other materials associated with unconventional drilling and hydraulic fracturing focused on one element—Ra.

“Our projections suggest that in systems closed to the release of gaseous Rn, estimates based solely on $^{226}\text{Ra}/^{228}\text{Ra}$ will underestimate the total activity present by a factor > 5 within 15 days following extraction as Ra decay product radionuclides ingrow. The level of radioactivity (in a closed ^{226}Ra decay product system) will continue to increase and reach a maximum approximately 100 years after extraction. At this time, when the long-lived ^{210}Pb and its decay products have reached equilibrium with ^{226}Ra , the total radioactivity will have increased by a factor > 8 ...”

45. *New York Times* research has revealed, in a plethora of confidential studies and other previously unpublicized material, the extent of hydrofracking risks to human health and the environment, including high levels of radioactive waste in Pennsylvania fracking wastewater. According to the Times, “The level of radioactivity in the wastewater has sometimes been hundreds or even thousands of times the maximum allowed by the federal standard for drinking water. There is no comprehensive federal standard for what constitutes safe levels of radioactivity in drilling wastewater.” Documents submitted to New York State and Pennsylvania authorities posted on the NYT site reveal that flowback “waters” and sludge can contain high levels of radioactivity. One Pa. report cites levels of radium 400 times the federal drinking water standard. New York State's Department of Environmental Conservation analyzed 13 samples of wastewater brought thousands of feet to the surface from drilling and found levels of radium 226, a derivative of uranium, as high as 267 times the limit considered safe for discharge into the environment and thousands of times federal drinking water standards.

nytimes.com/2011/02/27/us/27gas.html?_r=4&scp=5&sq=natural%20gas&st=cse

46. *Environmental and Human Health Impacts of Spreading Oil and Gas Wastewater on Roads*, T. L. Tasker et. al. *Environ. Sci. Technol.* 2018, 52, 7081–7091. From the abstract: “Thirteen states in the United States allow the spreading of O&G wastewaters on roads for deicing or dust suppression. In this study, the potential environmental and human health impacts of this practice are evaluated. Analyses of O&G wastewaters spread on roads in the northeastern, U.S. show that these wastewaters have salt, radioactivity, and organic contaminant concentrations often many times above drinking water standards. Bioassays also indicated that these wastewaters contain organic micropollutants that affected signaling pathways consistent with xenobiotic metabolism and caused toxicity to aquatic organisms like *Daphnia magna*. The potential toxicity of these wastewaters is a concern as lab experiments demonstrated that nearly all of the metals from these wastewaters leach from roads after rain events, likely reaching ground and surface water. Release of a known carcinogen (e.g., radium) from roads treated with O&G wastewaters has been largely ignored.”

While the Wayne’s enabling of fracking does not necessarily increase legal spreading of oil and gas waste on roads, this research points to the radioactivity that will be more present in the environment through frequent spills, accidents, and intentional dumping. For an idea of the frequency of such occurrences, see Greg Pace’s incomplete chronology of “incidents” in Ohio (attached with this submission).

The following articles address the psychosocial impacts of fracking and must be taken into account in the Wayne’s consideration of the economic, public health, and social consequences to the surrounding community of any decision to allow fracking under the new Plan.

47. *Assoc of unconventional natural gas development with depression symptoms and disordered sleep in PA*. Casey, J.A. et al. (2018). **Scientific Reports**, 8, 11375. doi: 10.1038/s41598-018-29747-2 “The purpose of this quantitative study was to evaluate the association of unconventional natural gas development (UNGD) with depression symptoms and disordered sleep diagnoses using the Patient Health Questionnaire-8 and electronic health record data from Geisinger adult primary care patients in Pennsylvania. Analyses included 4,762 participants with no, mild, moderate, and moderately severe or severe depression symptoms in 2014–2015. *Associations were observed between living closer to more and bigger wells and depression symptoms.*”

48. *Psychosocial implications of unconventional natural gas development: Quality of life in Ohio's Guernsey and Noble Counties* Michael P. Fisher et al., J of

Environmental Psychology 55 (2018) 90e98 doi.org/10.1016/j.jenvp.2017.12.008.

Abstract: As unconventional natural gas development (UNGD) activities such as “fracking” have proliferated across the U.S., research has begun to examine their impacts on human life. Much scholarship has centered on possible health and environmental impacts. However, a range of plausible psychosocial impacts has begun to emerge. Utilizing grounded theory methods and data from qualitative interviews with residents of two counties in Appalachian Eastern Ohio (Guernsey and Noble), we examined the quality of life (QoL) impacts on residents, who live and work amid UNGD.

“Quality of life impacts were reported in five core categories, specifically psychological stress, social stress, environment, physical health, and traffic. Psychological stress was a particularly salient theme, as residents living near UNGD found themselves anxious about the uncertainties of fracking; frustrated by interactions with oil and gas industry officials; stressed about noise or light pollution; and, in some instances, facing the possibility of moving from the region.” (submitted to Wayne 8-29-18 in Cantino packet #18)

49. Hirsch, J.K. et al. (2017). *Psychosocial impact of fracking: A review of the literature on the mental health consequences of hydraulic fracturing*. Int J of Mental Health and Addiction, 16, 1-15. doi: 10.1007/s11469-017-9792-5. Hirsch and colleagues reviewed existing scientific literature to summarize what is known about fracking and psychological function. They reviewed 23 articles published between 2012 and 2017. *They concluded that these studies consistently show that residents of communities UNGD experience worry, anxiety, and depression related to a number of factors associated with fracking. These factors included lifestyle; health; safety; financial security; exposure to neurotoxins; changes to landscape; and fear of outsiders and crime related to the influx of workers.*

50. Weinberger, B., et al. (2017). *Health symptoms in residents living near shale gas activity: a retrospective record review from the Environmental Health Project*. Preventive Medicine Reports, 8, 112-115. doi: 10.1016/j.pmedr.2017.09.002 The purpose of this descriptive study was to describe the health of adults living in southwestern PA communities with UNGD. The authors retrospectively reviewed records of 135 structured health assessments conducted between Feb. 2012 and October 2015. The authors report on the 51 adults in the sample who lived within 1 km (0.6 miles) of an unconventional natural gas well. *Symptoms reported in this sample are consistent with those reported in other self-report studies; 37% reported symptoms of stress/anxiety.*

51. McDermott-Levy, R., & Garcia, V. (2016). *Health concerns of northeastern Pennsylvania residents living in an unconventional oil and gas development county*. *Public Health Nursing*, 33(6), 502-510. doi: 10.1111/phn.12265 The purpose of this qualitative study was to describe the health concerns of residents experiencing unconventional oil and gas development (UOGD) in Wyoming County, Pennsylvania. Between July 2014 and May 2015, the authors conducted five focus groups with 27 residents. *Residents' responses reflected two broad themes: changing community and powerlessness. Related to powerlessness, residents' feelings of stress and anxiety about not knowing what to expect; powerlessness related to community changes; and lack of trust in local policymakers and protective agencies as well as concerns about health.*

52. Sangaramoorthy, T., et al. (2016). *Place-based perceptions of the impacts of fracking along the Marcellus shale*. *Social Science & Medicine*, 151, 27-37. doi: 10.1016/j.socscimed.2016.01.002 “The purpose of this qualitative study was to investigate potential health impacts of fracking. In 2013, two focus groups were conducted with community residents in Doddridge County, WV, where communities had been impacted by fracking operations.

“The authors identified in the focus groups that residents reported *distress over the transformation of the physical and natural environment, which led to conflicted meanings of place and compromised social identities as landowners and West Virginians. These changes negatively impacted residents' sense of belonging and attachment to place. Residents also expressed concern about environmental changes brought about by fracking such as increased traffic, land erosion and mudslides, wastewater, chemical runoff, and changes in air and water quality. Lastly, almost all participants reported that they suffered from health impacts such as fear, anxiety, and stress brought about by the uncertainty related to fracking.*”

53. Steinzor, N., Subra, W., & Sumi, L. (2013). *Investigating links between shale gas development and health impacts through a community survey project in Pennsylvania*. *New Solution*, 23(1), 55-83. doi: 10.2190/NS.23.1.e. The purpose of this community-based participatory research study was to describe the health symptoms of adults and children living near shale gas operations. Between August 2011 and July 2012, semi-structured interviews were conducted with 108 residents of 14 counties in Pennsylvania. Steinzor and colleagues state that *37% of residents*

reported depression and 35% reported severe anxiety. These symptoms were reported more frequently in households closer to the gas facilities than those farther away.

54. Resick L.K., et al. (2013). *The meaning of health among mid-Appalachian women within the context of the environment*. J of Env Studies and Sciences, 3(3), 290-296. doi: 10.1007/s13412-013-0119-y This qualitative study was conducted to understand the meaning of health within the context of the environment among women living in mid-Appalachia. In 2012, 14 women were individually interviewed using open-ended questions to elicit their perspectives about health and the environment. Analysis of the data revealed an overarching theme of a *sense of powerlessness over changes in the environment experienced by women living closest to natural gas drilling. This perceived sense of powerlessness influenced the women's experience of health and affected their immediate living space.*
55. *Assessment and longitudinal analysis of health impacts and stressors perceived to result from unconventional shale gas development in the Marcellus shale region.* Ferrar, K.J. ,et al. (2013). Int J of Occupational and Envir Health, 19(2), 104-112. doi: 10.1179/2049396713Y.0000000024 The purpose of this descriptive study was to describe the health impacts in a sample of community residents living with shale gas development. Interviews were conducted in 2010 and again in 2012 with a sample of community members living near Marcellus shale gas development in Pennsylvania. *Study participants attributed 59 unique health impacts, with stress being the most frequently-reported symptom. They identified 13 stressors: among the leading causes of stress reported were feelings of being taken advantage of, having their concerns and complaints ignored, and being denied information or misled by government agencies and industry. Overall, psychological symptoms were reported by 79% of respondents.*
56. *Development, land use, and collective trauma: The Marcellus shale gas boom in rural PA.* Perry, S.L. Culture, Agriculture, Food and Environ 34, 2012, 81-92. doi: 10.1111/j.2153-9561.2012.01066.x The purpose of this qualitative study was to describe a place and people undergoing rapid transition related to rapid development of UNGD development in a rural PA county. The author reported her preliminary findings from two years of ethnographic field work conducted from 2009-2011. Her ethnographic data suggest significant psychosocial stress associated with Marcellus shale gas development. Perry reported that residents expressed feelings of stress due to changes in their physical environment, community culture, and an increased sense of community conflict. *Many residents felt that their sense of place (in terms of home, security, connection to history, and hope for the future) was threatened as the rural community became industrialized.*

57. *The impact of exposure to air pollution on cognitive performance*, Xin Zhan et al. PNAS 8-27-18. 201809474; August 27, 2018. doi.org/10.1073/pnas.1809474115

Abstract: “This paper examines the effect of both cumulative and transitory exposures to air pollution for the same individuals over time on cognitive performance by matching a nationally representative longitudinal survey and air quality data in China according to the exact time and geographic locations of the cognitive tests. *We find that long-term exposure to air pollution impedes cognitive performance in verbal and math tests. We provide evidence that the effect of air pollution on verbal tests becomes more pronounced as people age, especially for men and the less educated. The damage on the aging brain by air pollution likely imposes substantial health and economic costs, considering that cognitive functioning is critical for the elderly for both running daily errands and making high-stake decisions.*” Submitted in Cantino pkt #32 8-30-18.

This research must be taken into account and the cumulative and long-term economic, public health, infrastructure, and environmental costs to the public of fracking infrastructure, including pipelines and compressor station operation, explosions, leaks, and accidents, assessed, whether they will be expected from private or Wayne-owned minerals. Wayne leasing will enable fracking not only of Wayne minerals but also of adjacent minerals that would not otherwise be economically viable and would therefore not occur without Wayne leasing.

In regard to pipeline impacts and accidents, the pipeline companies cited in the following reports are also operators of Ohio pipelines, and Ohio law and regulations are doing no better than PA in guaranteeing safety or even recouping expenses when these companies pollute the land and cause injuries and death to people from their accidents. The Wayne and USFS sanctioning of leasing federal minerals under the Wayne for fracking clearly has high potential economic costs to the region, thus condemning the 2006 Plan used to justify the 2012 (non-NEPA-based) RONI and SIR and subsequent unjustified (non NEPA-based) consent to the BLM to lease Wayne minerals for fracking.

Some costs to the region and the climate are illustrated almost daily with Appalachian pipeline explosions and consequent harm to people, property, air, and water quality, as well as untold emissions and climate impacts. These must

be assessed now. Two relevant news articles about one recent explosion follow:

58. *Gas Explosion in Center Township Beaver County* (post-gazette.com/local/west/2018/09/10/gas-explosion-in-center-township-Beaver-County/stories/201809100067). **Excerpts:**

“An explosion in a gas pipeline shook parts of Beaver County early Monday, destroying a house, garages and several vehicles and possibly bringing down six high-tension electric towers. Emergency crews responded to the explosion of the 24-inch methane line shortly after it was reported at 4:54 a.m. near Ivy Lane in Center Township, according to Center police Chief Barry Kramer and county emergency officials.”

“It lit this whole valley up,” Chief Kramer said. “People looked out their window and thought the sun was up.”

...A spokeswoman for Energy Transfer Corp. said that while an investigation is underway, officials believe a landslide may have ruptured the line.

Sam and Joyce Rosati and their 10-year-old niece managed to get out of their house on Ivy Lane just as the gas exploded and destroyed their home, said a next-door neighbor, Tom Demarco.

“They lost everything,” he said, adding that a barn on the Rosati property also was destroyed. He wasn’t sure if horses usually kept in the barn made it out safely.

Mr. Demarco, who has lived on Ivy Lane since 1989, said the fire the explosion caused was “fiercer than fierce, raging.”

“My house started shaking. The sky was pure red from the flames shooting.”

Chuck Belczyk awoke “from a dead sleep” when the explosion occurred. He lives about 200 yards from the pipeline.

“It was bright. I heard massive hissing,” Mr. Belczyk said. “My first thought was that it was an airplane crash.

Karen Gdula, who lives across the street from Mr. Belczyk, said, “I felt the earth shake.”

“In what officials said was “probably” related to the blast, six high-voltage towers were knocked down in the area of Bunker Hill Road, which runs alongside Interstate 376. As a precaution, authorities initially closed one lane of the highway before

PennDOT shut down the entire thoroughfare in both directions shortly after 7 a.m. The highway reopened by noon.

“We had a lot of voltage on the ground,” Chief Kramer said, although no injuries were reported from the downed lines. About 1,500 were without power in the Center area.

...Chief Kramer said emergency officials decided to let the fire burn out. By 7 a.m., it had extinguished itself.

...The company said residents whose property was damaged should call 1-800-445-5846.

...The Revolution pipeline had been in the commissioning phase — a kind of dress rehearsal — since Sept. 3, according to Ms. Granado. It wasn’t yet operating commercially, but gas was running through the pipe during the trial period, just as it would during normal operations, she said.

Ms. Granado didn’t know how much pressure was in the line before it burst; it is designed to operate at a maximum pressure of 1,440 pounds per square inch.

Recent rain has ETC and its regulators focused on erosion control, Ms. Granado said, when asked about past landslides. “It’s something definitely that is being actively managed.”

The Beaver County Conservation District was responsible for the pipeline’s environmental permitting and for inspecting whether ETC’s construction had proper erosion and sedimentation controls.

Jim Shaner, executive director of the Beaver County agency, said the controls were installed as designed “but they were not working.”

There were a number of landslides on steep hills, he said, because of the “degree of the slope and the amount of rain” that has soaked the region over the past year.

Most were minor, according to Mr. Shaner, but one was big enough to dump debris into Raccoon Creek. After state Department of Environmental Protection officials surveyed the damage, they issued a series of violations to ETC and, in June, came to a settlement that will require the company to monitor restoration of the creek for five years. It includes a \$145,250 fine for violations.

Mr. Shaner said the conservation district’s duty as the environmental permitting agency is to ensure that construction activities don’t pollute streams or wetlands. *The agency does not evaluate the pipeline design for safety.* [emphasis added]

A landslide was found to be the cause of an explosion in a new natural gas pipeline in West Virginia. TransCanada's Leach XPress burst into flames in June, six months after it was put into service. The segment that ruptured was at the bottom of a steep hill.

Energy Transfer announced its plans for the Revolution project in 2015. The pipeline was fashioned to pick up gas from Butler County and deliver it through gas gathering and natural gas liquids pipelines to ETC's Revolution cryogenic plant in Washington County.

There, natural gas liquids would be taken out of the gas stream and further separated into ethane and other hydrocarbons. From there, the liquids would travel to the Philadelphia area through Mariner East 2 while the gas would head to Ohio through another ETC pipeline, Rover.

The company said in a presentation in May that the Revolution pipeline was "mechanically complete" but was waiting for Rover and Mariner East 2 to come online before it was put into service. But ETC also said it was evaluating some interim uses for the pipeline before the other projects caught up.

Energy Transfer's reputation in Pennsylvania over the past few years has been dominated by its Mariner East 2 project, which involves laying a pair of pipelines across the southern part of the state to ferry natural gas liquids from Ohio to refineries and export terminals near Philadelphia. The effort has yielded dozens of environmental violations, drilling mud spills into creeks and streams, and a series of construction stops ordered by regulators that have delayed the pipelines' in-service dates. (*First Published September 10, 2018, 5:35am*)

59. *"What we know about the company who runs gas line that exploded.*

wpxi.com/news/top-stories/what-we-know-about-the-company-who-runs-gas-line-that-exploded/830991300): ...According to the Federal Office of Pipeline Safety, since 2006, the company has had 41 incidents resulting in more than \$11 million in property damages...And since 2006, Target 11 found three enforcement actions against the company listed on the federal website, the most serious in December of 2016 resulted in a \$24,000 fine. The Office of Pipeline Safety said the company did not provide records to demonstrate that their patrol pilot was qualified at the time he conducted 13 patrols by air on the pipeline right-of-way and seven months earlier in May 2016, the company was warned for failing to accurately notify the feds about the construction of ten or more miles of a new hazardous liquid pipeline in west Texas."

60. Attached with this bibliography are chronologies of oil and gas “incidents” – leaks, spills, explosions, and fires, compiled by Greg Pace, with both Ohio-specific and U.S. data from news reports and Emergency Management hotline reporting sites. This data must be considered as the Wayne contemplates costs to the public and to the environment of any fracking leases to be sanctioned under a new Plan.
61. Also to be considered is the density of fracking and oil and gas infrastructure and cumulative and synergistic impacts of additional infrastructure increasing both oil and gas and other industrial exposures to the SE Ohio population and environment. An indication of the density of oil and gas infrastructure can be obtained from the oil and gas threat map at oilandgasthreatmap.com/threat-map/ohio/ , which includes infrared videos, community stories, and threat radius.
62. Also important are both Ohio’s lack of regulation, law, and enforcement that would protect human health and the environment and the consequent costs to the public of the industry’s thus externalized costs. Although these subjects are too large to adequately address here, we include reference to OEPA’s response to a Working Group member, Lea Harper several days after the disastrous January 2019 Enbridge pipeline explosion in Noble County. Ms. Harper writes, “The Ohio EPA responded to my direct request asking if they sent anyone for air monitoring and they told me no. The industry knows that if there are not laws to protect people then the agencies don't use their discretion to do anything more than the letter of the law, even if they could. Without legal protections, there's no way to hold the regulatory agencies accountable for allowing people to unknowingly be exposed to toxins. The frackers have done a great job of regulatory capture as well as political compromise. There aren't even enough inspectors or emergency responders and adequate oversight to do the job that they should be doing in the face of this booming toxic industry. In fact, I wonder how much money Ohio is losing on this industry already that the taxpayer is subsidizing. It's \$800,000 a month in Pennsylvania. It's obvious the only way fracking can survive is by externalizing costs upon us. The real cost will be in the coming cancer clusters and cleanup, if even possible, when the LLC's fold up and leave us with their mess. Ms. Harper references, Oil & Gas Program Losing \$800K/Month Without Fee Increase; DEP Wants To Step Up Inspections Of Natural Gas Storage Fields (paenvironmentdaily.blogspot.com/2019/01/oil-gas-program-losing-800000month.html).”

Given that Ohio does not regulate off-gassing or venting from o&g and frackwaste facilities, has poor to no setback requirements,² does not require

² Rural setback requirements are 50’ for residences from frackpads. Waste disposal facilities, from which volatile organic compounds are vented directly from multi-million gallon tanks, have no setback rules at all.

green completion or test water or air around oil and gas facilities and infrastructure or even require aquifer mapping for frackwaste injection well permitting, and, as Lea Harper documents above, has inadequate monitoring and enforcement of emissions from spills and accidents, the research and other documentation of harm cited above suggest ominous consequences from Wayne's decision to frack in spite of never having evaluated impacts of this technology in an EIS-level, NEPA-based analysis.

Given current air pollution exposures and compromised water sources, especially with C-8, especially in the area of the Marietta District, and the complex chemical mixtures to which the population is already exposed, the grave impacts documented in the above research and in other documentation of harm from fracking and oil and gas infrastructure must be fully assessed, per NEPA, before the Wayne considers further leasing for fracking. Ohio law and regulations will not protect residents. The Wayne must assess public health impacts of further leasing, which will enable fracking both under and beyond Wayne jurisdiction, due to corporate interest engendered by additional acreage, in communities whose health is already compromised.

F. Other economic impacts of fracking:

Clearly all of the impacts of fracking detailed above – to climate, public health, water rights, air and water quality, and public safety—have significant economic costs that must be assessed. Other more direct economic impacts must also be evaluated:

Jobs creation is over-stated.

Far fewer jobs are directly tied to fracking than claimed by the industry. Of those jobs, most are transitory and filled by out-of-state workers who move from site to site.

- Keystone Research Center determined that the gas industry's claim of 48,000 jobs created between 2007 and 2010 from natural gas drilling in Pennsylvania was only

5,669 jobs – many of which were out-of-state hires. (Herzenberg, S., Drilling deeper into job claims, Keystone Research Center, June 20, 2011)

- The Multi-State Shale Research Collaborative released a six-state collaborative report demonstrating that the O&G industry has greatly exaggerated the number of jobs created by drilling and fracking in shale formations. The report found from the industry’s claims of 31 direct jobs created per well, only 4 jobs are created for each well. The report also showed that hundreds of thousands of ‘ancillary’ jobs that the drilling industry claims are related to shale drilling existed before drilling occurred. (Campbell, J. Report: Industry-backed studies exaggerate fracking job estimates. Politics on the Hudson. Nov. 21, 2013)
- The NY State Department of Environmental Conservation estimated that 77% of the workplace on initial shale gas drilling projects consists of transient workers from out-of-state. Not until the 30th year of shale gas development would 90% of the workforce be comprised of local New York residents. (NY State Department of Environ Conserv, Sept. 7, 2011, (6-233, 234).

Home Values Decline

- A Duke University study found homes that rely on well water in Pennsylvania dropped an average of \$30,167 when fracking took place within 1.5 kilometers (just under 1 mile). For these groundwater-dependent homes, a fracking well located within 1 km. (.62 miles) was linked to a 13.9% average decrease in home value. The study examined home sales between 1995 and 2012 in 36 counties in PA. (Muehlenbachs, L., et al. *The housing market impacts of shale gas development*. American Economic Review. 2015)
- The New York Times profiled the devastating impact heavy drilling had on Glasscock, County, Texas, especially its farming community. Farmers described increases in trash, traffic accidents, clashes over farmers selling groundwater to drillers, and economic impacts. Farmers said acres of farmland around a drill site: “...will probably never be suitable for fertile farming again.” (Batheja, A. *A county resents oil drilling, despite the money it brings in*. The New York Times, Oct. 30, 2014).
- The National Association of Realtors’ RealtorMag summarized a growing body of research, including a University of Denver survey showing the threat to property values from fracking and natural gas drilling. (Daily Real Estate News., *Fracking*

sparks concern over nearby home values. National Association of Realtors, Dec. 20, 2013)

- Reuters reported how O&G drilling has made properties “unsellable.” The analysis highlighted a Duke University working paper that found gas drilling near homes can decrease property values by an average of 16.7% if the house depends on well water. (Conlin, M., *Gas drilling is killing property values for some Americans.* Reuters, Dec. 12, 2013)
- The magazine *Governing: The States and Localities* covered the social, environmental, health and safety, and economic burdens endured by localities from fracking. “Fracking, in many cases, negatively impacts property values, which in turn depresses property tax revenue.” (Shafroth, F. *Fracking’s financial losers: local governments.* *Governing: The States and Localities*, Sept. 2014)

Road Damage, Truck Collisions and Crime

- Pittsburgh Post-Gazette reported that increases in crime followed the Pennsylvania gas drilling boom, with drunken driving arrests in Bradford County up 60%, DUI arrests up 50% in Towanda, and criminal sentencing up 35% in 2010. (Needles, Z. *Must crime follow Pennsylvania’s gas drilling boom.* Pittsburgh Post-Gazette, August 15, 2011)
- The Associated Press investigated areas with significant fracking activity, including Pennsylvania, Wyoming, North Dakota, and Texas where law enforcement is “seeing a sharp increase in drunken driving, bar fights, and other hell-raising.” (Levy, M. *Towns see crime, carousing surge amid gas boom.* Associated Press. Oct. 26, 2011)
- A study by the state agencies, the Montana All Threat Intelligence Center and the North Dakota State and Local Intelligence Center, found crime rose by 32% since 2005 in communities at the center of the oil and gas boom. (Montana All Threat Intelligence Center & North Dakota State and Local Intelligence Center. *Impact of population growth on law enforcement in the Williston Basin region.* Aug 17, 2012)
- An Associated Press analysis found traffic fatalities have spiked in heavily drilled areas of six states, whereas most other roads in the nation have become safer even as population has grown. In North Dakota drilling counties traffic fatalities increased 350%. (Begos, K., & Fahey, J. AP Impact: *Deadly side effect to fracking boom.* Associated Press May 5, 2014)

- A Colorado State Univ. research study examined the political economy of harm and crime associated with the oil and gas industry in rural Colorado around the rise of fracking. Researchers found 2,444 complaints between Nov. 2001 and June 2013 including issues around water, environment, noise, air quality, and land use. Researchers described citizen complaints as “extensive and complex” and concluded most were “persistent and omnipresent” rather than short-lived, isolated problems. (Opsal, T. & Shelley T. O. *Energy, crime, harm, and problematic state response in Colorado: A case of the fox guarding the hen house?* *Critical Criminology*, 22 (4), 561-577, 2014)
- Examining Pennsylvania Dept. of Transportation data, Ohio’s Star Beacon newspaper found fracking poses a safety threat on rural roads. Pennsylvania’s five busiest drilling counties reported a 107% increase in heavy truck crashes in 2011 than before the gas boom began. (Finnerty, J. *Fracking’s biggest safety threat is on rural roads*. Star Beacon, Dec. 26, 2014)

Fracking is neither necessary nor economically advantageous over clean energy generation.

- Stanford study: *U.S. roadmap to feasible and affordable clean energy*. *Energy and Enviro Sci*, 2015, 8, 2093–2117. The study details roadmaps for each of the 50 U.S. states to convert their all-purpose energy systems (electricity, transportation, heating/cooling, and industry) to ones powered by wind, water, and sunlight). The plans contemplate 80–85% of existing energy replaced by 2030 and 100% by 2050.
- The Economics of Clean Energy Portfolios, 2018, M. Dyson, et al. rmi.org/insight/the-economics-of-clean-energy-portfolios/. From the intro: “Advances in renewable energy and distributed energy resources offer lower rates and emissions-free energy while delivering all the grid reliability services that new power plants can...”
- U.S. [solar](#) employs more workers than any other [energy](#) industry, including coal, oil and natural gas combined, according to the U.S. Department of Energy's second annual [U.S. Energy and Employment Report](#). 6.4 million Americans now work in the traditional energy and the energy efficiency sector, which added more than 300,000 net new jobs in 2016, or 14 percent of the nation's job growth (ecowatch.com/solar-job-growth-2197574131.html) and similar news at usnews.com/news/at-the-edge/articles/2017-03-15/clean-energy-is-seeing-explosive-job-growth-dont-let-budget-kill-it)

G. Impacts of forest disruption on wildlife and native biodiversity

The following research is a sample of the extensive reports on profound effects on biodiversity and specific species and classes of organisms. It must be thoroughly examined and considered in contemplation of all forest disrupting activities considered for inclusion in the new Plan. While abstracts and excerpts are included, it is the responsibility of the Wayne planning team to look closely at each of these documents as well as citations they provide as appropriate to fully assess potential impacts of any Wayne activity proposed that will disrupt the Forest.

1. Fracking, ORV, and logging operations are very noisy. How will this impact species that call Wayne National Forest their home? “Noise pollution generated by natural gas extraction causes some avian species to avoid breeding sites (Blickley JL et al. *Experimental evidence for the effects of chronic anthropogenic noise on abundance of greater sage grouse at leks*. *Conserv Biol*. 2012 Jun;26(3):461-71. doi: 10.1111/j.1523-1739.2012.01840.x., resulting in reduced bird abundance. **Abstract:** Increasing evidence suggests that chronic noise from human activities negatively affects wild animals, but most studies have failed to separate the effects of chronic noise from confounding factors, such as habitat fragmentation. We played back recorded continuous and intermittent anthropogenic sounds associated with natural gas drilling and roads at leks of Greater Sage-Grouse (*Centrocercus urophasianus*). For 3 breeding seasons, we monitored sage grouse abundance at leks with and without noise. Peak male attendance (i.e., abundance) at leks experimentally treated with noise from natural gas drilling and roads decreased 29% and 73%, respectively, relative to paired controls. Decreases in abundance at leks treated with noise occurred in the first year of the study and continued throughout the experiment. Noise playback did not have a cumulative effect over time on peak male attendance. There was limited evidence for an effect of noise playback on peak female attendance at leks or male attendance the year after the experiment ended. Our results suggest that sage-grouse avoid leks with anthropogenic noise and that intermittent noise has a greater effect on attendance than continuous noise. Our results highlight the threat of anthropogenic noise to population viability for this and other sensitive species.

2. *Timing matters: traffic noise accelerates telomere loss rate differently across developmental stages*, A. M. Dorado-Correa et al., **Frontiers in Zoology** 15:29, Aug. 28, 2018. doi.org/10.1186/s12983-018-0275-8. **Abstract:** “Noise pollution is one of the leading environmental health risks for humans, linked to a myriad of stress-related health problems. Yet little is known about the long-term effects of noise on the health and fitness of wildlife. We experimentally investigated the direct and cross-generational effects of traffic noise on telomeres, a measure of cellular ageing that is predictive of disease and longevity in humans and other organisms. We exposed zebra finches (*Taenopygia guttata*) to three different treatment groups: 1) parents were exposed to traffic noise before and during breeding, together with their nestling young, 2) fledged juveniles but not their parents were exposed to traffic noise, and 3) control group birds were never exposed to traffic noise. Results: Although there was no significant effect of traffic noise exposure at early (pre-fledging) stages of offspring telomere length or loss rate, traffic noise exposure accelerated telomere loss in older (post-fledging) juveniles. **Conclusions:** The age-dependent differences found in this study in telomere loss could occur if parents buffer younger offspring against the detrimental effects of noise exposure and/or if younger offspring are less sensitive to noise exposure. Telomere length during early life has been shown to be positively related to lifespan and the observed noise-induced increase of telomere attrition rate could reduce the fitness of the affected birds and potentially alter the population dynamics of birds in noise polluted areas. Our data highlight the need to consider the developmental stage of an organism to better understand the ecological consequences of anthropogenic change.

3. Erin Bayne et al., *Impacts of Chronic Anthropogenic Noise from Energy-Sector Activity on Abundance of Songbirds in the Boreal Forest*, **Conservation Biology**, Vol 22, 5, 1186–1193 C 2008 onlinelibrary.wiley.com/doi/abs/10.1111/j.1523-1739.2008.00973.x From the abstract: “The effects of human activities in forests are often examined in the context of habitat conversion. Changes in habitat structure and composition are also associated with increases in the activity of people with vehicles and equipment, which results in increases in anthropogenic noise. Anthropogenic noise may reduce habitat quality for many species, particularly those that rely on acoustic signals for communication. We compared the density and occupancy rate of forest passerines close to versus far from noise-generating compressor stations and noiseless well pads in the boreal forest of Alberta, Canada. Using distance-based sampling, we found that areas near noiseless energy facilities had a total passerine density 1.5 times higher than areas near noise-producing energy sites. The White-throated Sparrow (*Zonotrichia albicollis*), Yellow-rumped Warbler (*Dendroica coronata*), and Red-eyed Vireo (*Vireo olivaceus*) were less dense in noisy areas. We used repeat sampling to estimate occupancy rate for 23 additional species. Seven had lower conditional or unconditional occupancy rates near noise generating facilities.

One-third of the species examined showed patterns that supported the hypothesis that abundance is influenced by anthropogenic noise. An additional 4 species responded negatively to edge effects.”

4. Nathan J. Kleist et al. *Chronic anthropogenic noise disrupts glucocorticoid signaling and has multiple effects on fitness in an avian community*, Proceedings of the National Academy of Sciences, 2017 [pnas.org/cgi/doi/10.1073/pnas.1709200115](https://doi.org/10.1073/pnas.1709200115).

Significance: “Studies examining relationships among habitat disturbance, physiology, and fitness in wild animals often produce contradictory or inconclusive results, casting doubt on current conservation physiology predictive frameworks linking stress and fitness. We apply a new framework drawn from experimental systems utilizing chronic inescapable stressors to explore how noise, an environmental stimulus common to wildlife habitats worldwide, disrupts stress hormone signaling and impacts fitness. We utilize a natural experiment to show that chronic, anthropogenic noise reduced baseline corticosterone levels, increased acute corticosterone response, and, at highest amplitudes, negatively impacted multiple measures of fitness across three species of birds. Our work brings conservation physiology theory involving wild animals into needed alignment with recent theories based on chronic stress in laboratory studies. **Abstract:** “Anthropogenic noise is a pervasive pollutant that decreases environmental quality by disrupting a suite of behaviors vital to perception and communication. However, even within populations of noise-sensitive species, individuals still select breeding sites located within areas exposed to high noise levels, with largely unknown physiological and fitness consequences. We use a study system in the natural gas fields of northern New Mexico to test the prediction that exposure to noise causes glucocorticoid-signaling dysfunction and decreases fitness in a community of secondary cavity-nesting birds. In accordance with these predictions, and across all species, we find strong support for noise exposure decreasing baseline corticosterone in adults and nestlings and, conversely, increasing acute stressor-induced corticosterone in nestlings. We also document fitness consequences with increased noise in the form of reduced hatching success in the western bluebird (*Sialia mexicana*), the species most likely to nest in noisiest environments. Nestlings of all three species exhibited accelerated growth of both feathers and body size at intermediate noise amplitudes compared with lower or higher amplitudes. Our results are consistent with recent experimental laboratory studies and show that noise functions as a chronic, inescapable stressor. Anthropogenic noise likely impairs environmental risk perception by species relying on acoustic cues and ultimately leads to impacts on fitness. *Our work, when taken together with recent efforts to document noise across the landscape, implies potential widespread, noise-induced chronic stress coupled with reduced fitness for*

many species reliant on acoustic cues.” (submitted in Cantino packet #17, 8-29-18)

This data on impacts of noise on birds must all be assessed and the cost of fracking and ATV authorization in our National Forest on biodiversity and the avian inhabitants of our Forest and its environs taken into account in decision-making for the Forest's new Plan. The implications of these studies for wildlife in general must also be assessed.

The results of the following research review must be analyzed for relevance to wildlife and domesticated animals in properties near Wayne-leasing-induced fracking for impacts, which should be quantified as impacts and costs of Wayne leasing if such leasing is to be considered in the next Plan.

5. Michelle Bamberger and RE Oswald, *Impacts Of Gas Drilling On Human And Animal Health*, New Solutions, Vol. 22(1) 51-77, 2012, doi: [dx.doi.org/10.2190/NS.22.1.e](https://doi.org/10.2190/NS.22.1.e)

ABSTRACT “Environmental concerns surrounding drilling for gas are intense due to expansion of shale gas drilling operations. Controversy surrounding the impact of drilling on air and water quality has pitted industry and lease-holders against individuals and groups concerned with environmental protection and public health. Because animals often are exposed continually to air, soil, and groundwater and have more frequent reproductive cycles, animals can be used as sentinels to monitor impacts to human health. This study involved interviews with animal owners who live near gas drilling operations. The findings illustrate which aspects of the drilling process may lead to health problems and suggest modifications that would lessen but not eliminate impacts. Complete evidence regarding health impacts of gas drilling cannot be obtained due to incomplete testing and disclosure of chemicals, and nondisclosure agreements. Without rigorous scientific studies, the gas drilling boom sweeping the world will remain an uncontrolled health experiment on an enormous scale.”

No additional restrictions have been placed on fracking operations since this survey was conducted. Ohio is especially lax in requirements with no green completion or vapor recovery required, no monitoring of water bodies near oil and gas operations, and poor noise level regulation and even poor enforcement of existing regulations.

The following critically important review, while focused on impacts of oil and gas development, details impacts and associations that are also relevant to disturbance from ORV/OHV, thinning, logging, and burning activities. Its detailed analyses and conclusions must be assessed for all relevant proposed Plan activities:

6. *Risks to biodiversity from hydraulic fracturing for natural gas in the Marcellus and Utica shales*, Erik Kiviat, *Annals Of The NY Acad Of Sciences: The Year in Ecology and Conservation Biology, 1286 (2013) 1–14 C 2013 doi: 10.1111/nyas.12146*. Excerpts on some of the risks applicable to the Wayne’s presumed plans to propose fracking be allowed in the new Plan *and to other disturbing activities the 2006 Plan allowed that may be considered for inclusion in a new Plan:*

“Four northeastern amphibian species have been shown to be adversely affected by approximately 50–1,000 mg L⁻¹ chloride, depending on the species and life stage, suggesting that **small amounts of HVHHF wastewater could render breeding habitats unsuitable**. Many lichens, liverworts, sphagnum mosses, conifers, aquatic plants, and bog plants are also sensitive to **salt**; numerous streams are already salinized from road deicing. Furthermore, lichens and stoneworts can be harmed by **heavy metals**. Wastewater ponds contain highly toxic synthetic chemicals and could potentially be **ecological traps** for water birds, muskrat, turtles, frogs, and aquatic insects. Mixtures of these chemicals will have [**synergistic**] **effects** that cannot be predicted by knowledge of individual chemicals. **Sediment pollution** of streams and other habitats may be caused by heavy equipment on rural roads mobilizing mineral particles in runoff or airborne dust, or by inadequate erosion control at HVHHF sites. In an HVHHF region of Arkansas, stream turbidity was correlated with well density. Suspended sediment additions to higher order streams could potentially harm benthic invertebrates and fish; native brook trout and freshwater mussels are among the most vulnerable taxa. **Dust** from roads can harm nearby plants and pollute streams.

“**Forest loss and fragmentation**: Loss of forest cover and change in the spatial pattern of cover are often confounded, but cause different responses. **Edge effects** on forest biota range from 10 m for trees to as much as 500 m for certain birds. **Forest fragmentation**, which affects dispersal, pollination, herbivory, and predation, is a major conservation concern in HVHHF landscapes; 20% or more of the forest cover may be removed for the establishment of HVHHF installations, and more than 80% of the land may be affected if a 100-m edge effect is considered. This loss and fragmentation of forest would result in the **warming and drying** of the remaining

forest, with **greater penetration by nonnative plants, songbird nest predators, and the brood-parasitic brown-headed cowbird** (*Molothrus ater*). Several **forest amphibians occur at lower abundances in forest within 25–35 m of clearcut edges, and juvenile forest amphibians have trouble dispersing across open habitats**. At five conventional gas well sites in West Virginia, three **salamander species** were more abundant closer to the forest edge, but less so in the drier southwestern aspect than in the moister northeastern aspect; edge effect was offset by rock and coarse woody debris (CWD) microhabitats. **Organisms sensitive to forest fragmentation** include lichens and bryophytes, orchids, other herbs, the West Virginia white butterfly (*Pieris virginiensis*), amphibians, and birds. **Orchids** are among the taxa most **sensitive to habitat change** in that many orchid species occur in *small, isolated populations and depend on narrow ranges of soil moisture, organic matter, light, and nutrients; they also have complex obligate relationships with mycorrhizal fungi and pollinators*. In addition, drying of air and soils near forest edges can degrade habitat for certain grape ferns (*Botrychium*). Pennsylvania [and Ohio!] forests serve as habitat reserves for many species. **Forest fragmentation and loss threaten populations of several breeding birds of conservation concern** in Pennsylvania and West Virginia, including **wood thrush** (*Hylocichla mustelina*), **cerulean warbler** (*Setophaga cerulea*), and **summer tanager** (*Piranga rubra*). Concern has been raised about potential HVHFF impacts on breeding populations of **area-sensitive forest interior songbirds, such as black-throated blue warbler** (*Setophaga caerulescens*) and **a wide-ranging forest raptor, the northern goshawk** (*Accipiter gentilis*). In a 5-year study of breeding birds at 469 sampling points in forest patches ranging from 0.1 to 3,000 ha in Maryland, Pennsylvania, West Virginia, and Virginia, *the percentages of forest cover within 2 km and the forest patch area were significant habitat variables for 40 and 38 species, respectively, of 75 species studied; 26 birds were considered area sensitive. It may take 75–100 years, or more, for cleared forests to regenerate and mature*. Forest floor species such as **salamanders and herbaceous plants have limited dispersal ability and may take as many additional years to recolonize regrown forests**. The guild of forest herbs, often diverse and abundant in mature Appalachian forests, contains many species vulnerable to environmental changes. Logging or clearing reduces herb diversity, and the **herb stratum may take several decades to recover**. **Herbivory by white-tailed deer** (*Odocoileus virginianus*) is harmful to many forest herbs; it is possible that clearing for wellpads, roads, and pipelines may create a landscape that will support more deer and may subject forest herb populations to **more intense grazing**. *One study reported that forests that are less than 70 years old supported fewer rare lichens and bryophytes than older forests; this observation may pertain to young forests that develop following abandonment of HVHFF installations.*

“Roads and pipelines: Roads act as corridors for the spread of **nonnative weeds**. Nonnative or weedy native plants will colonize disturbed soils at roads, wellpads, compressor stations, and pipelines, and spread from there into forests and other habitats. This has occurred at energy development sites in western North America. Among possible nonnative weeds that could colonize eastern HVVHF sites are common reed (nonnative haplotype of *Phragmites australis*), stiltgrass (*Microstegium vimineum*), Japanese knotweed (*Polygonum cuspidatum*), spotted knapweed (*Centaurea stoebe*), mugwort (*Artemisia vulgaris*), angelica tree (*Aralia elata*), autumn-olive (*Elaeagnus umbellata*), tree-of-heaven (*Ailanthus altissima*), and empress tree (*Paulownia tomentosa*). These plants thrive on habitats resulting from cut and fill, and are colonizing recent disturbances from surface mining, roads, and gas pipelines in the Catskill Mountains and Hudson Highlands of New York and other eastern regions. Common reed disperses along roads, and from there, into adjoining undisturbed habitats, where it may adversely affect plant and animal assemblages. The combination of disturbed roadside habitat and salinization from deicing salts is favorable for common reed. Vegetation of pipeline rights-of-way is managed by mowing or spraying **herbicide; runoff or spray drift may affect rare native plants in adjoining habitats**. Many *forest songbirds avoid roads, trails, pipelines, and human activities*. In western Canada, territories of the **ovenbird (*Seiurus aurocapillus*) straddled 3-m-wide cleared seismic exploration lines, but did not straddle 8-m-wide lines, leading to local population declines**. In another example, **red-backed salamander (*Plethodon cinereus*) was less abundant near gravel roads in mature forests in Virginia; this influence of roads on red-backed salamander appeared to be due to dessication of soils**. Some access roads and pipelines cross wetlands and streams, potentially creating barriers to movement of water and organisms. It takes an estimated 6,800 truck trips to fracture a single well. Many amphibians, reptiles, birds, and mammals are vulnerable to **road mortality**; in Ontario, numbers of dead frogs increased, and nearby breeding choruses decreased in intensity, in proportion to the amount of traffic on roads.

“**Hydrological alteration:** Many organisms of streams, wetlands, and temporary ponds require certain patterns of water levels and flows through the year (the hydropattern). Hydrological changes, including the withdrawal of surface waters, and increases in runoff caused by deforestation and impervious surfaces of wellpads and access roads, presumably affect the hydropatterns of streams, floodplains, wetlands, intermittent pools (vernal pools), springs, seeps, shallow groundwater, and karst complexes. Withdrawals from lakes and rivers for fracturing wells might reduce minimum instream flows in the summer....”

*The above report goes on to review additional hydrologic impacts on biodiversity, noise and light impacts, air quality, range-restricted species, cumulative impacts with extensive references, footnoted comprehensively within the text (omitted in my copy here). This is all **ESSENTIAL material for the Wayne staff to absorb and assess in drafting a new Plan, relevant to all activity disturbances proposed in any draft Plan.***

7. *Do Appalachian Herbaceous Understories Ever Recover from Clearcutting?* David Cameron Duffy and Albert J. Meier, **Conservation Biology**, Vol. 6 (2) Jun., 1992, 196-201. manoa.hawaii.edu/hpicesu/papers/1992_Do_Appalachian_Herbaceous.pdf
Abstract: “Life history characteristics of many herbaceous understory plants suggest that such species recover slowly from major perturbations such as clear cutting. We examined herbaceous cover and richness in the understories of nine primary ('old growth') forests in the southern Appalachian Mountains and of nine comparable secondary forests, ranging in age from 45 to 87 years since clear cutting. Neither cover nor richness increased with age in the secondary forests. This suggests three possibilities: (1) that recovery is so slow or variable among sites that 87 years is insufficient time to detect it; (2) that such forests will never recover to match remnant primary forests because climatic conditions are different today than when the forests became established; or (3) that herbaceous plants colonize pit and mound micro-topography caused by the death of trees, so that recovery must await the growth, death, and decomposition of the trees of the secondary forest. Whatever the mechanism, herbaceous understory communities in the mixed-mesophytic forests of the Appalachians appear unlikely to recover within the present planned logging cycles of 40-150 years, suggesting a future loss of diversity of understory herbaceous plants.”

This research is relevant and must be considered because the herbaceous layer in the Wayne is already highly compromised by fragmentation, past land use, and rapidly expanding deer and invasive vegetation populations. Further degradation by logging and burning will deplete the few areas of seed sources and further degrade the herbaceous layer, imperiling native biodiversity in the forest altogether.

8. Fracking operations in Ohio allow flaring of gas, sending plumes of burned and unburned gas and other chemicals into the sky. Some of us have seen these flares in Harrison County and other Ohio counties. They are noxious and a significant source of light and noise pollution. Studies show this process also affects plant diversity (J

of Ag and Ecology Research International, *The Impact of Gas Flaring on Plant Diversity in Ibeno Local Government Area*.

[researchgate.net/publication/276456443_The_Impact_of_Gas_Flaring_on_Plant_Diversity_in_Ibeno_Local_Government_Area](https://www.researchgate.net/publication/276456443_The_Impact_of_Gas_Flaring_on_Plant_Diversity_in_Ibeno_Local_Government_Area) The study examined the impact of gas flaring on plant diversity in Qua-Iboe Terminal (Q.I.T). A purposive sampling technique was adopted in choosing the [direction](#) of transects for data on plant species.

9. Fracking and the activities that support fracking such as infrastructure development (pipelines, well pads) harm and even destroy plants and their seed banks . A study conducted in the Fernow Experimental Forest in West Virginia showed that the forest ecosystem was affected by forest clearing, erosion, road building, and vegetation death from direct exposure to fluid spills, and there was an increase in the white-tailed deer population. This forest is a mixed mesophytic forest similar to the Wayne:

Effects Of Natural Gas Development On Forest Ecosystems. Mary Beth Adams, et al. [nrs.fs.fed.us/pubs/gtr/gtr-p-78papers/23adams78.pdf](https://www.nrs.fs.fed.us/pubs/gtr/gtr-p-78papers/23adams78.pdf). **Abstract:** “In 2004, an energy company leased the privately owned minerals that underlie the Fernow Experimental Forest in West Virginia. The Fernow, established in 1934, is dedicated to long-term research. In 2008, a natural gas well was drilled on the Fernow and a pipeline and supporting infrastructure constructed. We describe the impacts of natural gas development on the natural resources of the Fernow, and develop recommendations for landowners and land managers based on our experiences. Some of the effects (forest clearing, erosion, road damage) were expected and predictable, and some were unexpected (vegetation death from land application of fluids, an apparent increase in white-tailed deer presence). Although this is a case study, and therefore the results and conclusions are not applicable to all hardwood forests, information about gas development impacts is sufficiently rare that forest managers, research scientists, and the concerned public can learn from our experience.”

10. Fracking wastes have been found to contain water soluble radionuclides that are brought to the surface via produced water. “Elevated levels of chloride and bromide, combined with strontium, radium, oxygen, and hydrogen isotopic compositions, are present in the Marcellus shale wastewaters”: *Impacts of Shale Gas Wastewater Disposal on Water Quality in Western PA*, [Nathaniel R. Warner*](#), [C. A. Christie](#), [R. B. Jackson](#), and [A. Vengosh*](#) *Environ. Sci. Technol.*, 2013, 47 (20), pp 11849–11857. **Abstract:** The safe disposal of liquid wastes associated with oil and gas production in the United States is a major challenge given their large volumes and

typically high levels of contaminants. In Pennsylvania, oil and gas wastewater is sometimes treated at brine treatment facilities and discharged to local streams. This study examined the water quality and isotopic compositions of discharged effluents, surface waters, and stream sediments associated with a treatment facility site in western Pennsylvania. The elevated levels of chloride and bromide, combined with the strontium, radium, oxygen, and hydrogen isotopic compositions of the effluents reflect the composition of Marcellus Shale produced waters. The discharge of the effluent from the treatment facility increased downstream concentrations of chloride and bromide above background levels. Barium and radium were substantially (>90%) reduced in the treated effluents compared to concentrations in Marcellus Shale produced waters. Nonetheless, 226Ra levels in stream sediments (544–8759 Bq/kg) at the point of discharge were ~200 times greater than upstream and background sediments (22–44 Bq/kg) and above radioactive waste disposal threshold regulations, posing potential environmental risks of radium bioaccumulation in localized areas of shale gas wastewater disposal.

11. Peer reviewed studies show that watersheds surrounding frack well pads test positive for these radioactive substances. “Drilling companies deliberately spread wastewater on roads and fields. Pollutants from the water can then contaminate local waterways. Drilling operators sometimes spray wastewater on dirt and gravel roads to control dust or on paved roads to melt ice. (Public Employees for Environmental Responsibility, *Don’t Drink the Fracking Fluids! Toxic Well Flowback Pumped for Consumption by Wildlife and Livestock* (press release), 9 July 2013.). Many such contamination events involve the release of recovered fluid (called “produced water”), which consists of fracturing fluid and salts, heavy metals, hydrocarbons, and radioactive material accumulated from natural underground sources ([Howarth et al. 2011a](#)).
12. “Fluids from the drill pit were land-applied at two locations on the Fernow in June 2008, with nearly immediate impacts on vegetation. After the first fluid application site, many trees, shrubs, and understory plants showed immediate responses to the fluid application, with leaves turning brown, wilting, and subsequent leaf and bud mortality. We also observed that taller trees, whose leaves were not contacted by the fluids, also began showing decline symptoms about 10 days after the ground vegetation; these symptoms included leaf browning, leaf curling, and premature leaf drop. Premature leaf fall ranged from 227 to 1,395 kg ha⁻¹, or about 10 to 45 percent of annual autumn leaf fall biomass.” M. Adams, 2008 *Long-term leaf fall mass from three watersheds on the Fernow Experimental Forest, West Virginia*. In: Jacobs, D.F.; Michler, C.H., eds. *Proceedings, 16th central hardwood forest conference*.

2008 April 8-9; West Lafayette, IN. USDA, Forest Service, Northern Research Station. Gen. Tech. Rep. NRS-P-24,179-186.

13. Latta, SC et al. 2015. *Evidence from two shale regions that a riparian songbird accumulates metals associated with hydraulic fracturing*. *Ecosphere* 6(9):144. [dx.doi.org/10.1890/ES14-00406.1](https://doi.org/10.1890/ES14-00406.1) **Abstract:** “The risk of contamination of surface waters from hydraulic fracturing activities (i.e., fracking) to extract gas from underground shale formations has been viewed primarily in the context of localized point-source events such as spills with no evidence of contaminants entering food chains. We showed that in watersheds where hydraulic fracturing occurs, an obligate riparian songbird and top predator in headwater systems, the Louisiana Waterthrush (*Parkesia motacilla*), accumulated metals associated with the fracking process. In both the Marcellus and Fayetteville shale regions, barium and strontium were found at significantly higher levels in feathers of birds in sites with fracking activity than at sites without fracking. The question of what pathway these metals followed from the shale layers to enter the food chain was not resolved by this study, but our data suggested a recent origin for these metals in the riparian systems we studied because levels of barium and strontium in feather samples from reference sites in the Marcellus Region without fracking activity did not differ from historical samples of waterthrush feathers gathered prior to any fracking in the region. Our finding of similarly elevated levels of metals associated with fracking in two geographically distant shale formations suggests hydraulic fracturing may be contaminating surface waters and underscores the need for additional monitoring and study to further assess ecological and human health risks posed by the increasingly widespread development of unconventional sources of natural gas around the world.”

The following review of biotic impacts from oil and gas development also documents associations and impacts relevant to other forest disturbing activities and must be fully assessed.

14. *Biotic impacts of energy development from shale: research priorities and knowledge gaps* [Sara Souther](#) et al. *Frontiers in Ecology and the Environment*. 01 August 2014 **Abstract:** Although shale drilling operations for oil and natural gas have increased greatly in the past decade, few studies directly quantify the impacts of shale development on plants and wildlife. We evaluate knowledge gaps related to shale development and prioritize research needs using a quantitative framework that includes spatial and temporal extent, mitigation difficulty, and current level of understanding. Identified threats to biota from shale development include: surface and groundwater contamination; diminished stream flow; stream siltation; habitat loss and fragmentation; localized air, noise, and light pollution; climate change; and

cumulative impacts. We find the highest research priorities to be probabilistic threats (underground chemical migration; contaminant release during storage, during disposal, or from accidents; and cumulative impacts), the study of which will require major scientific coordination among researchers, industry, and government decision makers. Taken together, our research prioritization outlines a way forward to better understand how energy development affects the natural world.

15. Fragmentation from land clearing and infrastructure development affects plant reproduction: *Plant reproductive susceptibility to habitat fragmentation: review and Synthesis through a meta analysis*. Ahuilar, Ramiro. Ecology Letters, May 30, 2006. (ncbi.nlm.nih.gov/pubmed/16913941). **Abstract:** The loss and fragmentation of natural habitats by human activities are pervasive phenomena in terrestrial ecosystems across the Earth and the main driving forces behind current biodiversity loss. Animal-mediated pollination is a key process for the sexual reproduction of most extant flowering plants, and the one most consistently studied in the context of habitat fragmentation. By means of a meta-analysis we quantitatively reviewed the results from independent fragmentation studies throughout the last two decades, with the aim of testing whether pollination and reproduction of plant species may be differentially susceptible to habitat fragmentation depending on certain reproductive traits that typify the relationship with and the degree of dependence on their pollinators. We found an overall large and negative effect of fragmentation on pollination and on plant reproduction. The compatibility system of plants, which reflects the degree of dependence on pollinator mutualism, was the only reproductive trait that explained the differences among the species' effect sizes. Furthermore, a highly significant correlation between the effect sizes of fragmentation on pollination and reproductive success suggests that the most proximate cause of reproductive impairment in fragmented habitats may be pollination limitation. We discuss the conservation implications of these findings and give some suggestions for future research into this area.” Significance: Fracking could introduce additional fragmentation.
16. Road building, land clearing, and vehicles used for logging, oil and gas activities, burning, and ORV use introduce and encourage the spread of invasive species. “The evidence points to the gravel delivered to build pads and roads, and in mud on the tires and undercarriages of trucks traveling those roads.” *Invasive plants follow fracking into Marcellus Forests*, Karen Graham, Environment: July, 2017. (digitaljournal.com/news/environment/shale-gas-development-promotes-spread-of-invasive-plant-species/article/498352#ixzz5CBu7diXz) Significance: Given the amount of equipment brought onto the site, this will also introduce and encourage the spread of invasive species. “The evidence points to the gravel delivered to build

pads and roads, and in mud on the tires and undercarriages of trucks traveling those roads.”

17. Also see paper documenting impact of logging on spread of ailanthus and invasive stilt grass: *Initial Response Of Invasive Exotic Plant Species To Timber Harvesting In Southeastern Kentucky Forests*, Kevin Devine, Masters thesis, University of Kentucky, 2011. “Timber harvesting caused a significant increase in both *Ailanthus altissima* and *Microstegium vimineum* within harvested areas.”

18. Invasive stilt grass is enabled by logging, land clearing, and vehicle intrusions for gas and oil infrastructure and ORV use: *Effects of Microsites Created by Selective Harvesting on Growth of Microstegium vimineum in a Central Hardwood Forest*, Jordan M. Marshall and D. S. Buckley, *Forest Science*, 54(5):534–542. **Abstract:** ... Different categories of understory microsites resulting from cutting and the operation of logging machines within three selective harvest units were identified and characterized by measuring several environmental variables. *M. vimineum* was sown within the microsites categorized. Differences in growth of *M. vimineum* across different microsites were quantified. As percent canopy cover increased, *M. vimineum* percent cover, mean length, and mean number of nodes decreased. Also, as litter depth increased, *M. vimineum* percent cover and stem length decreased. In undisturbed microsites in which *M. vimineum* was not sown, the exotic grass was not a dominant species, whereas in all other microsites created by logging machine operation *M. vimineum* was a dominant species whether those areas were sown or colonized by wild populations. These results suggest that unique microsites created by logging may facilitate *M. vimineum* invasion of central hardwood forests. The apparent connection between soil and canopy disturbance and invasion by *M. vimineum* provides further impetus for careful planning and use of haul roads and skid trails.”

19. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Plenary of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services Sixth session, Medellin, Colombia, 18–24 March 2018 Agenda item 6 (b): Regional and subregional assessments of biodiversity and ecosystem services: regional and sub-regional assessment for the Americas (ipbes-6-inf-4-rev.1.pdf) includes extensive evaluation and discussion of the status of and threats to biodiversity, discussing fresh-water, forest, and wildlife health.

Some relevant excerpts:

“Large numbers of plant and animal species depend on these forest habitats. An estimated 90% of the resident or common migrant vertebrate species in the USA (Flather et al., *Wildlife Resource Trends in the United States: A Technical*

Document Supporting the 2000 RPA Assessment. Gen. Tech. Rep. RMRS-GTR-33. Fort Collins, USA: USDA, Forest Service, Rocky Mountain Research Station. 1999), and likely in Canada, use forest habitats....

“Several natural forest types and numerous species have been greatly reduced by human activities....Less than 1% of North American temperate deciduous forest has not experienced anthropogenic disturbance (Frelich, L.E. & Reich, *Wilderness conservation in an era of global warming and invasive species: A case study from Minnesota’s Boundary Waters Canoe Area Wilderness*. Natural Areas Journal, 29(4), 385–393. 2009).

“Temperate deciduous forests have a smaller fraction of original primary forest remaining than do boreal or tropical forests, although most of the original species remain present (Frelich, L. E. (1995). *Old forest in the Lake States today and before European settlement*. Natural Areas Journal 15(2), 157–167).

“94% of forest-associated vascular plants fully occupy their former range (Nelson, M. D., et al., (2016). National report on sustainable forests—2015: Conservation of biological diversity. In S. M. Stanton & G. A. Christensen (Eds.), *Pushing Boundaries: New Directions in Inventory Techniques and Applications: Forest Inventory and Analysis (FIA) Symposium 2015* (p. 375). Portland, USA: United States Department of Agriculture. doi.org/10.2737/PNW-GTR-931).

“Logging, grazing, fire suppression [in western fire-evolved forests] and manipulation of wildlife populations have altered forest composition, structure, and landscape. An estimated 32% of amphibian species and 12–15% of mammals, birds, reptiles, and fish are possibly extinct or at risk of extinction in USA forests (Nelson et al., 2016). In addition, 32–34% of vascular plants and select invertebrates are possibly extinct or at risk of extinction (Nelson et al., 2016) (Figure 3.17).” (p. 249)

“Generally, species richness within forest stands (alpha diversity) remains lower in recent compared to ancient forests, even when recent forests are decades or centuries old (Flinn, K.M., & Vellend, M. 2005. *Recovery of forest plant communities in post-agricultural landscapes*. *Frontiers in Ecology and the Environment*, 3(5), 243-250).

“This biotic homogenization is legacy of human land-use that may endure for decades if not centuries (Lepš, J., & Rejmánek, M. (1991). *Convergence or divergence: what should we expect from vegetation succession?* *Oikos*, 261-264.; Vellend, M. et al., 2007. *Effects of exotic species on evolutionary diversification*. *Trends in Ecology & Evolution*, 22(9), 481-488; Deines, J. M., et al. (2016).

Changes in forest composition in Ohio between Euro-American settlement and the present. The American Midland Naturalist, 176(2), (pp.247-271).” (p. 401)

20. Fragmentation from proposed Wayne activities must be fully quantified and its impacts assessed, using data such as from the global fragmentation study, *A global evaluation of forest interior area dynamics using tree cover data from 2000 to 2012*, Kurt Riitters et al., *Landscape Ecol* (2016) 31:137–148, DOI 10.1007/s10980-015-0270-9. **Abstract:** **Context:** Published maps of global tree cover derived from Landsat data have indicated substantial changes in forest area from 2000 to 2012. The changes can be arranged in different patterns, with different consequences for forest fragmentation. Thus, the changes in forest area do not necessarily equate to changes in forest sustainability. **Objective:** The objective is to assess global and regional changes in forest fragmentation in relation to the change of forest area from 2000 to 2012. **Methods** Using published global tree cover data, forest and forest interior areas were mapped in 2000 and 2012. The locations of forest interior change were compared to the locations of overall forest change to identify the direct (pixel level) and indirect (landscape level) components of forest interior change. The changes of forest interior area were compared to the changes of total forest area in each of 768 ecological regions. **Results:** A 1.71 million km² (3.2 %) net loss of global forest area translated to a net loss of 3.76 million km² (9.9 %) of forest interior area. The difference in loss rates was consistent in most of the 768 ecological regions. The indirect component accounted for 2.44 million km² of the net forest interior change, compared to 1.32 million km² that was attributable to the direct component. **Conclusion:** Forest area loss alone from 2000 to 2012 underestimates ecological risks from forest fragmentation. In addition to the direct loss of forest, there was a widespread shift of the remaining global forest to a more fragmented condition.
21. The Wayne must quantify and fully assess impacts of proposed activities that would affect soil quality and therefore water quality and biotic components of forest by disturbance of forest soils. *Linkages between forest soils and water quality and quantity*, D. Neary et al. *Forest Ecology and Management* 258 (2009) 2269–2281. **Abstract:** The most sustainable and best quality fresh water sources in the world originate in forest ecosystems. The biological, chemical, and physical characteristics of forest soils are particularly well suited to delivering high quality water to streams, moderating stream hydrology, and providing diverse aquatic habitat. Forest soils feature litter layers and high organic contents, both of which contribute to an abundant and diverse micro- and macro-fauna. Root systems under forests are extensive and relatively deep compared to agricultural lands and grasslands. Together, these biological conditions create soils with high macroporosity, low bulk density, and highly saturated hydraulic conductivities and infiltration rates.

Consequently, surface runoff is rare in forest environments, and most rainfall moves to streams by subsurface flow pathways where nutrient uptake, cycling, and contaminant sorption processes are rapid. Because of the dominance of subsurface flow processes, peak flows are moderated and baseflows are prolonged. Conversion of forests to row crops, pastures, or lawns almost always results in deterioration of water quality. In North America, the majority of municipalities ultimately rely on forested watersheds to provide adequate quantities of high quality water for human use. This is particularly true in the western and eastern parts of the continent where human populations are large or growing rapidly. Forest soils provide the perfect conditions for creating high quality water supplies. This paper provides a historical perspective of the linkage between forest soils and water quantity and quality over the past century, and it also makes predictions about research directions in the area of forest soil and water quality linkages.

22. Hartmann, Martin et al., “Resistance and resilience of the forest soil microbiome to logging-associated compaction,” *The ISME Journal* 8: 226-244 (2014). From the abstract: “Compaction significantly reduced abundance, increased diversity, and persistently altered the structure of the microbiota. Fungi were less resistant and resilient than bacteria[.] [...] Compaction detrimentally affected ectomycorrhizal species[.] [...] This study demonstrates that physical soil disturbance during logging induces profound and long-lasting changes in the soil microbiome and associated soil functions[.]” From the research: “Soil compaction has been recognized as a major disturbance associated with forest management. Economically efficient harvesting requires the use of heavy machines, causing severe compaction of the soil particularly during wet conditions and along skid trails and landings. Alterations in soil porosity affect pore connectivity, water infiltration, air permeability, temperature, rooting space, nutrient flow and biological activity, often resulting in increased surface runoff, soil erosion, nutrient leaching and greenhouse gas emission. As a consequence, the soil system can suffer substantial, persistent and sometimes irreversible damage, which ultimately reduces forest productivity and ecosystem functionality. Given that the affected area can range between 10 and 40% of the total logged stand, the impact on the ecosystem can be substantial.” At p. 226-227
23. Soil compaction is a major problem inherently linked to economically efficient logging operations. Its costs to ecosystem services must be addressed before Wayne considers logging and other soil compacting intrusions as activities in the new Plan.
24. Finally, the Planning Team must revisit in great detail the legal appeal (Appeal # 06-13-00-0050) of the 2006 Wayne Forest Plan ROD filed May 12, 2006, on behalf of Heartwood, Buckeye Forest Council and Sierra Club, being re-submitted separately

by Loraine McCosker. The numerous deficiencies of the Wayne 2006 Plan are detailed there and highly relevant to the new Plan development process. All must be considered. To mention just a few: The 2006 Plan's inadequate choosing of management indicator species (MIS) is discussed in detail. Two excerpts: "There are no bats, no salamanders, no snakes, no frogs, no fish. These are important aspects of the environment that do indicate environmental response to management activities. For example, there is a study by the Forest Service research branch out of Missouri that showed that salamanders are extremely sensitive to logging, and that they can all but be eliminated from an area by clearcutting, and severely reduced in population by even selective logging." (p. 82); "The Plan does not provide for any amphibians in its MIS list. Five amphibians are either on the Regional Forester Sensitive Species list or proposed. FEIS, Appendix, p. F3-1 1. The Eastern Hellbender is a habitat specialist that's habitat is disappearing, i.e. clean, cool, relatively shallow streams with many large rocks scattered on the bottom with many large rocks scattered on the bottom with substrates of sand and gravel. Hellbenders need well-oxygenated, cool, highflow water. Nothing in the Plan indicates this habitat is a goal or necessary to achieve the Plan's purposes." (p. 96)

The Plan does not adequately assess cumulative effects or protect aquatic species. A brief excerpt: "However, as discussed above, forest-wide and riparian standards are arbitrary and capricious and are not sufficient to protect aquatic species, especially vulnerable threatened and endangered (T&E) species, from the harmful impacts of sediment released during activities such as logging and road-building. These standards are especially ineffective to prevent the cumulative, adverse effects of sedimentation. Neither the Biological Assessment (BA) nor the FEIS adequately consider the cumulative impacts to aquatic T&E species. The BA and the FEIS focus only on the impacts of activities on the Forest. These species are also under tremendous pressure from logging, mining and other activities on private lands, yet there is no analysis of these impacts in either the BA or the FEIS. The Forest Service has failed to evaluate the indirect and cumulative effects on aquatic T&E species, as required by the ESA regulations. 50 C.F.R. § 402.02 (definition of effects, action area, and cumulative effects); § 402.12(a) (BA must evaluate the potential effects of the action), (f)(4) (suggesting the BA consider cumulative effects). The "effects of the action" as defined in the consultation regulations are similar to "cumulative effects" under NEPA because the agency must add the effects of the action and certain other impacts to the "environmental baseline," which includes "the past and present impacts of all Federal, State or private actions and other human activities in the action area. . . 50 C.F.R. § 402.02." (p. 112)

The legal appeal details the USFS's requirement to consider the relative values of services it may provide under the mis-sanctified Multiple Use Sustained Yield

(MUSYA) doctrine: “The Multiple Use, Sustained Yield Act defines “multiple use,” which is the covenant by which the Forest Service not only is under, but which is repeatedly reiterated to the public across the country, as the following:

(a) ‘Multiple use’ means the management of all the various renewable surface resources of the National Forests so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output.

“Under the NFMA, it is required that this be considered during planning. (36 CFR 219.1) Pursuant to the language in this act, each national forest must complete a “*relative value analysis*” to comply with both the NFMA regulations and the Multiple Use, Sustained Yield Act. An opinion in the U.S. District Court of the Southern District of Illinois regarding the forest management plan of the Shawnee National Forest (Sierra Club, RACE et al v. US.D.A., S. Dist. IL 1996, affirmed, 7th Cir. 1998) addressed this issue and explained it in detail:

MUSYA requires the Secretary to coordinate management of the various renewable resources on forest lands ‘with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output.’ 16 U.S.C. § 529, 53 1(a) (1988). The plaintiffs argue that a proper ‘relative values analysis’ requires the Forest Service to consider whether such renewable resources are being supplied from the private lands surrounding and intermingled with the . . . National Forest. The plaintiffs argue that the ALRMP fails to conduct this type of analysis and, as a result, overemphasizes resource uses such as artificially maintained openland areas, logging, oil and gas leasing, and ATV use and underemphasizes such resource uses as wilderness and wildlife habitat for neotropical migratory birds.

“In support of their argument, the plaintiffs point to the Congressional findings enacted as part of the NFMA, which state, in relevant part, that: ‘Congress finds that . . . to serve the national interest, the renewable resource program must be based on a comprehensive assessment of present and anticipated uses, demand for, and supply of renewable resources from the Nation’s public and private forests and rangelands,

thorough analysis of environmental and economic impacts, coordination of multiple use and sustained yield opportunities as provided in the [MUSYA], and public participation in the development of the program. 16 U.S.C. § 1600(3) (1988)

... “In the current situation, the new Forest Service management plan doesn’t contain a relative value analysis. *It does not appear that lands outside the Wayne were considered such as part of a global or eco-regional perspective. The Wayne treats the Wayne as an island instead of landscape.*

“Therefore, in order to properly consider the relative value of these conditions, Forest Service should have looked at the frequency and abundance of this un-fragmented, maturing forest natural community elsewhere in the region, compared with habitats such as farm fields, pastures, logged areas, and other disturbance habitats. Such an honest analysis would show that the natural community associated with a large, un-fragmented, mature forest is found in few other places in Ohio. This analysis is missing. Therefore the Wayne does not tell the public how what it offers is either the same or different from what else is offered by public lands in the region. (pp. 118-120)

The following brief excerpt from the Appeal’s section on old-growth addresses a few of the critical issues raised in this appeal in relation to the Wayne’s ill-considered neglect of this most valuable benefit that the Forest should provide:

“The foremost expert on old-growth eastern forests, that is, the person who has visited and surveyed the most remnants of the old-growth, is Mary Byrd Davis. Dr. Davis joins Heartwood and Buckeye Forest Council in opposing the 2006 Wayne National Forest Land and Resource Management Plan in its current incarnation due to its (1) further fragmentation of the forest; (2) unbalanced emphasis on timber production; (3) failure to value and allow forests to reach old growth; (4) failure to protect non-timber resources of the forest; and (5) failure to conserve endangered species. See Attachment 3.

“...What was once Ohio’s dominant eco-system is now its rarest eco-system. When Mary Byrd Davis surveyed eastern states for remaining old-growth areas over 10 acres in size, she could only find 1,400 total acres in Ohio, with the largest patch being about 200 acres in a area called Morgan Sisters on the fronton Unit of the Wayne National Forest (Wayne NF). Every other patch was substantially smaller. Because it takes more than 200 acres to be considered an ecosystem, the old-growth forest ecosystem was effectively extirpated from Ohio together with many species that require large tracts of land without significant human activities on them.

“The science of Conservation Biology, which the Forest Service is now obliged by law to consider, is in general agreement that plant and animal species are best protected in large landscape-sized ecosystems, connected by wildlife corridors where possible, and with the restoration of traditional native species when feasible, including predators. Any management activity will favor some species and hurt others as most species live in particular biological niches or habitats. What is good for a Scarlet Tanager (i.e., closed canopy forests) is bad for a Henslow Sparrow (grassland-obligate bird). Thus, the debate comes down to which species are most in need of protection and how much land do those species require if one is managing habitat with an eye toward Conservation Biology.

“The Forest Service avoids this critical issue analysis entirely by simply declaring that it wants to preserve all the current species found on the Wayne NF, but its management plan clearly favors those species least in need of protection, except for small efforts on behalf of the handful of species on the Wayne NF that are federally-listed. For example, we have seen that old-growth forests, once common, are now an endangered or extirpated ecosystem in Ohio, together with almost all the forest species that require relative seclusion from human activities. Yet, the plan adopted by the Forest Service for the Wayne (Modified E Alternative) provides for management areas that allow timber harvesting on 202,777 acres out of a total of 238,053 (Table S-8) or 85.2% of its total land for timber harvesting. Most of the remaining land is available for oil and gas wells and related disturbing activities, or for human recreation areas (which total 4,078 additional acres) like the Lake Vesuvius area. Those species needing old-growth forest and seclusion from most human activities (except perhaps non-motorized recreation like hiking or primitive camping or seasonal hunting) are simply out of luck as only 16,478 total acres or 6.9% are available for them (Table S-30) and, as we have seen, only 200 acres of these areas arguably meets the definition of old-growth at this time.

“Saving Ohio’s species most in need of protection is obviously not very important to the Forest Service, but is very important to Ohioans, as expressed in scores of submitted comments. The overwhelming majority of submitted written and oral comments requested either a cessation of all commercial logging or substantially reduced logging as compared with the old plan. Yet, out of the seven alternatives the Forest Service offered to the public, the one with the least amount of land available for logging, and the only one with less than 85% of the land slated for eventually logging, was Alternative F, which set aside 73.5% of the land for logging. Not surprisingly, most environmental groups rejected all the alternatives, as the Forest Service clearly was unwilling to listen to the public on this and many other issues. The amazing part is that the Forest Service refused to change its obsession with logging despite the strong comments by the Sixth Circuit Court of Appeal on this

issue regarding the last forest plan. To understand the ludicrous nature of the Forest Service's preferred plan, consider that a single black bear, a state-endangered species, needs 2 to 5 square miles of forest habitat (i.e., 1,280 to 3,200 acres) to survive. A genetically viable population of 30 breeding pairs of black bears would thus need a minimum of 76,800 acres to assure long-term survival of this species in Ohio. Black bears avoid areas with high road densities (as do elk), and so the Forest Service obviously has no plans to permit the recovery of species like this to Ohio because it plans to increase road densities.

“Likewise, many forest-interior bird species need large landscape-scale tracts (i.e., tens of thousands of acres) to avoid nest predation by invasive cowbirds and egg predation by forest-edge species like raccoons and opossums. Yet, as noted above, the Forest Service's plan would involve overall more net road building and “edge” areas, which are known to facilitate cowbird invasions and other nest predators as well as exotic invasive species. Their plan moves the Wayne NF in the opposite direction that almost all conservation biologists would recommend to save forest “sensitive” species. The Forest Service states, truthfully, that the Plan allocates 16,478 acres to Future Old Forest, but what the Forest Service ignores is that the 16,478 acres is distributed across the forests so you have FOF in narrow strips and isolated bunches, especially in the Marietta Unit. (pp. 12-14 of May 12 Appeal # 06-13-00-0050)” (pp. 12-14)

The Wayne Planning Team must review in detail this critical legal document and all of its substantive analyses of the deficiencies of the 2006 Plan. The appeal and its associated reference documents have been in the possession of the Wayne for more than twelve years. The arguments made then by forest experts and an educated public are of utmost importance to consider in drafting of the new Plan.

H. Prescribed fire

The misuse of fire and abuse of our National Forest to meet industrial logging goals, exacerbated by financial incentives that benefit the Forest Service, must stop. The size, locations, and purposes claimed for fires set by USFS are must all be challenged based on science. Furthermore, researchers paid by USFS money are not objective and their conclusions suspect, given the money stream for USFS-set fires. Investigations have shown that the USDA Forest Service has utilized a highly ineffective yet increasingly expensive prescribed burn

program for many years and that the most important factor increasing the cost of fires is incentives. (Randal O’Toole, Reforming the Fire Service: An Analysis of Federal Fire Budgets and Incentives, Thoreau Institute, 2002, ti.org/firesvc.pdf: “Another factor is the decline in the national forest timber program, which left the Forest Service looking for a new ‘mission.’ Such a new mission was created when Congress reacted to the severe fires of 2000 by doubling federal land fire budgets, effectively increasing the Forest Service’s budget by nearly 40 percent.”) With such money earmarked for fire programs, eastern forest managers have taken advantage of the situation and created a budget-maximizing scheme that claims that fire is needed in the east....This type of thinking excludes a full cost accounting of the program’s real costs, which are externalized to area residents in the form of increased health risks, [and] increased fire risk, lost ecosystem services.”

On November 8, 2018, working group members Paul Knoop, Loraine McCosker, and Heather Cantino visited Wayne Forest sites with District Ranger Jason Reed and Dan Anerino, Assistant Forest Fire Management Officer on Big Bailey Run Road and in the Long Ridge unit to observe and learn about areas that have been received prescribed burns over a period of years (the last of three burns done eight years ago) and to visit forests proposed to be burned (an EA has been issued and a FONSI prior to citizen comment period for the Long Ridge project). Mr. Reed stated during the visit that there has been no documentation or survey by the Wayne of any biotic populations -- amphibians, reptiles, birds, mammals, flora or fungi – other than trees prior to or following burning. The condition of the soil, rich and aerated in the pre-burn sites vs. hard-packed in the post-burn site, was striking, as was the condition of the understory, with extended exotic invasives and greenbrier in the middle of the post-burn site, in contrast to the pre-burn site’s with its emerging woody native trees, evidence of native flora, and thick leaf litter. (We did witness a handful of small oaks emerging in the highly impacted understory.) The burned forest with its compacted thin soil, limited native understory plants, damaged trees, and significantly less leaf litter, is in essence a highly impacted fragmented forest with significant invasives present.

Given that neither the Athens District Ranger nor the Assistant Forest Fire Management Officer apparently even noticed the goldenseal we walked through in the proposed burn site on Big Bailey Run Rd. (they said there was no flora to disturb) and given their acknowledgment that the Wayne does no pre- and post-assessment of non-target impacts), it is imperative that biologists

knowledgeable about flora and species other than trees be involved in planning for ALL Wayne activities proposed in the new Plan.

1. ***Reassessment of the use of fire as a management tool in deciduous forests of eastern North America.*** [Matlack GR, Conserv Biol.](#) 2013 Oct;27(5):916-26. doi: 10.1111/cobi.12121. **Abstract:** “Prescribed burning is increasingly being used in the deciduous forests of eastern North America. Recent work suggests that historical fire frequency has been overestimated east of the prairie-woodland transition zone, and its introduction could potentially reduce forest herb and shrub diversity. Fire-history recreations derived from sedimentary charcoal, tree fire scars, and estimates of Native American burning suggest point-return times ranging from 5-10 years to centuries and millennia. Actual return times were probably longer because such records suffer from selective sampling, small sample sizes, and a probable publication bias toward frequent fire. Archeological evidence shows the environmental effect of fire could be severe in the immediate neighborhood of a Native American village. Population density appears to have been low through most of the Holocene, however, and villages were strongly clustered at a regional scale. Thus, it appears that the majority of forests of the eastern United States were little affected by burning before European settlement. Use of prescribed burning assumes that most forest species are tolerant of fire and that burning will have only a minimal effect on diversity. However, common adaptations such as serotiny, epicormic sprouting, resprouting from rhizomes, and smoke-cued germination are unknown across most of the deciduous region. Experimental studies of burning show vegetation responses similar to other forms of disturbance that remove stems and litter and do not necessarily imply adaptation to fire. *The general lack of adaptation could potentially cause a reduction in diversity if burning were introduced. These observations suggest a need for a fine-grained examination of fire history with systematic sampling in which all subregions, landscape positions, and community types are represented. Responses to burning need to be examined in noncommercial and nonwoody species in rigorous manipulative experiments. Until such information is available, it seems prudent to limit the use of prescribed burning east of the prairie-woodland transition zone.*” (emphasis added)
2. In 1999, ODNR’s Division of Forestry, in its Shawnee Wilderness Area Management Plan 1999-2009, stated that naturally occurring wildfires are not typical in Ohio and that there is no natural role for fire in Ohio forests: “Forest fires in this region of Ohio are not a naturally occurring phenomena [sic]. Virtually all wildfires in Ohio are man-caused, in contrast to the western United States where dry lightning is a significant cause of fire and often an important part of the forest ecology. The occurrence of lightning-caused fires is rare in Ohio and statistically insignificant.

Although man-caused fires have played a role in the history of the Shawnee Wilderness Area, discussion of the ‘natural role of fire,’ which is so important to western forest and wilderness fire plans, simply cannot be applied to a wilderness in an Appalachian hardwood forest...Fires may be a significant contributor to non-point source pollution in Ohio’s hill country, as the fires remove the soil’s protective cover. Large trees are at least scarred by these fires, and sometimes killed.” (ODNR Division of Forestry. *Shawnee Wilderness Area Management Plan*. Effective Date: September 14, 1999 thru September 14, 2009) The same arguments were made in the first Shawnee Wilderness Area Management Plan, passed in 1989.

3. This assessment is consistent with the scrutiny of the historical fire myth by Emily Russell in her paper, *Indian-Set Fires in the Forests of the Northeastern United States*, Ecology, Vol. 64(1) 1983, pp. 78-88, jstor.org/stable/1937331. **Abstract:** “The historical evidence for the Indians' burning the forests of the northeastern United States is reevaluated. Of 35 documents that describe vegetation or Indian life in the 16th or 17th centuries, only half mention any use of fire except for cooking. Only six purportedly first-hand accounts might refer to purposeful, widespread, and frequent use of fire. These six are all consistent with use of fire only locally near camps or villages, or with accidentally escaped fires. It is concluded that the frequent use of fires by the Indians to burn the forests was probably at most a local occurrence. The Indians' presence in the region and their use of fire for many purposes did, however, increase the frequency of fires above the low levels caused by lightning, and thus had some effect on the vegetation; for example, grasses characterized the ground cover at small, local, frequently burned sites.”
4. Oak regeneration in SE Ohio is not natural but encouraged by frequent cutting for the 19th century charcoal industry (Appendix D of the Wayne National Forest FEIS 2006) as well as likely by human-caused burns prior to the 20th century. As stated in the *Economic Analysis of the Shawnee State Forest* (GreenFire Consulting Group, LLC, Bloomington, IN 47404, (812) 336-0360, greenfireconsulting.com), “It should then not be surprising that with human-caused fires largely under control and fires caused by lightning rare in this part of the country, a gradual shift in species composition away from oak dominance would occur. After all, forests in eastern Ohio are part of the Appalachian Mixed Mesophytic Forest type, and that forest type is not dominated by oaks, except that oaks would be found to be dominant on drier sites, like ridge-tops.

“There is therefore nothing alarming or unnatural in the fact that oaks are gradually receding and maples are claiming more space, if indeed there was an unnatural, human-caused level of logging and fire activity that had given oaks an unnatural advantage over other species. To twist things around and claim that this historic state

is somehow preferable over a forest that naturally develops, cannot be considered acceptable logic or ecologically justified. From a broader perspective, intervening to restore a land cover type that only came about because of massive human disturbances in the first place has no justification. Basically, DOF plans to maintain an artificial state that requires ongoing intervention through burning. By setting a goal of restoring oak-hickory, a goal that has no obvious connection to any pressing public need, and by committing forest resources and taxpayer money to that goal, DOF neglects other pressing issues that could be addressed in DOF's plans for the Shawnee State Forest. Two of the most important, both essential to protection of native biodiversity and severely undermined by prescribed fires, are restoration of large, continuous interior expanses of forest and NNIS control.

“In addition to oak restoration being a questionable goal, there are also reasonable doubts about the effectiveness of logging and prescribed burns promoting oaks. Doubts about the effectiveness of prescribed burns in regenerating oaks were expressed by Dr. Wayne Clatterback, Associate Professor at the University of Tennessee Institute of Agriculture in an April 24, 2007 article in the Portsmouth Daily Times. He said he had seen first-hand attempts to regenerate oaks through controlled burning: “I have seen it over the last eight to ten years, and the research I’ve seen shows there is really no difference.”

...”In 2003, Loftis and Arthur, University of Kentucky forest ecology professors, with the help of Daniel Boone National Forest staff, started a large-scale study on 1,000 to 1,200 acres, on sites ranging from ridgetops to coves, which were burned either frequently and infrequently. The purpose of the study was to support Kentucky’s Daniel Boone National Forest fire management that had the objective of reducing white pines and red maples and therefore supposedly regenerating oaks. Five years after the burns, the researchers found that red maple seedlings had shown a larger growth response than had oaks.” Any observed long-term or catastrophic decline of oaks may actually result from factors having nothing to do with explanations offered so far. The same may be true for any observed increase in oaks over the last hundred years. The shift in hardwood forests towards oak domination may well be explained by eradication of the American chestnut.” (USDA Forest Service Southern Station. “Can Fire Help Regenerate Oaks?” *Compass* Issue 9. Accessed 2-25-2010. srs.fs.usda.gov/compass/issue9/03canfire.htm)

“DOF itself, in its June 15, 2005 Shawnee Open House documents, explains how oaks were exposed to various stress factors every year from 1999 to 2005. Those stress factors included drought, defoliation by caterpillars, the ice storm, chestnut borers, Armillaria root disease, and inch worms. DOF therefore offers many plausible explanations of oak mortality. Oak mortality is a very different issue from

the supposed regeneration problems used to justify prescribed burns. The burns are not meant to address oak mortality. They are meant to increase chances of survival and growth of young oak trees compared to other species.

“When looking at the issue of oak decline from the perspective of oaks being weakened and dying, the question arises as to what may weaken oaks that they cannot withstand those stressors more effectively. From an ecological perspective, there could be a wide variety of possible explanations:

- Ohio’s forests are under stress from air pollution, which could be taking a toll on oaks. For example, sulfur dioxide emitted from coal-firing plants makes forest soil more acidic. Different kinds of oaks have different sensitivities to sulfur dioxide. Also, ground level ozone has been found to be an important factor in oak mortality. (Ayers, Harvard, Charles E. Little and Jenny Hager, eds., *An Appalachian Tragedy, Air Pollution and Tree Death in the Eastern Forests of North America*, Sierra Club Books, San Francisco: 1998, p. 55.)
 - Changing global climate conditions that bring about more droughts and floods as well as new insects and diseases, could each or in combination damage, weaken, and kill oaks. (See Shawnee and Brush Creek State Forests Open House Documents. June 15, 2005, See Section “Forest Health Update – Oak Decline.”)
 - Repeated logging, especially in hilly terrain, may be a factor in oak mortality due to soil erosion, depletion of nutrients, and changes in soil chemistry and microorganisms. As we show in more detail below, practices of industrial forestry radically change the forest environment from how it would develop naturally, and it would be very surprising if there were no effects from this on resilience of individual species of trees or the forest ecosystem as a whole (see below on healthy forests and description of old-growth forests).”
5. In relation to both logging and burning considered by the Wayne as potential activities, increasing carbon loss from soil due to climate warming must be assessed. The drying and warming of soil from burning and logging has significant climate implications and must be assessed for climate and biotic impacts given climate, soil C loss, and drying projections. See Crowther et al., *Quantifying global soil carbon losses in response to warming*, Nature, Vol. 5 (40), Dec. 2016, doi:10.1038/nature20150, and Bond-Lamberty et al., *Globally rising soil heterotrophic respiration over recent decades*, Nature, Vol. 560, Aug. 2108, doi.org/10.1038/s41586-018-0358-x
 6. Fire impacts on soil temperature and microclimates must be assessed before considering further prescribed burning by the Wayne. *Fire increases drought vulnerability of Quercus alba juveniles by altering forest microclimate and nitrogen availability*, Tyler Refsland and Jennifer Fraterrigo, Functional Ecology, Aug. 2018,

doi: 10.1111/1365-2435.13193. “Maximum daily air temperatures from April – October 2015 were 1.31 °C (\pm 0.6 °C) higher in burned than unburned plots...Our findings are novel in that they suggest recurrent surface fires can have lasting effects on forest understory microclimate, which in turn have negative consequences for juvenile trees exposed to drought.”

7. In addition to threatening forest biodiversity, including woody and non-woody plants, fungi, and fauna, prescribed fire doesn't necessarily benefit oaks.
Prescription side effects: Long-term, high-frequency controlled burning enhances nitrogen availability in an Illinois oak-dominated forest. Quinn A. Taylor and M. Midgley, *Forest Ecology and Management* 411 (2018) 82–89.
8. A critique of key research previously used to support prescribed burns must be considered: Todd Hutchinson's work, among others, to used support prescribed burning, but a close analysis of what Hutchinson actually says shows how inappropriate that is. First, below, are quotes from Hutchinson (2005) that directly refute claims made by USFS and Ohio Division of Forestry to support prescribed burning. Then follows a critique of one of Hutchinson's papers, showing the flaws in the study that make it a totally inadequate basis for decisions about large scale burns of the sort USFS and DOF conduct. Note, also, that Todd Hutchinson works for the U.S. Forest Service, which has supported prescribed burns and receives federal financial support to fund salaries tied to conducting burns.

I. Hutchinson, T. Fire and the herbaceous layer of eastern oak forests. *Fire in Eastern Oak Forests: Delivering Science to Land Managers. Proceedings of a Conference: November 15-17, 2005; Columbus, OH.* U.S. Department of Agriculture, Forest Service, Northern Research Station, pp. 136-149.

This is a review paper, some of which concerns oak forests farther west (Missouri and Illinois), which are drier and more prone to natural fire than Ohio forests. But there are several statements in this paper that are worth quoting:

- “For nearly all rare plants that occur in oak forest landscapes, the effects of fire are unknown.” (p. 143)
- “To promote landscape-scale plant diversity, it may be desirable to apply periodic fire to dry upland sites while continuing to exclude fire from mesic sites.” (p. 143)
- “Prior to burning, invasives should be treated to reduce the likelihood of post-burn establishment. The abundant establishment of invasive species after fire almost surely would have a negative impact on native herbaceous communities” (p. 144)

II. Critique of Hutchinson et al. 2005 (“Prescribed fire effects on the herbaceous layer of mixed-oak forests”, Canadian Journal of Forest Research 35: 877-890):

Timing of burns. Re “Prescribed fires were conducted from late March to mid-April each year.”(p. 879): There is a large difference in the degree of emergence of the spring flora between late March and mid-April. Some years, depending on the weather, very few plants have emerged by late March. But by mid-April, almost invariably at this point, most species have emerged and many are in flower. Spring burns in the 21st century cannot qualify as “dormant-season burns.” ***This study cannot be used to justify spring burns.***

Rare species were not considered. “To reduce noise in the species data, we deleted rare taxa (present in <3% of the 540 plot samples)” (p. 879). ***Yet the rare species are arguably the most important ones from the standpoint of preserving biodiversity. This study tells us nothing about the effect of prescribed burns on at-risk species.***

Scarcity of invasive species. “Only 15 species were nonnative, and none of these were abundant either before or after fire treatments.”(p. 880) There are no invasive species included in Appendix A (a list of the common species in the study area). The authors say “Our results indicate that repeated fires do not cause large changes in herb layer vegetation and can increase the small-scale richness of native herbaceous species *without facilitating the invasion of exotic species*” (p. 886, italics added). ***On the contrary, this study does not demonstrate anything about the effect of fire on invasive species.*** In order for exotic species to invade, there has to be a seed source. If there were few non-native species in the area before the fire treatments, the fact that they didn’t increase after the fire could simply be the result of there not being any seeds of invasive species present. No matter how ideal the conditions for the growth of a species, it won’t invade if it can’t get there. Furthermore, we are not told which, if any, of the 15 non-native species that were present are known to be invasive in Ohio; most non-native species are not invasive, and perhaps none of these 15 is. ***A study by Glasgow and Matlack showed that fire does encourage the spread of Asian stilt-grass if seeds are present.***

Cover of herb layer not measured. As noted (p. 886), only presence or absence of species was measured, not the abundance or cover of a species within a quadrat. A species could be reduced from 100 individuals to 1 individual but would simply be recorded as present in that quadrat both before and after. The authors state (p. 886): “Some species and species groups that did not show large differences in frequency or richness among treatments did exhibit substantial differences in cover.” No

further information is provided on which species showed large differences in cover or whether they increased or decreased in the burned areas.

Short duration of study. This study was done over a 5-year period. Much longer-term studies are needed to determine the true impacts on the herb layer of single and periodic burns.

No permanent quadrats. Different quadrats were sampled each year. As acknowledged (p. 886), “permanent quadrats can detect change better than random quadrats.”

Summary: This brief analysis shows how flawed and inadequate some studies are that have been used by USFS and DOF to justify their burn programs. It also shows how crude the science is that is used to support prescribed burning. This study, like others used to justify burns by USFS and DOF, can certainly not be used to justify large scale burning.

9. **Buckeye Environmental Network Prescribed Burn Position Statement**

Adopted October 2009; updated January 2019:

The Buckeye Environmental Network (BEN, formerly Buckeye Forest Council) is a membership-based organization that works to support grassroots environmental and environmental justice organizing and to protect Ohio's native forests.

Executive Summary:

BEN opposes the use of prescribed burns in Ohio’s public forests, as well as on public lands other than in special, carefully evaluated circumstances, such as maintaining prairie fragments, and then only with thorough monitoring and protection of sensitive species before burning.

- Fire is not a common natural occurrence in SE Ohio, particularly on the large scale—covering lowlands as well as ridgetops and hundreds to thousands of acres—of recent prescribed burns conducted by Ohio’s Division of Forestry and the U.S. Forest Service.
- Fire is harmful to many species, to the forest as a whole, to Ohioans’ health, and to the global environment.
- The stated rationales for the practice are either unnecessary and inappropriate (fuel reduction, biodiversity enhancement) or supported by insufficient scientific evidence and with little to no analysis of off-target species and climate, air and water impacts to justify the large-scale burns being conducted (promotion of oak regeneration).

- Conducting prescribed burns in late March or April, after the herb layer and turtles have emerged and grouse, turkeys, and songbirds are nesting, is a particular concern and must be stopped immediately.
- All prescribed burning projects on public land should be required to undergo full environmental impact analyses with full opportunity for meaningful public input per National Environmental Policy Act guidelines, which obligate the agency to make decisions based on high-quality information, including accurate scientific analyses and full examination of impacts on climate, biodiversity, and sensitive species.

Buckeye Environmental Network Prescribed Burn Position Statement:

The Buckeye Environmental Network (BEN, formerly Buckeye Forest Council) opposes the use of prescribed burns in public forests, and on public land except to maintain the small, natural prairie openings (e.g., Buffalo Beats Prairie) that occur in widely scattered localities. BEN is extremely concerned about both Ohio Division of Forestry (DOF) and Wayne NF's extensive use of this management practice at scales hundreds of times greater than any natural fire and in forest types, including mesic areas, totally un-adapted to fire. Although proponents of prescribed burns claim that there is scientific support for this practice, it remains controversial among forest ecologists, and the few published studies are insufficient to justify the widespread, frequent, and large-scale burns currently being conducted.

With insufficient and inappropriate justifications, DOF and USFS are burning vast areas of public woodland in a part of the country where fire is unnecessary, is not a common natural occurrence, and is harmful to many species, to the forest as a whole, to Ohioans' health, and to the global environment. DOF and USFS should be preserving forests as carbon sinks instead of releasing greenhouse gases that contribute to global climate change.

DOF's own documents support BEN's position. To quote from DOF's *1999-2009 Shawnee Wilderness Area Management Plan*, "Forest fires in this region of Ohio are not a naturally occurring phenomena [*sic*]. Virtually all wildfires in Ohio are man-caused, in contrast to the western United States where dry lightning is a significant cause of fire...[D]iscussion of the 'natural role of fire,' which is so important to western forest and wilderness fire plans, simply cannot be applied to a wilderness in an Appalachian hardwood forest...Fires may be a significant contributor to non-point source pollution in Ohio's hill country, as the fires remove the soil's protective cover. Large trees are at least scarred by these ground fires, and sometimes, killed."

Unlike western forests, our forests are moist: wood rots rapidly, so little accumulates as fuel. The same 1999 DOF Shawnee Wilderness Plan states, "the forest ecology is

much different in eastern Appalachian hardwoods such as Shawnee State Forest versus the western forests. In the west, fuels will indeed accumulate and frequent fire will prevent the serious damage of an occasional, large, crown fire. In Ohio, potential fuels decompose with sufficient speed to prevent dangerous fuel buildup levels...Planned prescribed burns or 'let burn fires' are not necessary for fuel reduction."

Although there may be "fuels" produced from exceptional ice storms, prescribed burning is not an appropriate way to deal with them. A fire hot enough to destroy them also severely damages living trees. A cooler burn just armors the downed wood with charcoal, sealing out moisture and rot, thereby making it more persistent and flammable fuel for subsequent fire. "Ladder fuels" likewise cannot be addressed by fire because burn intensity cannot be controlled in vertical fires and living trees get cooked in the process. According to the same 1999 DOF document quoted above, "Prescribed burns during an off season can cause as much tree mortality as fast-burning fires during peak fire season."

Fire harms our native forest species, which are not adapted to fire because they have not evolved with frequent fire. Fire encourages many invasive plant species, a growing threat to our native forests. Other documented negative effects include (but are not limited to) increased air pollution and greenhouse gas emission and consequent threats to human health and well being, reduced carbon storage, increased soil pH, increased soil temperature and decreased soil moisture, loss of nutrients, increased sediment loads in streams, increased water temperature and pH, and reduced populations of non-target species.

Burning is of special concern in areas that fail to meet clean air standards for particulate matter, which include most SE Ohio counties. Permission is no longer needed from OEPA, which is therefore derelict in not assessing impacts of these DOF and USFS forest fires on regional air quality. Ohio has a State Implementation Plan (SIP) for Particulate Matter (PM), which found that much of rural southeast Ohio exceeds "acceptable" pollution levels, while lamenting inadequate monitoring. The added pollution burden from DOF and USFS forest fires is poorly monitored and represents an unacceptable as well as unnecessary addition to regional air pollution.

Unlike historic fires of earlier centuries, which would have been small (most 3-5 acres) and confined to ridgetops, DOF and USFS conduct high-intensity burns from ridgetops to cove bottoms over many hundreds or even a thousand acres at a time.

In contrast, the average wildfire in Ohio is still only 3-5 acres³ and usually restricted to dry ridges and south or west-facing slopes. Fire is likely to have less negative impact on ridge-top and dry slope habitats, where oaks are often dominant in the canopy. In coves, bottomlands, and on north- and east-facing slopes, the moister conditions support a more diverse forest inhabited by species that rarely encounter natural fire and are not adapted to survive it.

Timing is also critical. Some DOF and USFS burns are conducted in late March or even April, when most of the forest herb layer, reptiles, and amphibians have emerged, many flowering species are in bloom, and many birds are already nesting. Forest herbs use much of the stored food in their roots and rhizomes to send up shoots in March and April. They depend on photosynthesis during the growing season to replenish their stored food. The most important part of the growing season for these species is the early spring, before the trees leaf out and reduce the sunlight reaching the herb layer. Moreover, many forest herbs (so-called “spring ephemerals” such as dutchman’s-breeches, toothwort, and mayapple) have a short growing season, the above-ground shoots dying back in May or June. If forest herbs lose their above-ground parts to fire at the peak of their growing season, they have much less stored food to re-emerge the following spring, which will weaken them, making them more vulnerable to natural stresses such as insects and disease.

March and April burns are also destructive to some birds, particularly those that nest on the ground or the shrub layer. For example, turkeys and grouse already have nests and eggs in April in southern Ohio. It can reasonably be assumed that many turkey and grouse nests are destroyed by prescribed burns. Moreover, the loss of leaf litter and deadening of the shrub layer that results from burning reduces the abundance of some neotropical migrants such as ovenbirds that nest on or near the ground, even though they begin nesting later in the spring. Reptiles, including box turtles and the endangered timber rattlesnake, are also active in April and cannot move fast enough to escape the flames. Although some snakes may escape into safe sites such as rock crevices, it is likely that many other snakes and turtles are injured or killed by the flames. One can only guess at the impact that prescribed burns have on insects, other invertebrates, fungi, and soil organisms, which play important and poorly understood roles in the ecosystem.

There is no scientific support for the kind (not confined to ridges), scale or timing of the burning being conducted by USFS and DOF. Studies cited as supposedly supporting burn programs have at least three serious deficiencies: they do not

³ Andy Ware, then of DOF, quoted in report on the Shawnee Forest fire by Cheryl Carpenter and Guy Denny, Aug. 2009; similar figures available on ODNR website and stated by Greg Smith, DOF spokesperson, cited by Cincinnati.com (4-12-17)

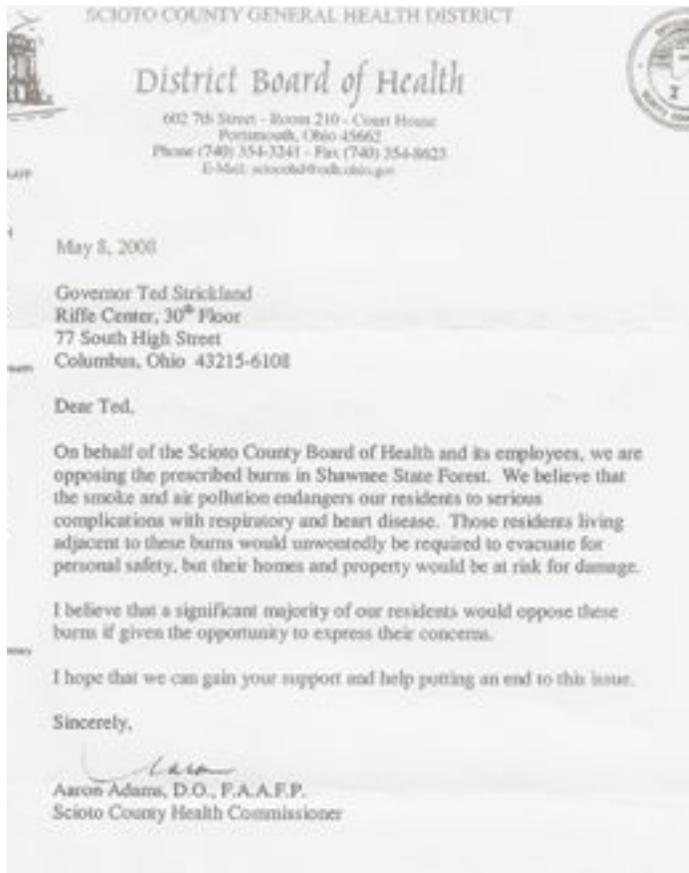
examine the long term impact on the flora and fauna, the effect on rare species is not measured or monitored, and most consider only “dormant season” burns, not those done in late March or April. DOF and USFS are, in effect, conducting a huge, uncontrolled experiment by introducing on a vast scale a destructive force that does not occur naturally, without having investigated the potential ecological impact in small, controlled experiments. And they are doing so in forests that we—Ohio’s citizens—own, and at taxpayers’ expense.

The use of prescribed fire in eastern public forests has increased in the past three decades. Agency projections indicate further increase of the practice in the next decade. This increase appears to be driven by the availability of public funds appropriated by Congress, primarily in response to widespread fires in high-risk areas of the west that resulted in major loss of property and life. Some of these funds are being used on public lands in eastern forests, even though these lands do not pose the same level of risk to rural communities. Furthermore, the best way to protect homes is to protect the structures themselves and the immediate area around them. Burning Ohio forests does not protect homes. Instead, DOF and USFS fires actually produce vast amounts of dead wood and char the exterior of both standing and felled wood with an armor that becomes impervious to rot, creating rather than eliminating wildfire risk. And multiple instances of agency-set prescribed fires getting out of bounds or firebrands starting wildfires have occurred in Ohio, including the infamous 2870-acre Shawnee State Forest fire that resulted after a DOF prescribed burn on an 86° day with low humidity and high winds (gusts to 35 mph were predicted). Attached is a letter from the Scioto County Board of Health to then-governor Ted Strickland opposing prescribed burning of Shawnee State Forest on the basis of county residents’ health. Local residents have no say in DOF or any meaningful say in USFS burns. Only immediately adjacent residents are notified of USFS burns beyond the legal notice of permits issued in one newspaper in the county.

Other stated justifications for prescribed burning in Ohio include enhancing biodiversity and promoting oak regeneration. Fire is a legitimate tool to enhance biodiversity in prairies and other ecosystems in which fire is a common natural occurrence, but this is not the case in Ohio forests. The causes of oak decline in the eastern U.S. are controversial, and fire suppression has been suggested as one contributing factor, but experimental studies conducted in Ohio have yielded no convincing evidence that prescribed burns of the sort carried out by DOF and USFS promote oak regeneration. Furthermore, the research that does suggest possible effectiveness largely neglects to look at non-target species impacts, ecosystem

impacts, and costs to climate, including site and surrounding area temperature and moisture impacts, and to soil, air and water quality.

The best way to protect the oaks in our public forests is to leave them standing rather than burning or cutting them.



Above is Scioto County District Board of Health's opposition to prescribed burns. Mr. Adams' concerns reflect ours in relation to Wayne burning our forests, especially given that notice to nearby residents is minimal and inadequate, and Ohio EPA no longer even requires permits (just notification) before burns are conducted.

I. Supporting the Forest to contribute to sustainable economies: low-impact recreation, healthy forests, clean air and water, and non-timber forest products

The Wayne must assess the economic value of intact forests as well as the costs of USFS destructive activities, including logging, burning, oil and gas leasing, whether or not the extraction is on Wayne land, to the local community as well

as the planet. A plethora of data exists on the economic value of intact forests for their ecosystem services (as opposed to extractive ecosystem goods), including air and water purification, carbon sequestration, biodiversity, and low-impact recreation and consequent increased tourism to SE Ohio. And the Wayne must assess the comparative value of mature forest in comparison to the much more commonly available early-successional and scrublands to the region and the planet.

It is the Wayne's responsibility to fully assess the value of Wayne assets when left alone and the decrease in value when disturbed by Wayne practices authorized by the 2006 Plan, including logging, burning, and management for early successional forest, as well as leasing for fracking, which was not authorized by the 2006 Plan. A few of many relevant citations follow.

1. *Return on the Investment From the Land & Water Conservation Fund.* November 2010 The Trust for Public Land. conservationtools.org/library_items/1034-Return-on-the-Investment-From-the-Land-Water-Conservation-Fund: The Trust for Public Land conducted an analysis of the return on the investment of dollars for federal land acquisition at sixteen locations that received significant Land and Water Conservation Fund (LWCF) acquisition funds between 1998 and 2009. For the 131,000 acres of land preserved, every \$1 of LWCF funds spent returns almost \$4 in economic value. Additionally, the 10.6 million annual visitors to these areas spend \$511 million in the surrounding local communities.
2. *Return on Environment: The Economic Value of Protected Open Space in Southeastern Pennsylvania.* January 2011. www.dvrpc.org/reports/11033A.pdf From the executive summary: "This study estimates the value of protected open space in southeastern Pennsylvania by measuring impacts across four areas: (1) the effects of protected open space on residential property values, (2) the value associated with environmental services provided by southeastern Pennsylvania's protected open spaces, (3) the value of recreational activity on protected open space and associated avoided health-care costs, and (4) jobs and revenue created as a result of activity on and connected to protected open space. This analysis indicates that protected open space adds significant value to the regional economy..."
3. *Economic Impacts of Protecting Rivers, Trails and Greenway Corridors.* 1995. <https://www.railstotrails.org/resourcehandler.ashx?id=4250>

4. IMPACT OF OPEN SPACE ON PROPERTY VALUES, cga.ct.gov/2006/rpt/2006-R-0344.htm. May 2006. The report cites various studies and results. One of particular relevance: “A 1993 Maryland study found preservation of a significant tract of forest land accounted for at least 10% of the value of a house within one mile of the tract in Baltimore County and at least 15% of the value of a house within one-quarter mile.”
5. The Power of Outdoor Recreation Spending in Pennsylvania: How hunting, fishing, and outdoor activities help support a healthy state economy. Nov., 2018. trcp.org/wp-content/uploads/2018/12/TRCP-and-Southwick-PA-Economic-Analysis-12-6-18.pdf
This study quantifies the 2016 economic contributions associated with fishing, hunting, and other forms of outdoor recreation within Pennsylvania by providing several key economic measures: participant expenditures, job totals, total economic output, salaries and wages, and contributions to the state’s gross domestic product (GDP).
6. The impact of wilderness and other wildlands on local economies and regional development trends. Gundars Rudzitis; Rebecca Johnson, 2000. (fs.usda.gov/treearch/pubs/21923 (and at conservationtools.org/library_items/1036-The-Impact-of-Wilderness-and-Other-Wildlands-on-Local-Economies-and-Regional-Development-Trends) The recent declines in the 1990s of timber harvests and resource extraction have been accompanied by some of the most rapid population increases in the nation. And they are expected to continue. Survey research and modeling studies show that environmental amenities in and around federal wilderness and other wildland areas attract people to live and stay in these areas. Studies also show that people move into these areas and firms and jobs then follow them. The relationship between timber harvesting and regional growth no longer holds except in a small number of places. The research indicates that we must recognize that places and their social and physical environments are critical in understanding why people and firms migrate and regions develop. The rapid growth of areas around federally designated wilderness reveals a preference for development that maintains or improves the quality of life by fitting harmoniously into the natural and social environment. It also reveals a search by people for the “good” life. The “good” life is lived in place, and what, in part, makes a place unique in the West is a lot of public open space, a clean environment, wildness and friendly neighbors.
7. Another example of benefits of clean energy compared to gas that must be considered if the Wayne is planning to consider further leasing for fracking in its new Plan: *Quantifying the health and environmental benefits of wind power to natural gas*, Donald McCubbin and B.K. Sovacool, Energy Policy 53 (2013) 429–441
dx.doi.org/10.1016/j.enpol.2012.11.004
8. *Comprehensive national database of tree effects on air quality and human health in the United States*, Satoshi Hirabayashi and D. J. Nowak, Environmental Pollution 215

(2016) 48e57 “Trees remove air pollutants through dry deposition processes depending upon forest structure, meteorology, and air quality that vary across space and time. Employing nationally available forest, weather, air pollution and human population data for 2010, computer simulations were performed for deciduous and evergreen trees with varying leaf area index for rural and urban areas in every county in the conterminous United States. The results populated a national database of annual air pollutant removal, concentration changes, and reductions in adverse health incidences and costs for NO₂, O₃, PM_{2.5} and SO₂. The developed database enabled a first order approximation of air quality and associated human health benefits provided by trees with any forest configurations anywhere in the conterminous United States over time....The new database will allow for more detailed estimates of air quality and human health benefits due to changes in LAI through time as forest structure changes. However, to better estimate the future tree effects, future scenarios of local weather, air quality, population density and urban developments should be employed.” This data must be assessed by the Wayne in considering any actions that will reduce forest cover or introduce further fragmentation or forest threats.

9. The Wayne must quantify and assess its stock of old trees to inform management decisions. It should consider the following research on the Daniel Boone NF to help determine the extent (if any) of old forest and old forest characteristics in the Wayne and the potential for aging forest to be protected to attain old growth characteristics over time. *The Development Of Old-Growth Structural Characteristics In Second-Growth Forests Of The Cumberland Plateau, Kentucky, U.S.A.*, Robert James Scheff, Jr., Master Of Science thesis, December, 2012. **Abstract:** Prior to Euro-American colonization beginning in the late 1700s and subsequent periods of land conversion and intensive resource extraction, most forest on the Cumberland Plateau in Kentucky would have existed in a state meeting one or more of the definitions of old-growth forest in use today. However, many recovering, mature forests currently exist that might be redeveloping old-growth structure and function. To assess the development of old-growth forest characteristics in second-growth forests, 70 – 90 year old (young) and 140 – 160 year old (old) hardwood forests in the Daniel Boone National Forest were examined for a suite of structural characteristics to discern patterns of structural and successional development. Old forest was distinguishable from young forest, having reached thresholds similar to old-growth for presence of large canopy trees, coarse woody debris volume and size distribution, multi-age distribution, age of oldest trees, and complex canopy structure. Both ages of forest met thresholds for total basal area and met some proposed thresholds for stem density. Neither age of forest met suggested minimum densities for old-growth for snags > 30 cm DBH, though old forest had almost three times that of young forest, and nearly approached values reported for old-growth forest. Young and old forest also exhibited different patterns in oak and maple

dynamics. Understory maples and overstory oaks recruited synchronously in young forest during the 1920s and 1930s, while recruitment of both species in old forest was temporally more broadly distributed.”

10. In determining management priorities, the presence of particular forest classes in the wider landscape must be considered and the ability of private, fragmented forest to provide each class assessed. Thus the relative abundance of early successional forest in the region and the paucity and value of interior old forest must be considered. Since it is only on protected lands that large blocks of interior forest can be ensured, the Wayne must prioritize such valuable forest over the much more common early successional forest, whether or not there is an extensive amount of it on the Wayne itself.

The World Wildlife Fund describes the value of our forests: “The Mixed Mesophytic Forest ecoregion represents one of the most biologically diverse temperate regions of the world. Forest communities often support more than 30 canopy tree species at a single site, and rich understories of ferns, fungi, perennial and annual herbaceous plants, shrubs, small trees, and diverse animal communities. Songbirds, salamanders, land snails, and beetles are examples of some particularly diverse taxa. Indeed, the ecoregion harbors some of the richest and most endemic land snail, amphibian, and herbaceous plant biotas in the U.S. and Canada. The ecoregion’s freshwater communities are the richest temperate freshwater ecosystems in the world, with globally high richness and endemism in mussels, fish, crayfish, and other invertebrates....

“Over 95 percent of this habitat, perhaps more, has been converted or degraded at some point in the last 200 years. Only a few very small and scattered fragments of undisturbed or old-growth forests still remain, most less than a few hectares in size (Davis 1993). Forests were converted for agriculture, coal mining, logging for charcoal, dams, and road building. Most of the agricultural lands have subsequently failed and are being abandoned, with an increase in the growth of secondary, or pioneer, forests. These regrowing forests lack many of the features and much of the diversity of undisturbed, or old-growth forests, namely large trees, variable age classes of trees, structural complexity such as multiple canopy layers, and diverse and abundant wildflowers, salamanders, fungi, land snails, and other invertebrate taxa. Because of the intensity and broad extent of clearing of forests over the last two centuries, many forest-specialist species appear to have been extirpated over large portions of the landscape. If source populations in undisturbed forest fragments are not imbedded in or adjacent to regrowing tracts, large areas of secondary forests may remain depauperate into the future.

“Secondary forests have the capacity to conserve a great deal of biodiversity and represent, in combination with the last fragments of undisturbed forest, the best

opportunity to conserve the region's biodiversity over the long-term. Larger, unroaded blocks of forest can also act as source pools for breeding migratory songbirds that are experiencing negative reproductive rates due to cowbird parasitism and nest predation by meso-predators in the mosaic of smaller forest fragments across the landscape. Trees within secondary forests are beginning to attain sizes that are attractive to logging interests. A landscape-scale conservation strategy for conserving large, interconnected blocks of mature forests urgently needs to be developed and implemented....

“Fragmentation is highest in the northern part of the ecoregion, primarily in southwestern Pennsylvania and Ohio. The southern section of the ecoregion is comparatively less fragmented and has better potential for restoration into larger blocks within the context of a conservation strategy.” (worldwildlife.org/ecoregions/na0402)

11. Burrascano et al., “Commonality and variability in the structural attributes of moist temperate old-growth forests: A global review,” *Forest Ecology and Management* 291: 458-479 (2013). [uvm.edu/rsenr/wkeeton/pubpdfs/Burrascano, Keeton, Sabatini, and Blasi_FEM_2013.pdf](http://uvm.edu/rsenr/wkeeton/pubpdfs/Burrascano,Keeton,Sabatini,andBlasi_FEM_2013.pdf) From the paper: “We focus on late-successional stands since most temperate forests are either managed for wood production or reflect the longterm influence of human activities. As a consequence, old-growth forest structural features are underrepresented in most contemporary landscapes (Bauhus et al., 2009; Rhemtulla et al., 2009) and biodiversity provisioning and other functions associated with them are frequently impaired (Siitonen, 2001; Hatanaka et al., 2011). Though some extended rotation systems may approximate old growth structural conditions (Keeton, 2006; Bauhus et al., 2009), most silvicultural regimes narrow the range of possible developmental processes as well as the type and spatial distribution of structures, since they do not allow the stands to develop past the maturation phase or they selectively remove certain structures, like large or dead trees (Hunter, 1999)

“... old-growth forests are known to host high plant (Aude and Lawesson, 1998; Burrascano et al., 2009), fungi (Odor et al., 2006; Persiani et al., 2010) and animal diversity (Mikusinski and Angelstam, 1998; McKenny et al., 2006; Winter and Moller, 2008). Recent studies have also shown the importance of old-growth forests in storing high quantities of carbon both as aboveground biomass (Keith et al., 2009; Keeton et al., 2010) and in soils (Zhou et al., 2006) and their ability, in some cases, to maintain positive Net Primary Productivity very late into stand development (Field and Kaduk, 2004; Luysaert et al., 2008; Xu et al., 2012). Based on the services they provide, old-growth forests represent an important reference point for evaluating human impacts on forest ecosystems, and for understanding forest development processes through observation of the temporal and spatial interactions between successional processes, disturbance events, and tree mortality (Peterken, 1996; Keeton, 2006; Rhemtulla et al., 2009; Hoover et al., 2012).

“Our review showed old-growth forests to host significantly higher amounts of biomass than mature forests, stored both in LAB (live aboveground biomass) and in CWD (coarse woody debris) pools. Furthermore, the global data showed a significant positive correlation between LAB and stand age. This is consistent with recent models describing carbon dynamics in boreal and temperate forests, supporting the hypothesis of a potential for continued carbon accumulation late into stand development (Keeton et al., 2011), both in broadleaf and conifer stands (Luyssaert et al., 2008), often mediated by variation in climate, ecoregion and forest type (Keith et al., 2009; Hudiburg et al., 2009; Stegen et al., 2011). The analysis of trends in aboveground biomass in late-successional systems is of primary importance because it correlates also with carbon allocation to belowground biomass (Cheng et al., 2007) and to total ecosystem carbon (Houghton, 2005; Hoover et al., 2012) that is often difficult to quantify. LAB is the quickest pool to recover after disturbance, and likely a full accounting of all pools, especially C stored in soil, would reveal stronger differences between old-growth and mature forests than comparing LAB alone (Zhou et al., 2006; Rhemtulla et al., 2009).

Furthermore high CWD volumes and LLT (large living trees density) densities in old growth forests, which were evident in our data, also influence the provision of habitat for late-successional biodiversity. CWD is a key ecosystem feature supporting high levels of biodiversity, for instance by providing diverse microhabitats for numerous specialized and saproxylic organisms (Grove, 2002; Odor et al., 2006; Mckenny et al., 2006). The long-term availability of deadwood may be related to the persistence of many saproxylic organisms (Lassauce et al., 2011) with low dispersal capabilities that may be driven to local or regional extinction in the absence of a temporal continuity in the deadwood substrate, due to intensive management (Siitonen, 2001). Also LLT, besides storing a large amount of carbon, provide **habitat functions for a number of threatened or ecologically important temperate forest species**, ranging from fungi to lichens, saproxylic beetles, birds and bats (Mikusinski and Angelstam, 1998; Ruffell et al., 2007; Persiani et al., 2010; Hatanaka et al., 2011). These functions relate to the great variety of microhabitats large trees offer, including rough bark, trunk hollows, exposed deadwood, sapflows, dead branches, and dead tops (Nilsson et al., 2002; Winter and Moller, 2008).

The Wayne must prioritize support for old-growth and old forests for climate, biodiversity, air and water purification, and providing the highest longterm economic benefit to the American people as required by congressional mandate. All activities proposed for the new Plan must be assessed for their long-term costs and benefits to the American people.

Non Timber Forest Products

The Wayne National Forest is home to many medicinal plants such as goldenseal and ginseng. These species have cultural and historical to people in the region. These plants are listed under Appendix II of the Convention on International Trade in Endangered Species (CITES). Medical studies are proving that their value as medicinal plants is more than anecdotal (hindawi.com/journals/bmri/2018/1843142/ and ncbi.nlm.nih.gov/pmc/articles/PMC3100400/) Additionally, wild populations are threatened as people use national and state forest as “the Commons.”

1. Non-timber forest products in Central Appalachia: market opportunities for rural development (poster abstract) Hammett, A.L.; Chamberlain, J.L.1999. Proceedings, North American Conference on Enterprise Development Through Agroforestry: Farming the Agroforest for Specialty Products <https://www.srs.fs.usda.gov/pubs/1242>
Abstract: The gathering of forest products has supplemented the incomes of Central Appalachia residents for many generations. Non-timber forest products (NTFPs) can be grouped within four general categories: edibles such as mushrooms; medicinal and dietary supplements, including ginseng, ginkgo, and St. John’s wort; floral products such as moss, grape vines, and ferns; and specialty wood products including carvings, utensils and containers. Increased NTFP harvest may have serious long-term effects on the forest ecosystem and efforts to sustainably manage the region’s forests. Less is known about managing forests for NTFPs than for timber-based products, even though they contribute significantly to local and regional economies. The region’s NTFP industry is growing rapidly, perhaps faster than the timber industry. Some estimate that NTFP markets have grown nearly 20 percent in the last few years. The size of Virginia’s NTFP industry has been estimated at \$35 million. In 1991, Virginia collected and exported nearly 6.5 tons of ginseng worth more than \$1.8 million. Despite the value of these products, little is known about the extent of harvesting or the long-term effects of this extraction. The Appalachian forests have vast diversity, much less is known about the multitude of other NTFPs found in our forests. Information is needed that draws attention to critical issues related to non-timber forest products. Through interviews, and structured and unstructured meetings with local communities, the project team has gathered data needed to better understand this burgeoning forest use and essential for developing policies to sustain forest resources. Local management practices, the value and volume of products traded, and the scope of NTFP markets have been documented. Those who gather, market, and manage NTFP resources were involved at all stages of the research. This work will show that NTFPs offer opportunities both for increased income in rural areas, and the sustainable management of forest resources.

2. Special Issue "Non-Timber Forest Products and Bioeconomy: Management, Value Chains, Challenges and Opportunities" To be published July 2019. **Abstract:** Non-Timber Forest Products (NTFPs) may be defined as any product or provisioning ecosystem service other than commercial timber that is produced in natural and human dominated landscapes including forests and other vegetation formations. They include fruits and nuts, hypogeous and epigeous fungi, medicinal and aromatic plants, fish and game, vegetables, resins and essential oils, wood for carving, construction and energy, as well as a range of barks and fibers, such as cork, bamboo and rattans, among a number of other multi-purpose trees, palms and grasses. They have traditionally played a key role in human well-being through their contribution to livelihoods, trade, traditions and culture, and they are experiencing increasing importance in the diversification of the formal and informal forest-based bioeconomy across the globe. Thus, according to the Millennium Ecosystem Assessment (2005), there are more than 150 NTFPs internationally traded, in addition to a broad diversity of products of local importance. For instance, recent estimates of the total value of NTFPs in Europe amount to 2.27 billion Euro (State of Europe's Forests 2015 Report), representing a significant proportion of the value of total roundwood removals (~10 %) that, moreover, may still be a considerable underestimation of their real value given the significant deficiencies concerning national statistics on NTFPs harvesting and trade. The production systems, management and value chains of NTFPs are framed within complex socio-ecological and socio-economic contexts at multiple scales, facing important challenges and opportunities that deserve attention to further understand the role of NTFPs in human well-being and bioeconomies, so that their full potential can be unlocked from the local to the global level in a changing world.

“This Special Issue of Forests is focused on Non-Timber Forest Products, their production systems, management, value chains and their importance for well-being and bioeconomy, as well as on the challenges and opportunities concerning the diversification of the provisioning forest ecosystem services other than commercial timber and their impact on human development and well-being. Research articles may focus on any aspect explicitly dealing with NTFPs including also land-use and policy-making studies at multiple scales where NTFPs may play a key role combined with timber and other ecosystems services. Papers addressing the impact of global change on different NTFPs and value chains and their impact on future human well-being are encouraged. Excellent and thorough review papers synthesizing the state of the art of different aspects of the management, value chains and relevance of NTFPs are also welcome.

3. Ginseng Role in the new Appalachian Economy from Appalachian Voices 2015 appvoices.org/2015/07/20/ginsengs-growing-role-in-appalachias-new-economy From the article: “Another big draw is the fact that wild ginseng, perhaps the best known of

Appalachian wild medicinal plants, fetches anywhere from \$700 to \$1,200 per dried pound. While it's possible to cultivate ginseng on a commercial scale in large fields, the resulting crop is deemed to be of lower quality than its wild-grown counterparts...[Scott] Persons has spent his career developing a technique known as "wild simulated" cultivation, where ginseng plants are deliberately planted in small patches in woodlands. This allows for resources and energy to be concentrated, streamlining the process. He's also developed techniques that can produce a product identical to that of ginseng that would pop up naturally in the wild... While Scott's presentation was exclusively on ginseng, Davis and Grimsley focused their talks on other plants, such as goldenseal, black cohosh and even some medicinal plants native to China. All three presenters stress how cultivating these plants in our woodlots and gardens can help to preserve threatened wild stock from being over harvested."

4. The ecology and biology of *Panax quinquefolium*. *American Midland Naturalists*, 129, 357-372. Anderson, R., Fralish, J. Armstrong, J. (1993).
5. An Appalachian tragedy: Air pollution and tree death in the Eastern Forests of North America. Ayers, H., et al. (Eds) (1998).
6. Social and economic impacts of wild harvested products. Doctoral Dissert., WVU 1999.
7. National Forests as the New Appalachian Commons. Bolgiano, C. Presented at the Appalachian Studies Association Meeting, (March 20, 1999).
8. Gold in the Woods. Bolgiano, C. (2000). *American Forests*, 105 (4), 7-10.
9. Market economics of ginseng. USDA Forest Service Encyclopedia of Southern Appalachian Forests Ecosystem (2005).
10. Laws and Regulations to protect endangered species. Endangered Species Act 1973. fs.fed.us/wildflowers/rareplants/conservation/lawsandregulations
11. The forest commons. Fritsch, A. *Appalachian Science in the Public Interest*. (1997).
12. Sustainable use of non-traditional forests products; Alternative forest-based income. Proceedings of the Conference on Natural Resources Income opportunities on private lands. (1998, April 5-7) 141-147.
13. Ginseng harvest ban on Daniel Boone National Forest, August 2018 Sentinel Echo, KY: "WINCHESTER-- In an effort to reestablish wild ginseng populations on national forest lands, ginseng harvest is prohibited in the Daniel Boone NF. The agency issued a ban on ginseng harvest in 2016. "After years of noticeable ginseng decline across the forest, we stopped issuing permits to collect ginseng as a way to proactively stop the decline," said

Forest Supervisor Dan Olsen. "Some recovery time is needed for ginseng to become reestablished in the forest as a healthy, self-sustaining population."

The root of ginseng plants is marketed internationally as an herbal medicine for various ailments, but Western research has provided no conclusive evidence of beneficial health claims. Much of wild ginseng's decline is attributed to illegal harvest methods. Overharvesting, out-of-season collection, the taking of mature plants without planting seed for future crops, and the taking of all or most plants from a population are some of the contributing factors.

"Forest Service biologists have observed decreasing ginseng numbers for years now," said Forest Service botanist David Taylor. "It finally reached a point that harvest needed to be managed more closely." The illegal harvest and poaching of ginseng is a problem across southern Appalachia, and in some areas, the species has completely disappeared," said Taylor. In wild ginseng's population range, Kentucky ranks at the top in ginseng harvests. Other states with high collection rates include West Virginia, Tennessee and North Carolina.

To provide for future crops, wild ginseng collectors in Kentucky are required by law to plant seeds from harvested plants within 50 feet of the harvest location. The plants collected must be at least five years old and have three or more leaves.

On national forest lands, anyone removing wild ginseng plant or its parts is considered theft. Penalties for poaching may include a fine up to \$5,000 or a 6-month sentence in federal prison, or both..." [sentinel-echo.com/news/local_news/ginseng-harvest-ban-continues-on-national-forest-lands/article_197a4bcb-24b8-529d-b5bf-b98ab3262a84.html](https://www.sentinel-echo.com/news/local_news/ginseng-harvest-ban-continues-on-national-forest-lands/article_197a4bcb-24b8-529d-b5bf-b98ab3262a84.html) (emphasis added)

While NTFP in the Wayne may be a source of income, harvesting must not degrade the Forest and must be managed and enforced adequately. We reference here the Biodiversity Working Group's discussion of the precariousness of NTP and caution needed in managing this resource sustainably.