December 24, 2018

<u>Via United Parcel Service and E-mail</u>

Wayne National Forest
Attn: Plan Revision
13700 US HWY 33
Nelsonville, OH 45764
WaynePlanRevision@fs.fed.us

Re: Wayne National Forest Assessment Phase Comments

Dear Wayne National Forest Plan Revision Team:

We are writing to submit information for the Forest Service's consideration during the assessment phase of the forest plan revision process for the Wayne National Forest. This letter specifically addresses new information supporting a ban on fracking and oil and gas leasing in the Wayne National Forest, which we urge the Forest Service to adopt in the new plan. Virtually none of this information was considered when the Forest Plan was last revised in 2006, or when the Forest Service reviewed the impacts of fracking in its 2012 Supplemental Information Report (2012 SIR). Further, the 2012 SIR—an internal review of new information that was never subject to public comment—could not have fulfilled NEPA's requirement for public participation and public disclosure. A new EIS must thoroughly evaluate the effects of climate change and fracking.

One issue that has never been considered by either the 2006 Forest Plan or 2012 SIR is the impact of fossil fuel production on climate change. A growing body of studies shows that to avoid the worst effects of climate change and stay within scientifically advised temperature limits, drastic and immediate cuts in greenhouse gas emissions are needed. Indeed, there is *no room for new fossil fuel extraction*, and even oil and gas production in currently operating fields must be phased out. Opening up new areas of the Wayne National Forest to oil and gas leasing and high-volume hydraulic fracturing or "fracking" would undermine efforts to reduce emissions to scientifically-advised limits.

In addition, the Forest Service has not previously considered numerous studies published in recent years showing that fracking is unsafe for human health. Exposure to airborne pollutants from oil and gas and/or fracking operations increases the risk of cancer, poor infant health and development, respiratory illnesses, and cardiology-related hospitalization, among other effects. These public health risks should be of top concern to the Forest Service, given the many people living on private inholdings in the Wayne, and the potential for oil and gas facilities to be sited near homes. Ohio law requires only a 100-foot setback for oil and gas operations from homes in rural areas, OAC 1501:9-9-05**,** but numerous experts have recommended far greater setbacks from homes and sensitive populations. Fracking also poses dangers to public health and safety in the form of increased groundwater and surface water contamination and seismicity risks.

One other issue that deserves a close look is the harms fracking inflicts on forest habitat and wildlife. Fracking in the Wayne National Forest will destroy and degrade an extraordinarily diverse habitat that is home to numerous rare and sensitive wildlife and plant species. The Wayne contains important Appalachian mixed mesophytic forest, one of the most biologically diverse temperate regions of the world. It contains approximately 90 species of fish, 59 amphibian and reptile species, 50 species of mammals, 158 bird species, and 2,000 species of trees and plants. Industrial operations will result in clearcutting, stream sedimentation, forest fragmentation, toxic spills and leaks, stream depletions, and noise and dust. New studies about the impacts of these activities on wildlife and plant species, and declining populations due to other human-caused threats, should compel the Forest Service to prohibit oil and gas leasing and fracking in the Wayne, and restore and preserve the forest for plant and wildlife habitat. We are especially concerned about imperiled bat species like the Indiana bat, Northern long-eared bat, tricolored bat, and little brown bat; herp species like the Eastern hellbender salamander; and rare mussel species, including the pink mucket pearly mussel, fanshell, sheepnose, and snuffbox.

A. Existing Carbon Budgets for Avoiding the Worst Effects of Climate Change Do Not Permit Any New Fossil Fuel Development, Including Fracking in the Wayne

Scientific research has established that there is no room in the global carbon budget for new fossil fuel extraction if we are to avoid the worst dangers from climate change. Instead, new fossil fuel production and infrastructure must be halted and most existing production must be phased out to meet the Paris Agreement climate targets and avoid catastrophic climate dangers. The cumulative lifecycle emissions from oil and gas leasing and fracking in the Wayne National Forest should be put in context of this reality, and global and U.S. carbon budgets to avoid catastrophic climate change effects. At a time when the U.S. must rapidly ratchet down GHG emissions to avoid the worst dangers of climate change, the Forest Service should not be committing to new fossil fuel development and infrastructure on our public lands that locks in carbon-intensive oil and gas production for years into the future.

The United States has committed to the climate change target of holding the long-term global average temperature "to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels"[1] under the Paris Agreement.[2] The United States signed the Paris Agreement on April 22, 2016 as a legally binding instrument through executive agreement,[3] and the treaty entered into force on November 4, 2016. The United States remains a party to that agreement notwithstanding President Trump's pronouncement of intent to withdraw the U.S. from the Agreement. The Paris Agreement codifies the international consensus that climate change is an "urgent threat" of global concern.[4]

[1] United Nations Framework Convention on Climate Change, Conference of the Parties, Nov. 30-Dec. 11, 2015, Adoption of the Paris Agreement Art. 2, U.N. Doc. FCCC/CP/2015/L.9 (December 12, 2015), http://unfccc.int/resource/docs/2015/cop21/eng/l09.pdf ("Paris Agreement").
[2] On December 12, 2015, 197 nation-state and supra-national organization parties meeting in Paris at the 2015 United Nations Framework Convention on Climate Change Conference of the Parties consented to the Paris Agreement committing its parties to take action so as to avoid dangerous climate change.
[3] United Nations Treaty Collection, Chapter XXVII, 7.d Paris Agreement, List of Signatories; U.S. Department of State, Background Briefing on the Paris Climate Agreement (December 12, 2015). Although not every provision in the Paris Agreement is legally binding or enforceable, the U.S. and all parties are committed to perform the treaty commitments in good faith under the international legal principle of *pacta sunt servanda* ("agreements must be kept"). Vienna Convention on the Law of Treaties, Art. 26.
[4] *See* Paris Agreement, at Annex (*"Recognizing* the need for an effective and progressive response to the urgent threat of climate change on the basis of the best available scientific knowledge").

The Agreement recognized the 1.5°C climate target because 2°C of warming is no longer considered a safe guardrail for avoiding catastrophic climate impacts and runaway climate change.[5]

Notably, a 2018 report from the Intergovernmental Panel on Climate Change (IPCC), the authoritative international scientific body for the assessment of climate change, quantified the devastating harms that would occur at 2°C warming, highlighting the necessity of limiting warming to 1.5°C to avoid catastrophic impacts to people and life on Earth.[6] According to the IPCC's analysis, the damages that would occur at 2°C warming compared with 1.5°C include more deadly heatwaves, drought and flooding; 10 centimeters of additional sea level rise within this century, exposing 10 million more people to flooding; a greater risk of triggering the collapse of the Greenland and Antarctic ice sheets with resulting multi-meter sea level rise; dramatically increased species extinction risk, including a doubling of the number of vertebrate and plant species losing more than half their range, and the virtual elimination of coral reefs; 1.5 to 2.5 million more square kilometers of thawing permafrost area with the associated release of methane, a potent greenhouse gas; a tenfold increase in the probability of ice-free Arctic summers; a higher risk of heat-related and ozone-related deaths and the increased spread of mosquito-borne diseases such as malaria and dengue fever; reduced yields and lower nutritional value of staple crops like corn, rice, and wheat; a doubling of the number of people exposed to climate-change induced increases in water stress; and up to several hundred million more people exposed to climate-related risks and susceptible to poverty by 2050.[7]

Scientific research has estimated the global carbon budget – the cumulative amount of carbon dioxide that can be emitted – for maintaining a likely chance of meeting the Paris climate target of 1.5°C or well below 2°C. According to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), total cumulative anthropogenic CO_2 emissions must remain below 400 $GtCO_2$ from 2011 onward for a 66 percent probability of limiting warming to 1.5°C, and below 1,000 $GtCO_2$ from 2011 onward for a 66 percent probability of limiting warming to 2°C above pre-industrial levels.[8] The 2018 IPCC special

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[5] Hansen, James et al., Target atmospheric CO_2: Where should humanity aim?, 2 The Open Atmospheric Science Journal 217 (2008); Anderson, Kevin & Alice Bows, Beyond 'dangerous' climate change: emission scenarios for a new world, 369 Philosophical Transactions of the Royal Society 20 (2011); Hansen, James et al., Assessing "dangerous climate change": Required reduction of carbon emissions to protect young people, future, generations and nature, 8 PLoS ONE e81648 (2013); IPCC [Intergovernmental Panel on Climate Change], Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, [Core Writing Team, R.K. Pachauri & L.A. Meyer (eds.)], IPCC, Geneva, Switzerland (2014), http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf at 72-73; U.N. Subsidiary Body for Scientific and Technological Advice, Report on the Structured Expert Dialogue on the 2013-2015 review, FCCC/SB/2015/1NF.1 (2015), http://unfccc.int/resource/docs/2015/sb/eng/inf01.pdf.; Hansen, James et al., Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observation that 2°C global warming could be dangerous, 16 Atmospheric Chemistry and Physics 3761(2016); Schleussner, Carl-Friedrich et al., Differential climate impacts for policy-relevant limits to global warming: the case of 1.5C and 2C, 7 Earth Systems Dynamics 327 (2016).

[6] IPCC [Intergovernmental Panel on Climate Change], Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (October 6, 2018), http://www.ipcc.ch/report/sr15/.

[7] *Id.* at Summary for Policymakers.

[8] IPCC [Intergovernmental Panel on Climate Change], 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis, Contribution of Working Group I to the Fifth Assessment Report of the

report on *Global Warming of 1.5°C* provided a revised carbon budget for a 66 percent probability of limiting warming to 1.5°C, estimated at 420 $GtCO_2$ and 570 $GtCO_2$ depending on the temperature dataset used, from January 2018 onwards.[9] At the current emissions rate of 42 $GtCO_2$ per year, this carbon budget would be expended in just 10 to 14 years, underscoring the urgent need for transformative global action to transition from fossil fuel use to clean energy.[10]

Importantly, a 2016 global analysis found that the carbon emissions that would be emitted from burning the oil, gas, and coal in the world's *currently operating* fields and mines would fully exhaust and exceed the carbon budgets consistent with staying below 1.5°C or 2°C.[11] Further, the reserves in currently operating oil and gas fields alone, even excluding coal mines, would lead to warming beyond 1.5°C. An important conclusion of the analysis is that *most* of the existing oil and gas fields and coal mines will need to be closed before their reserves are fully extracted in order to limit warming to 1.5 degrees.[12] Some existing fields and mines will need to be closed to limit warming to 2 degrees.[13]

In short, there is no room in the carbon budget for *new* fossil fuel extraction *anywhere*, including in the United States.[14] Additionally, most of the world's existing oil and gas fields and coal mines will need to be closed before their reserves are fully extracted to meet a 1.5°C target. The United States has an urgent responsibility to lead in this transition from fossil fuel production to 100 percent clean energy as a nation with ample technical capabilities and resources, and due to our dominant role in driving climate change and its harms. The U.S. is the world's largest historic emitter of greenhouse gas pollution, responsible for 26 percent of cumulative global CO_2 emissions since 1870, and is currently the world's second highest emitter on an annual and per capita basis.[15]

Intergovernmental Panel on Climate Change [Stocker, T.F. et al. (eds.)], Cambridge University Press (2013) at 25; IPCC [Intergovernmental Panel on Climate Change], Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)], IPCC, Geneva, Switzerland (2014) at 63-64 & Table 2.2.

[9] IPCC [Intergovernmental Panel on Climate Change], Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (October 6, 2018), http://www.ipcc.ch/report/sr15/.

[10] *Id.*

[11] Oil Change International, The Sky's Limit: Why the Paris Climate Goals Require a Managed Decline of Fossil Fuel Production (September 2016), http://priceofoil.org/2016/09/22/the-skys-limit-report/.

[12] Oil Change International, The Sky's Limit California: Why the Paris Climate Goals Demand That California Lead in a Managed Decline of Oil Extraction, May 2018, http://priceofoil.org/ca-skys-limit at 7, 13.

[13] Oil Change International, The Sky's Limit: Why the Paris Climate Goals Require a Managed Decline of Fossil Fuel Production (September 2016) at 5, 7.

[14] This conclusion was reinforced by the IPCC Fifth Assessment Report which estimated that global fossil fuel reserves exceed the remaining carbon budget (from 2011 onward) for staying below 2°C (a target incompatible with the Paris Agreement) by 4 to 7 times, while fossil fuel resources exceed the carbon budget for 2°C by 31 to 50 times. *See* Bruckner, Thomas et al., 2014: Energy Systems. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press (2014), http://ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_chapter7.pdf at Table 7.2.

[15] Global Carbon Project, Global Carbon Budget (November 13, 2017) at 10, 18, 32, http://www.globalcarbonproject.org/carbonbudget/17/presentation.htm

Research on the United States' carbon budget and the carbon emissions locked in U.S. fossil fuels similarly establishes that the U.S. must halt new fossil fuel production and rapidly phase out existing production to avoid the worst dangers of climate change. Scientific studies have estimated the U.S. carbon budget consistent with a 1.5°C target at 25 $GtCO_2eq$ to 57 $GtCO_2eq$ on average,[16] depending on the sharing principles used to apportion the global budget across countries.[17] The estimated U.S. carbon budget consistent with limiting temperature rise to 2°C – a level of warming well above what the Paris Agreement requires and which would result in devastating harms – ranges from 34 $GtCO_2$ to 123 $GtCO_2$,[18] depending on the sharing principles used. Under any scenario, the remaining U.S. carbon budget compatible with the Paris climate targets is extremely small.

An analysis of U.S. fossil fuel resources demonstrates that the potential carbon emissions from already leased fossil fuel resources on U.S. federal lands would essentially exhaust the remaining U.S. carbon budget consistent with the 1.5°C target. This analysis estimated that recoverable fossil fuels on U.S. *federal lands* would release up to 349 to 492 $GtCO_2eq$ of carbon emissions, if fully extracted and burned.[19] Of that amount, *already leased* fossil fuels would

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[16] Robiou du Pont, Yann et al., Equitable mitigation to achieve the Paris Agreement goals, 7 Nature Climate Change 38 (2017), and Supplemental Tables 1 and 2. Quantities measured in $GtCO_2eq$ include the mass emissions from CO_2 as well as the other well-mixed greenhouse gases (CO_2,methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and SF_6) converted into CO_2-equivalent values, while quantities measured in $GtCO_2$ refer to mass emissions of just CO_2 itself.

[17] Robiou du Pont et al. (2017) averaged across IPCC sharing principles to estimate the U.S. carbon budget from 2010 to 2100 for a 50 percent chance of returning global average temperature rise to 1.5°C by 2100, consistent with the Paris Agreement's "well below 2°C" target, and based on a cost-optimal model. The study estimated the U.S. carbon budget consistent with a 1.5°C target at 25 $GtCO_2eq$ by averaging across four equity principles: capability (83 $GtCO_2eq$), equal per capita (118 $GtCO_2eq$), greenhouse development rights (-69 $GtCO_2eq$), and equal cumulative per capita (-32 $GtCO_2eq$). The study estimated the U.S. budget at 57 $GtCO_2eq$ when averaging across five sharing principles, adding the constant emissions ratio (186 $GtCO_2eq$) to the four above-mentioned principles. However, the constant emissions ratio, which maintains current emissions ratios, is not considered to be an equitable sharing principle because it is a grandfathering approach that "privileges today's high-emitting countries when allocating future emission entitlements." For a discussion of sharing principles, see Kartha, S. et al., Cascading biases against poorer countries, 8 Nature Climate Change 348 (2018).

[18] Robiou du Pont et al. (2017) estimated the U.S. carbon budget for a 66 percent probability of keeping warming below 2°C at 60 $GtCO_2eq$ based on four equity principles (capability, equal per capita, greenhouse development rights, equal cumulative per capita), and at 104 $GtCO_2eq$ based on five principles (adding in constant emissions ratio, but see footnote above). For a 66 percent probability of keeping warming below 2°C, Peters et al. (2015) estimated the U.S. carbon budget at 34 $GtCO_2$ based on an "equity" approach for allocating the global carbon budget, and 123 $GtCO_2$ under an "inertia" approach. The "equity" approach bases sharing on population size and provides for equal per-capita emissions across countries, while the "inertia" approach bases sharing on countries' current emissions. Similarly using a 66 percent probability of keeping warming below 2°C, Gignac et al. (2015) estimated the U.S. carbon budget at 78 to 97 $GtCO_2$, based on a contraction and convergence framework, in which all countries adjust their emissions over time to achieve equal per-capita emissions. Although the contraction and convergence framework corrects current emissions inequities among countries over a specified time frame, it does not account for inequities stemming from historical emissions differences. When accounting for historical responsibility, Gignac et al. (2015) estimated that the United States has an additional cumulative carbon debt of 100 $GtCO_2$ as of 2013. *See* Peters, Glen P. et al., Measuring a fair and ambitious climate agreement using cumulative emissions, 10 Environmental Research Letters 105004 (2015); Gignac, Renaud and H. Damon Matthews, Allocating a 2C cumulative carbon budget to countries, 10 Environmental Research Letters 075004 (2015).

[19] Ecoshift Consulting, et al., The Potential Greenhouse Gas Emissions of U.S. Federal Fossil Fuels, Prepared for Center for Biological Diversity & Friends of the Earth (2015), http://www.ecoshiftconsulting.com/wpcontent/uploads/Potential-Greenhouse-Gas-Emissions-U-S-Federal-Fossil-Fuels.pdf.

release 30 to 43 $GtCO_2eq$ of emissions, while as yet unleased fossil fuels would emit 319 to 450 $GtCO_2eq$ of emissions. Thus, carbon emissions from *already leased* fossil fuel resources *on federal lands alone* (30 to 43 $GtCO_2eq$) would essentially exhaust the U.S. carbon budget for a 1.5°C target (25 to 57 $GtCO_2eq$), if these leased fossil fuels are fully extracted and burned. The potential carbon emissions from unleased fossil fuel resources (319 to 450 $GtCO_2eq$) would exceed the U.S. carbon budget for limiting warming to 1.5°C many times over.[20] This does not include the additional carbon emissions that will be emitted from fossil fuels extracted on non-federal lands, estimated up to 500 $GtCO_2eq$ if fully extracted and burned.[21] This research further establishes that the United States must halt new fossil fuel projects and close existing fields and mines before their reserves are fully extracted to achieve the Paris climate targets and avoid the worst damages from climate change.

Furthermore, research that models emissions pathways for limiting warming to 1.5° or 2°C shows that a rapid end to fossil fuel extraction in the United States is critical. Specifically, research indicates that g*lobal* fossil fuel CO_2 emissions must *end entirely* by mid-century and likely as early as 2045 for a reasonable likelihood of limiting warming to 1.5° or 2°C. [22] Under the U.S. carbon budget, the United States must end fossil fuel CO_2 emissions even earlier: between 2025 and 2030 on average for a reasonable chance of staying below 1.5°C, and between 2040 and 2045 on average for a reasonable chance of staying below 2°C.[23] Ending U.S. fossil fuel CO_2 emissions between 2025 and 2030, consistent with the Paris climate targets, would require an immediate halt to new production and closing most existing oil and gas fields and coal mines before their reserves are fully extracted.

Ending the approval of new fossil fuel production and infrastructure is also critical for preventing "carbon lock-in," where approvals and investments made now can lock in decades worth of fossil fuel extraction that we cannot afford. New approvals for wells, mines, and fossil fuel infrastructure -- such as pipelines, marine and rail import and export terminals -- require upfront investments that provide financial incentives for companies to continue production for decades into the future.[24] Given the long-lived nature of fossil fuel projects, ending the approval

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[20] Ecoshift Consulting, et al., The Potential Greenhouse Gas Emissions of U.S. Federal Fossil Fuels, Prepared for Center for Biological Diversity & Friends of the Earth (2015), 4.

[21] Ecoshift Consulting, et al., The Potential Greenhouse Gas Emissions of U.S. Federal Fossil Fuels, Prepared for Center for Biological Diversity & Friends of the Earth (2015), at 3 ("the potential GHG emissions of federal fossil fuels (leased and unleased) are 349 to 492 Gt CO2e, representing 46% to 50% of potential emissions from all remaining U.S. fossil fuels").

[22] Rogelj, Joeri et al., Energy system transformations for limiting end-of-century warming to below 1.5°C, 5 Nature Climate Change 519 (2015); IPCC [Intergovernmental Panel on Climate Change], Global Warming of 1.5°C, an IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (October 6, 2018), http://www.ipcc.ch/report/sr15/.

[23] *See* Climate Action Tracker, USA (last updated 30 April 2018), http://climateactiontracker.org/countries/usa at Country Summary figure showing U.S. emissions versus year.

[24] Davis, Steven J. and Robert H. Socolow, Commitment accounting of CO2 emissions, Environmental Research Letters 9: 084018 (2014); Erickson, Peter et al., Assessing carbon lock-in, 10 Environmental Research Letters 084023 (2015); Erickson, Peter et al., Carbon lock-in from fossil fuel supply infrastructure, Stockholm Environment Institute, Discussion Brief (2015); Seto, Karen C. et al., Carbon Lock-In: Types, Causes, and Policy Implications, 41 Annual Review of Environmental Resources 425 (2016); Green, Fergus and Richard Denniss, Cutting with both arms of the scissors: the economic and political case for restrictive supply-side climate policies, Climatic Change https://doi.org/10.1007/s10584-018-2162-x (2018).

of new fossil fuel projects avoids the lock-in of decades of fossil fuel production and associated emissions.[25]

In sum, the long-lived GHG emissions and fossil fuel infrastructure that would result from oil and gas leasing and fracking in the Wayne National Forest will contribute to undermining climate commitments under the Paris Agreement and increasing climate change impacts, at a time when there is urgent need to keep most fossil fuels in the ground. The Forest Service should adopt a ban on fracking in the Wayne National Forest, and close all unleased acreage to oil and gas development.

B. The Forest Service Must Consider Air Quality Impacts and Associated Public Health Impacts that Will Result From Oil and Gas Leasing and Fracking

The 2006 Forest Plan lacks any quantitative or meaningful qualitative analysis of the air quality impacts from management or extractive activities in the Wayne National Forest, let alone from the impacts of fracking. The 2012 SIR also failed to conduct such an analysis. For the plan revision, the Forest Service should consider information regarding the types of air pollutants emitted during oil and gas operations, their specific sources, and their health effects, all described in extensive detail below. It should use this information to inventory and quantify all pollution emissions from oil and gas operations in the Wayne National Forest, and analyze their cumulative impacts on air quality and human health, in connection with all other air pollution sources in and around the Wayne.

The Forest Service should also survey and perform a qualitative analysis of the numerous studies addressing the public health impacts of fracking. A number of literature reviews are available which document both significant knowledge gaps and risks to public health, including:

(1) Concerned Health Professionals of New York, Physicians for Social Responsibility, Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking (Unconventional Gas and Oil Extraction), Fifth Ed. (March 2018)[26]
(2) Hays, Jake and Seth B. C. Shonkoff, Toward an Understanding of the Environmental and Public Health Impacts of Unconventional Natural Gas Development: A Categorical Assessment of the Peer-Reviewed Scientific Literature, 2009-2015, PLoS ONE 11(4): e0154164. e0154164. doi:10.1371/journal.pone.0154164 (2016)[27]

A searchable and exhaustive citation database of peer-reviewed journal articles pertaining to shale gas and oil extraction, including air quality and health impacts, is housed on the PSE

[25] Erickson et al. (2015): "The essence of carbon lock-in is that, once certain carbon-intensive investments are made, and development pathways are chosen, fossil fuel dependence and associated carbon emissions can become 'locked in', making it more difficult to move to lower-carbon pathways and thus reduce climate risks." Green and Denniss (2018): "When production processes require a large, upfront investment in fixed costs, such as the construction of a port, pipeline or coalmine, future production will take place even when the market price of the resultant product is lower than the long-run opportunity cost of production. This is because rational producers will ignore 'sunk costs' and continue to produce as long as the market price is sufficient to cover the marginal cost (but not the average cost) of production. This is known as 'lock-in.'"
[26] Available at https://www.psr.org/wp-content/uploads/2018/04/Fracking_Science_Compendium_5.pdf.
[27] Available at http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0154164.

Healthy Energy website at https://www.psehealthyenergy.org/our-work/shale-gas-research-library/.

The Forest Service should consider these literature reviews along with the studies described in sections (iii) and (iv) below to evaluate the human health risks of fracking to communities in and around the Wayne and to workers involved in fracking operations.

1. Types of Air Emissions

Numerous impacts of fracking and other oil and gas extraction techniques are directly associated with the hundreds chemical additives employed and the resultant air pollution. These chemicals fall into a number of categories: *breakers* to lower fracking fluid viscosity before fracking fluid flows back, proppants to keep newly-formed fractures open, *gelling agents* to pry open fractures, *biocides* to prevent bacteria from degrading gelling agents, *carriers* for aiding in transport of other fluids, and *crosslinkers* to increase viscosity of fluids to increase fracking effectiveness.[28]

Many chemicals amongst these categories are designated as Hazardous Air Pollutants (HAPs), which can enter the air during the venting of gases during fracking or the evaporation of chemicals from fracking and produced fluids, leading to dangerous human exposures.[29] For instance, ethylbenzene, formaldehyde, and methylene chloride are all known or suspected carcinogens, while methanol is linked to reproductive harm, and hydrochloric acid and hydrofluoric acid can cause both eye irritation and respiratory harm.[30] Therefore, being in close proximity to fracking operations can lead to serious health effects. Some of the same chemicals are used in both fracking and conventional oil and gas operations, so some risks posed by fracking are also found with conventional methods.[31]

There are also emissions from other aspects of the oil and gas extraction process, including the emission of natural gas itself, in forms such as methane (predominantly) and ethane. For instance, hydrogen sulfide is contained in natural gas, with long-term exposure to hydrogen sulfide linked to respiratory infections, eye, nose, and throat irritation, breathlessness, nausea, dizziness, confusion, and headaches.[32] Also, the diesel equipment used to pump the fracking fluids into the well produces nitrogen oxide ("NOx") and particulate matter ("PM") emissions. Additionally, some volatile organic compounds ("VOCs"), such as the BTEX compounds (benzene, toluene, ethylbenzene, and xylene), when exposed to light can transform

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[28] Stringfellow, William et al., Identifying chemicals of concern in hydraulic fracturing fluids used for oil production, 220 Environmental Pollution 413 (2017).
[29] Sierra Club et al. comments on New Source Performance Standards: Oil and Natural Gas Sector; Review and Proposed Rule for Subpart OOOO (Nov. 30, 2011) ("Sierra Club Comments") at 13.
[30] Agency for Toxic Substances and Disease Registry (ATSDR), ATSDR A-Z Index, https://www.atsdr.cdc.gov/az/a.html (last visited on July 12, 2018) ("ASTDR A-Z Index"); Californians Against Fracking, Fracking and Dangerous Drilling in California, Briefing Book, Center for Biological Diversity (Accessed July 13, 2018), https://www.biologicaldiversity.org/campaigns/california_fracking/pdfs/fracking-and-drilling-in-california.pdf.
[31] Stringfellow, William et al., Comparison of chemical use between hydraulic fracturing, acidizing, and routine oil and gas development, 12 PLoS One 4 (2017).
[32] U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Report to Congress on Hydrogen Sulfide Air Emissions Associated with the Extraction of Oil and Natural Gas (EPA-453/R-93-045) at i (Oct. 1993) ("USEPA 1993").

into PM. When gases are flared instead of vented, the combustion during flaring may cause emissions of PM and NOx.[33] NOx and PM are both criteria pollutants which must be regulated under the National Ambient Air Quality Standards (NAAQS) due to their potential to cause primary and secondary health effects. They both contribute to the formation of ozone, another criteria pollutant.[34] Concentrations of these criteria pollutants along with two others, carbon monoxide and sulfur dioxide, have been shown to increase in regions where unconventional oil and gas recovery techniques are permitted. Indeed, persistent violations of the newly promulgated 2015 ozone NAAQS within the portions of the Uintah Basin resulted in a non-attainment designation for the area under the Clean Air Act. Criteria pollutants are associated with an array of health impacts:[35]

> *Nitrogen oxides* (NOx) react with ammonia, moisture, and other compounds to form small particles. These small particles penetrate deeply into sensitive parts of the lungs and can cause or worsen respiratory diseases, such as emphysema and bronchitis, and can aggravate existing heart disease, leading to increased hospital admissions and premature death. NO_x and volatile organic compounds react in the presence of heat and sunlight to form ozone.
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> *Particulate matter* (PM) - especially fine particles - contains microscopic solids or liquid droplets that are so small that they can get deep into the lungs and cause serious health problems. Numerous scientific studies have linked particle pollution exposure to a variety of problems, including: premature death in people with heart or lung disease, increased mortality, nonfatal heart attacks, irregular heartbeat, aggravated asthma, decreased lung function, and increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.[36]
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> *Sulfur Dioxide* (SO_2) – has been shown to cause an array of adverse respiratory effects including bronchoconstriction and increased asthma symptoms.[37] Studies also show a connection between short-term exposure and increased visits to emergency departments and hospital admissions for respiratory illnesses, particularly in at-risk populations including children, the elderly, and asthmatics.[38]

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[33] California Council on Science and Technology, Advanced Well Stimulation Technologies in California (2016) ("CCST 2016"), http://ccst.us/publications/2014/160708-blm-report.pdf, at 248; McKenzie, Lisa M. et al., Human Health Risk Assessment of Air Emissions From Development of Unconventional Natural Gas Resources, 424 Science of the Total Environment 79 (2012) ("McKenzie 2012); Shonkoff, Seth B.C. et al., Environmental Public Health Dimensions of Shale and Tight Gas Development, 122 Environmental Health Perspectives 787 (2014) ("Shonkoff 2014").

[34] United States Environmental Protection Agency (U.S. EPA), Criteria Air Pollutants, https://www.epa.gov/criteria-air-pollutants (last visited on July 10, 2018.)

[35] United States Environmental Protection Agency (U.S. EPA), Criteria Air Pollutants, https://www.epa.gov/criteria-air-pollutants (last visited on July 10, 2018.)

[36] U.S. Environmental Protection Agency, Particulate Matter, (PM) https://www.epa.gov/pm-pollution/health-and-environmental-effects-particulate-matter-pm (Accessed July 13, 2018); Ostro, Bart et al., Long-term Exposure to Constituents of Fine Particulate Air Pollution and Mortality: Results from the California Teachers Study, 118 Environmental Health Perspectives 3 (2010)

[37] U.S. Environmental Protection Agency, Sulfur Dioxide https://www.epa.gov/so2-pollution/sulfur-dioxide-basics#effects, available at (accessed July 13, 2018).

[38] *Id.*

Carbon Monoxide (CO) can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. At extremely high levels, CO can cause death.[39] Exposure to CO can reduce the oxygen-carrying capacity of the blood. People with several types of heart disease already have a reduced capacity for pumping oxygenated blood to the heart, which can cause them to experience myocardial ischemia (reduced oxygen to the heart), often accompanied by chest pain (angina), when exercising or under increased stress.[40] For these people, short-term CO exposure further affects their body's already compromised ability to respond to the increased oxygen demands of exercise or exertion.[41]

Ozone (O_3) can trigger or worsen asthma and other respiratory ailments.[42] It has been linked to pneumonia, COPD, asthma, bronchitis, emphysema, and premature death. Ground level ozone can have harmful effects on sensitive vegetation and ecosystems. Ozone may also lead to loss of species diversity and changes to habitat quality, water cycles, and nutrient cycles.

Likewise, the BTEX compounds, which contribute to the formation of criteria pollutants, pose great potential harms. Benzene, for instance, is a known human carcinogen that has been linked to blood disorders such as leukemia, immune system damage and chromosomal mutations. The other BTEX compounds (toluene, ethylbenzene, xylene) have varying effects, including damage to the brain and nervous system, kidneys, and liver, with symptoms of exposure including fatigue, drowsiness, headaches, dizziness, confusion, eye and respiratory tract irritation, and loss of muscle coordination.[43]

Due to such chemical prevalence, research continues to mount on the health risks of fracking, well stimulation, and other oil and gas activities.[44] Research has found that people living near drilling sites have a higher risk for developing cancer,[45] increased asthma attacks,[46] higher hospitalization rates, and more upper respiratory problems and rashes.[47] For pregnant

[39] U.S. Environmental Protection Agency, Carbon Monoxide, available at https://www.epa.gov/co-pollution/basic-information-about-carbon-monoxide-co-outdoor-air-pollution#Effects (accessed July 13, 2018).
[40] *Id.*
[41] *Id.*
[42] U.S. Environmental Protection Agency, Health Effects of Ozone Pollution, available at https://www.epa.gov/ozone-pollution/health-effects-ozone-pollution (accessed July 10, 2018).
[43] Suh, H. H., Bahadori, T., Vallarino, J., & Spengler, J. D. (2000). Criteria air pollutants and toxic air pollutants. *Environmental Health Perspectives*, *108*(Suppl 4), 625;
Agency for Toxic Substances and Disease Registry (2015, November 4). *ATSDR A-Z Index.* Retrieved from https://www.atsdr.cdc.gov/az/a.html ;
Jia, C., & Batterman, S. (2010). A critical review of naphthalene sources and exposures relevant to indoor and outdoor air. *International Journal of Environmental Research and Public Health*, *7*(7), 2903-2939.

[44] PSE Healthy Energy, The Science on Shale Gas Development, https://www.psehealthyenergy.org/our-work/publications/archive/the-science-on-shale-gas-development/ (last visited on July 10, 2018).
[45] McKenzie, L.M. et al., Childhood hematologic cancer and residential proximity to oil and gas development, 12 PLoS One 2 (2017).
[46] Rasmussen, Sara G. et al., Association Between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations, 176 JAMA Internal Medicine 9 (2016).
[47] Rabinowitz, Peter M. et al., Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania, 123 Environmental Health Perspectives 21 (2015).

women, living closer to drilling sites is associated with a higher risk of having babies with birth defects, high-risk pregnancies and premature births, and low-birthweight babies.[48]

2. Sources of Air Emissions

Harmful air pollutants are emitted during every stage of unconventional oil and gas development, including drilling, completion, well stimulation, production, and disposal, as well as from transportation of water, sand, and chemicals to and from the well pad.[49] The well stimulation stage can emit diesel exhaust, VOCs, particulate matter, ozone precursors, silica, and acid mists.[50]

VOCs, NOx, methane, and ethane are potent ground-level (tropospheric) ozone precursors that are emitted by oil and gas drilling and fracking operations.[51] VOCs can form ground-level (tropospheric) ozone when combined with nitrogen oxides (“NO_X”) from compressor engines, turbines, other engines used in drilling, and flaring,[52] in the presence of sunlight. This reaction can diminish visibility and air quality and harm vegetation. Many regions around the country with substantial oil and gas operations are now suffering from extreme ozone levels due to heavy emissions of these pollutants.[53] A recent study of ozone pollution in the Uintah Basin of northeastern Utah, a rural area that experiences hazardous tropospheric ozone concentrations, found that oil and gas operations were responsible for 98 to 99 percent of VOCs and 57 to 61 percent of NO_X emitted from sources within the Basin considered in the study’s inventory.[54]

Drilling and casing the wellbore require substantial power from large equipment. The engines used typically run on diesel fuel, which emits particularly harmful types of air pollutants when burned. Similarly, high-powered pump engines are used in the fracturing and completion phase. This too can amount in large volumes of air pollution. In total, VOCs emitted by car and truck engines, as well as the drilling and completion stages of oil and gas production, make up

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[48] Stacy, Shaina L. et al., Perinatal Outcomes and Unconventional Natural Gas Operations in Southwest Pennsylvania, 10 PLoS One 6 (2015).
[49] McCawley, Michael, Air Contaminants Associated with Potential Respiratory Effects from Unconventional Resource Development Activities, 36 Seminars in Respiratory and Critical Care Medicine 379 (2015); Shonkoff 2014.
[50] *Id.*
[51] U.S. Environmental Protection Agency, Integrated Science Assessment (ISA) for Ozone (O3) and Related Photochemical Oxidants (2013).
[52] *See, e.g.*, U.S. Environmental Protection Agency, Oil and Gas Sector: Standards of Performance for Crude Oil and Natural Gas Production, Transmission, and Distribution: Background Technical Support Document for Proposed Standards at 3-6 (July 2011); Armendariz, Al, Emissions for Natural Gas Production in the Barnett Shale Area and Opportunities for Cost-Effective Improvements (2009) (“Armendariz 2009”) at 24.
[53] Armendariz 2009 at 1, 3, 25-26; Koch, Wendy, *Wyoming's Smog Exceeds Los Angeles' Due to Gas Drilling*, USA Today (May 9, 2011); Craft, Elena, Environmental Defense Fund, Do Shale Gas Activities Play a Role in Rising Ozone Levels? (2012); Colorado Dept. of Public Health and Environment, Conservation Commission, Colorado Weekly and Monthly Oil and Gas Statistics (July 6, 2012) at 12.
[54] Lyman, Seth & Howard Shorthill, Final Report: 2012 Uintah Basin Winter Ozone & Air Quality Study, Utah Department of Environmental Quality (2013) (“Lyman 2013).

about 3.5 percent of the gases emitted by oil or gas operations.[55] Vehicles and equipment are also responsible for generating harmful particulate matter.[56]

Flaring and venting of gas are also potential sources of air emissions. Gas flaring and venting can occur in both oil and gas recovery processes when underground gas rises to the surface and is not captured as part of production. Emissions from flaring typically include carbon monoxide, nitrogen oxides, benzene, formaldehyde and xylene, but levels of these smog-forming compounds are seldom measured directly.[57]

Fugitive emissions can occur at every stage of extraction and production, often leading to high volumes of gas being released into the air. Methane emissions from oil and gas production are as much as 270 percent greater than previously estimated by calculation.[58] Studies show that fugitive emissions from pneumatic valves (which control routine operations at the well pad by venting methane during normal operation) and equipment leaks are higher than EPA estimates.[59] This is of great concern because ground-level ozone can be formed by methane in substantial quantities as it interacts with nitrogen oxides and sunlight.[60] One paper modeled reductions in various anthropogenic ozone precursor emissions and found that "[r]educing anthropogenic CH_4 emissions by 50% nearly halves the incidence of U.S. high-O_3 events . . . ."[61]

Ethane, also a greenhouse gas, breaks down and reacts with sunlight to create smog. Ethane emissions have risen steeply in recent years due to U.S. oil and gas production. A recent study documented that ethane emissions in the Northern Hemisphere increased by about 400,000 tons annually between 2009 and 2014, with the majority coming from North American oil and gas activity, reversing a decades-long decline in ethane emissions.[62] About 60 percent of the drop in ethane levels that occurred over the past 40 years has already been made up in the past five years. At this rate, U.S. ethane levels are expected to hit 1970s levels in about three years. About two percent of global ethane emissions originate from the Bakken Shale oil and gas field alone, which emits 250,000 tons of ethane per year.[63] Because global ethane levels were decreasing

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[55] Brown, Heather, Memorandum to Bruce Moore, U.S.EPA/OAQPS/SPPD re Composition of Natural Gas for use in the Oil and Natural Gas Sector Rulemaking, July 28, 2011 ("Brown Memo") at 3.
[56] Earthworks, Sources of Oil and Gas Pollution (2011); Bay Area Air Quality Management District, Particulate Matter Overview, Particulate Matter and Human Health (2012).
[57] Physicians for Social Responsibility and Concerned Health Professionals of NY, Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking, Fourth Edition, November 17, 2016 ("PSR 2016").
[58] Miller 2013.
[59] Allen, David et al., Measurements of Methane Emissions at Natural Gas Production Sites in The United States, 110 PNAS 17768 (2013) ("Allen 2013"); Harriss, Robert et al., Using Multi-Scale Measurements to Improve Methane Emission Estimates from Oil and Gas Operations in the Barnett Shale Region, Texas, 49 Environ. Sci. Technol. 7524 (2015).
[60] Fiore, Arlene et al., Linking Ozone Pollution and Climate Change: The Case for Controlling Methane, 29 Geophys. Res Letters 19 (2002) ("Fiore 2002"); U.S. Environmental Protection Agency, Oil and Gas Sector: New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants Reviews Proposed Rule, 76 Fed. Reg 52,738 (Aug 23, 2011).
[61] Fiore 2002; *see also* Martin, Randal et al., Final Report: Uinta Basin Winter Ozone and Air Quality Study Dec 2010 - March 2011 (2011) at 7.
[62] Helmig, Detlev et al., Reversal of Global Atmospheric Ethane and Propane Trends Largely Due to US Oil and Natural Gas Production, 9 Nature Geoscience 490 (2016).
[63] Kort, Eric A. et al., Fugitive Emissions From the Bakken Shale Illustrate Role of Shale Production in Global Ethane Shift. 43 Geophysical Research Letters 4617 (2016).

until 2009, the U.S. shale gas boom is thought to be responsible for the global increase in levels since 2010.

Fracking can pollute air hundreds of miles from the well pad. For example, ethane pollution in Baltimore, Maryland and Washington, D.C, has been attributed to the rapidly increasing natural gas production in the upwind, neighboring states of Pennsylvania and West Virginia.[64]

Evaporation from pits can also contribute to air pollution. Pits that store drilling waste, produced water, and other waste fluid may be exposed to the open air. Chemicals mixed with the wastewater—including the additives used to make fracking fluids, as well as volatile hydrocarbons, such as benzene and toluene, brought to the surface with the waste—can escape into the air through evaporation. Some pits are equipped with pumps that spray effluents into the air to hasten the evaporation process. For example, evaporation from fracking waste pits in western Colorado was found to have added tons of toxic chemicals to the air, increasing air pollution in Utah.[65] In Texas, toxic air emissions from fracking waste pits are unmonitored and unregulated.[66] In California, unlined disposal pits for drilling and fracking waste are documented sources of contamination.[67] Even where waste fluid is stored in so-called "closed loop" storage tanks, fugitive emissions can escape from tanks.

Truck traffic related to oil and gas extraction contributes to air emissions. Trucks capable of transporting large volumes of chemicals and waste fluid typically use large engines that run on diesel fuel, also increasing threats of NO_x and PM emissions.

3. Health Impacts of Increased Air Pollution

The potential harms resulting from increased exposure to the dangerous air pollutants from unconventional oil and gas development are serious and wide-ranging. A growing body of scientific research has documented adverse public health impacts from unconventional oil and gas development, including studies showing air pollutants at levels associated with reproductive and developmental harms and the increased risk of morbidity and mortality.[68] A comprehensive review of the risks and harms of fracking to public health came to several key findings related to

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[64] Vinciguerra,Timothy et al, Regional Air Quality Impacts of Hydraulic Fracturing and Shale Natural Gas Activities: Evidence From Ambient VOC Observations. 110 Atmospheric Environment 144 (2015).

[65] Maffly, Brian , *Utah grapples with toxic water from oil and gas industry*, The Salt Lake Tribune, August 28, 2014, available at http://archive.sltrib.com/story.php?ref=/sltrib/news/58298470-78/danish-flats-ponds-company.html.csp; The company responsible for the waste pits was found to have operated without a permit, underreported emissions and provided erroneous data to regulators.

[66] Center for Public Integrity. *Open Pits Offer Cheap Disposal for Fracking Sludge But Health Worries Mount,* October 2, 2014.

[67] Stringfellow, William T. et al., Impacts of Well Stimulation on Water Resources, In California Council on Science and Technology, *An Independent Assessment of Well Stimulation in California,* Volume 2, Chapter 2 (2015) ("CCST 2015") at 110-113.

[68] Hays, Jake & Seth B.C. Shonkoff , Towards an Understanding of the Environmental and Public Health Impacts of Unconventional Natural Gas Development: A Categorical Assessment of the Peer-Reviewed Scientific Literature, 11 PLoS ONE e0154164 (2016); Shonkoff 2014; Webb, Ellen et al., Developmental and reproductive effects of chemicals associated with unconventional oil and natural gas operations, 29 Rev Environ Health 307 (2014); McKenzie 2012; Clean Air Task Force, Fossil Fumes: A Public Health Analysis of Toxic Air Pollution From the Oil and Gas Industry, June 2016, available at http://www.catf.us/resources/publications/files/FossilFumes.pdf.

air pollution: (1) "drilling and fracking emissions contribute to toxic air pollution and smog (ground-level ozone) at levels known to have health impacts," (2)"public health problems associated with drilling and fracking, including reproductive impacts and occupational health and safety problems, are increasingly well documented"; and (3)"fracking infrastructure poses serious potential exposure risks to those living near it." [69]

The range of illnesses that can result from the wide array of air pollutants from fracking were summarized in a study by Dr. Theo Colburn, which charts which chemicals have been shown to be linked to certain illnesses.[70] This study analyzed air samples taken during drilling operations near natural gas wells and residential areas in Garfield County, Colorado and detected 57 chemicals between July 2010 and October 2011, including 44 with reported health effects.[71] For example:

> Thirty-five chemicals were found to affect the brain/nervous system, 33 the liver/metabolism, and 30 the endocrine system, which includes reproductive and developmental effects. The categories with the next highest numbers of effects were the immune system (28), cardiovascular/blood (27), and the sensory and respiratory systems (25 each). Eight chemicals had health effects in all 12 categories. There were also several chemicals for which no health effect data could be found.[72]

The study found extremely high levels of methylene chloride, which may be used as cleaning solvents to remove waxy paraffin that is commonly deposited by raw natural gas in the region. These deposits solidify at ambient temperatures and build up on equipment.[73] While none of the detected chemicals exceeded governmental safety thresholds of exposure, the study noted that such thresholds are typically based on "exposure of a grown man encountering relatively high concentrations of a chemical over a brief time period, for example, during occupational exposure."[74] Consequently, such thresholds may not apply to individuals experiencing "chronic, sporadic, low-level exposure," including sensitive populations such as children, the elderly, and pregnant women.[75] For example, the study detected polycyclic aromatic hydrocarbon (PAH) levels that could be of "clinical significance," as recent studies have linked low levels of exposure to lower mental development in children who were prenatally exposed.[76] In addition, government safety standards do not take into account "the kinds of effects found from low-level exposure to endocrine-disrupting chemicals…, which can be particularly harmful during prenatal development and childhood.[77]

Adverse health impacts documented among residents living near drilling and fracking operations include reproductive harms, increased asthma attacks, increased rates of

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[69] Physicians for Social Responsibility and Concerned Health Professionals of NY, Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking, Fourth Edition, November 17, 2016 ("PSR 2016").
[70] Colborn 2011; Colborn 2012;*see* note 120 & accompanying text below.
[71] Colborn 2012 at pp. 21-22 (pages refer to page numbers in attached manuscript and not journal pages).
[72] Colborn 2012 at 11.
[73] *Id*. at 10.
[74] *Id*. at 11-12.
[75] *Id*. at. 12.
[76] *Id*. at 10-11.
[77] *Id*. at 12.

hospitalization, ambulance runs, emergency room visits, self-reported respiratory problems and rashes, motor vehicle fatalities, trauma, and drug abuse. A 2016 review concluded:

> By several measures, evidence for fracking-related health problems is emerging across the United States. In Pennsylvania, as the number of gas wells increase in a community, so do rates of hospitalization. Drilling and fracking operations are correlated with elevated motor vehicle fatalities (Texas), asthma (Pennsylvania), self-reported skin and respiratory problems (southwestern Pennsylvania), ambulance runs and emergency room visits (North Dakota), infant deaths (Utah), birth defects (Colorado), high risk pregnancies (Pennsylvania), premature birth (Pennsylvania), and low birthweight (multiple states). Benzene levels in ambient air surrounding drilling and fracking operations are sufficient to elevate risks for future cancers in both workers and nearby residents, according to studies. Animal studies show that two dozen chemicals commonly used in fracking operations are endocrine disruptors that can variously disrupt organ systems, lower sperm counts, and cause reproductive harm at levels to which people can be realistically exposed.[78]

A rigorous study by Johns Hopkins University, which examined 35,000 medical records of people with asthma in Pennsylvania, found that people who live near a higher number of, or larger, active gas wells were 1.5 to 4 times more likely to suffer from asthma attacks than those living farther away, with the closest groups having the highest risk.[79] Relatedly, in a 2018 study of pediatric asthma-related hospitalizations, it was found that children and adolescents exposed to newly spudded unconventional natural gas development wells within their zip code had 1.25 times the odds of experiencing an asthma-related hospitalization compared to children who did not live in these communities. Furthermore, children and adolescents living in a zip code with any current or previous drilling activity had 1.19 times the odds of experiencing an asthma-related hospitalization compared to children who did not live in these communities. Amongst children and adolescents (ages 2-18), children between 2 and 6 years of age had the greatest odds of hospitalization in both scenarios.[80]

A recent Yale University study identified numerous fracking chemicals that are known, probable, or possible human carcinogens (20 air pollutants) and/or are linked to increased risk for leukemia and lymphoma (11 air pollutants), including benzene, 1,3-butadiene, cadmium, diesel exhaust, and polycyclic aromatic hydrocarbons.[81]

In a 2018 study by McKenzie et al. conducted in the Denver Julesberg Basin on the Colorado Northern Front Range (CNFR), it was found that the currently established setback

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[78] PSR 2016 at 93.

[79] Rasmussen, Sara G. et al., Association Between Unconventional Natural Gas Development in the Marcellus Shale and Asthma Exacerbations, 176 JAMA Internal Medicine 1334 (2016).

[80] Willis, Mary D. et al., Unconventional natural gas development and pediatric asthma hospitalizations in Pennsylvania, 166 Environmental Research 402 (2018).

[81] Elliot, Elise G. et al., A Systematic Evaluation of Chemicals in Hydraulic-Fracturing Fluids and Wastewater for Reproductive and Developmental Toxicity, 27 Journal of Exposure Science and Environmental Epidemiology 90 (2016).

distance of 152 m (500 ft) does little to protect people in that proximity. In analyses of nonmethane concentrations from 152 to >1600 m from oil and gas facilities, it was found that the EPA's minimum cumulative lifetime excess cancer risk benchmark of 1 in a million was exceeded. Cumulative lifetime excess cancer risk increased with decreasing distance from the nearest oil and gas facility. Residents living within 610 m of and oil and gas facility had an overall cancer risk in excess of the EPA's upper bound for remedial action of 1 in 10,000. Furthermore, residents within 152 m of an oil and gas facility had an overall excess cancer risk of 8.3 in 10,000, along with an increased likelihood of neurological, hematological, and developmental health effects. Over 95% of the total risk was due to benzene, with additional risk due to the presence of toluene, ethylbenzene, xylene, and alkanes.[82]

Numerous studies also suggest that higher maternal exposure to fracking and drilling can increase the incidence of high-risk pregnancies, premature births, low-birthweight babies, and birth defects. A study of more than 1.1 million births in Pennsylvania found evidence of a greater incidence of low-birth-weight babies and significant declines in average birth weight among pregnant women living within 3 km of fracking sites.[83] The study estimated that about 29,000 U.S. births each year occur within 1 km of an active fracking sties and "that these births therefore may be at higher risk of poor birth outcomes." A study of 9,384 pregnant women in Pennsylvania found that women who live near active drilling and fracking sites had a 40 percent increased risk for having premature birth and a 30 percent increased risk for having high-risk pregnancies.[84] Another Pennsylvania study found that pregnant women who had greater exposure to gas wells -- measured in terms of proximity and density of wells -- had a much higher risk of having low-birthweight babies; the researchers identified air pollution as the likely route of exposure.[85] In rural Colorado, mothers with greater exposure to natural gas wells were associated with a higher risk of having babies with congenital heart defects and possibly neural tube defects.[86]

Other studies have found that residents living closer to drilling and fracking operations had higher hospitalization rates[87] and reported more health symptoms including upper respiratory problems and rashes.[88]

Workers suffer high risks from toxic exposure and accidents.[89] One study of the occupational inhalation risks caused by emissions from chemical storage tanks associated with

[82] McKenzie, Lisa et al., Ambient Nonmethane Hydrocarbon Levels Along Colorado's Northern Front Range: Acute and Chronic Health Risks, 52 Environmental Science & Technology 4514 (2018).
[83] Currie, Janet et al., Hydraulic fracturing and infant health: New evidence from Pennsylvania, 3 Science Advances e1603021 (2017).
[84] Casey, Joan A., Unconventional Natural Gas Development and Birth Outcomes in Pennsylvania, USA, 27 Epidemiology 163 (2016).
[85] Stacy, Shaina L. et al., Perinatal Outcomes and Unconventional Natural Gas Operations in Southwest Pennsylvania. 10 PLoS ONE e0126425 (2015).

[86] McKenzie, Lisa M., Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado, 122 Environmental Health Perspectives 412 (2014).
[87] Jemielita, Thomas et al., Unconventional Gas and Oil Drilling Is Associated with Increased Hospital Utilization Rates. 10 PLoS ONE e0131093 (2015).

[88] Rabinowitz, Peter M. et al., Proximity to Natural Gas Wells and Reported Health Status: Results of a Household Survey in Washington County, Pennsylvania, 123 Environmental Health Perspectives 21 (2015).

fracking wells found that chemicals used in 12.4 percent of wells posed acute non-cancer risks, chemicals used in 7.5 percent of wells posed acute cancer risks, and chemicals used in 5.8 percent of wells posed chronic cancer risks.[90] As summarized below:

> Drilling and fracking jobs are among the most dangerous jobs in the nation with a fatality rate that is five times the national average and shows no sign of abating. Occupational hazards include head injuries, traffic accidents, blunt trauma, burns, inhalation of hydrocarbon vapors, toxic chemical exposures, heat exhaustion, dehydration, and sleep deprivation. An investigation of occupational exposures found high levels of benzene in the urine of wellpad workers, especially those in close proximity to flowback fluid coming up from wells following fracturing activities. Exposure to silica dust, which is definitively linked to silicosis and lung cancer, was singled out by the National Institute for Occupational Safety and Health as a particular threat to workers in fracking operations where silica sand is used. At the same time, research shows that many gas field workers, despite these serious occupational hazards, are uninsured or underinsured and lack access to basic medical care.[91]

Methods of collecting and analyzing emissions data often underestimate health risks by failing to adequately measure the intensity, frequency, and duration of community exposure to toxic chemicals from fracking and drilling; failing to examine the effects of chemical mixtures; and failing to consider vulnerable populations.[92] Of high concern, numerous studies highlight that health assessments drilling and fracking emissions often fail to consider impact on vulnerable populations including environmental justice communities[93] and children.[94] For example, a recent analysis of oil and gas development in California found that 14 percent of the state's population totaling 5.4 million people live within a mile of at least one oil and gas well.

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[89]Esswein, Eric J. et al., Occupational Exposures to Respirable Crystalline Silica During Hydraulic Fracturing, 10 Journal of Occupational and Environmental Hygiene 347 (2014); Esswein, Eric et al., Evaluation of Some Potential Chemical Exposure Risks during Flowback Operations in Unconventional Oil and Gas Extraction: Preliminary Results, 11 Journal of Occupational and Environmental Hygiene D174 (2013); Harrison, Robert J. et al., Sudden Deaths Among Oil and Gas Extraction Workers Resulting from Oxygen Deficiency and Inhalation of Hydrocarbon Gases and Vapors — United States, January 2010–March 2015. 65 MMWR Morb Mortal Wkly Rep 6 (2016); PSR 2016.

[90] Chen, Huan & Kimberly E. Carter, Modeling potential occupational inhalation exposures and associated risks of toxic organics from chemical storage tanks used in hydraulic fracturing using AERMOD, 224 Environmental Pollution 300 (2017).

[91] PSR 2016 at 80

[92] Brown, David et al., Understanding Exposure From Natural Gas Drilling Puts Current Air Standards to the Test. 29 Reviews on Environmental Health 277 (2014).

[93] NRDC [Natural Resources Defense Council], Drilling in California: Who's At Risk?, October 2014 ("NRDC 2014"); Clough, Emily & Derek Bell, Just Fracking: A Distributive Environmental Justice Analysis of Unconventional Gas Development in Pennsylvania, USA, 11 Environmental Research Letters 025001 (2016); McKenzie, Lisa M. et al., Population Size, Growth, and Environmental Justice Near Oil and Gas Wells in Colorado, 50 Environmental Science & Technology 11471 (2016).

[94] Webb, Ellen et al., Potential Hazards of Air Pollutant Emissions From Unconventional Oil and Natural Gas Operations on The Respiratory Health of Children And Infants. 31 Reviews on Environmental Health 225 (2016).

More than a third of these residents, totaling 1.8 million people, also live in areas most burdened by environmental pollution.[95]

4. Health and Safety Buffers around Oil and Gas Sites

Due to the prevalence of oil and gas extraction, an area of growing interest in public health is the relationship between the proximity of modern oil and gas extraction, nearby communities, and health impacts. Published studies examining this relationship have considered health outcomes, exposure to toxic health risks, and setback requirements that would be adequate to ensure the health and safety of people living in close proximity to oil and gas infrastructure.[96]

The overarching conclusion is that the closer people live to oil and gas wells, the more likely it is that they will be exposed to toxic air contaminants, and the more likely the risk of adverse health effects. For instance, Rabinowitz et al. (2015) found an increased number of upper respiratory symptoms and skin conditions among residents who lived less than 1 km (3,280 feet) from an active well, compared with residents who lived more than 2 km (6,561 feet) from an active well.[97] Kassotis et al. (2014) found elevated levels of endocrine disrupting chemicals in water sources 1 mile (5,280 feet) away from oil and gas operations. This study noted that near one of the investigated facilities, some of the animals in the area were no longer producing live offspring.[98]

Macey et al. (2014), in investigating several areas with setback regulations for oil and gas operations, found high concentrations of carcinogenic VOCs at distances greater than setback regulations, including formaldehyde up to 2,591 feet and benzene up to 885 feet away from wells in Wyoming and Pennsylvania. This study also found that in Colorado's Boulder and Weld Counties, hydrogen sulfide concentrations exceeded the minimum risk level.[99] Thus, the safe setback distance implied by this study is 2,591 feet, as opposed to the 350 ft setback requirement in Wyoming, or the 500 ft setback requirements in Colorado and Pennsylvania. In considering the results the Rabinowitz et al. (2015) study, focused in Pennsylvania, an even higher setback of 6,561 feet is suggested.

It is important to note that the risks to public health from oil and gas extraction are not limited to toxic exposures. A study by Boyle et al. (2017) found that homes up to 600 m (1,968 feet) away from a natural gas compressor station experienced outdoor noise levels in excess of the US EPA's recommended limit of 55 dBA 100% of the time.[100] Other studies have found non-

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[95] NRDC 2014.

[96] Wong, N.J, Existing scientific literature on setback distances from oil and gas development sites (2017). http://www.stand.la/uploads/5/3/9/0/53904099/2500_literature_review_report-final_jul13.pdf.

[97] Rabinowitz, P.M. et al., Proximity to natural gas wells and reported health status: results of a household survey in Washington County, Pennsylvania. 123 Environmental Health Perspectives 21 (2015).

[98] Kassotis, C.D. et al., Estrogen and androgen receptor activities of hydraulic fracturing chemicals and surface and ground water in a drilling-dense region. 155 Endocrinology 897 (2014).

[99] Macey, G.P. et al., Air concentrations of volatile compounds near oil and gas production: a community-based exploratory study. 13 Environmental Health 82 (2014).

[100] Boyle, M.D. et al., A pilot study to assess residential noise exposure near natural gas compressor stations. 12 PloS One 30174310 (2017).

auditory impacts of noise on health such as annoyance, sleep disturbance, daytime sleepiness, hypertension, cardiovascular disease, and diminished cognitive performance in school children.[101]

There are also added risks from explosions similar hazards. Haley et al. (2016) considered the minimum setback distance that would be safe in the event of a blow-out or explosion event at an oil or gas facility. They found that the average evacuation zone for such an event is 0.8 miles, or 4,224 feet, based on historical evacuation data. Setbacks to guard against such hazards are important to consider since accidents have resulted from inadequate setback distances. For instance, On April 17, 2017, a one-inch abandoned pipeline exploded under a home in Firestone, Colorado, killing two people and badly burning a third. The gas well head was located just 178 feet from the home.[102] A proper setback in place could have prevented this catastrophe from happening.

Existing setback laws range from 150 to 1,500 feet. In some cases, setbacks are statewide, while in others, they are at the local level. In Colorado, for example, regulations require a 500 ft setback from residences and a 1000 ft setback from high occupancy buildings. Meanwhile, in Utah setbacks are at the county level, with Duchesne County having a setback of 300 ft, and Uintah County having a setback of 1000 ft from residences.[103] However, the growing consensus is that these setbacks are inadequate to protect public health. In analyzing the risks associated with drilling in the Marcellus Shale, the University Of Maryland School Of Public Health recommended a minimum setback distance of 2,000 ft from well pads in the state. In a recent report from the Los Angeles County Department of Public Health, it was found that even a 1,500 ft setback would be inadequate to protect from all of the public health and safety hazards associated with proximity to oil and gas infrastructure.[104]

In 2016, the Southwest Pennsylvania Environmental Health Project (EHP) convened a consortium of 18 professionals with expertise in public health, medicine, environmental sciences, policy, and risk analysis to determine an acceptable setback distance based on consensus. The result was 89% agreement on a 6,600 ft setback. There was also consensus on greater setback distances in areas where there are vulnerable subpopulations, such as schools, preschools, and hospitals.[105] Thus, there is building agreement that oil and gas activities in close proximity to

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[101] *See e.g.*, Basner, M. et al., Auditory and non-auditory effects of noise on health, 383 The Lancet 1325 (2014).
[102] Kelly, D., Deadly House explosion in Colorado traced to uncapped pipe from gas well. Los Angeles Times, May 2, 2017. http://www.latimes.com/nation/nationnow/la-na-colorado-explosion-20170502-story.html (Accessed July 12, 2018).

[103] Utah Division of Oil, Gas, and Mining, Oil and Gas Residential Setbacks: Overview of Other State Regulations (August 2013), https://fs.ogm.utah.gov/bbooks/2013/08_Aug/Briefing/1_Oil&GasResidentialSetbacks_OverviewOfOtherStateRegulations.pdf.
[104] Los Angeles County Dept. of Public Health, Public Health and Safety Risks of Oil and Gas Facilities in Los Angeles County, February 2018, http://publichealth.lacounty.gov/eh/docs/PH_OilGasFacilitiesPHSafetyRisks.pdf.
[105] Health and Unconventional Oil & Gas Development: Delphi Study Results. *South West Pennsylvania Environmental Health Project Technical Reports*, Issue 4. (Accessed July 12, 2018), available at http://www.marsparentgroup.com/uploads/3/0/3/4/30347031/issue_4__health_and_unconventional_oil___gas_development_-delphi_study_results.pdf; *see also* Brown, David et al. The Problem of Setback Distance for Unconventional Oil & Gas Development: An analysis of expert opinions. Southwest Pennsylvania Environmental

people yield an undue health burden. Setbacks that ensure the safety of communities should be implemented in the interim between now and an ultimate phase out of oil and gas extraction.

C. The Forest Service Must Consider Risks to Water Resources from Fracking

Fracking in the Wayne National Forest would put water resources at risk, as described in Exhibit A at pages 21-36. In addition, the EPA recently completed its study on the impacts of fracking on drinking water resources, which found scientific evidence that hydraulic fracturing activities can impact drinking water resources under some circumstances.[106] The report identifies certain conditions under which impacts from hydraulic fracturing activities can be more frequent or severe.[107] The EPA identified a number of risk factors that may increase the risks of drinking water contamination, all of which are present in the Wayne National Forest:

- **Risk factor 1:** Water withdrawals for hydraulic fracturing in times or areas of low water availability, particularly in areas with limited or declining groundwater resources.

  The Wayne National Forest is an area of limited water resources in terms of both groundwater and surface waters, compared to the enormous water demands of fracking in the Utica and Marcellus shales. In Ohio, the average amount of water used in fracking increased from 5.6 million gallons per well in 2011 to 7.6 million gallons in 2014.[108] FracTracker has found that the fracking industry in Ohio now uses roughly 10-14 million gallons of water per well, up from 4-5 million gallon demands in 2010, which means that freshwater demand for this industry is increasing 15% per year."[109] In addition, increasing water use per well is not simply attributable to increasing horizontal well lateral lengths (or increased fracking to tap a larger area). A new study shows that increasing water use rates per well are outpacing the increased rates of oil and gas production per well.[110] In other words, net water use per unit of energy produced, or overall water intensity for fracking operations, is increasing. This trend in increased water intensity starting in 2014 coincides with a sharp drop in oil prices, suggesting oil and gas operators have increased water use per frack to increase oil and gas output, and make frack wells more cost-effective.[111] In eastern Ohio "super laterals" are becoming more common, but these laterals require more gallons of water on a per lateral foot basis: according to FracTracker, "Ohio's hydraulically fractured laterals require 970-1,080

Health Project Technical Reports, Issue 2 (May 9, 2016) (finding agreement among experts for at least a quarter-mile setback and greater distances for vulnerable populations).

[106] USEPA, Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States (2016) ("USEPA 2016").
[107] *See id*. at ES-3.
[108] Arenschield, Laura. Drillers Using more water to frack Ohio shale, Columbus Dispatch (Feb. 8, 2016), available at http://www.dispatch.com/content/stories/local/2016/02/07/drillers-using-more-water-to-frack-ohio-shale.html#.
[109] Auch, Ted, Fracking's Freshwater Supply and Demand in Eastern Ohio, FracTracker Alliance (Feb. 28. 2018) ("Auch 2018"), available at https://www.fractracker.org/2018/02/freshwater-supply-demand-eastern-ohio/.
[110] Kondash, Andrew J., et al., The intensification of the water footprint of hydraulic fracturing, Science Advances (Aug. 15, 2018), available at http://advances.sciencemag.org/content/advances/4/8/eaar5982.full.pdf.
[111] *Id*.; Auch 2018.

gallons of freshwater per lateral foot (GPLF), but super laterals would need an astounding 4,470 GLPF."[112]

However, because "[t]here is no agency (federal or state) that regulates water withdrawals from streams and rivers in the State of Ohio," the only limits on an operator's ability to withdraw water would be landowner's consent. [113] According to EPA, without management of the rate and timing of withdrawals, surface water withdrawals have the potential to affect both drinking water quantity and quality, especially in seasonal low-flow periods.[114] In Ohio's Marcellus and Utica Shales, reuse of wastewater is uncommon.[115]

Drillers have proposed depleting water from the Little Muskingum River and Witten Fork for federal frack wells in the Wayne National Forest, which the 2012 SIR failed to take into account.[116] Depletions from the Little Muskingum River Basin could degrade its "exceptional" surface waters (so designated by Ohio EPA), which provide important habitat for diverse aquatic species, including macroinvertebrates and fish.[117] Depleting these streams that feed the Ohio River could also impact water quality and flows in the Ohio River.

- **Risk factor 2:** 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.

  Enormous volumes of wastewater are produced in the completion of horizontal wells in Ohio, and major spills have occurred in the state. For example:

  - In 2010, a fracturing flowback pit was cut by a track hoe in 2010, causing more than 1.5 million gallons of fluid to spill into the environment.[118]

  - In 2008, the back wall of a pit in Ohio gave way, causing pit contents to spill and flow towards a creek.[119]

  - In June 2014, the Statoil Eisenbarth well pad located in Monroe County, close to the proclamation boundary of the Marietta Unit, caught fire and took nearly a week to completely extinguish. "As a result of fire-fighting efforts and flow back from the well head, significant quantities of water and unknown quantities of products on the well pad left the Site and entered an unnamed tributary of

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[112] Auch 2018.
[113] 2012 SIR at 29.
[114] EPA 2016 at 4-37.
[115] EPA 2016 at 4-36.
[116] Eclipse Resources, Rolland A 1H Permit (July 28, 2017).
[117] Ohio EPA, Beneficial Use Support Document Little Muskingum River Basin (2016), available at http://epa.ohio.gov/Portals/35/rules/Little%20Musky.pdf.
[118] ODNR, Notice of Violation No. 1278508985 (June 21, 2010).
[119] ODNR, Notice of Violation No. 2016754140 (May 16, 2008).

Opossum Creek that ultimately discharges to the Ohio River." [120] The runoff killed approximately 70,000 fish in a 5-mile long fish kill. Opossum Creek, the location of the Eisenbarth fish kill, is partially located within the proclamation boundary of the Marietta Unit.

- The Rover pipeline, which cuts through the northeast corner of the Wayne National Forest has been plagued with numerous mishaps and spills during its construction. Ohio EPA has "registered more than 30 environmental complaints…including a leak of at least 2 million gallons — the state says it could be as much as 5 million gallons — of drilling mud" in Stark County.[121] The spill occurred over roughly "500,000 square feet of wetland near the Tuscarawas River…[Such] [d]ischarges can affect water chemistry and potentially suffocate wildlife, fish and microinvertebrates."[122] The developer ETP initially led regulators to believe that the spill contained only non-toxic, but environmentally harmful, drilling "mud."[123] Later, diesel fuel was detected in the spilled mud in at least three separate locations, in violation of the terms of ETP's permit for mud composition, as well as its permit for the storage of the leaked material in a quarry located roughly "1,000 feet from the city of Massillon's public water system intake."[124]

- The massive Rover spill is by no means an isolated incident. As of May 2017, the Ohio EPA has fined ETP for 18 separate spills, including at least seven spills that have impacted waterways, wetlands, and public drinking water sources.[125]

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[120] *See, e.g.*, U.S. Environmental Protection Agency Pollution/Situation Report, Statoil Eisenbarth Well Response, POLREP #1, *available at* http://www.theoec.org/sites/default/files/Eisenbarth%20well%20pad%20fire.pdf; Junkins, Casey, *EPA: 70K Fish, Aquatic Life Killed*, Wheeling Intelligencer, July 22, 2014, *available at* http://www.theintelligencer.net/page/content.detail/id/607167.html; Ohio Environmental Protection Agency, Directors Final Findings & Orders NPDES In the Matter of Statoil USA Onshore Properties, Inc. (November 6, 2015).

[121] Mandel, Jenny, Ohio takes legal action over Rover construction violations, Environment & Energy News Reporter (Jul. 11, 2017), available at https://www.eenews.net/energywire/stories/1060057181/search?keyword=Ohio+takes+legal+action+over+Rover+construction+violations.

[122] Renault, Marion, Ohio pipeline construction spill sends 2 million gallons of mud into two Ohio wetlands, The Columbus Dispatch, (Apr. 20, 2017), *available at* http://www.dispatch.com/news/20170420/pipeline-construction-spill-sends-2-million-gallons-of-drilling-mud-into-two-ohio-wetlands.

[123] *Id.*

[124] Mandel, Jenny, Diesel found in Ohio Rover spill draws new fines, Environment & Energy News Reporter, (Jun. 9, 2017), *available at* https://www.eenews.net/energywire/stories/1060055786/search?keyword=Diesel+found+in+Ohio+Rover+spill+draws+new+penalties.

[125] Mufson, Steven, Pipeline spill by Dakota Access company could have a "deadly effect", The Washington Post, (May 8, 2017), *available at* https://www.washingtonpost.com/news/energy-environment/wp/2017/05/08/pipeline-spill-by-dakota-access-company-could-have-a-deadly-effect/?utm_term=.0ff8270e7d7f; Renault, Marion, Feds shut down new drilling along Rover pipeline project, Columbia Dispatch (May 11, 2017), *available at* http://www.dispatch.com/news/20170511/feds-shut-down-new-drilling-along-rover-pipeline-project; Sierra Club Ohio Chapter, Rover Pipeline Proves to be Disastrous Update (May 31, 2017), *available at* http://www.sierraclub.org/ohio/blog/2017/05/rover-pipeline-proves-be-disastrous-update.

Eighteen storm water permit violations have also been reported.[126] This includes a spill of 50,000 gallons occurring just one day after the Stark County spill and also impacting a sensitive wetland in Richland County.[127] The pattern of non-compliance with the State's environmental laws has prompted the Ohio EPA to request the state's attorney general to initiate civil proceedings for violations of environmental laws addressing air and water quality,[128] and has also led the Ohio EPA to issue further enforcement orders against Rover for violations of state and federal environmental laws.[129]

Frack chemicals and wastewaters may have chronic effects on aquatic organisms aside from immediate lethal effects, including endocrine-disrupting effects,[130] and impacts on microbial community structure and functioning in sediments and stream waters, altering nutrient cycling and antibiotic resistance.[131]

A new study analyzing spill records in several states (Colorado, New Mexico, North Dakota, and Pennsylvania) show spills are a chronic risk of oil and gas development: 2-16% of wells report a spill each year, while 75-94% of spills occur within the first three years of well life when wells were drilled, completed, and had their largest production volumes.[132] According to another nationwide review of oil and gas spills since 2009, 2,500 spills have been reported to have affected groundwater, but this is likely an undercount as many oil and gas agencies don't track whether spills affect water, or even spills.[133] Overall, 10,348 spills, blowouts and other mishaps at oil and gas sites occurred in 2015; 11,283 such events occurred in 2014.[134] At least 76 spills occurred in Ohio in 2015, 43 of which affected water resources.[135]

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[126] Mandel, Jenny, Diesel found in Ohio Rover spill draws new fines, Environment & Energy News Reporter, (Jun. 9, 2017), *available at* https://www.eenews.net/energywire/stories/1060055786/search?keyword=Diesel+found+in+Ohio+Rover+spill+draws+new+penalties.

[127] Mufson, Steven, The company behind the Dakota Access pipeline is in another controversy, Washington Post, (Apr. 27, 2017), *available at* https://www.washingtonpost.com/news/energy-environment/wp/2017/04/27/the-company-behind-the-dakota-access-pipeline-is-in-another-controversy/?utm_term=.fd37869145a2.

[128] Mandel, Jenny, Ohio takes legal action over Rover construction violations, Environment & Energy News Reporter, (Jul. 11, 2017), https://www.eenews.net/energywire/stories/1060057181/search?keyword=Ohio+takes+legal+action+over+Rover+construction+violations.

[129] Ohio Environmental Protection Agency, In the Matter of Rover Pipeline LLC, Directors Final Findings and Orders, (Jul. 7, 2017), http://epa.ohio.gov/Portals/35/enforcement/Rover.pdf.

[130] He, Yuhe, et al., Effects on Biotransformation, Oxidative Stress, and Endocrine Disruption in Rainbow Trout (Oncorhynchus mykiss) Exposed to Hydraulic Fracturing Flowback and Produced Water, Environ. Sci. Technol., (2017) 51, 940−947, doi: 10.1021/acs.est.6b04695.

[131] Fahrenfeld, N.L., Shifts in microbial community structure and function in surface waters impacted by unconventional oil and gas wastewater revealed by metagenomics, Science of the Total Environment, 580 (2017) 1205–1213, http://dx.doi.org/10.1016/j.scitotenv.2016.12.079.

[132] Patterson, Lauren A. et al. Unconventional Oil and Gas Spills: Risks Mitigation Priorities, and State Reporting Requirements, Environ. Sci. Technol., 51(5), pp 2563–2573 (2017), doi: 10.1021/acs.est.6b05749.

[133] Soraghan, Mike & Pamela King, Drilling mishaps damage water in hundreds of cases, Energywire (Aug. 8, 2016), available at https://www.eenews.net/stories/1060041279.

[134] *Id.*

[135] *Id.*

Recently, in Pennsylvania, a shale gas driller was fined $1.2 million when a wastewater impoundment leaked and contaminated the drinking water of five Westmoreland County families.[136] The families are still without adequate, permanent water supplies and still depend on bottled water.

- **Risk factor 3:** Injection of hydraulic fracturing fluids into wells with inadequate mechanical integrity, allowing gases or liquids to move to groundwater resources.

  Studies show that well casing failures are a chronic problem regardless of whether wells are old or new, fracked or not fracked.[137] For example:

  > A ProPublica review of well records, case histories and government summaries of more than 220,000 well inspections found that structural failures inside injection wells are routine. From late 2007 to late 2010, one well integrity violation was issued for every six deep injection wells examined — more than 17,000 violations nationally. More than 7,000 wells showed signs that their walls were leaking. Records also show wells are frequently operated in violation of safety regulations and under conditions that greatly increase the risk of fluid leakage and the threat of water contamination.[138]

  In a study of 18 wells drilled in south Texas between 1990 and 2011, 61 percent had well integrity or barrier failures mainly in shale zones.[139]

  In addition, Ohio only recommends monthly monitoring of "mechanical integrity" of Class II wastewater injection wells unless doing so is "not feasible" for operators.[140] In

[136] Hopey, Don, Shale gas driller fined $1.2M for contaminating drinking water in Westmoreland, Pittsburgh Post-Gazette (Feb. 28, 2017), available at http://www.post-gazette.com/local/westmoreland/2017/02/28/WPX-Energy-Appalachia-shale-gas-company-fined-Pennsylvania-water-contamination-Westmoreland-County/stories/201702280305.

[137] Johnson, R. et al., The Environmental Costs and Benefits of Fracking, Annu. Rev. Environ. Resour. 2014. 39:7.1-7.36 (see pp. 7.11-7.14 for discussion of well failure rates); Johnson, Robert B., The integrity of oil and gas wells, 111 Proceedings of the National Academy of Science 1092 (2014), available at http://www.pnas.org/content/111/30/10902; Ingraffea, A., Fluid Migration Mechanisms Due to Faulty Well Design and/or Construction: An Overview and Recent Experiences in the Pennsylvania Marcellus Play, Physicians Scientists & Engineers for Healthy Energy (Oct. 2012) (noting casing failures are "not rare" in the oil and gas industry"); Environment America, Fracking by the Numbers: The Damage to Our Water, Land and Climate from a Decade of Dirty Drilling , 11 (2016) (noting data from fracking wells in Pennsylvania from 2010 to 2012 show a 6 to 7 percent rate of well failure due to compromised structural integrity).

[138] Lustgarten, Alexander, Are Fracking Wastewater Wells Poisoning Groundwater Beneath Our Feet?, Scientific American (June 2012), available at https://www.scientificamerican.com/article/are-fracking-wastewater-wells-poisoning-ground-beneath-our-feeth/.

[139] Davies, Richard, Oil and gas wells and their integrity: Implications for shale and unconventional resource exploitation, Marine and Petroleum Geology, vol. 58 available at http://www.sciencedirect.com/science/article/pii/S0264817214000609.

[140] Steinzor, Nadia & Bruce Baizel, Earthworks. Wasting away: Four states' failure to manage gas and oil field waste from the Marcellus and Utica Shale (April 2015), 34, available at https://www.earthworksaction.org/files/publications/WastingAway-FINAL-lowres.pdf.

2007, a frack well with insufficient and improperly placed cement led to contamination of 26 drinking water wells in Brainbridge Township, Ohio.[141]

- **Risk factor 4:** Injection of hydraulic fracturing fluids directly into groundwater resources.

  An EPA report has singled out Ohio for not requiring operators disposing of waste to reveal its chemical content, increasing the risk of groundwater contamination by harmful chemicals.[142]

- **Risk factor 5:** Discharge of inadequately treated hydraulic fracturing wastewater to surface water.

  Ohio Revised Code 1509.22 allows facilities to "store," "recycle," "treat," "process," and "dispose" of oil and gas wastewater if done pursuant to a permit or order granted by the Ohio Division of Oil & Gas Resources Management (DOGRM). Although this statute directs DOGRM to adopt rules governing the aforesaid activities, the state of Ohio has never adopted the applicable rules. As a result, the discharge or disposal of recycled, treated, or processed oil and gas wastewater is not subject to any enumerated state standards or prohibitions. Nor are there any applicable state standards governing treatment methods, volumes, or chemical parameters applicable to recycled, treated, or processed wastewater.

  Moreover, Ohio Revised Code 1509.226 allows Ohio political subdivisions to authorize the discharge of oil and gas wastewater on local roadways for dust and ice control purposes. Runoff of this wastewater could potentially contaminate surface waters.

- **Risk factor 6:** Disposal or storage of hydraulic fracturing wastewater in unlined pits resulting in contamination of groundwater resources.

  Ohio does not have specific standards for pits, requiring only that they "prevent the escape" of waste substances. *See* ORC § 1509.22(C)(2).[143] Pit liners are not required.[144] Between 1983 and 2007, 63 incidents of spills contaminating groundwater were caused by leaks from unlined pits.[145] Improper construction or maintenance of production pits was the primary cause of groundwater contamination, accounting for nearly 44% (63) of all documented contamination incidents.[146]

In sum, fracking operations pose numerous risks to water resources in the Wayne National Forest, which could endanger both public health and wildlife.

141 USEPA 2016 at 6-28.
142 *Id*. at 36.
143 Steinzor 2015 at 16.
144 Richardson, Nathan, The State of State Shale Gas Regulation, Resources for the Future, 51 (June 2013).
145 USEPA 2016 at 8-44.
146 Steinzor 2015 at 14.

D. The Forest Service Should Consider Increased Seismicity Risks from Fracking

Exhibit A at pages 65-68 describe extensive research linking oil and gas wastewater injection to earthquakes, including seismicity in Ohio. With increasing water use for fracking operations in Ohio (discussed above in section D) wastewater injection volumes will surely increase and increase the risk of earthquakes. There are at least two injection wells located in the Wayne National Forest's Marietta Unit, which could be sites for waste disposal for fracking in the Wayne.[147]

In addition, new studies have shown that fracking and not just wastewater injections can induce earthquakes. Induced seismicity has been linked to fracking events in Ohio, Oklahoma, and Canada.[148] Indeed, a 2015 study showed that 77 earthquakes occurring in March 2014 near Youngstown, Ohio triggered a microfault previously unknown to operators and regulators, including a magnitude 3.0 earthquake.[149]

According to the Ohio Department of Natural Resources the locations of deep, active faults in Ohio are unknown:

> The origins of Ohio earthquakes, as with earthquakes throughout the eastern United States, are poorly understood. Those in Ohio appear to be associated with ancient zones of weakness in the Earth's crust that formed during rifting and continental collision events about a billion years ago. These zones are characterized by deeply buried and poorly known faults, some of which serve as the sites for periodic release of strain that is constantly building up in the North American continental plate due to continuous movement of the tectonic plates that make up the Earth's crust. [150]

Without a better understanding of the location of deep faults in Ohio and the risk of a fracking or wastewater injection triggering a fault in a particular locale, fracking and underground wastewater injection cannot be presumed safe.

The unpredictable nature of fracking-induced earthquakes is highlighted by a recent earthquake in the Wayne National Forest. On April 2, 2017, a 3.0 earthquake occurred in the

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[147] Center for Biological Diversity, Marietta Unit Lease Parcel and Well Map (2018).
[148] Arenschield, Laura, Study ties 77 Ohio earthquakes to two fracking wells, Columbus Dispatch (Jan. 8, 2015) ("Arenschield 2015"), available at http://www.dispatch.com/content/stories/local/2015/01/08/Research-ties-Ohio-quakes-to-fracking.html; Skoumal, Richard, et al., Earthquakes Induced by Hydraulic Fracturing in Poland Township, Ohio (2015), available at http://www.bssaonline.org/content/early/2015/01/01/0120140168.abstract; Soraghan, Mike, Okla. officials link some quakes to fracking, E&E News Energywire (Dec. 12, 2016), available at http://www.eenews.net/energywire/stories/1060047006/; Gronewold, Nathaniel, New research suggests fracking triggered active faults, E&E News Energywire (November 28, 2016), available at http://www.eenews.net/energywire/stories/1060046240/; Mahani, Alireza B. et al., Fluid Injection and Seismic Activity in the Northern Montney Play, British Columbia, Canada, with Special Reference to the 17 August 2015 Mw 4.6 Induced Earthquake, 107 Bulletin of the Seismological Soc'y of Am. 542 (2017)..
[149] Arenschield 2015.
[150] ODNR, Earthquakes and Seismic Risks in Ohio, http://geosurvey.ohiodnr.gov/earthquakes-ohioseis/seismic-risk-in-ohio.

Marietta Unit near Graysville, a site within five miles of eight Utica shale fracking sites.[151] This area of southeastern Ohio does not have a long history of earthquake activity.[152] Fracking operations within the vicinity of the earthquake's epicenter were suspended, and Ohio Department of Natural Resources is investigating whether fracking may have caused the earthquake.

In light of these risks, a recent study that outlines a framework for risk assessment to analyze potential harm to sensitive infrastructure from induced seismicity in Canada, recommends an "exclusion zone within a 5 km radius (in horizontal space) surrounding vulnerable high-consequence facilities…[and] and monitoring and response protocol to ensure that activity rates beyond the exclusion zone, to approximately 25 km, are kept below a specified limit."[153] The study stresses that these recommendations are meant to address induced seismicity from the hydraulic fracturing process, and that wastewater disposal wells may require a larger exclusion zone of 10 km.[154] The Forest Service should consider the potential for manmade earthquakes to impact sensitive infrastructure such as pipelines, bridges, and dams in and around the Wayne National Forest.

E. The Forest Service Should Consider Impacts to Wildlife Habitat from Fracking

The Wayne National Forest is an important refuge for a number of rare and sensitive species, whose populations have already been decimated by human development. These species are already highly vulnerable to other stressors such as disease and climate change; additional stressors from fracking would compound these threats.

1. Indiana Bat, Northern Long-Eared Bat, Tri-Colored Bat and Little Brown Bat

Several imperiled bat species inhabit the Wayne National Forest, including the federally listed endangered Indiana Bat and "threatened" Northern long-eared bat; and two species which are undergoing status reviews for federal listing, the tri-colored bat and little brown bat. Fracking operations would destroy and degrade these species' habitat, and would undermine their recovery from white-nose syndrome and resiliency to climate change.

a. Horizontal Well Development

Increased surface disturbance from horizontal well pad, pipeline, and other oil and gas infrastructure would destroy habitat for the Indiana bat and other sensitive bat species. The 2012 SIR underestimates the amount of forest clearing from horizontal well pad development and

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[151] Renault, Marion, Ohio investigates cause of weekend earthquake in drilling region, Columbus Dispatch (April 4, 2017) ("Renault 2017"), available at http://www.dispatch.com/news/20170404/ohio-investigates-cause-of-weekend-earthquake-in-drilling-region; *see also* Center for Biological Diversity, Marietta Unit Lease Parcel and Well Map (2018).
[152] Renault 2017.
[153] Atkinson, Gail, Strategies to prevent damage to critical infrastructure due to induced seismicity. Department of Earth Sciences, Western University, Canada (2017) ("Atkinson 2017"), available at http://www.inducedseismicity.ca/wp-content/uploads/Atkinson2017-FACETS.pdf.
[154] *Id.*

related infrastructure, as explained in Exhibit B at pages 7-9. Further, leasing of federal minerals could open up new private mineral acreage for development, and cause increased disturbance of and industrial activities on private land that provides habitat for bat species, as explained in Exhibit B at pages 3-7.[155] The Indiana bat's extremely slow reproduction rate (at most, one pup per year) and specialized summer roosting habitat needs (mature or dying trees or oak or hickory trees with exfoliating bark) compound these threats for the species.[156] The little brown bat has similarly slow reproduction rates. Maximizing availability of summer roosting trees is thus essential to recovery of the species, while loss of roosting trees would undermine its survival and recovery.

Several studies document that oil and gas wastewater pits pose a significant risk to migratory birds and other wildlife, including bats.[157] Insects that become trapped on the surface of these pits attract bats, which may then become exposed to toxic chemicals, or end up tangled in netting covering the pits' surfaces.[158] Ohio law allows for the continuous use of wastewater pits during the producing life of a well, so long as pits are periodically drained (at least every 180 days). Ohio Administrative Code (OAC) § 1501:9-3-08; Ohio Revised Code (ORC) § 1509.22(C)(4).[159] But no requirement in the Forest Plan prohibits the use of wastewater pits on either private or federal surface in the Wayne.

Dewatering of streams and increased spills and leaks could deplete and contaminate these species' drinking water sources. Further, noise from industrial operations would disturb both hibernating and roosting bats. Forcing bats to abandon their roosts can have severe consequences "if young are abandoned at a maternity roost, predation increases, or there is a loss of access to important nearby foraging or alternative roosting areas." [160] Even if bats do not relocate, noise pollution may force individuals to:

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[155] *See also* Downing, B., Strong support in southern Ohio for Wayne NF drilling, Akron Beacon Journal, Ohio.com (Jan. 22, 2016), available at http://www.ohio.com/blogs/drilling/ohio-utica-shale-1.291290/strong-support-in-southern-ohio-for-wayne-nf-drilling-1.656368 (Ohio legislators stating leasing of the Wayne National Forest would give private citizens the opportunity to develop the minerals they own); Chenetski, Hannah, Washington Co. Commissioners support drilling in Wayne National Forest, The News Center (May 26, 2016), available at http://www.thenewscenter.tv/content/news/Washington-Co-Commissioners-support-drilling-in-Wayne-National-Forest-381011331.html (same point made by Washington County commissioners).

[156] *See* USFWS, Characteristics of Indiana Bat Summer Habitat (2008), available at https://www.fws.gov/northeast/njfieldoffice/pdf/ibatsummerhab.pdf; Kniowski, Andrew et al., Summer Ecology of Indiana Bats in Ohio (2011), available at https://www.dot.state.oh.us/Divisions/Planning/SPR/Research/reportsandplans/Reports/2011/Environmental/134387_FR.pdf .

[157] See, e.g., Ramirez, Pedro, U.S. Fish and Wildlife Service Region 6, "Migratory Bird Mortality in Oil and Gas Facilities in Colorado, Kansas, Montana, Nebraska, North Dakota, South Dakota, Utah, and Wyoming" (Feb. 2013), *available at*: https://www.fws.gov/mountain-prairie/contaminants/papers/R6726C13.pdf.

[158] Ramirez, Pedro, U.S. Fish and Wildlife Service, "Reserve Pit Management: Risks to Migratory Birds" at 9 (Sept. 2009), available at https://www.fws.gov/migratorybirds/pdf/management/reservepitmanagementriskstomigbirds.pdf.

[159] Ohio law also allows for temporary reserve pits for the storage of drilling and well stimulation wastes. ORC § 1509.072. These reserve pits are to be closed within two months of well completion in non-urbanized areas. ORC 1509.072(A). However, this two-month operating period may be extended by up to six or more additional months if certain conditions are satisfied. ORC § 1509.072.

[160] California Department of Transportation, Technical Guidance for Assessment and Mitigation of Traffic Noise and Road Construction Noise on Bats (July, 2016) at 62-63.

> invest…time and energy in vigilance behavior—time and energy often redirected from other critical behaviors such as care of young, foraging, rest, and proper thermoregulation…This vigilance is also normally accompanied by varying levels of stress that can potentially result in dysfunctional behaviors and/or changes in important physiological and hormonal conditions that may…affect the survival and well-being of individuals and colonies.[161]

In addition, studies have shown that anthropogenic noise and light pollution, including pollution associated with natural gas extraction, can impair the ability of bats to forage for food; this is true for bat species that utilize echolocation to hunt as well as species that forage by listening for prey sounds.[162]

b. White-Nose Syndrome

White-nose syndrome is a fatal disease affecting hibernating bats that is named for a white fungus that appears on the muzzle and other parts of bats. The disease has spread rapidly across the eastern and midwestern United States, and is estimated to have killed more than 6 million bats in the Northeast and Canada.[163] Bats with white-nose syndrome "act strangely during cold winter months, including flying outside during the day and clustering near the entrances of caves and other hibernation areas."[164] These abnormal behaviors "may contribute to the untimely consumption of stored fat reserves causing emaciation, a characteristic documented in a portion of the bats that die from WNS."[165] The Indiana bat, Northern long-eared bat,tri-colored bat, and little brown bat have all experienced severe population losses from the disease.

White-nose syndrome has spread to 19 counties in Ohio,[166] including in the Wayne National Forest in Lawrence County, [167] but Ohio officials believe the disease is more widespread.[168] It has also spread to West Virginia's Wetzel County, which lies directly across

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161 *Id.* at 63.

162 Legakis et al., Survey of the bats of the Athens metropolitan area, 38 Myotis (2000) 41–46; Schaub et al., Foraging bats avoid noise, 211 Journal of Experimental Biology (2008) 174– 3180; Francis et al., Noise pollution alters ecological services: enhanced pollination and disrupted seed dispersal, 279 Proc. R. Soc. B.-Biol. Sci. (2012) 2727–2735; Siemers, B.M. & A. Schaub, Hunting at the highway: traffic noise reduces foraging efficiency in acoustic predators, 278 Proc. R. Soc. B.-Biol. Sci. (2011) 1646–1652; Jones, G., Sensory Ecology: Noise Annoys Foraging Bats, 18 Current Biology 23 R1098-R1100 (2008); *See also* Kiviat, E., Risks to biodiversity from hydraulic fracturing for natural gas in the Marcellus and Utica shales, 1286 Annals of the New York Academy of Sciences 1 (2013) at 5.

163 USFWS, White-nose syndrome: The devastating disease of hibernating bats in North America (May 2016), *available at* https://www.whitenosesyndrome.org/sites/default/files/resource/white-nose_fact_sheet_5-2016_2.pdf.

164 *Id.*

165 USGS, National Wildlife Health Center, White-Nose Syndrome, *available at* http://www.nwhc.usgs.gov/disease_information/white-nose_syndrome/.

166 Lyttle, E. Hikers spreading fungus that's killing Ohio bats. *The Columbus Dispatch.* June 15, 2016 ("Lyttle 2016"), available at http://www.dispatch.com/content/stories/local/2015/06/15/humans-have-role-in-spread-of-bat-ills.html.

167 USFS, White-nose Syndrome Detected in Ohio (Mar. 30, 2011), *available at* http://www.fs.usda.gov/wps/portal/fsinternet/!ut/p/c4/04_SB8K8xLLM9MSSzPy8xBz9CP0os3gjAwhwtDDw9_AI8zPyhQoY6BdkOyoCAGixyPg!/?ss=110914&navtype=BROWSEBYSUBJECT&cid=STELPRDB5288711&navid=180000000000000&pnavid=null&position=News&ttype=detail&pname=Wayne%20National%20Forest-%20News%20&%20Events.

168 Lyttle 2016.

from Monroe County, on the other side of the Ohio River, and very near the Marietta Unit.[169] In 2011, the Forest Service performed a review of new information regarding the Wayne National Forest Plan and white-nose syndrome and concluded that supplementation of the environmental review for the Forest Plan was not necessary at that time. However, since then, a 2013 study has determined that white nose syndrome threatens the Indiana bat with a high risk of extirpation throughout large parts of its range.[170] The study concluded:

> Our sensitivity analyses indicated that management actions devoted to increasing, in order, winter, summer, and fall survival of breeding adult females would have the greatest potential for mitigating impacts of WNS on Indiana bat populations. Management actions for improving survival, however, may be difficult to achieve because these parameters are quite high (95% seasonal survival) in the absence of WNS. Alternatively, increasing reproduction, while less efficient at addressing a declining population trajectory, has more room for improvement; further, if management actions on the breeding grounds to improve reproduction also improve adult female summer survival, our global sensitivity analyses suggest improved performance in the other parameters may occur as well. *Because of the heightened risk faced by small, range-restricted populations* (Terborgh and Winter, 1980; Gilpin and Soulé, 1986; Schoener and Spiller, 1987), *it is also prudent in the face of this potential extinction agent to limit additive sources of mortality.* Our model suggests a timeframe for action, for the species is expected to reach its lowest level of abundance by the early 2020s, no more than a decade hence.[171]

Recent dramatic population declines support these findings. The USFWS recently released the 2017 Indiana Bat (*Myotis sodalist*) Population Status Update.[172] The Status Update provides an overview of Indiana bat population trends over time by state and region. The Status Update shows a range-wide population decline of 3.5% from 2015-2017, the most recent review period.[173] Over that same time period Ohio has experienced a 39.9% decline in Indiana bat populations since 2015, and near 70% drop since 2009.[174] The Status Update also shows that Ohio is not the only state experiencing dramatic bat population decline; Vermont, West Virginia, and Tennessee have seen Indiana bat populations decline by 64%, 54%, and 48% respectively over the same time period.[175] In fact, only two of the eighteen states studied have seen increases in bat populations from 2015-2017.[176]

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[169] White-Nose Syndrome.org, WNS Information Resources (2017), available at https://www.whitenosesyndrome.org/resources.

[170] Thogmartin, Wayne E. et al. White-nose syndrome is likely to extirpate the endangered Indiana bat over large parts of its range, Biological Conservation, Vol. 160, pp. 162-172 (April 2013), *available at* http://www.sciencedirect.com/science/article/pii/S0006320713000207.

[171] *Id.*

[172] United States Fish and Wildlife Service, 2017 Indian Bat (*Myotis sodalist*) Population Status Update, (available at https://www.fws.gov/Midwest/endangered/mammals/inba/pdf/2017IBatPopEstimate5July2017.pdf). (Hereafter “Status Update”).

[173] *Id.* at Table 3.

[174] *Id.* at 2.

[175] *Id.*

[176] *Id.*

The Forest Service has also acknowledged rapid declines of all bat species in Ohio likely from white-nose syndrome, including once common species, and uncertainties in their ability to recover:

> In Ohio, hibernaculum surveys from pre-2011 (before WNS) to 2014 (post-WNS) suggest an 85% decline in the winter bat population (Norris 2014). A 2014 mid-winter bat census at the Lawrence County mine indicated the collapse (99% decline) of the hibernating bat population. Statewide summer acoustic surveys in Ohio indicate a declining trend in the number of overall bat detections (all species) recorded. For instance, a comparison of the number of calls detected in 2014 to 2011 suggests 47% fewer bats detected overall (Norris 2014J. Preliminary bat capture data collected on the WNF during the summer of 2014 suggest relative declines in several previously common species that are now WNS-affected, including little brown bats and NLEBs. The averaged pre-WNS (1997-2008) bat capture rate for all species (6.6 bats per net-night) declined by 75% to1.64 bats per net-night in 2014 (post-WNS). While there is evidence that there may be some persistence of WNS -affected bats on the landscape in the longest affected areas of the northeastern USA (unpublished data, 7th Annual White-Nose Syndrome Workshop, 8-12 Sept 2014, St. Louis, MO), and bats can and do survive and heal from the disease (Fuller et al. 2011), long-term survivorship is difficult to predict due to the newness of the disease.[177]

The state's two largest hibernacula— a closed limestone mine in Preble County near the Indiana border west of Dayton, where nearly 40,000 bats had once been observed, and a shuttered mine in Lawrence County near Ohio's southern tip— have been particularly hit hard, both with population declines exceeding 90%.[178]

The potential for white-nose syndrome to wipe out the Indiana bat and other bat species in large parts of its range makes these species' population much more sensitive to other threats, including oil and gas development. It is therefore crucial to reduce these threats. In addition, these species' very low reproductive rates prevent them from recovering quickly from population declines associated with white nose syndrome and other threats.

c. Climate Change

Climate change is also projected to shift the Indiana bat's range, because the species' reproductive cycles, hibernation patterns, and migration are closely linked to temperature. Climate change is expected to result in increasing temperatures throughout the Midwest.[179]

One landmark study projects that warming summer temperatures will cause "maternity colonies in the western portion of the range [including Ohio]…to begin to decline and possibly

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[177] Wayne National Forest Supervisor's Office Letter to Dan Everson U.S. Fish and Wildlife Service initiating formal conferencing for the northern long-eared bat, 5 (February 19, 2015) ("WNF 2015").
[178] *Id.*; Lyttle 2016.
[179] Pryor, S. C., et al., Ch. 18: Midwest. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 418-440 (2014), doi:10.7930/J0J1012N.

disappear in the next 10–20years," causing the range to shift northeast-ward.[180] The researchers note that "the effects of climate change should be considered in future threats analyses and conservation strategies for the Indiana bat," and that "management actions which foster high reproductive success and survival…will be critical for the conservation and recovery of the species."[181] One conservation strategy that could increase reproductive success and survival of the Indiana bat is protection of interior forest habitat, including maternal roosting areas. The 2006 Forest Plan EIS notes studies showing that the Indiana bat increases its use of roosts in interior forest during unusually warm or rainy weather.[182] Climate change is likely to increase the frequency of heat waves and heavy downpours in Appalachia.[183]

In addition, increasing temperatures and stream flows declines (especially in drought-prone areas) are expected to reduce reproductive rates of insectivorous bat populations, such as little brown bats, due to reduced water availability for lactating females, which need more water than non-lactating females.[184] Other threats from climate change include warmer winters stimulating increased winter activity, which could deplete limited energy reserves and lead to starvation; extreme weather events such as heat waves, which could lead to mass mortality; and the increased prevalence of fungal disease (including white-nose syndrome), the spread of which may be exacerbated by increased arousals and energetic stress.[185]

2. Eastern Hellbender

The Eastern hellbender is an extremely rare salamander found in the Little Muskingum River in the Wayne's Marietta Unit,[186] and is currently under consideration for listing under the Endangered Species Act. This species needs high-quality streams, such as those in the Little Muskingum River watershed, and is highly sensitive to development and degradation of its stream habitat. New research has shown that higher populations correspond with higher forest cover levels, likely due to the fact that increased development increases sedimentation and degradation of habitat, as explained further in Exhibit C on pages 8, 10-12. Accordingly, increased sedimentation and runoff from forest-clearing and industrial development could be detrimental to populations in the Lower Muskingum River. The Eastern hellbender, like other amphibian species, is also extremely vulnerable to climate change, as further explained in Exhibit C on page 19, and could experience reductions in its habitable range.

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[180] Loeb, Susan C.& Eric A. Winters, Indiana bat summer maternity distribution: effects of current and future climates, Ecology and Evolution 2013; 3(1):103–114, *available at* http://onlinelibrary.wiley.com/doi/10.1002/ece3.440/abstract.
[181] *Id.*
[182] 2006 Forest Plan EIS F1-23; *see also* Miller, Nancy E., et al., Summer Habitat in Northern Missouri, The Indiana Bat: Biology and Management of an Endangered Species (2002), 166-67.
[183] USFS, Central Appalachians Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the Central Appalachians Climate Change Response Framework Project (2015), 78, 81-83.
[184] Adams, Rick A., Bat reproduction declines when conditions mimic climate change projections for western North America, Ecology, 91(8), 2010, pp. 2437-2445.
[185] Sherwin, Hayley A., et al., The impact and implications of climate change for bats, Mammal Review (2012).
[186] *See* USFS, Little Muskingum Rive Aquatic Survey, https://www.fs.usda.gov/detail/r9/home/?cid=fsm9_006081; BLM, Final Environmental Assessment, NEPA #: DOI-BLM-Eastern Statess-0030-2016-0002-EA, Oil and Gas Leasing, Wayne National Forest, Marietta Unit of the Athens Ranger District, Monroe, Noble, and Washington Counties, Ohio (Oct. 2016), p. 50 available at https://eplanning.blm.gov/epl-front-office/projects/nepa/53939/95291/115246/Final_EA_Wayne_NF_Marietta_Unit_updatedversion.pdf.

3. Pink Mucket Pearly Mussel, Fanshell, Snuffbox, and Sheepnose

Water depletions, surface disturbance and resulting sedimentation and runoff (from both private and federal surface activities), and toxic spills and leaks all pose threats to mussel species found in the Wayne National Forest or downstream of the forest.

The endangered snuffbox mussel and sheepnose mussel may be present in waterways within the Wayne National Forest.[187] The fanshell is found immediately downstream of the Marietta Unit in the Belleville and Racine pools of the Ohio River in Wood County, West Virginia and in the lower Muskingum River.[188] And the pink mucket has been found in the Belleville, Racine, Gallipolis, and Greenup pools of the Ohio River and potentially still exists in the lower Muskingum River; its distribution is presumed to be in Gallia, Meigs, Morgan, Washington, and Lawrence counties.[189] The fanshell and pink mucket's host fish are also found within the Wayne National Forest. Because the host fish may move between the streams in the Wayne and the Ohio River, they may play a role in the life cycle of these mussels.[190] Accordingly, any impacts to these fish species could also harm the endangered mussels that depend on these fish. For example, a spill that wiped out a large proportion of host fish in the Wayne National Forest, could reduce the number of host fish in the Ohio River and undermine the pink mucket and fanshell's ability to carry out their full life cycle.

Recent studies also show that climate change may be accelerating mussel population declines by reducing their habitable range. Increased warming in the future is likely to reduce their ranges even more.[191] Higher water temperatures could also reduce the survival and growth of juvenile mussels.[192] The ability of species to adapt to higher temperatures will depend on their sensitivity to heat, but thermal sensitivity of particular species is poorly understood. Given these uncertainties, the Forest Service should reduce other threats to mussel species in the Wayne to increase their chances of recovery and survival in a warming climate.

F. The Forest Planning Process Should Be Guided by the Specific Conditions and Management Needs of Each Forest Unit and its Watersheds

The Wayne National Forest is composed of three non-contiguous units spanning twelve counties, each with different resources, plant and wildlife species, and management challenges. Accordingly, each unit should be managed according to its specific resource conditions. For example, the Athens and Ironton units suffer higher levels of stream impairment due to pollution and acid mine drainage from previous mining, while the Marietta Unit's Little Muskingum River basin contains many highly pristine waterways, but suffers from agricultural-related nonpoint source pollution. In addition, the Ironton Unit contains the largest areas of intact interior forest of all three units, making it especially important for interior forest species.

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187 BLM, Final Programmatic Environmental Assessment, Oil and Gas Leasing, Wayne National Forest, Marietta Unit of the Athens Ranger District, Monroe, Noble, and Washington Counties, Ohio (Oct. 2016), at 49.
188 Forest Plan EIS, Appendix F1, Biological Assessment at F1-112.
189 *Id*. at F1-126 – F1-127.
190 *Id*. at F1-116, F1-122.
191 Bolotov, Ivan N., et al. Climate Warming as a Possible Trigger of Keystone Mussel Population Decline in Oligotrophic Rivers at the Continental Scale, Scientific Reports, (2018) 8:35, doi:10.1038/s41598-017-18873-y.
192 Ganser, Alissa M., et al., The effects of elevated water temperature on native juvenile mussels: implications for climate change, Freshwater Science, 2013, 32(4):1168-1177, doi: 10.1899/12-132.1.

The 2006 Forest Plan, however, projects and analyzes forest-wide development levels for the entire forest without regard to the differences between each unit and its resources. For example, under the 2006 Forest Plan, 50 acres of utility corridor development is allowed across the entire forest, but this forest-wide cap fails to take into account the different impact this level of development would have in the Marietta Unit's high-quality watersheds compared to the Athens or Ironton Units, or the difference in fragmentation effects between development in the Ironton Unit's large blocks of interior forest versus more fragmented management areas. The revised forest plan should set limits on development for each management area and/or watershed according to the specific local resource conditions and management needs of each area or watershed, rather than treat all development acreage allowances as interchangeable.

Finally, with respect to oil and gas development, the Forest Service must identify all lands that could be potentially leased for oil and gas development on a map (including reserved or outstanding mineral interests underlying federal surface that could transfer to federal ownership in the future). This would inform the Service's identification of areas that should be open or closed to oil and gas development, the areas in which proposed oil and gas stipulations should apply, and alternatives to those proposals—all of which must be identified on maps. *See* 36 C.F.R. § 228.102(c)(1)-(2). The current Forest Plan does not provide these required maps. The maps would in turn inform an environmental effects analysis of each alternative, and facilitate meaningful public disclosure of specific resources that could be impacted by oil and gas development.

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In conclusion, we urge the Forest Service to put an end to oil and gas leasing and fracking in the Wayne National Forest by considering and adopting a no-leasing and no-fracking alternative in its Forest Plan revision. Numerous studies and new information show that opening up new areas to oil and gas leasing and fracking will detrimentally impact climate change, air quality, public health, water resources, seismicity, and wildlife.

Thank you for considering our concerns.

Sincerely,

Wendy Park, Senior Attorney
Center for Biological Diversity
1212 Broadway, #800
Oakland, CA 94612
510-840-7138
wpark@biologicaldiversity.org

Nathan Johnson, Director, Public Lands
Ohio Environmental Council & OEC Action Fund
1145 Chesapeake Avenue, Suite I
Columbus, 43212
(614) 487-5841
NJohnson@theOEC.org

Heather Cantino, Steering Committee Chair
Athens County Fracking Action Network
Athens, Ohio
acfanohio@gmail.com

Roxanne Groff, Chair
Buckeye Environmental Network
14222 Marietta Run Road
Amesville, Ohio 45711
roxannegroff1227@gmail.com

David Nickell, Chair
Heartwood
P.O. Box 1926
Bloomington, IN 47402
info@heartwood.org

Elly Benson
Staff Attorney
Sierra Club
2101 Webster Street, Suite 1300
Oakland, CA 94612
415-977-5753

Loraine McCosker
Sierra Club, Ohio Chapter
loraine.mccosker@gmail.com
https://www.sierraclub.org/ohio

Becca Pollard, Co-founder
Keep Wayne Wild
keepwaynewild@gmail.com