[redacted]

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Submitted via: comments-eastern-wayne-ironton@fs.fed.us

RE: The Sunny Oaks Project and Oak Management in Southeast Ohio

Dear Rachel,

The [redacted] submits the following oak management literature review as comment on the Wayne National Forest's proposed Sunny Oaks Project. The studies cited herein are being submitted under separate cover.

In addition, [redacted] endorses and herein incorporates by reference the January 11, 2019 comments submitted on behalf of the [redacted] (attached).

The [redacted] also intends to submit further comments pursuant to the recently extended comment deadline for this project. Both alternatives, as proposed, require full NEPA analysis in an environmental impact statement (EIS).

Thank you for your consideration.

Sincerely,

[redacted]

"If oak is the king of trees, as tradition has it, then the white oak, throughout its range, is the king of kings."
–Donald Peattie, A Natural History of Trees of Eastern and Central North America (1991).

"White oak is the standard by which all other oaks are measured. The majesty of a mature tree warrants pause for reflection."
–Michael Dirr, Dirr's Encyclopedia of Trees and Shrubs (2011).

"White oak (*Quercus alba*) is an outstanding tree among all trees."
–Burns & Honkala, Silvics of North America. Vol. 2: Hardwoods (1990).

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

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

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

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

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

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

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

The unique characteristics and survival strategies of white oak – slow rate of growth, shade tolerance, notably poor stump sprouting ability at maturity (Brose et al. 2008), and exceptionally long lifespan – make it an especially poor competitor in aggressive even-age harvest regimes (Abrams 2016; Swaim et al. 2018; Hutchinson et al. 2012; Rebbeck et al. 2011; Dillaway et al. 2007; Abrams 2003).

Clearcutting is a major driver of oak ecosystem loss, generally. Robust emerging data shows that silvicultural (and commercial) clearcutting consistently and dramatically accelerates the decline of oak ecosystems in the Central Hardwood Region (Steiner et al. 2018; Dey 2014; Swaim et al. 2018; Swaim et al. 2016; Morrissey et al. 2010).

E. White Oak recruits best in small gaps.

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

In southeast Ohio, light levels of between 6 – 18% (achieved via prescribed fire alone or in combination with thinning treatments) have been shown to successfully grow oak seedlings; light levels above 18% may favor oak competitors and thereby disfavor oak regeneration (Iverson et al. 2017; Hutchinson et al. 2012; see also, Parrott et al. 2011).

F. The 2006 Forest Plan does not adequately reflect current scientific understanding of silvicultural prescriptions for oak management.

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

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

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

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

2. Shelterwood prescriptions

In addition, shelterwood treatments generally fail to increase oak stocking density and distribution and provide excessive light levels that favor competing species. Best available science holds that shelterwood treatments: (1) generally cannot correct for an initial lack of oak seedling numbers and spatial distribution (Steiner et al. 2008; Brose et al. 2008; Vickers et al. 2019; Hutchinson et al. 2016; Dey 2014; Schuler and Miller 1995; Loftis 1990), and (2) are not the best method for enhancing the size of oak seedlings (see Iverson et al. 2017). This is noteworthy because the 2006 Forest Plan incorrectly assumes that shelterwood treatments are the likely best option when oak seedlings are small, scarce, or absent: "When oak advanced reproduction is small, scarce, or absent, the shelterwood regeneration method will most likely produce the best results." 2006 Forest Plan Appendix E, at E-7 and 8.

3. Clearcut prescriptions

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

Sufficient numbers and distribution of competitive (large) oak seedlings and saplings must be in place prior to final overstory removal for oak regeneration treatments to be successful. While this principle has been known for decades (Sander et al. 1976), recent studies further support and highlight the principle (Dey 2014; Dey et al. 2010; Swaim et al. 2018; Swaim et al. 2016; Rebbeck et al. 2011; Loftis 2004). Moreover, this principle is especially important and relevant, given the demonstrated low numbers and sparse distribution of competitive oak seedlings in the Wayne and the region, and given the dramatic recent increase in the Wayne's assigned timber targets. The assessment report should acknowledge these important factors.

Annotated Bibliography: White Oak in Southeast Ohio Forests

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

White oak (*Quercus alba*) is losing volume in Ohio, decreasing 7.3 percent from 2012 levels. Notably, white oak joins the insect-devastated white ash (-21.1%) as the only major tree species experiencing volume declines in the state. By contrast, northern red oak has seen a 9.5% volume increase since 2012.

> SUPPORTING LITERATURE:
> **Albright, Thomas A., "Forests of Ohio, 2017," Resource Update FS-171. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4 p. (2018).**

The decline in Ohio's white oak is driven by unsustainable timber harvest. White oak continues to be removed at rates exceeding net growth. In Ohio, white oak's growth to removal ratio (G:R) is 0.7:1. And, the present rate of unsustainable harvest is accelerating.

> SUPPORTING LITERATURE:
> *See* **Albright, Thomas A., "Forests of Ohio, 2016," Resource Update FS-139. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4 p., at 3 (2017)** (reporting white oak G:R at 0.8:1).

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

Recent scholarship shows that oak, generally, was a stronger component of southeast Ohio's canopies prior to European settlement than it is today.

> SUPPORTING LITERATURE:
> *See* **Deines et al., "Changes in Forest Composition in Ohio Between Euro-American Settlement and the Present,"** ***Am. Midl. Nat.,*** **176:247-271 (2016)** (Table S3, page 270: Presettlement forest composition of Gallia County = 59.4% "Oak"; Lawrence County = 57.0% "Oak"; Table S4, page 271: Modern era forest composition for Gallia County = 21.1% oak; Lawrence County = 36.5%).

White oak, specifically, dominated the Wayne National Forest's region prior to European settlement, accounting for 40% of witness trees in southeast Ohio.

> SUPPORTING LITERATURE
> *See, e.g.,* **Abrams, Marc D., "Where Has All the White Oak Gone?,"** ***BioScience,*** **Volume 53, Issue 10, 1 October, Pages 927–939, at 927 (2003)** ("Before European settlement, oak was the dominant genus in the forests throughout much of what is now the eastern United States. Among the oaks, white oak (*Quercus alba*) reigned supreme."); **<u>Dyer, James M., "Using witness trees to assess forest change in southeastern Ohio,"</u>**

***Can. J. For. Res.* 31: 1708-1718, at 1711 (2001)** ("The presettlement forests of southeastern Ohio were dominated by white oak, which accounted for 40.0% of all witness trees. White oak is still the most abundant species today, but it accounts for only 14.5% of trees [per 1991 FIA data]."); **Abrams, M.D., "History of eastern oak forests," in Keyser, et al., Managing Oak Forests in the Eastern United States, at 13 (2016)** ("Another casualty of the clearcut era [1870-1920] was white oak, one of the east's most dominant tree species, which declined in many eastern forests between the presettlement and present day. This decline is attributed to white oak not being as well adapted to intensive disturbance regimes compared to northern red oak and chestnut oak.").

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

An emerging trend in the best available oak management science is the acknowledgement that individual oak species have their own individual management needs and requirements. The 2006 Forest Plan and FEIS do not account for this important development in scientific understanding, and instead treat "oak" and "oak-hickory" as a uniform management category.

SUPPORTING LITERATURE:
See, e.g., **Keyser, et al., Managing Oak Forests in the Eastern United States, at 20 (2016)** ("Due to the sheer number of oak species found in the United States, a variety of management strategies are required because each species has individual requirements for proper management."); **Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? Growth and biomass," *Canadian Journal of Forest Research*, Vol. 41, pp. 2219-2230, at 2226 (2011)** ("Although it is well known that different oak species, even those found within the eastern deciduous biome, differ in shade tolerance, drought resistance, productivity, and longevity (Burns and Honkala 1990), management recommendations to promote advance reproduction are often developed as though they are a single species." At p. 2226. "Forest management treatments should consider these [shade tolerance and seedling growth rate] differences among oak species. When these [northern red, white, and chestnut] oaks occur together in mixed stands, it will be difficult to develop a prescription that benefits each species' needs." At p. 2228); **Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? II. Gas exchange and chlorophyll responses," *Canadian Journal of Forest Research*, Vol. 42, pp. 1025-1037 (2012)** ("[W]hite oak appears to have the potential to maintain positive carbon gain under denser shade compared with either chestnut or northern red oak seedlings. White oak's physiological attributes as well as its slow growth and extended longevity (up to 600 years) support a survival strategy that is unique to that of other upland oak species." At p. 1035; "To target white oak seedling regeneration, we propose that light levels need not be increased above 18% of full sun; to target chestnut and northern red oaks, light levels need not be increased above 25% of full sun." At p. 1035); **Hutchinson et al., "Repeated prescribed fires alter gap-phase regeneration in mixed-oak forests," *Can. J. For. Res.* 42: 303-314, at 312 (2012)** ("Of the five common upland oaks in our region, white oak is the most shade tolerant and our findings suggest that white oak seedlings were able to persist in the burned stands prior to gap formation, despite relatively low-light conditions, and then exhibited significant

height growth after gap formation."); **Abrams, Marc D., "Where Has All the White Oak Gone?," *BioScience*, Volume 53, Issue 10, 1 October, Pages 927–939, at 928 (2003)** ("[T]here is evidence of a dramatic decline in white oak forests from presettlement to the present day. In contrast, red oak (*Quercus rubra*) and chestnut oak (*Quercus prinus*), which were not nearly as important as white oak in the presettlement forest, increased significantly during and after the 19th century. […] It has been reported that white oak, which grows more slowly, did not recover from catastrophic disturbances as well as some other eastern oak species. […] Anthropogenic impacts during the late 19th and early 20th centuries were tantamount to a 'perfect storm' for most forests in the eastern United States. This period represented both the height and the tail end of the clear-cutting era and the catastrophic wildfires that followed, the state of the Smokey the Bear era of fire suppression, and the beginning and peak of the chestnut blight. In response, white oak has declined while other oaks have prospered.").

The slow growth rates, shade tolerance, and long lifespans of white oaks are not adequately accounted for in the 2006 Forest Plan and FEIS. These unique white oak characteristics are material to management considerations, and should therefore receive greater attention in the revised plan.

SUPPORTING LITERATURE:
Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? Growth and biomass," *Canadian Journal of Forest Research*, Vol. 41, pp. 2219-2230 (2011) ("White oak seedlings were the slowest growers and demonstrated the most root-centered growth, with root to shoot ratios almost twice that of either chestnut or northern red oak seedlings. […] These differences need consideration when developing oak management prescriptions for specific oaks." At abstract. "Differences in seedling (shoot plus root) mass were quite dramatic with chestnut and northern red oak seedlings averaging 16.8 ± 0.4 g compared to white oak averaging 8.8 ± 0.4 g. This nearly twofold difference in seedling mass validates the slow-growth survival strategy of white oak. […] Forest management treatments should consider these differences among oak species. When these oaks occur together in mixed stands, it will be difficult to develop a prescription that benefits each species' needs." At p. 2228. "The slow-growing white oak may be able to persist longer in low-light conditions by developing a root system that will accumulate stored carbohydrates and be poised to respond to a light-creating disturbance. In stands with either a shelterwood cut or a final removal harvest, the slow-growing white oak would not persist but would instead be overtopped and outcompeted by faster growing neighbors. In stands with no immediate harvest planned (e.g., 10-20 years), multiple low-intensity burns over several years or herbicide application to the understory and midstory could be used to increase the competitive status of white oak regeneration by reducing the density of the sapling layer. The vigor and competitiveness of white oak regeneration would improve as it developed a larger root system in these relatively low-light environments. […] If regeneration of a white oak stand is the desired goal, then the implementation of a slower, more gradual approach to opening up the canopy may be necessary." At p. 2229); **Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? II. Gas**

exchange and chlorophyll responses," ***Canadian Journal of Forest Research*, Vol. 42, pp. 1025-1037 (2012)** ("The white oak seedlings in the current study allocated about three times more carbon to root systems compared with either chestnut or northern red oak. […] White oak seedlings were able to maintain a positive carbon balance in dense shade." At p. 1032. White oak had the lowest respiration rates, and had maximum carbon exchange rates in 6% of full sun. At p. 1034. For all three species, "the light saturation point of photosynthesis occurred between 18% and 25% of full sun, although white oak grown at lower light levels displayed some plasticity. […] This suggests that the photosynthetic capacity is saturated with no additional benefits afforded to oaks. If light levels are higher, only faster-growing shade intolerant competitors such as red maple and black cherry, which display more plastic growth responses, would benefit." At p. 1035); **Burns & Honkala, Silvics of North America. Vol. 2: Hardwoods. USDA For. Serv., Agri. Handbk. 654, Washington, DC. pp. 605-613 (1990)** ("White oak (*Quercus alba*) is an outstanding tree among all trees[.]" At p. 605. "White oak can produce seeds prolifically, but good acorn crops are irregular and occur only every 4 to 10 years. […] The area seeded by individual trees is small and therefore widespread reproduction depends on adequate distribution of seedbearing trees. […] white oak seedlings established at the time of overstory removal normally grow too slowly to be of value in stand reproduction." At p. 608. Individual trees have been recorded at 600 years old. At p. 609. "White oak is generally classed as intermediate in tolerance to shade. It is most tolerant in youth and becomes less tolerant as the tree becomes larger. White oak seedlings, saplings, and even pole-size trees are nevertheless able to persist under a forest canopy for more than 90 years. […] White oak usually becomes dominant in the stand because of its ability to persist for long periods of time in the understory, its ability to respond well after release, and its great longevity." At p. 610); **McShea & Healy, Oak Forest Ecosystems: Ecology and Management for Wildlife, at p. 193 (2002)** (Because white oak acorns germinate in the fall, they are typically not dispersed long-distances by animal agents such as jays. Unlike red oaks, white oak reproduction generally remains in clumps near and around parent trees. This is evidenced in the greater clumping of white oak seedlings and adult trees, and in the greater shade tolerance of young white oaks.).

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

The unique characteristics and survival strategies of white oak – slow rate of growth, shade tolerance, poor stump sprouting ability at maturity, and exceptionally long lifespan – make it a poor competitor in aggressive even-age harvest regimes.

SUPPORTING LITERATURE:
See, e.g., **Abrams, M.D., "History of eastern oak forests," in Keyser, et al., Managing Oak Forests in the Eastern United States, at 13 (2016)** ("Another casualty of the clearcut era [1870-1920] was white oak, one of the east's most dominant tree species, which declined in many eastern forests between the presettlement and present day. This decline is attributed to white oak not being as well adapted to intensive disturbance regimes compared to northern red oak and chestnut oak."); **Swaim et al., "Overstory species response to clearcut harvest across environmental gradients in hardwood**

forests," *Forest Ecology and Management* 428: 66-80, at 71 (2018) (Although all oak declined sharply after clearcut harvests in southern Indiana, white oak was especially hard hit in some locations: "In post-harvest stands, *Q. alba* nearly disappeared altogether on poor sites (steeper slopes and low pH)[.]"); **Hutchinson et al., "Repeated prescribed fires alter gap-phase regeneration in mixed-oak forests," *Can. J. For. Res.* 42: 303-314, at 312 (2012)** ("[T]he successful regeneration of white oak is often more difficult than that of other upland oaks, particularly in even-aged management systems, due to its slow juvenile growth rates."); **Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? Growth and biomass," *Canadian Journal of Forest Research*, Vol. 41, pp. 2219-2230, at 2229 (2011)** ("In stands with either a shelterwood cut or a final removal harvest, the slow-growing white oak would not persist but would instead be overtopped and outcompeted by faster growing neighbors. […] If regeneration of a white oak stand is the desired goal, then the implementation of a slower, more gradual approach to opening up the canopy may be necessary."); **Abrams, Marc D., "Where Has All the White Oak Gone?," *BioScience*, Volume 53, Issue 10, 1 October, Pages 927–939, at 928 (2003)** ("It has been reported that white oak, which grows more slowly, did not recover from catastrophic disturbances as well as some other eastern oak species. […] Anthropogenic impacts during the late 19th and early 20th centuries were tantamount to a 'perfect storm' for most forests in the eastern United States. This period represented both the height and the tail end of the clear-cutting era and the catastrophic wildfires that followed, the state of the Smokey the Bear era of fire suppression, and the beginning and peak of the chestnut blight. In response, white oak has declined while other oaks have prospered."); **Dillaway et al., "Light availability influences root carbohydrates, and potentially vigor, in white oak advance regeneration" *Forest Ecology and Management* 250, pp. 227–233 (2007)**; **Brose et al., "Prescribing Regeneration Treatments for Mixed Oak Forests in the Mid-Atlantic Region," U.S. Forest Service, General Technical Report NRS-33 (2008)**, *see* Table 3.2 (p. 25) (taken from Sander, Johnson, & Watt, "A Guide for Evaluating the Adequacy of Oak Advance Reproduction," U.S. Forest Service, General Technical Report NC-23 (1976)).

Table 3.2.—Expected percentage of oak stumps that will sprout after cutting

	D.b.h of parent tree (inches)			
Species	2 to 5	6 to 11	12 to 16	17+
Black oak	85	65	20	5
Chestnut oak	100	90	75	50
Northern red oak	100	60	45	30
Scarlet oak	100	85	50	20
White oak	80	50	15	0

Clearcutting is a major driver of oak ecosystem loss. Robust emerging data shows that silvicultural (and commercial) clearcutting consistently and dramatically accelerates the decline of oak ecosystems in the Central Hardwood Region.

SUPPORTING LITERATURE:

See, e.g., **Steiner et al., "A test of the delayed oak dominance hypothesis at mid-rotation in developing upland stands,"** ***Forest Ecology and Management*** **408: 1-8, at 2-3 (2018)** (examining 46 oak-dominated stands in Pennsylvania that were clearcut between 1968 and 1976: "Overall, oak declined from a pre-harvest average of 81% of BA to a 4th-decade average of 35%, red maple increased from 8% to 34%, and other species taken together increased from 11% to 31%. […] [These shifts] were strongest in the ApPl [Appalachian Plateau Province], where oak declined from 78% to 6% and red maple increased from 16% to 58%."); **Dey, Daniel C., "Sustaining Oak Forests in Eastern North America: Regeneration and Recruitment, the Pillars of Sustainability,"** ***For. Sci.*** **60(5): 926 –942, at 929 (2014)** ("Since the 1950s, it has been increasingly observed that clearcutting Eastern oak forests was resulting in stands being dominated by, in particular, yellow-poplar and red maple."); **Swaim et al., "Overstory species response to clearcut harvest across environmental gradients in hardwood forests,"** ***Forest Ecology and Management*** **428: 66-80, at 67, 73, and 78 (2018)** ("[Clearcutting] was frequently viewed as a panacea for regenerating *Quercus* species and was implemented across much of the eastern United States from the 1960s through the 1980s. Subsequent observations in post-harvest stands often found composition shifting away from *Quercus* domination towards a mix of hardwood species, raising concerns about the efficacy of clearcutting. […] Results from this long-term study illustrate a dramatic shift in species composition 23 years after clearcutting on the HNF. Following overstory removal, all stands experienced decreased importance of *Quercus* and *Carya* species and increased importance of other species including *A. rubrum*, *L. tulipifera*, *P. grandidentata*, and *P. serotina*. This corresponds with other reports of poor competition by *Quercus* species following clearcut harvests in southern Indiana and elsewhere in the CHR [Central Hardwood Region]. […] If clearcut harvesting continued throughout the CHR, then it is likely that *Quercus* would continue to decrease in importance, and with each forest rotation there would be fewer and fewer *Quercus* stems until the genus is lost or relegated to the status of a minor associate in the new forest types. As the number of seed-bearing *Quercus* trees decrease in the overstory from one rotation from the next, the likelihood of abundant oak advance reproduction decreases. Therefore, relying on *Quercus* stump sprouts to perpetuate *Quercus* in new stands is a losing strategy in the long-term because not all large, older overstory *Quercus* are vigorous sprouters."); **Swaim et al. "Predicting the height growth of oak species (*Quercus*) reproduction over a 23-year period following clearcutting,"** ***Forest Ecology and Management*** **364: 101-112, at 101-102 and 108 (2016)** ("During the late 20th century, silvicultural clearcutting was used extensively across the hardwood forests of the eastern United States. A major goal of this management technique was to regenerate new stands of shade intolerant and mid-tolerant species, typically aspen and oak species, respectively. […]Subsequent research has shown that the past widespread use of silvicultural clearcutting failed to perpetuate oak dominance, especially on productive sites. […] Due to the lack of large oak advanced reproduction, clearcut stands in southern Indiana have shifted away from the oak-dominated forests that existed before harvest."); **Morrissey et al., "Overstory species composition of naturally regenerated clearcuts in an ecological classification framework,"** ***Plant Ecology*** **208:21–34 (2010).**

E. <u>White Oak recruits best via small gaps.</u>

Recent best available science demonstrates that white oak establish well in small canopy gaps, and that, historically, white oak attained landscape dominance by recruiting in small canopy gaps (~ $1/20^{th}$ an acre).

SUPPORTING LITERATURE:
Hutchinson et al., "Repeated prescribed fires alter gap-phase regeneration in mixed-oak forests," *Can. J. For. Res.* 42: 303-314 (2012) (studying canopy gaps created by white oak mortality in Ohio's Vinton Furnace State Experimental Forest, and finding robust white oak regeneration in repeatedly burned small canopy gaps of $1/20^{th}$ to $1/10^{th}$ of an acre: "We found that larger white oak regeneration was abundant in moderate-sized canopy gaps (200-400 m^2) [$1/20^{th}$ to $1/10^{th}$ of an acre] that had been burned repeatedly prior to gap formation. Although uneven-aged management is not typically used in oak forests, our results suggest that for white oak, the most shade tolerant of the upland oaks, the use of repeated burns prior to the creation of moderate-size canopy openings may be a feasible regeneration strategy. Periodic fires coupled with natural canopy openings of various sizes are thought to have sustained the presettlement-era dominance of white oak across much of the eastern United States." At p. 312. The percentage of full sunlight was significantly greater in burned gaps (18.7%) than in unburned gaps (7.3%). At p. 307. The burned stands had more large oak regeneration and also much lower levels of shade intolerant saplings and poles. At p. 310); **McEwan et al., "Fire and gap dynamics over 300 years in an old-growth temperate forest," *Applied Vegetation Science* 17: 312-322, at pp. 319-320 (2014)** (proposing that gap dynamics combined with fire drove centuries-long white and chestnut oak dominance on the Cumberland Plateau in Kentucky); **Buchanan, Megan L. & Hart, Justin L., "Canopy disturbance history of old-growth *Quercus alba* sites in the eastern United States: Examination of long-term trends and broad-scale patterns," *Forest Ecology and Management* 267: 28-39 (2012)** (analyzing tree-ring series from 44 *Quercus alba* old-growth sites located throughout the species' distributional range, and finding that "70% of the [884] sampled *Q. alba* trees never experienced a large gap-scale disturbance" and instead recruited in small gaps. At p. 34. Of the 30% of white oaks (269 of 884) that did experience a "large gap-scale" release – which might roughly equate to a group opening or shelterwood treatment – only 144 (16% of 884) experienced the release within 50 years of establishing. At pp. 30, 34, and 37-38); **Rentch et al., "Spatial and temporal disturbance characteristics of oak-dominated old-growth stands in the central hardwood forest region," *For. Scie*. 49(5): 778-789 (2003)** (Examining spatial and temporal disturbance characteristics of five oak-dominated old-growth stands in the central hardwood region, and finding that most oaks recruited via small canopy openings less than or equal to $1/20^{th}$ an acre in size: "Large (> 1000 m^2) [i.e., > $1/5^{th}$ an acre] canopy gaps were identified; however, most oaks recruited via smaller (≤ 200 m^2) [i.e., ≤ $1/20^{th}$ an acre] canopy disturbances involving two or more trees that occurred, on average, every 16 yr. These trees also reached overstory positions without being overtopped. However, in contrast to the even-aged structure resulting from stand-initiating events, these disturbances resulted in a spatially and temporally dispersed multicohort age structure. This disturbance regime is also consistent with conditions that

are favorable to the establishment of shade-tolerant species […] Most silvicultural prescriptions for oak forests propose even-aged management. […] Yet, the variety of growth strategies exhibited by these old trees, and the age structures of these stands, suggest that persistent human use of fire, coupled with the frequent creation of canopy openings of various sizes, were integral components of the historic fire disturbance regimes of these forests, and the key to establishment and survival of a competitive oak understory, and eventual accession of oaks into the overstory." At p. 787); **Abrams, Marc D., "Where Has All the White Oak Gone?,"** ***BioScience*****, Volume 53, Issue 10, 1 October, Pages 927–939 (2003)** ("Some understory white oaks are nearly a century old. As this and many other old-growth white oak forests are uneven-aged, I believe that this species routinely recruited in small to moderate canopy gaps before European settlement, with adequate regeneration maintained through periodic burning." At p. 935. "Before European settlement, white oak grew successfully in uneven-aged forests. Periodic fires kept populations of fire-sensitive, later-successional species at a minimum and allowed adequate oak regeneration (including seedling sprouts) to persist. When a gap in the overstory was formed by natural disturbance or the death of an old tree, the understory white oaks, which could persist for up to a century, would respond by growing toward the canopy. […] Paleoecological and dendroecological evidence suggests that the process of fire and gap-phase regeneration in white oak forests went on for many hundreds and thousands of years." At p. 937); **Parrott et al., "Effects of midstory removal on underplanted black oak and white oak in the western Cumberland Plateau" Gen. Tech. Rep. NRS-P-78 (2011).**

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

SUPPORTING LITERATURE:
Iverson, L. R., T. F. Hutchinson, M. P. Peters, and D. A. Yaussy, "Long-term response of oak-hickory regeneration to partial harvest and repeated fires: influence of light and moisture." ***Ecosphere*** **8(1) (2017)** (13-year longitudinal study over two areas in southeast Ohio. The study evaluated the influences of topography, moisture, burn intensity, thinning, and competition on regeneration response. "Based on this study, we recommend for topographically appropriate dry and intermediate sites, a partial harvest [i.e., thinning] followed by two or three dormant-season fires (depending on fire intensity) allowing roughly 6-18% light to penetrate the forest floor. This will promote oak-hickory into the advanced oak regeneration status." At abstract. "Mesic plots rarely attained greater numbers regardless of light levels, but wherever open sky was >6% on intermediate and dry plots, there were substantial gains in large oak-hickory seedlings through time."At p. 12. "Canopy openness in the range of 6—18% was sufficient to promote oak-hickory regeneration. Opening the canopy above that, for example, >24% open sky through high-intensity fire, though also resulting in abundant large oak-hickory seedlings, is not necessary." At p. 18. "light levels >6% open sky were frequently sufficient for successful oak-hickory advancement." At p. 19. "Our key findings and recommendations including the following: (3) increase canopy openness to between 6%

> and 18%—less light prevents oak-hickory growth while greater light levels may favor shade-intolerant competitors; […] (5) patience is required in restoring oak-hickory—long-term management strategies and investments are required[.]" At p. 20); **Hutchinson et al., "Repeated prescribed fires alter gap-phase regeneration in mixed-oak forests,"** ***Can. J. For. Res.*** **42: 303-314 (2012)** (studying canopy gaps created by white oak mortality in Ohio's Vinton Furnace State Experimental Forest, and finding robust white oak regeneration in repeatedly burned small canopy gaps of 1/20th to 1/10th of an acre. The percentage of full sunlight was significantly greater in burned gaps (18.7%) than in unburned gaps (7.3%). The burned gaps had more large oak regeneration and also much lower levels of shade intolerant saplings and poles.).

F. <u>The 2006 Forest Plan does not adequately reflect current scientific understanding of silvicultural prescriptions for oak management.</u>

The 2006 Forest Plan (at Appendix E-12 and E-21) concludes that uneven-age harvest methods are inferior to even-age methods for regenerating oak, including white oak (*Quercus alba*). These conclusions should be revised, because best available scientific information demonstrates that seedlings of the relatively shade tolerant white oak best establish and recruit in small gaps.

> Regarding Single Tree Selection, the Forest Plan inaccurately states: "High levels of sun light are required for the survival and growth of advanced oak regeneration, and these light conditions cannot be achieved by the single tree selection method. (Fischer, 1979)" At p. E-12.
>
> Regarding Group Selection, the Forest Plan inaccurately states: "This method of cutting would likely result in the oak component of the future stand to be […] less than the component created with even-aged treatments. One reason for the less effective oak regeneration is the large amount of edge in each group. The more mesic and shade-tolerant species would have an advantage along these shaded edges, while the oaks may thrive in the centers and northern edges of each group. Eventually, the amount of oak in the entire stand will decrease so that only the dry south slopes and ridgetops would be stocked with significant numbers of oaks." At p. E-21.
>
> SUPPORTING LITERATURE:
> *See, e.g.*, Appendix Sections 3, 4, and 5 and supporting literature, above.

Shelterwood treatments generally fail to increase oak stocking density and distribution, and provide excessive light levels that favor competing species. Best available science holds that shelterwood treatments: (1) generally cannot correct for an initial lack of oak seedling numbers and spatial distribution (Steiner, et al. 2008), and (2) are not the best method for enhancing the size of oak seedlings (*see* Iverson, et al. 2017).

The above points are noteworthy because the 2006 Forest Plan incorrectly assumes that shelterwood treatments are the likely best option when oak seedlings are small, scarce, or absent: "When oak advanced reproduction is small, scarce, or absent, the shelterwood regeneration method will most likely produce the best results." 2006 Forest Plan Appendix E, at E-7 and 8.

SUPPORTING LITERATURE:

See, e.g., **Steiner et al., "Oak Regeneration Guidelines for the Central Appalachians,"** ***Northern Journal of Applied Forestry*** **25(1), at 11 (2008)** ("Although the growth of established oak seedlings can be expected to accelerate after a shelterwood cut (when combined with fencing, if necessary), it is less clear whether managers can depend on periodic acorn crops to increase oak seedling densities. ORSPA results indicate that, without a fortuitous acorn crop, less desirable species may benefit most from the improved growing conditions. In other words, experience shows that shelterwoods often fail to achieve the objective of enhancing oak regeneration. […] [S]helterwoods do little to supplement the oak regeneration cohort unless a heavy seed crop occurs within the 1st or (perhaps) 2nd year after harvest. […] [A] strong component of oak regeneration can not develop without an excellent acorn crop, which can be as infrequent as once in a decade. […] We recommend that shelterwoods be used only in stands in which 65% or more of sample milacre plots contain oak seedlings. Our long-term data set shows clearly that nonsprout regeneration of an oak component was always minimal in stands where this criterion was not met."); **Iverson, L. R., T. F. Hutchinson, M. P. Peters, and D. A. Yaussy, "Long-term response of oak-hickory regeneration to partial harvest and repeated fires: influence of light and moisture."** ***Ecosphere*** **8(1), at 20 (2017)** (recommending that managers use thinning and fire to "increase canopy openness to between 6% and 18%—less light prevents oak-hickory growth while greater light levels may favor shade-intolerant competitors"); **Loftis, David L., "A Shelterwood Method for Regenerating Red Oak in the Southern Appalachians,"** ***Forest Science*** **36:4, pp. 917-929 (1990)**; **Vickers et al., "Using a tree seedling mortality budget as an indicator of landscape-scale forest regeneration security,"** ***Ecological Indicators*****, article in press (2019)**; **Hutchinson et al., "The devil is in the small dense saplings: A midstory herbicide treatment has limited effects on short-term regeneration outcomes in oak shelterwood stands"** ***Forest Ecology and Management*** **372: 189-198 (2016)**; **Schuler and Miller, "Shelterwood treatments fail to establish oak reproduction on mesic forest sites in West Virginia - 10-year results," Gen. Tech. Rep. NE-197, pp. 375-387 (1995)**.

The 2006 Forest Plan states that "clearcutting is the most effective method to regenerate [a] stand to species dominated by oak and hickory […] [when] there are adequate numbers of advanced oak seedlings over 4½ feet tall are vigorous and have well-developed root systems." 2006 Forest Plan Appendix E, at E-6-7. However, this statement contradicts best available scientific information relating to white oak management (*see* Appendix Sections 3, 4, 5, and supporting literature). And, the 2006 Plan does not recognize the severe scarcity of oak reproduction that characterizes the understories of oak-dominated stands in southeastern Ohio and the Central Hardwood Region, generally. Small oak seedlings are relatively rare, and competitive (large) oak seedlings and saplings are exceptionally rare. This severe scarcity means that clearcutting is inappropriate for oak regeneration purposes (let alone white oak regeneration purposes) on almost all sites, including dry and intermediate sites.

SUPPORTING LITERATURE:

See, e.g., **Iverson, L. R., T. F. Hutchinson, M. P. Peters, and D. A. Yaussy, "Long-term response of oak-hickory regeneration to partial harvest and repeated fires: influence of light and moisture."** ***Ecosphere*** **8(1), at 15 (2017)** (Finding only 2% of 237 understory plots in southeast Ohio oak-dominated stands were stocked with competitive oak seedlings, including only 3 of 130 plots on dry to intermediate sites); **Iverson et al., "Spatial modeling and inventories for prioritizing investment into oak-hickory restoration,"** ***Forest Ecology and Management,*** **424: 355-366, at 360-61 (2018)** (Finding that, even on the "Dry Oak" southeast Ohio landform type, only 25% of sample plots were considered "stocked" with oak seedlings, regardless of seedling size or competitive status; and, finding only 10% of plots on the intermediate "Dry-Mesic Mixed Oak Hardwood (DMMOH) forest landtype to be stocked, again, irrespective of seedling size. "For purposes of planning silvicultural interventions at the landscape scale, we developed an Oak Stocking Index (OSI) that emphasized whether or not plots were stocked with oak seedlings rather than their specific stage of development." At. P. 360. Given the exceptional rarity of large oak seedlings and saplings, <u>competitive</u> (large) oak understory stocking is likely far lower on these landscapes than the respective 25% and 10% size-neutral stocking reported.); **Paulus et al., "Structural and compositional shifts in forests undergoing mesophication in the Wayne National Forest, southeastern Ohio,"** ***Forest Ecology and Management*** **430: 413-420 (2018)** (stating with regards to plots sampled in the Wayne National Forest "the relative density of red maple (*Acer rubrum*) large saplings on dry ridges increased 25% [over 22 years], while zero oaks were recorded in the large sapling layer on dry ridges in 2016." At abstract. "While authors have repeatedly predicted oak regeneration to be more successful in areas of low moisture, this has only been demonstrated on truly xeric sites." At p. 418. "Our results support observations that oak regeneration is primarily restricted to dry sites, albeit in low densities, if present at all." At p. 419); **Dey et al., "An Ecologically Based Approach to Oak Silviculture: A Synthesis of 50 Years of Oak Ecosystem Research in North America,"** ***Revista Columbia Forestal Vol.*** **13 (2): 200-222, at 201 (2010)** ("Many oak stands have either few or no oak advance reproduction, and when present, it is small and noncompetitive."); **Dey, Daniel C., "Sustaining Oak Forests in Eastern North America: Regeneration and Recruitment, the Pillars of Sustainability,"** ***For. Sci.*** **60(5): 926 –942, at 931 (2014)** ("Commonly, the sizes of oak advance reproduction in mature forests are small, usually <20 cm tall and 4 mm in basal diameter and have low regeneration potential or are absent altogether, especially on the more productive sites.").

Sufficient numbers of competitive (large) oak seedlings must be present prior to substantial overstory removal in order for oak regeneration to succeed. While this principle has been known for decades, recent studies further support and highlight the principle. Moreover, this principle is especially important and relevant, given the demonstrated low numbers and sparse distribution of competitive oak seedlings in the Wayne and the region.

SUPPORTING LITERATURE:
See e.g., **Dey, Daniel C., "Sustaining Oak Forests in Eastern North America: Regeneration and Recruitment, the Pillars of Sustainability,"** ***For. Sci.*** **60(5): 926 – 942, at 931 (2014)** ("One thing is clear: in a wide range of oak ecosystems throughout eastern North America, sufficient numbers of large (e.g., > 12-mm basal diameter) oak

advance reproduction are required to sustain oak stocking into the future. […] Reliance on oak stump sprouting to sustain current oak stocking is a failed strategy[.]"); **Dey et al., "An Ecologically Based Approach to Oak Silviculture: A Synthesis of 50 Years of Oak Ecosystem Research in North America,"** ***Revista Columbia Forestal Vol.*** **13 (2): 200-222, at 208 (2010)** ("Oak germinants have relatively slow shoot growth even in full sunlight. They are easily suppressed by competing vegetation during stand reinitiation. This is why regenerating stands with abundant but small oak reproduction (< 10 mm basal diameter) that establishes after harvesting succeed to species other than oak."); **Swaim et al. "Predicting the height growth of oak species (*Quercus*) reproduction over a 23-year period following clearcutting,"** ***Forest Ecology and Management*** **364: 101-112, at 108 and 110-11 (2016)** ("Due to the lack of large oak advanced reproduction, clearcut stands in southern Indiana have shifted away from the oak-dominated forests that existed before harvest. In our study, most of the advance reproduction of oak species was <1.2 M tall prior to harvest. This pool of small seedlings remained the shortest of all reproduction present in year 6. […] The height growth winners in year 23 were the same stems that were winning in years 12 and 6. […] Initial height was the best predictor of future height growth in all species, further highlighting the poor competitive status of small oak reproduction."); **Swaim, et al., "Overstory species response to clearcut harvest across environmental gradients in hardwood forests,"** ***Forest Ecology and Management*** **428: 66-80, at 78 (2018)** ("In the current study, Quercus importance drastically decreased following clearcut harvests, likely due to a lack of large advance reproduction that would have competed better in the post-harvest environment."); **Rebbeck, Joanne et. al., "Do chestnut, northern red, and white oak germinant seedlings respond similarly to light treatments? Growth and biomass,"** ***Canadian Journal of Forest Research,*** **Vol. 41, pp. 2219-2230, at 2219 (2011)** ("A continuing problem in the Appalachian region of eastern North America is the sustainability and regeneration of oak species within forests as overstory oaks are eliminated through natural mortality or harvesting. Typically, stand composition shifts to more shade-tolerant species such as red maple and American beech because of an inadequate number of competitive oak seedlings."); **Sander, Johnson, and Watt, "A Guide for Evaluating the Adequacy of Oak Advance Reproduction," USDA Forest Service General Technical Report NC-23, NCFES, at 4-5 (1976)** (noting that oak advanced reproduction with a minimum height of 4.5 feet is the only class that will significantly contribute to future stand composition, and that "It is firmly established that the oak component of new stands following harvest cutting depends on size, number, and distribution of the oak advance reproduction."); **Loftis, David L., "Upland Oak Regeneration and Management," in Spetich, Martin A., ed. "Upland oak ecology symposium: history, current conditions, and sustainability." Gen. Tech. Rep. SRS-73 (2004)**.