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Hoosier
National
Forest

Report for the Houston South Restoration Project

Environmental Assessment

Effects to Vegetation

Travis Swaim

Forest Silviculturist

Hoosier National Forest

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Introduction

The Houston South Project proposes thinning, shelterwood, selection, and clearcut harvests, along with midstory and crop-tree release treatments, in oak-hickory, maple-beech, and pine forest types. The overall project area is approximately 23,363 acres broken into 13,533 acres of National Forest System (NFS) lands and 9,830 acres of non-Forest Service lands. Commercial timber treatments are proposed on 3,971 acres, with another 404 acres of proposed non-commercial treatments. Forest vegetation in this area has changed over the past 100 years due to fire exclusion and lack of surrogate disturbances, creating an increase in the number of small diameter, late-seral tree species (Fig.1). The overarching purpose and need for this project is to perpetuate oak ecosystems on the landscape, remove non-native pine and restore stands to native hardwood species, and to create 4 to 12 percent of the area in young forest habitat as directed in the 2006 Land and Resource Management Plan for the Hoosier National Forest (USDA 2006).

Figure 1. Increasing numbers of small diameter, late-seral species below a chestnut oak canopy.

Located in southern Indiana, the HNF contains approximately 204,000 acres of NFS land. The Forest was established by proclamation in 1935 and became a national forest in 1954. The land is split into two ranger districts: Tell City Ranger District and Brownstown Ranger District. A "checkerboard" mix of public and private lands exist within each district boundary.

The Hoosier comprises approximately 25 percent of the public lands in Indiana and is within a day's drive of several major metropolitan areas including Chicago, Fort Wayne, Indianapolis, Evansville, St. Louis, Louisville, and Cincinnati. Principal routes to the HNF are Highway 37 from the north and south, and Highways 58, 50, 150, and 64 from the east and west.

The Houston South Project is located entirely within Jackson and Lawrence Counties, with approximately 22,559 and 804 acres, respectively. Major travel routes to the project area include Highways 58 and 135. Towns located in the immediate area include Kurtz, Freetown, and Houston.

Regulatory Framework

Forest Plan Direction

- Standards and guidelines for vegetation management are provided by the 2006 Land and Resource Management Plan for the Hoosier National Forest (hereinafter referred to as the Forest Plan). The predominant Management Area (MA) in the Houston South Project is MA 2.8 which encompasses 18,956 acres (both NFS and non-NFS lands) or 81 percent of the project area. For NFS lands in MA 2.8, timber harvest is considered an appropriate tool for creating a diverse array of plant and animal habitat (USDA 2006). **For the purposes of this report, only lands falling within MA 2.8 are analyzed.**

Monitoring

- In accordance with Forest Service Manual 2470.3, design regeneration harvests and reforestation practices to assure that lands are satisfactorily restocked within 5 years of regeneration harvest (USDA 2014). Any area treated with a regeneration harvest must be monitored for five years to ensure proper regeneration is occurring.

The following laws and executive orders were also followed in creating the recommendations for the Houston South Project area:

Laws and Regulations

- Organic Administration Act of 1897 (at 16 U.S.C. 475, 551)
- Weeks Law of 1911, as amended (at 16 U.S.C. 515, 552)
- Multiple-Use Sustained-Yield Act of 1960 (16 U.S.C. 528-531)
- National Environmental Policy Act (NEPA) of 1969 (16 U.S.C. 4321 et seq.)
- Forest and Rangeland Renewable Resources Planning Act (RPA) of 1974, as amended by National Forest Management Act (NFMA) of 1976 (16 U.S.C. 1600-1614, 472a)
- Healthy Forests Restoration Act (HFRA) of 2003 (16 U.S.C. at 1611-6591)
- Bankhead-Jones Farm Tenant Act of 1937 (50 Stat. 525, as amended; 7 U.S.C. 1010-1012)

Executive Orders

- Executive Order 11514 issued March 5, 1970, as amended by E.O. 11991 issued May 24, 1977
- Executive Order 11990 issued May 24, 1977

Site Description

Ecological Land Types

Making sense of vegetation patterns on the Hoosier National Forest is possible by using the concept of Ecological Land Types (ELTs). The National Hierarchical Framework of Ecological Units is a system for stratifying the Earth into progressively smaller areas of increasingly uniform ecological units and potentials. Ecological types are classified and ecological units are mapped based upon associations of those factors (such as climate, water, soils, hydrology, or potential natural communities) that regulate the structure and function of ecosystems. The primary purpose of delineating mapping units at various scales is to identify areas that have similar capabilities and potentials for management. Uses of the hierarchy vary according to management information needs and level of analysis. Table 1 displays the ecological hierarchy for the Houston South project. Please refer to McNab and Avers (1994) for descriptions of the broader scale ecological units and Zhalnin and Parker (2005) for descriptions of specific ecological units.

Table 1. Ecological hierarchy for the Houston South Project.

Planning and Analysis Scale	Ecological Units	Purpose, Objectives, and general use	General Size Range
Eco-region Global Continental Regional	**Domain** 200 Humid Temperate **Division** 220 Hot Continental **Province** 222 Eastern Broadleaf Forest	Broad applicability for modeling and sampling. Strategic planning and assessment. International Planning.	1,000,000s to 10,000s of square miles
Subregion	**Section** 222E Interior Low Plateau, Highland Rim **Subsection** 222Em Brown County Hills	Strategic, multi-forest, statewide and multi-agency analysis and assessment	1,000s to 10s of square miles
Landscape	**Landtype Associations** 222*Em*02 Chestnut Oak Dry-Mesic Upland Hills	Forest or area-wide planning, and watershed analysis	10,000s to 1,000s of acres
Land Unit	**Landtypes** ELT 1 - Ridges ELT 2 - Slopes ELT 4 - Bottomlands **Landtype Phases**	Project and management area planning and analysis	1000s to less than 100 acres

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At the subsection scale, a broad, general picture of resource capabilities is displayed. The Houston South Restoration project occurs within the Brown County Hills subsection. As described by Zhalnin and Parker (2005), this subsection is characterized by deeply dissected uplands underlain by siltstone, shale, and sandstone. The soils are well drained acid silt loams with minor amounts of loess. Bedrock is near the surface, but rarely crops out. Natural communities are rather uniform in composition. Upland sites are dominated by oak-hickory, especially chestnut oak (*Quercus prinus*), and ravines with mesic species such as American beech (*Fagus grandifolia*), northern red oak (*Q. rubra*), sugar maple (*Acer saccharum*), and white ash (*Fraxinus americana*). Forestry and agriculture are the predominant land uses.

At the landscape scale, ecological units are identified as land type associations (LTAs) and are defined by general topography, geology, soil, potential natural community patterns, and local climate. The Houston South project falls entirely within the Chestnut Oak Dry-Mesic Upland Hills LTA. Vegetation in this LTA is dominated by oak species on the uplands. Chestnut oak is common in the overstory, with red maple (*A. rubrum*) and sassafras (*Sassafras albidum*) in the understory. Greenbriar (*Smilax* spp.), blueberry (*Vaccinium pallidum*), and sedges, notably *Carex picta* dominate the ground layer. Mesic sites are dominated by sugar maple, American beech, norther red oak, and white ash in the overstory. Mapleleaf viburnum (*Viburnum acerifolium*), spicebush (*Lindera benzoin*), jack-in-the-pulpit (*Arisaema triphyllum*), and Panicgrass (*Panicum* spp.) are common in the ground layer.

The basic mapping units for the project are the Ecological Landtype (ELT) and the Ecological Landtype Phase (ELTP). ELT mapping units are based on more narrowly defined criteria such as soil drainage, slope, position on the landscape, relationship to streams, or landform. These factors influence or reflect the microclimate, productivity, and manageability of a site. These mapping units are also the best representations of topography and landforms and can be used to characterize the physical environment of the project area. Units may also have small inclusions of different soils, soil drainages, slopes, and landforms. Ridges, Slopes, and Bottomlands are the three ELTs found within the project boundary. ELTPs further refine the ecological land types by characterizing the herbaceous vegetation, seedlings, saplings, and trees. Please refer to Table 2 for a list of ELTPs found within the Houston South project area.

Table 2. ELTPs for the Houston South Project.

ELT #	ELT Name	ELTP #	ELTP Name	Predominate canopy species/associates	Potential Habitat Type	%
1	Ridge	10	*Quercus prinus-alba/Vaccinium*, Dry Ridges	Chestnut oak, white oak, black oak & pignut hickory	Dry Forest, Open lands	2.8%
		11	*Quercus alba-Acer saccharum/Parthenocissus,* Dry-Mesic Ridges	White oak, black oak & pignut hickory	Dry Forest, Open lands	0.2%
		12	*Fagus-Acer saccharum/Arisaema,* Mesic Ridges	Sugar maple, northern red oak, black oak, white oak & yellow-poplar	Dry Forest, Mesic Forest, Open Lands	8.5%

2	Slope	20	*Quercus prinus-Quercus alba/Carex picta-Vaccinium*, Dry Slopes	Chestnut oak, white oak, black oak, pignut hickory	Barrens, Dry Forest, Open land	28.0%
		21	*Quercus alba-Acer saccharum/Parthenocissus*, Dry-Mesic Slopes	White oak, black oak, pignut hickory & chestnut oak	Dry Forest, Mesic Forest, Open Lands	0.3%
		22	*Fagus-Acer saccharum/Arisaema*, Mesic Slopes	Sugar maple, white oak, northern red oak, American beech & pignut hickory	Mesic Forest, Open lands	28.2%
4	Bottomlands	40	*Fagus-Acer saccharum/Arisaema*, Mesic Bottomlands	Sugar maple & American beech	Mesic Forest, Open lands, Wetlands	2.1%
		41	*Platanus/Asarum*, Wet-Mesic Bottomlands	Sugar maple, American sycamore, American elm & American beech	Mesic Forest, Open lands, Wetlands	4.7%
		42	*Acer saccharum/Asarum-Boehmeria*, Bottomlands	Sugar maple, red maple, American beech, northern red oak & yellow-poplar	Mesic Forest, Open lands, Wetlands	16.1%
		43	*Acer saccharinum/Boehmeria*, Bottomlands	Silver maple, boxelder, green ash & American sycamore	Mesic Forest, Open lands, Wetlands	8.4%
5	Water	50			Rivers	< 1%
				Total		100%

During formulation of silvicultural treatments ELTPs were utilized as a guide to predict and understand expected vegetative responses in the post-treatment environment. This information was also verified by on the ground field visits and silvicultural stand exam data.

Existing Condition

Forest Type and Age Class

Both the Houston South Restoration Project and the Hoosier National Forest fall within the Central Hardwood Region (CHR) as described by Johnson *et al*. (2009). The project area is typical of the CHR in both forest type and age class with the exception of the non-native pine plantations. Existing conditions for the project area are listed in Table 3.

Much of the project area is characterized by mature to over mature hardwood stands. Stands over 80 years old are typical, covering 55% of NFS lands in the project. Many of these stands consist of mature to over mature chestnut oak, white oak, and black oak as dominant canopy components. Many of these trees are at an age where they begin to naturally senesce. Graphs showing age class distributions for the Houston South Project and the Pleasant Run Unit can be found in the Figures 5 and 7, respectively. Both show bimodal distributions with spikes in the 30-39 and 100-109 age classes. The spike in the 30-39 age class is due to clearcut harvests in the area during the

1980s. The spike in the 100-109 age class is due to very little management in the area (other than the 1980s) since those stands regenerated.

Table 3. Summary of Forest Type by Age Class on NFS land in the Project Area (acres).

AGE CLASS	FOREST TYPE							
	Elm-Ash-Sycamore	Maple-Beech	Mixed Pine	Oak-Hickory	Oak-Pine	Shortleaf-Virginia Pine	White Pine	Grand Total
0-9	-	-	-	-	-	-	-	0
10-19	20	51	-	28	-	-	8	108
20-29	19	243	-	66	-	3	1	332
30-39	94	240	-	337	2	7	15	696
40-49	53	153	-	263	36	26	104	635
50-59	8	208	5	359	17	77	61	736
60-69	12	353	-	484	85	34	80	1,048
70-79	-	391	-	576	18	-	2	987
80-89	-	199	-	1,037	22	-	-	1,258
90-99	-	136	-	1,188	-	-	-	1,325
100-109	-	157	-	1,473	-	-	-	1,631
110-119	-	71	-	772	-	-	-	843
120-129	-	75	-	150	-	-	-	225
130-139	-	-	-	166	-	-	-	166
140+	-	-	-	80	-	-	-	80
Grand Total	**207**	**2,280**	**5**	**6,978**	**180**	**148**	**272**	**10,071**

Oak-Hickory Forest

For several millennia, oaks have been the predominate species on upland sites throughout much of the Central Hardwood Region (Abrams 2005). According to contemporary estimates, oak forest types comprise 51% of all forest lands in the east (Spetich *et al*. 2002), with the upland oak-hickory forest type covering over 100 million acres in the region (Sander *et al*. 1983). The oak-hickory forest type currently dominates canopies in the Houston South Project, covering 69% of all forested NFS land within the project boundary (Table 3). Despite their widespread canopy dominance, the inability of oak reproduction to compete with large shade-tolerant advance reproduction and aggressive pioneer species has created concern about the sustainability of oak ecosystems (Lorimer 1993; Dey 2002; Brose *et al*. 2012). Maintaining oak forests is consequential for trophic systems that largely depend on *Quercus* as a foundation genus (McShea *et al*. 2007), as well as wood-related industries that utilize oak sawtimber for a variety of products (Dey *et al*. 2010).

The successional replacement of oak that has been documented throughout the Midwest is largely due to changes in historic disturbance regimes that once promoted oak on mesic and dry-mesic sites. Oak reproduction has the ability to repeatedly resprout following above ground disturbance largely due to stored reserves in the root systems. This trait makes oak a strong competitor in systems where low-to moderate-intensity surface fires occur at high frequencies. Throughout the east, the use of fire by Native Americans likely allowed fire adapted species to flourish prior to European settlement (Abrams 2005; Nowacki and Abrams 2008). As Europeans began to populate eastern North America they altered this regime, often increasing fire frequency, which further benefitted fire adapted oak species. A quantitative fire history study was conducted in the Boone Creek watershed on the Tell City Ranger District of the HNF. Stem analysis from the study showed that fires intense enough to scar trees occurred at varying intervals throughout human occupation, with a mean fire return interval of 8.4 years between 1656 and 1992 (Guyette *et al.* 2003). Starting in the 1920s, fire suppression was promoted throughout this region, thus altering the historic disturbance regime and creating drastic reductions in oak-hickory regeneration (Wagner *et al*. 2018). Figure 2 displays the current trend as oaks are slowly replaced by maples in Indiana forests.

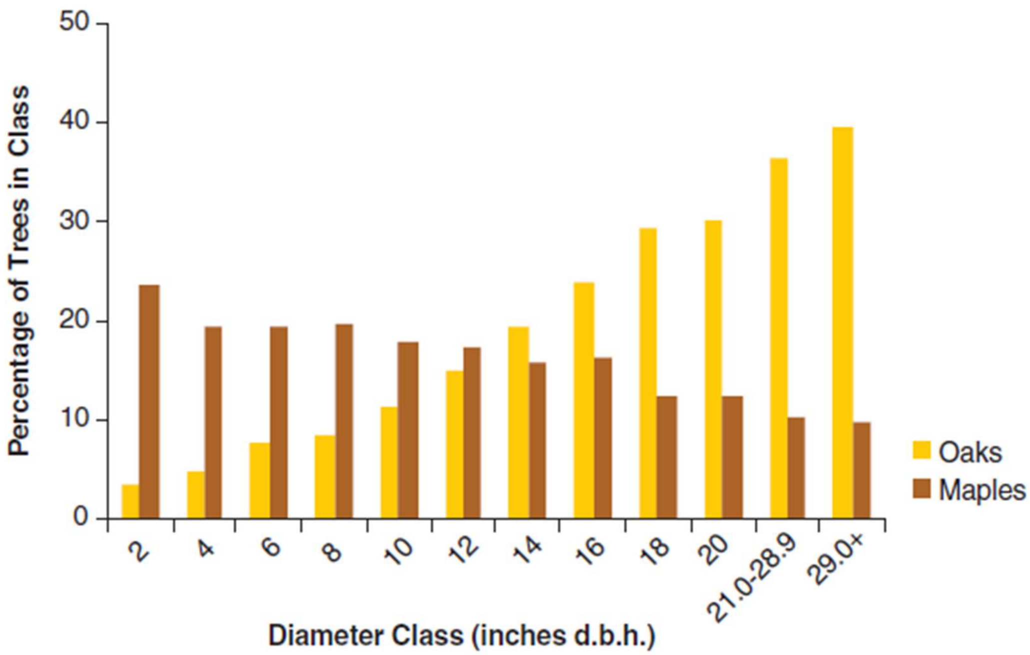

Figure 2. Oaks and maples on forest land as a percentage of all trees by diameter class (Indiana 2013)

Field inspections and stand exam data have verified this same demographic shift on many sites within the Houston South Project. Decades of research have shown that oak seedlings require periodic disturbances that remove or kill overstory trees and thus increase light levels, allowing oak seedlings to eventually reach the overstory (Johnson *et al*. 2009). Well-designed harvests using group selection, shelterwood, clearcutting, and other silvicultural methods can create the proper conditions needed to regenerate oak (Dey 2014, Wagner *et al*. 2018). Prescribed fire has also been repeatedly shown to be an effective tool for regenerating oak (Abrams 1992, Dey 2014, Wagner *et al*. 2018). Different combinations of these treatments will be utilized in the Houston South Project.

Pine Forest

Currently, 6% of the Houston South Project area is characterized by a pine forest type (Table 3). These stands are overstocked with common basal areas of 150-200 ft^2/acre (Appendix, Figs. 8 & 9). Most of this ground was highly degraded agricultural ground at the time of incorporation as NFS land. These pine plantations were first established following the dust bowl era of the 1930s to mitigate against further erosion that was causing severe damage to ecosystems across the Midwest. Pine seedlings not native to southern Indiana, such as eastern white pine and shortleaf pine, were in surplus at many nurseries in region. Planting them on abandoned agricultural ground was the best way to quickly prevent erosion which was occurring at an accelerated rate. Much of this planting was completed by the Civilian Conservation Corps. While these pine plantations served an important purpose on the HNF, they have now surpassed their growth potential and are degrading on many sites. Management direction includes full removal of the non-native pine to restore stands to native hardwood species (USDA 2006). The best method to achieve this goal is total removal of the pine via harvest, which allows us to grow new, healthy hardwood seedlings. These treatments also allow an opportunity to create early-successional forest habitat that is rare on the contemporary landscape.

Mesic Upland Hardwood Forest

Mesic upland forests, some of the most productive sites on the HNF, are also found within the project boundary. These sites are generally composed of American beech and sugar maple. Generally speaking, these sites are not considered good for regenerating oak-hickory species because they receive heavier competition from species such as maple, beech, and tulip-poplar. Nevertheless, these stands often exist in an overstocked state and are prime candidates for uneven-aged management.

Forest Health and Stocking

Chestnut oak

Insect and disease activity has been documented in and around the Houston South Project area. An intensive aerial survey was conducted in 2018 by Forest Health Specialists from Indiana Department of Natural Resources (IDNR). The aerial survey was conducted over Jackson-Washington State Forest (SF), Morgan-Monroe SF, Yellowwood SF, Brown County State Park (SP), and the Brownstown District of the HNF which includes the Houston South Project. Mortality detected usually occurred in groups of 1 to less than 5 trees. However, some areas had multiple small groups. On Yellowwood SF adjacent to Brown County SP, several large areas of mortality were detected. Some areas included the entire forest tract. Active decline still occurred on scattered trees, determined to be chestnut oak from close observation from the helicopter. Ground surveys have confirmed mortality of chestnut oak in the project area, with mortality of other oak species occurring to a lesser extent. Foresters and Forest Health Specialists have concluded that this disease is an extension of the 2012 drought followed by Armillaria root rot, Hypoxylon Canker, Two Lined Chestnut Borer, and *Phytophthera*

cinnamomi. However, since mortality continues to occur each year – 2016, 2017 and 2018 – there is concern for a new disease or disease complex, and the role of *P. cinnamomi* is of concern.

Eastern White Pine

Ground surveys in the project area have also detected heavy needle loss in eastern white pine stands (Fig. 3). This is a recent issue that is in early stages of documentation on the HNF and throughout the eastern United States. Symptoms include significant shedding of needles. These symptoms were first documented on the HNF in summer of 2018 and have persisted throughout spring of 2019. Pathologists have investigated similar white pine needle damage in Ohio but were unable to diagnose the specific fungal agent. All that is known at this time is that it appears to be a pathogen complex.

Overstocked Stands and Drought

Competition for limited resources in overcrowded stands reduces the capacity of trees to photosynthesize. These effects are compounded during periods of drought, not unlike the drought that hit the Houston South Project area in 2012. Trees growing at reduced photosynthetic capacity may be unable to produce sufficient carbohydrates to allocate to all of their priorities. Moreover, the photosynthate trees produce is allocated in a particular hierarchy. Sugars are allocated first to maintenance respiration (keeping the living cells alive), followed by new foliage and fine roots, then reproductive structures (if it's a seed year), and after that, primary growth, and finally to production of secondary growth concurrent with allocations to secondary metabolites (Oliver and Larson 1990). Consequently, trees experiencing competition induced moisture stress may have insufficient photosynthate to allocate to priorities lower in the hierarchy including secondary growth as well as the production of secondary metabolites for defense against key pests such as borers and pathogenic fungi. It is likely that the 2012 drought weakened chestnut oak, eastern white pine, and other species in overstocked stands to a point where they are more susceptible to insect and disease infestations. Figure 4 graphs the overstocked conditions that currently exist in upland hardwood stands in the Houston South Project (see Figures 8 and 9 in the Appendix for current shortleaf and eastern white pine stocking levels). Typical

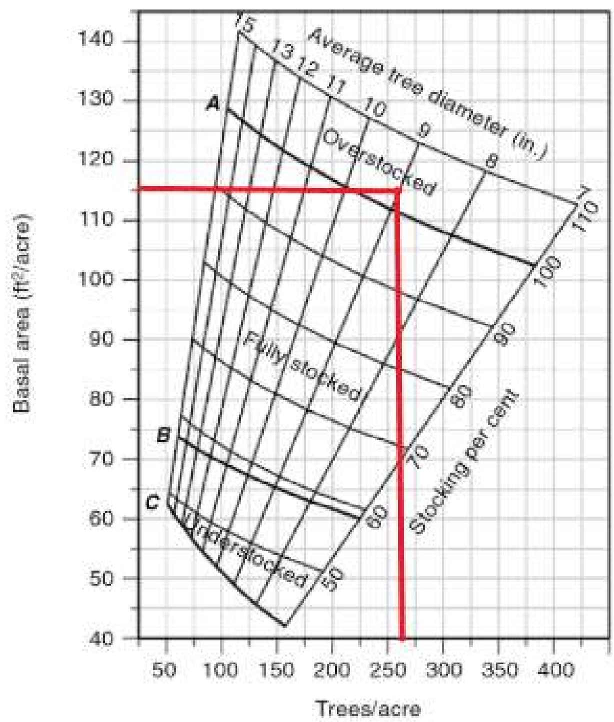

Figure 4. Relation of average basal area, average trees per acre, and average diameter to stocking percent in upland hardwood stands in the Houston South Project (stocking chart from Gingrich 1967). Houston South averages are represented by the red lines. Anything at or above the A-line is considered overstocked.

management strategies for overstocked stands involve reduction of stocking via thinning harvests or regenerating the stand with younger, more vigorous seedlings via regeneration harvests. Without management overstocked conditions will be compounded by the effects of climate change, as summer and fall seasons are expected to become hotter and drier. As this shift occurs species such as sugar maple and tulip-poplar would suffer, while many species in the oak family are expected to be better adapted to climate shifts (Phillips *et al*. 2018), therefore treatments aimed at perpetuating oak on the landscape should help mitigate the effects of climate change in southern Indiana.

Desired Condition

The desired condition for the Houston South proposed action includes the following elements:

- Restore dry hardwood forest ecosystems that have been degraded by a lack of fire and limited oak-hickory regeneration;
- Restore mesic forestland habitats degraded by a lack of stand age class diversity and structural diversity;
- Improve age class distribution by regenerating areas of non-native pine and mature hardwoods to early successional forest habitat;
- Lower stand densities to increase tree growth and vigor and resistance to insects and disease;
- Restore native mixed hardwood ecosystems by removing non-native pine; and
- Improve health of all harvest areas making them more adaptable to climate change.

Desired conditions for the HNF are described in the Forest Plan (USDA 2006). Historic forest conditions (reference conditions) can provide a context for understanding the ecological processes (including fire) that shaped the upland hardwood forests in this area. Reference conditions are typically described as conditions encountered by the first Euro-American settlers. Species composition and forest structure have changed drastically since early settlement due to intensified land use practices and fire prevention over the last century.

Need for Change

The need for change can be summarized as follows:

- Forest composition, density, and structure are on a trajectory moving further away from reference conditions, as beech and maple would continue to convert stands away from oak and hickory.
- Growth in mature and immature stands is declining and disease and insect activity is locally heavy due to overstocked conditions. Without treatment to reduce stocking levels these conditions are likely to intensify.
- The project area does not contain a single stand in the 0-9 year age class (Table 3). A suite of species depend on young forest habitat which has become rare on the landscape in contemporary forests (Winstead 2014). Without treatment that alters stand structure the desired conditions will not be met.

Environmental Consequences

Methodology

The project area was inventoried utilizing protocols developed in the Hoosier National Forest's Common Stand Exam protocols version 1.1. The overstory forest was inventoried utilizing a 10 BAF variable radius plot. Understory conditions were inventoried in a fixed-radius 1/750th acre subplot. All seedlings and saplings greater than 0.5 feet tall were tallied. A total of 1,605 stand exam plots were completed within the project boundary. All of this data was uploaded into the FSVeg database and stand tables were produced. These tables, in conjunction with field visits and analysis of ELTPs, allowed interpretation of existing conditions and formulation of treatment proposals for the project.

Spatial and Temporal Context for Effects Analysis

The area currently being affected for this vegetation management proposal is wholly contained within the boundaries of the Houston South Restoration Project. Harvest activities in Alternative A (Action Alternative) would be implemented within roughly 12-15 years after the Environmental Assessment is signed. A total of 20 years will likely be needed to account for post-harvest burning.

Most cumulative effects that occur due to management activities would be beneficial to the area. These effects include decreased inter-tree competition, increased age class diversity, release of residual trees, reduced insect and disease risk, higher resiliency to climate change, and increased oak-hickory regeneration. If additional management activities occur within the area too soon after the proposed activities there may be negative effects. One possible side-effect could be an increase in soil compaction due to multiple entries. However, most of the negative effects would be mitigated for during the implementation of the activity. Any negative effects from the proposed activities will decrease to marginal levels roughly 10 years after completion of activities.

Past, Present, and Foreseeable Activities Relevant to Cumulative Effects Analysis

Past Timber Harvest

Past timber harvest in the Houston South planning area includes 2,127 acres since 1975 (Table 4). The majority of the harvest treatments were salvage harvests that occurred in 1998 due to tornado damage in 1996. The most recent harvest within the planning area was the Buffalo Pike Timber Sale in 2016. This sale was comprised of 52 acres of single-tree and group selection. Current recommendations for the proposed action include 484 acres of commercial treatment that would overlap old harvest units. These treatments consist mostly of hardwood thinning and selection harvests. These two treatments make up 18% of the 2,127 acres of prior harvest.

Table 4. Past harvest activity in the Houston South Project.

Past Activity	Time Period	Acres
Other Harvest (mainly clearcut)	1973-1988	849
Salvage Harvest	1998	1,226
Selection Harvest	2016	52
Total:		**2,127**

Harvest activities in the 1970s and 80s mainly consisted of regeneration harvests in the form of clearcuts. At the time, these harvests reset stand ages back to the 0-9 year class. The clearcuts are represented by a spike in the 30-39 year age class (Fig. 5). Many of these stands were oak dominated prior to cutting, but the lack of advance oak regeneration in these stands allowed forest types to shift towards more mesic species such as sugar maple and tulip-poplar (Swaim *et al*. 2018).

A small amount of stand ages were reset by the 1996 tornado and the subsequent 1,226 acres of salvage harvests. These are represented by the slight rise seen between the 10-19 and 20-29 year age classes (Fig. 5). Although age classes were set back in a few stands, most stands did not see a significant change in age class since only individual trees suffered tornado damage.

The Buffalo Pike Timber Sale was completed in 2016 within the project boundary. This sale consisted of selection harvests aimed at converting largely mature even-aged stands towards uneven-aged stands. It also reduced densities in overstocked stands thus freeing up growing space and valuable resources for residual trees.

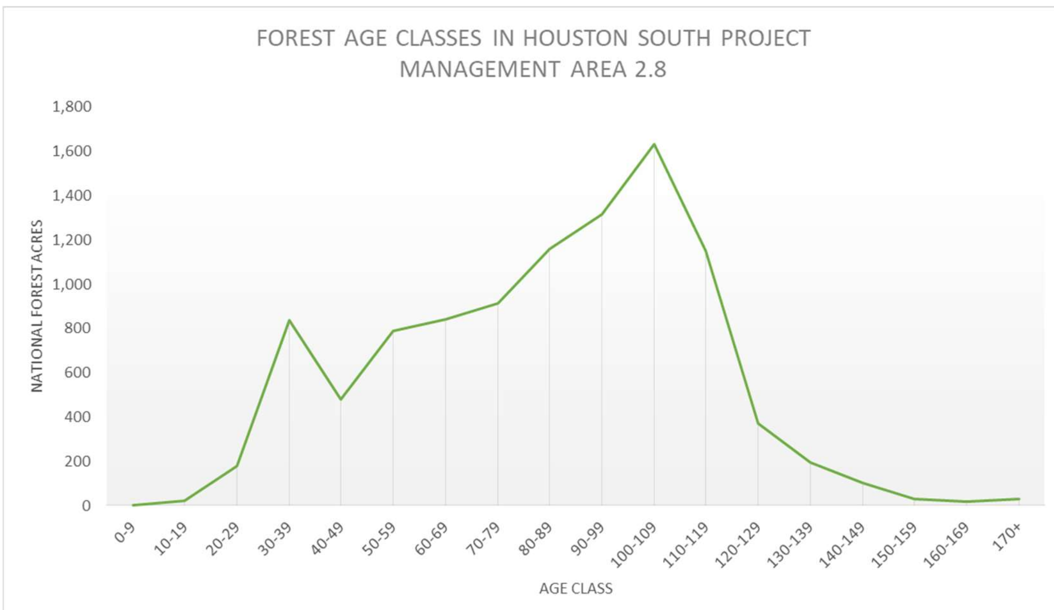

Figure 5. Forest age classes in the Houston South Project (Management Area 2.8).

Past Prescribed Fire

Prescribed burns were conducted in 2004 and 2007 in the area affected by the 1996 tornado and subsequent salvage harvests. Another area near Fork Ridge was treated with prescribed fire in 2010, 2012, and 2019. In both instances the previous use of fire has helped thin shade tolerant midstory species and establish layers of advance oak and hickory regeneration. The combined effects of these past burns with the currently proposed treatments should be positive. Proposed harvest treatments will alter light conditions for advance oak and hickory and allow them to recruit to the upper canopy, thus perpetuating oak ecosystems on the landscape.

Activities on Non-NFS lands

There are 9,830 acres of non-NFS lands within the project boundary. This includes roughly 6,600 acres of forest/shrubland/wetland. Evidence of past timber harvest is evident on private ground adjacent to NFS land, but estimating the number of acres harvested on private ground over a given time period is difficult. It is assumed that harvest methods utilized on private ground consists of dimeter limit cutting and selection harvests.

An estimated 2,600 acres of agricultural land are also located within the project boundary. It is assumed that herbicide is applied to these lands on a yearly basis. USDA statistics show herbicide active ingredients were applied to 98 percent of acres planted to corn, and almost two-thirds of all active ingredients used on corn were herbicides. Glyphosate isopropylamine salt was the most widely used pesticide overall, and the active ingredient used in the greatest amount with over 1 pound applied per acre (USDA 2011).

Active forest management has recently been conducted on the Maumee Boy Scout Reservation within the project boundary (2013-2019). Treatments include 91 acres of understory restoration, 25 acres of stand improvement, and creation of a 24 acre regeneration opening via timber harvest (personal communication with Chris Neggers, The Nature Conservancy 2019).

Future Treatments

Foreseeable future treatments on NFS lands in the project area include crop tree release treatments in the footprint of the shelterwood, clearcut, and group selection harvests. It is estimated that these treatments would be conducted within 15 to 20 years after timber harvest.

There is a high likelihood that non-native invasive vegetation will also be treated in the project area. These treatments were previously authorized under the decision for the Non-native Plant Control Program Analysis (USDA 2009).

Alternative A – Proposed Action

Vegetative Treatments

Silvicultural treatments are proposed to address the need for change and desired conditions for the project. Tables 5 shows proposed harvest and stand improvement treatments by alternative. A detailed prescription will be prepared for each treatment area.

Table 5. Proposed silvicultural treatments by alternative.

	Treatment	Veg Type	Alternative A	Alternative B
Timber Harvest	Clearcut*	Pine	401	0
	Shelterwood*	Hardwood	703	0
	Hardwood Thinning	Hardwood	2,327	0
	Pine Thinning	Pine	78	0
	Selection	Hardwood	462	0
Stand Improvement	Midstory Removal	Hardwood	234	0
	Crop Tree Release	Hardwood	170	0
	Total Acres		**4,375**	**0**

***Total even-aged management = 1,106 acres**

Clearcut – 401 acres

This treatment is assigned to non-native pine plantations. Per the Forest Plan, clearcut harvests will be used when they are the optimum harvest method to achieve stated management objectives such as conversion of non-native pine to native hardwoods and providing habitat for early successional forest species. For this treatment, with the exception of trees that are left for wildlife, all merchantable trees on an area would be harvested at one time. Small unmerchantable trees would also be felled, girdled, or eliminated with selective herbicide applications. A list of herbicides and application methods are shown in Table 7. This regeneration method favors establishment and development of early- to mid-seral species more intolerant of shade. Studies on the HNF have shown mixed results on the establishment of oak and hickory species following hardwood clearcuts (Jenkins and Parker 1997, Seifert *et al*. 2005, Morrissey *et al*. 2008, Swaim *et al*. 2018). None of these studies looked at stands that were burned following harvest. It is likely that clearcut harvests on dry to dry-mesic sites, in conjunction with prescribed fire, will develop a strong oak-hickory component in subsequent stands. Clearcut harvests will be limited to 10 acre patches per the Forest Plan (USDA 2006).

Shelterwood - 703 acres

Shelterwood harvests are defined as the cutting of most trees, leaving those needed to produce sufficient shade to produce a new age class in a moderated microenvironment (Helms 1998). The goal of the shelterwood system in this project is to establish and foster advance oak and hickory seedlings to ensure oak ecosystems are perpetuated on the landscape following the final overstory removal. Shelterwood systems can be completed in either two or three stages. In the three stage shelterwood, the first treatment typically involves removal of midstory stems to create an understory light environment conducive to establishment of oak and hickory seedlings. Midstory stems would be removed via felling, girdling, selective herbicide application, prescribed fire, or a combination of all of the above. The second stage involves removal of roughly half of the overstory density via harvest. This stage allows even more sunlight to the forest floor helping recruit advance oak and hickory seedlings into competitive positions. When oak-hickory seedlings are present in desirable quantities, the third and final stage, the overstory removal is completed. The two stage shelterwood system follows the same guidelines minus the initial midstory treatment. Shelterwood harvests will be limited to 10 acre patches per Forest Plan direction (USDA 2006).

Hardwood and Pine Thinning – 2,327 and 78 acres, respectively

This treatment is assigned to overstocked hardwood and pine stands. Thinning is considered an intermediate treatment aimed at reducing stand densities to improve growth, enhance forest health, and recover potential mortality (Helms 1998). Thinning is considered an appropriate treatment for stands without adequate regeneration in place prior to harvest. In general, thinning prescriptions would reduce stand densities by approximately one-third. Unmerchantable stems near travel corridors (roads and trails) that are damaged during harvest may be felled to improve visual quality of the area.

Selection - 462 acres

Single-tree selection seeks to remove individual trees from all size classes more or less uniformly throughout the stand. The objective of this treatment is to promote growth of the remaining trees and provide space for regeneration (Helms 1998). It also promotes age class diversity by removing large, senescing trees to create individual tree gaps capable of recruiting younger midstory trees to the upper canopy. This technique often favors shade-tolerant trees and is prescribed on mesic sites. Approximately one-third of the density would be removed from the stand. Unmerchantable stems near travel corridors (roads and trails) that are damaged during harvest may be felled to improve visual quality of the area.

Group Selection is a system in which trees are removed and new age classes are established in small groups (Helms 1998). Stands in the project area would be on a 100 year rotation and would be entered approximately every 20 years. During each entry roughly 20 percent of the stand would be put into groups. Thus, on a 50 acres stand, 10 acres of groups would be created during an entry. Individual groups may not be larger than 3 acres (USDA 2006). Single-tree selection would be implemented between the groups. Groups are determined at the time of sale layout by evaluating ground conditions.

Midstory Removal – 234 Acres

Midstory removal is assigned to stands where oak-hickory species dominate canopies but little to no oak-hickory regeneration is apparent. This treatment involves, with the exception of trees left for wildlife, removal of all midstory stems to enhance light conditions below the upper canopy. This is not a commercial treatment. Midstory stems would be removed via felling, girdling, or selective herbicide application. The goal is to allow small amounts of sunlight to the forest floor to create an environment conducive to establishment of oak and hickory seedlings. No trees would be cut from April 15th through September 15th to avoid bat roosting periods.

Crop Tree Release – 170 Acres

Crop tree release is a widely applicable technique used to enhance the performance of individual trees (Miller *et al*. 2007). It is an intermediate silvicultural treatment intended to provide increased growing space to selected trees through the removal of crown competition from adjacent trees. A crop tree is defined as one that exhibits desirable characteristics that help meet management objectives, has the ability to respond to treatment, and can remain competitive for many years (Miller *et al*. 2007). For this project, this treatment is assigned to stands that were clearcut in the mid to late 1980s with no other management activities since initial harvest. Desired species to release include those from the oak and hickory groups. A two-sided release of selected crop trees will be implemented via felling, girdling, or selective herbicide application to adjacent competitors. The estimated number of crop trees per acre is 40. This is not a commercial treatment. No trees would be cut from April 15th through September 15th to avoid bat roosting periods.

Herbicide Application

Selective herbicide applications are proposed for site preparation and stand improvement activities on 1,970 acres. Forestry herbicides are a versatile, cost-effective tool that can be used in a variety of ways to help manage forest vegetation (Kochenderfer *et al*. 2012). Table 6 shows average stems per acre to be treated in each area proposed for herbicide use.

Table 6. Proposed areas for selective herbicide treatments and average stems per acre to be treated with herbicide.

Treatment Area	Acres	Objective	Average stems per acre to be treated
Clearcut	401	Site preparation for natural regeneration; post-harvest	219
Shelterwood	703	Site preparation for oak-hickory regeneration; pre- and/or post-harvest	238
Selection	462	Site preparation for natural regeneration in group selection areas; post-harvest	179
Midstory Removal	234	Site preparation for oak-hickory regeneration	226
Crop Tree Release	170	Release of crop trees	80
Total	**1,970**		

Herbicide use for stand improvement and site prep activities typically requires a single application to attain the desired effects. Herbicide would be applied specifically to the trunks and stumps of targeted woody vegetation resulting in a relatively small area of application with little to no herbicide contacting the soil. The maximum amount of herbicide used in a given treatment should remain well below the maximum forestry use rate per year as identified on the manufacturer's label. For example, when using Arsenal® (imazapyr) for stem injection treatments (hack and squirt), the maximum use rate for forestry treatments is 96 ounces/acre/year. Assuming 3 inch wide hacks and an average tree diameter at breast height (dbh) of 6 inches, 705 stems could be treated with a concentrate treatment or 9,600 stems could be treated with a dilute treatment. The average number of stems per acre to be treated in this project (Table 6) are considerably lower than the number that could be treated without exceeding the maximum use rate of the herbicide.

Numerous studies have demonstrated that modern herbicides can be safely applied in forests. Forestry herbicides inhibit biochemical pathways that are specific to plants. Commonly used and recommended forestry herbicides are very low in animal toxicity and do not bioaccumulate. Because of their low toxicity and minimal environmental hazards, most herbicides used in forestry operations are classified as "non-restricted use" meaning they are available to the general public and no license is required for landowners to buy them and apply them on their own land. Research has shown that herbicides used in forestry biodegrade relatively fast after application (Kochenderfer *et al*. 2012). See Tables 8 and 9 in the Appendix for herbicide risk characterizations for wildlife and the environment.

Proposed herbicides for this project would include a subset of those identified for use under previous decisions in which a Finding of No Significant Impact (FONSI) was prepared (USDA 2009, USDA 2018). A list of proposed herbicides and targeted use can be found in Table 7.

Table 7. Proposed herbicides and targeted use for undesirable native species.

Chemical Name	Examples of Trade Names	Targeted Use	Examples of Native Trees to be Targeted	Risk Assessment
Glyphosate	Accord®	Cut-Stump Treatment	Sugar maple, red maple, American beech	SERA 2011a
Imazapyr	Arsenal®	Stem Injection	Sugar maple, red maple, American beech	SERA 2011b
Triclopyr	Garlon®3A Garlon®4	Cut-Stump and/or Basal-Spray Treatment	Sugar maple, red maple, American beech	SERA 2011c

Direct, Indirect, and Cumulative Effects

Direct and Indirect Effects

Table 8. Comparison of direct effects of each alternative.

Purpose and Need	Alternative A	Alternative B
Restore dry hardwood forest ecosystems that have been degraded by a lack of fire and limited oak-hickory regeneration	937	0
Restore mesic forestland habitats degraded by a lack of stand age class diversity and structural diversity	462	0

Improve age class distribution by regenerating areas of non-native pine and mature hardwoods to early successional forest habitat	1,104	0
Lower stand densities to increase tree growth and vigor and resistance to insects and disease	2,867	0
Restore native mixed hardwood ecosystems by removing non-native pine	401	0
Improve health of all harvest areas making them more adaptable to climate change	4,375	0

Cumulative Effects

Age Class Distribution

Potential cumulative effects for vegetation would include changes to age class distribution. Past disturbances within the project area include tornado damage occurring in 1996 with subsequent salvage harvest and prescribed fire use. Those acres affected by the blowdown were figured into overall age class distribution for the project area. The use of fire following the salvage harvests, along with burns in the Fork Ridge area, does affect vegetation at the same spatial scale of the project area, but did not shift age class in any measurable way.

Though logging may occur on private lands the effects of those treatments do not overlap in space with those on NFS lands. Furthermore, management on non-Federal lands isn't expected to adjust age classes due to the types of harvest anticipated (diameter limit and selection).

A small amount of forest management has occurred on the Maumee Boy Scout Reservation within the last 6 years. This includes the creation of one 24 acre regeneration opening via timber harvest. While this does redistribute acres into a younger age class, it has little effect on age class distribution across the entire landscape.

Future stand improvement treatments, such as crop tree release, would overlap spatially with the project. These treatments would occur roughly 15 to 20 years following clearcut, shelterwood removal, and group selection harvests. These treatments would not change age class distribution since only select trees would be removed. After reviewing the past, present, and reasonably foreseeable future activities, there is minimal opportunity beyond treatments proposed in this project to shift age class distribution in any meaningful direction, therefore there are no cumulative effects on age class distribution.

Herbicide Applications

Alternative A proposes select herbicides to treat native undesirable vegetation. Proposed herbicides were selected largely for their low toxicity to humans and the environment. Foreseeable future activities in the project area include possible treatment of non-native invasive vegetation with the same herbicides proposed in this project. It is possible that these treatments could overlap spatially, but precautions would be taken to ensure they do not overlap temporally.

This will ensure application rates do not exceed those recommended on the manufacturers' label, therefore there are no cumulative effects from overlapping herbicide applications.

Within the project boundary there are an estimated 2,600 acres of agricultural land on private ground. It is safe to assume that herbicides are used on much of this land either to spot-treat pastures or to treat entire fields, sometimes multiple times each year. These applications are not considered because it is unlikely that herbicides applied on NFS lands would translocate sufficiently to combine with them. Nor would National Forest applications involve the treatment of food crops.

Alternative B – No Action

Direct, Indirect, and Cumulative Effects

By definition, direct and indirect effects (40 CFR 1508.8), and cumulative effects (40 CFR 1508.7) result from the proposed action, and thus are not germane to the no action alternative.

Alternative B allows the continued presence of non-native pine within the project area. Shade tolerant species would continue to develop underneath oak dominated stands increasing the likelihood of demographic shifts in forest types towards a maple-beech dominated forest, decreasing the sustainability of the oak-hickory ecosystem in the project area and, to a lesser extent, the entire forest. Stand densities would continue to increase causing competition for limited resources. This could lead to tree stressors that lend themselves to increased insect and disease outbreaks and mortality. Age class distribution would continue to deviate from desired conditions towards an older, more homogenous forest habitat more supportive of late, rather than early successional wildlife species. Wildlife benefits would be altered as hard mast species are replaced by soft mast competitors.

Design Features and/or Mitigation Measures

Recommended Design Features for Herbicide Application

The Forest would take a multi-step approach to reduce the effect of herbicides on non-target vegetation:

1. When using chemical methods, choose a method that, when applied directly, targets the undesirable plants with little over-spray (e.g. cut-stump, basal bark, hack-n-squirt),

2. Apply herbicide when adjacent native plants are dormant (early spring or late fall),

3. If application is necessary during the growing season, use selective herbicides or a selective method of application to reduce effects to the surrounding non-target vegetation.

4. Apply only formulations approved for aquatic use in or next to surface waters. Minimize the use of triclopyr (ester formulation) or surfactants used with glyphosate (terrestrial version) within ephemeral, intermittent or perennial stream corridors, or within 100 feet of streams, lakes, ponds or wetlands.

5. Herbicide applicators would follow label directions and not exceed any mixing or application rates. In addition, temporarily close treatment areas when warranted (e.g. heavily used trails near treatments).

6. All applicators will be either a Indiana state licensed applicator, or supervised by one, according to OISC (Office of Indiana State Chemist) regulations.

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Appendix

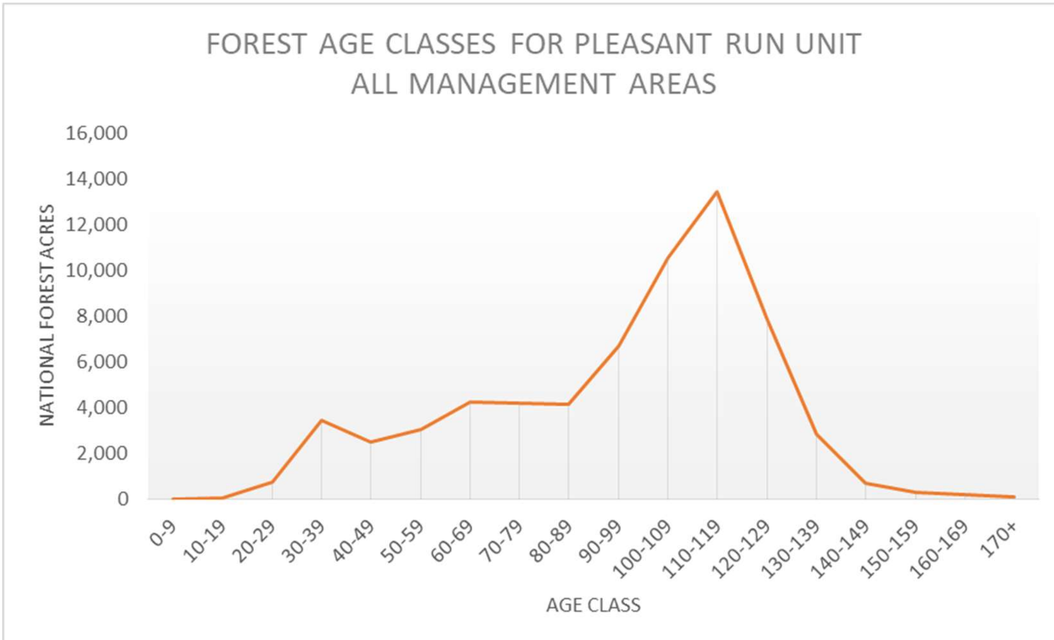

Figure 7. Forest age class distribution for the Pleasant Run Unit, Hoosier National Forest.

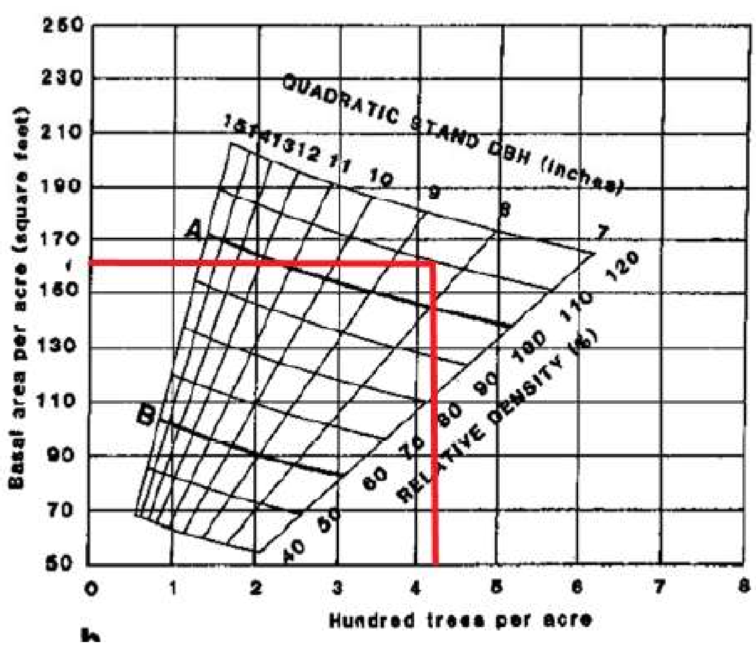

Figure 8. Relation of average basal area, average trees per acre, and average diameter to stocking percent in shortleaf pine stands in the Houston South Project (stocking chart from Rogers 1983). Houston South averages are represented by the red lines. Anything at or above the A-line is considered overstocked.

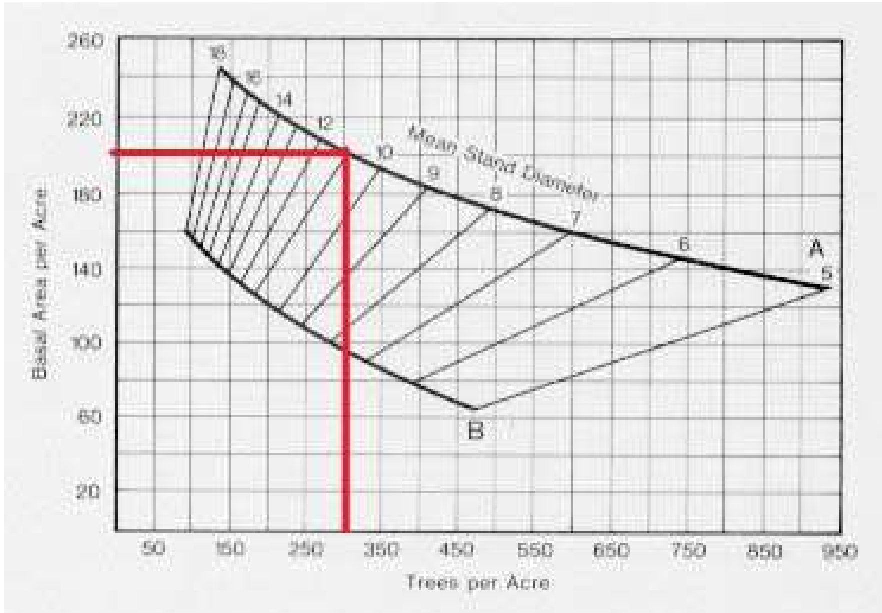

Figure 9. Relation of average basal area, average trees per acre, and average diameter to stocking percent in eastern white pine stands in the Houston South Project (stocking chart from USDA 1973). Houston South averages are represented by the red lines. Anything at or above the A-line is considered overstocked.

Table 9. Herbicide risk characterization for wildlife.

Herbicide Risk Characterizations for Wildlife	
Glyphosate (SERA 2011a)	
Mammals, Birds, and Terrestrial Invertebrates	Effects to birds, mammals, fish, and invetebrates are minimal. Based on the typical application rate of 2 lbs. a.e./acre, none of the hazard quotients for acute or chronic scenarios reach a level of concern even at the upper ranges of exposure. For the application of 7lbs. a.e./acre, there is some level of concern with direct spray of honey bees, for large mammals consuming contaimnated vegetation, and smallbirds consuming contaminated insects. These concerns are based on conservative dosing studies and environmental conditions that are not likely to occur in the field. The studies showing adverse effects are using formulations that are not legal, or available, in the U.S.
Aquatic Organisms	Some formulations of glyphosate are much more acutely toxic to fish andaquatic invertebrates than technical grade glyphosate or other fomrulations of glyphosate. This difference in actue toxicity among formlations appears to be due largely to the use of surfactants that are toxic to fish and invertebrates.
Soil Microorganisms	Transient decreases in the population of soil fungi and bacteria may occur in the field after the application of glyphosate at application rates that are

Herbicide Risk Characterizations for Wildlife	
	substantially less than those used in Forest Service programs. However, several field studies have noted an increase rather than decrease in soil microorganisms or microbial activity, including populations of fungal plant pathogens, in soil after glyphosate exposures. While the mechanism of this apparent enhancement is unclear, it is plausible that glyphosate treatment resulted in an increae in the population of microorganisms in soil because blyphosate was used as a carbon source and/or treatment with glyphosate resulted in increased nutrients for microorganixms in the soil secondary to damage to plants.
Imazapyr (SERA 2011b)	
Mammals, Birds, and Terrestrial Invertebrates	In terrestrial animals and birds, imazapyr is practically non-toxic. Adverse effects in terrestrial or aquatic animals do not appear to be likely. The weight of evidence suggests that no adverse effects in mammals, birds, fish, and terrestrial or aquatic invertebrates are plausible using typical or worst-case exposure assumptions at the typical application rate of 0.45 lb/acre or the maximum application rate of 1.25 lb/acre. Although imazapyr has been tested in only a limited number of species and under conditions that may not well-represent populations of free-ranging non-target organisms, the available data are sufficient to assert that no adverse effects on animals are anticipated based on the information that is available.
Aquatic Organisms	Imazapyr does not appear to be very toxic to aquatic fish or invertebrates.
Soil Microorganisms	Imazapyr is relatively non-toxic to soil microorganisms, aquatic invertebrates, and fish. Imazapyr is not expected to bioaccumulate in the food chain.
Triclopyr (SERA 2011c)	
Mammals, Birds, and Terrestrial Invertebrates	Contaminated vegetation is the primary concern in the use of triclopyr and that high application rates will exceed the level of concern for both birds and mammals in longer exposure scenarios.
Aquatic Organisms	An application rate of 1 lb/acre, acute and chronic risks to quatic animals, fish or invertebrates, as well as risk to aquatic plants are low with use of the salt form of triclopyr. At the highest application considered in this risk assessment, 9 lbs a.e./acre, the risks to aquatic animals remain substantially below a level of concern. The ester form of triclopyr is projected to be somewhat more hazardous when used near bodies of water where runoff to open water may occur. Applications of the ester formulation can reach levels of concern at 3 lb. a.e./ac for fish and amphibians, 1.5 lb. q.e/ac for aquatic insects and 1.0 lb. a.e./ac for aquatic plants.
Soil Microorganisms	The potential for substantial effects on soil microorganisms appears to be low. An application rate of 1 lb/acre is estimated to result in longer term soil concentrations that range from 0.24ppm to 2.2 ppm – which are a factor of 3 below chronic levels for earthworms (6.0ppm). Using the

Herbicide Risk Characterizations for Wildlife	
	laboratory studies to characterize risk, transient inhibition in the growth of some bacteria or fungi might be expected. This could result in a shift in the population structure of microbial soil communities but substantial impacts on soil – i.e., gross changes in capacity of soil to support vegetation – do not seem plausible. This is consistent with the field experience in the use of triclopyr to manage vegetation.

Table 10. Herbicide risk characterization for the environment.

Herbicide Risk Characterization for the Environment	
Glyphosate (SERA 2011a)	
Solubility	Glyphosate is strongly adsorbed to soil particles, which prevents it from excessive leaching or from being taken-up from the soil by non-target plants. Glyphosate is degraded primarily by microbial metabolism, but strong adsorption to soil can inhibit microbial metabolism and slow degradation. Photo- and chemical degradation are not significant in the dissipation of glyphosate from soils.
Half Life	For glyphosate, the half-life ranges from several weeks to years, but averages two months. In water, glyphosate is rapidly dissipated through adsorption to suspended and bottom sediments, and has a half-life of 12 days to 10 weeks. Foliar half life averages 7-10 days.
Toxicity	By itself, glyphosate has relatively low toxicity to birds, mammals, and fish, and at least one formulation (Rodeo®) is registered for aquatic use. Some surfactants that are included in some formulations of glyphosate are highly toxic to aquatic organisms, and these formulations are not registered for aquatic use.
Imazapyr (SERA 2011b)	
Solubility	Imazapyr is a weak acid herbicide and environmental pH will determine its chemical structure, which in turn determines its environmental persistence and mobility. Below pH5, the adsorption capacity of imazapyr increases which limits its movement in soil. Above pH 5, greater concentrations of imazapyr become negatively charged, fail to bind tightly with soils, and remail available for plant uptake and/or microbial breakdown. Imazapyr has not been reported in water runoff despite its potential mobility.
Half Life	The half-life of imazapyr in soil ranges from one to five months, and in aqueous solutions, imazapyr may undergo photodegradation with a half-life of two days. Foliar half life ranges from 15-27 days.
Toxicity	Imazapyr has low toxicity to fish, yet algae and submersed vegetation are not affected. Imazapyr is not highly toxic to mammals or birds. This herbicide is excreted from mammalian systems rapidly with no bioaccumulation in tissues.
Triclopyr (SERA 2011c)	
Solubility	Triclopyr is relatively persistent and has only moderate rates of adsorption to soil particles, therefore, offsite movement through surface or sub-

	surface runoff is a possibility. In water, the salt formulation is soluble, and with adequate sunlight, may degrade in several hours. The ester is not water soluble and can take significantly longer to degrade. Because it can bind with the organic fraction of the water column, it can be transported to the sediments.
Half Life	Degradation occurs primarily through microbial metabolism in soils, but photolysis and hydrolysis can be important as well. The average half-life of triclopyr acid in soils is 30 days. Foliar half lifed is 15 days.
Toxicity	Triclopyr can cause eye damage (corrosive/irreversible) if splashed into the eyes during application. Both the salt and ester formulatons are relatively non-toxic to terrestrial vertebrates and invertebrates. However, the ester forumulation can be extremely toxic to fish and aquatic invertebrates.