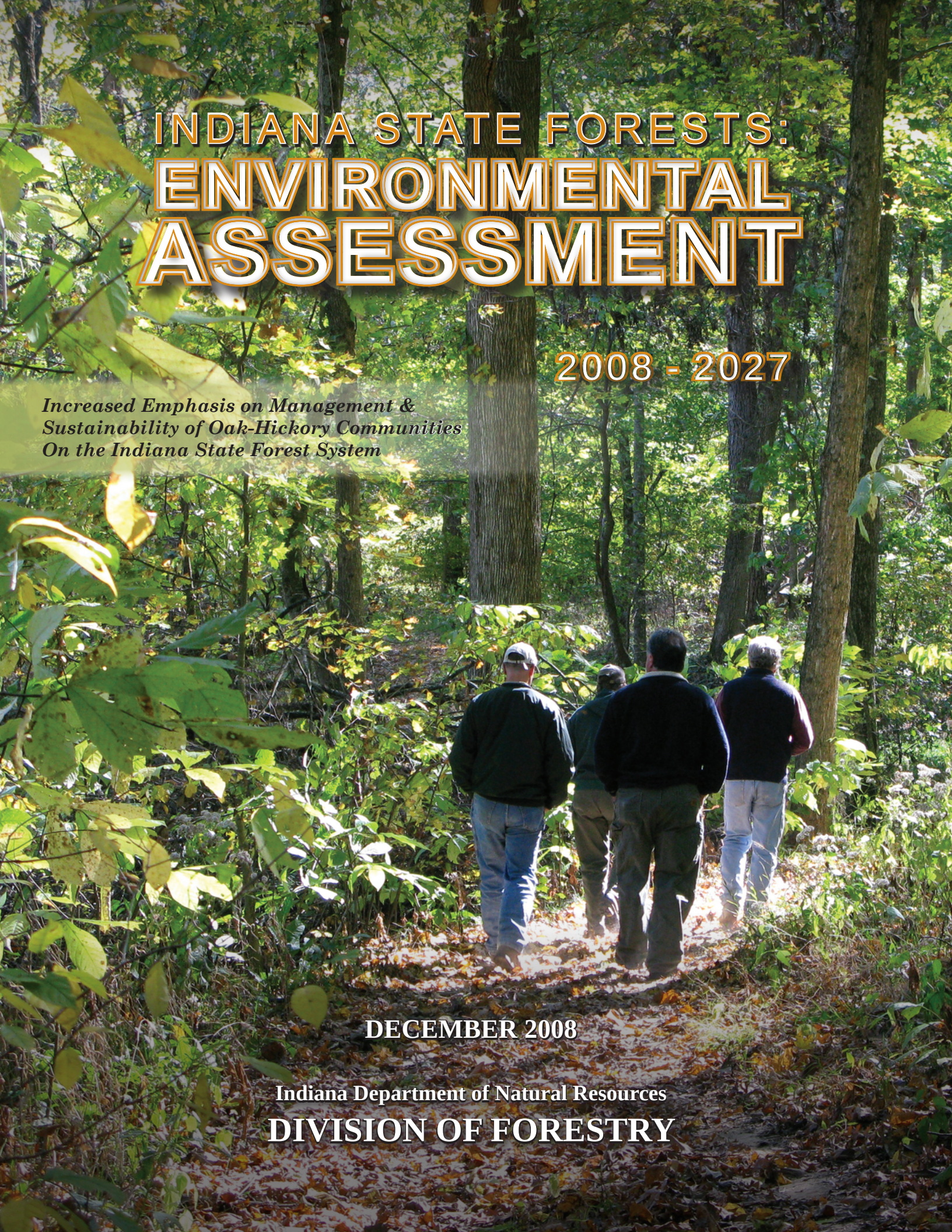

INDIANA STATE FORESTS: ENVIRONMENTAL ASSESSMENT

2008 - 2027

Increased Emphasis on Management & Sustainability of Oak-Hickory Communities On the Indiana State Forest System

DECEMBER 2008

Indiana Department of Natural Resources

DIVISION OF FORESTRY

ENVIRONMENTAL ASSESSMENT

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Indiana Department of Natural Resources

DIVISION OF FORESTRY

INDIANA DEPARTMENT OF NATURAL RESOURCES

The mission of the Indiana Department of Natural Resources is to serve as stewards of the natural, cultural, historic, and recreational resources for the benefit of present and future generations.

The mission of the DNR Division of Forestry Property Section is to manage, protect and conserve the timber, water, wildlife, soil and related forest resources for the use and enjoyment of present and future generations, and to demonstrate proper forest management to Indiana landowners.

STATE FOREST ENABLING LEGISLATION

The legislation that provides the foundation for the management of state forests (IC 14-23-4-1) states: "It is the public policy of Indiana to protect and conserve the timber, water resources, wildlife, and topsoil in the forests owned and operated by the division of forestry for the equal enjoyment and guaranteed use of future generations. However, by the employment of good husbandry, timber that has a substantial commercial value may be removed in a manner that benefits the growth of saplings and other trees by thinnings, improvement cuttings, and harvest processes and at the same time provides a source of revenue to the state and counties and provides local markets with a further source of building material."

MISSION OF THE PROPERTY SECTION

To manage, protect and conserve the timber, water, wildlife, soil and related forest resources for the use and enjoyment of present and future generations, and to demonstrate proper forest management to Indiana landowners.

VISION OF THE PROPERTY SECTION

We, the employees of the property section of the Division of Forestry, will demonstrate sound forest stewardship in our management of the Division's public forest lands. These lands will provide forest products, outdoor recreation, educational opportunities and other benefits, both tangible and intangible. We will conserve, protect, enhance and make available the varied forest resources of state forest properties for the present and future citizens of Indiana.

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Cover photo by John Seifert

1.0 Purpose and Need for Action

1.1 Introduction

This document is an Environmental Assessment of the timber management program on the State Forests of Indiana conducted by the Indiana Department of Natural Resources (IDNR) Division of Forestry (DoF). Although the DoF is exempt from the requirements of IC 13-12-4 by IC 14-23-4-1(b), the intent of this document is to summarize and evaluate any potential environmental impacts. This document outlines the activities of the State Forest Timber Program for the 20-year period from 2008 through 2027.

In 2006, the Indiana General Assembly amended IC 14-23-4-1 to exempt forestry management practices of the Division of Forestry from the requirements of IC 13-12-4 that requires an environmental assessment. Prior to 2006, the Division of Forestry operated under one or more categorical exemptions from the requirement to perform an environmental assessment that was granted by the Environmental Management Board in 1977 to include forest land management and wildlife habitat improvement activities. Even though not legally required to do so, the Division of Forestry nevertheless voluntarily prepared an environmental assessment in May 2001.

The forest land management activities reviewed in this environmental assessment while comprehensive are not a major state action that significantly affects the quality of the human environment and for which a much more detailed environmental impact statement would be required. The 20-year period outlined in this document covering forest land management activities from 2008 through 2027 is in keeping with IC 13-12-4-5(2)(E) that requires state agencies to recognize the long-range character of potential environmental problems. This documents also implements IC 13-12-4-5(2)(G) requiring the initiation and use of ecological information in the planning and development of resource oriented projects.

To the fullest extent possible, state agencies are to use a systematic interdisciplinary approach in natural resource planning including appropriate consideration of unquantified environmental amenities. Plans that significantly affect the quality of the human environment must have an analysis of the environmental impact, unavoidable effects, alternatives, short-term use vs. long-term productivity, and any irreversible or irretrievable commitments of resources.

Through extensive public input into the Division's 2008-2013 strategic plan, the public indicated a desire for the Division to conduct an Environmental Assessment (EA) for the timber management program on the State Forests. The division proposes this EA in an effort to satisfy the concerns of Indiana taxpayers.

During calendar year 2006, the DoF initiated a process to certify the State Forest management program through two independent certifying organizations. Both the Sustainable Forestry Initiative and the Forest Stewardship Council certified the Division's State Forest

program as meeting the requirements of their rigorous, nationally and internationally respected standards. The Division submits to annual surveillance audits, conducted in November 2007 and again in November 2008, and remains in good standing with both certifying organizations. The Division submitted to this dual certification effort voluntarily as another good faith effort to satisfy the concerns of Indiana taxpayers. Results of certification audits and the annual surveillance audits are available on the DoF pages of the DNR web site at www.in.gov/dnr/forestry/13166.htm.

1.2 Background

The state forest system was established in 1903 and currently consists of about 154,000 acres in 10 administrative units, located in 23 different counties in Indiana (Figure 1). Administrative units range in size from 300 acres to 50,000 acres and are located mostly in the southern half of Indiana. DoF properties contain about 3 percent of the total forestland in Indiana, and most of the remainder is held in private ownership. The state forests were initially created to restore eroded, worn-out land after small subsistence farms began to be abandoned early in the century, as directed by the Indiana Code:

IC 14-23-4

Chapter 4. State Forest Management

IC 14-23-4-1

Legislative intent

Sec. 1. (a) It is the public policy of Indiana to protect and conserve the timber, water resources, wildlife, and topsoil in the forests owned and operated by the division of forestry for the equal enjoyment and guaranteed use of future generations. However, by the employment of good husbandry, timber that has a substantial commercial value may be removed in a manner that benefits the growth of saplings and other trees by thinnings, improvement cuttings, and harvest processes and at the same time provides a source of revenue to the state and counties and provides local markets with a further source of building material.

(b) Notwithstanding subsection (a), IC 13-12-4 does not apply to forestry management practices of the division of forestry.

As added by P.L.1-1995, SEC.16. Amended by P.L.66-2006, SEC.27.

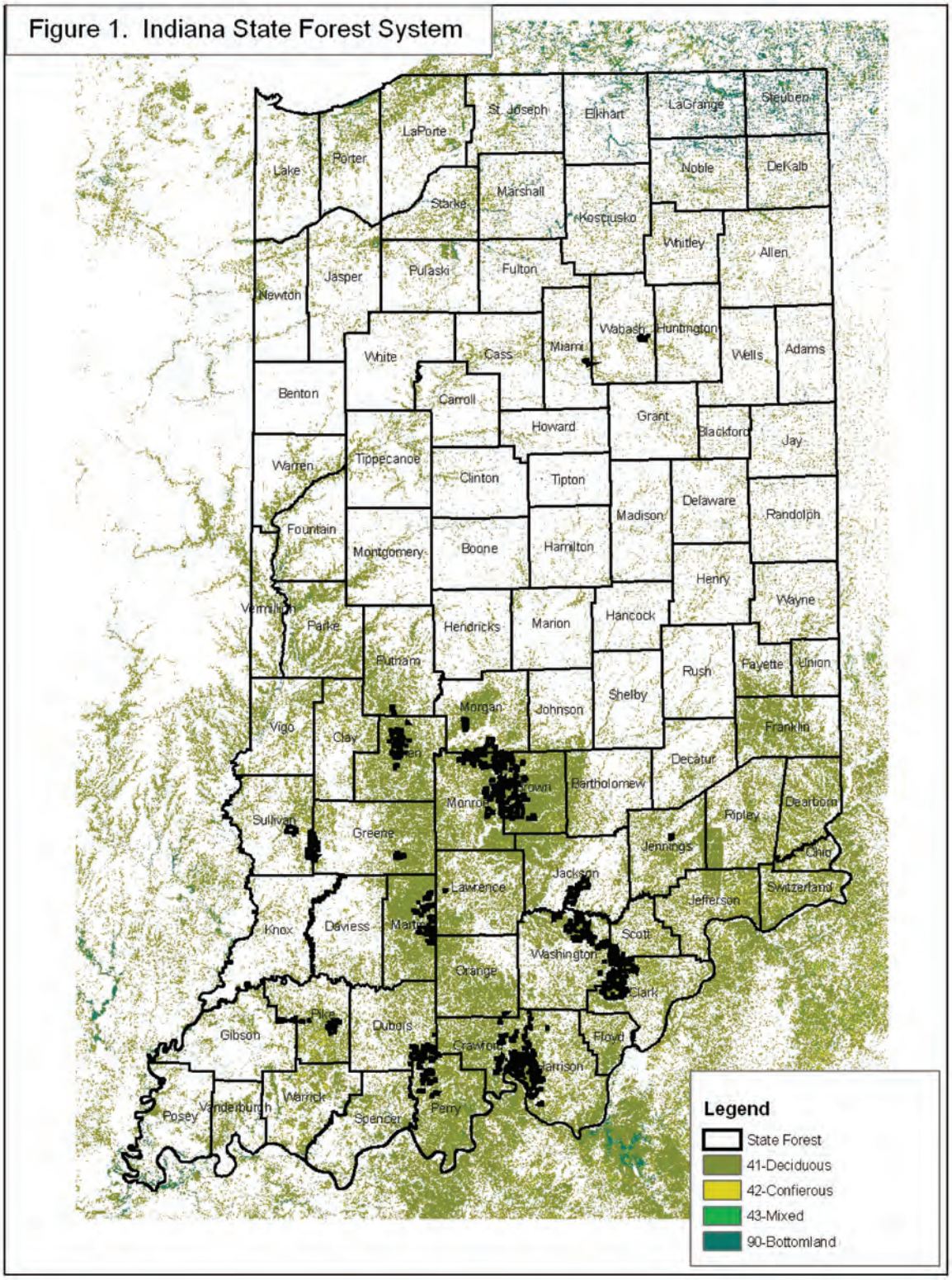


Figure 1. Indiana State Forest System
St. Joseph
Elkhart
LaGrange
Steuben
LaPorte
Lake
Porter
Noble
DeKalb
Starke
Marshall
Kosciusko
Whitley
Allen
Jasper
Pulaski
Fulton
Newton
Wabash
Huntington
Wells
Adams
White
Cass
Miami
Benton
Carroll
Grant
Howard
Blackford
Jay
Warren
Tippecanoe
Clinton
Tipton
Madison
Delaware
Randolph
Fountain
Montgomery
Boone
Hamilton
Henry
Wayne
Vermillion
Parke
Hendricks
Marion
Hancock
Putnam
Rush
Fayette
Union
Morgan
Johnson
Shelby
Vigo
Clay
Franklin
Decatur
Bartholomew
Monroe
Dearborn
Ripley
Sullivan
Greene
Jennings
Ohio
Jackson
Lawrence
Switzerland
Jefferson
Knox
Daviess
Scott
Washington
Orange
Clark
Gibson
Dubois
Crawford
Floyd
Harrison
Posey
Vanderburgh
Warrick
Spencer
Perry
Legend
State Forest
41-Deciduous
42-Confierous
43-Mixed
90-Bottomland

Early state forest management focused on reforesting eroded area, creating wildlife habitat, demonstrating good forest land management, providing public recreation, and conserving forest resources (IDNR 2005). This early philosophy is still a major part of DoF's current management system. The state forests are managed for multiple uses/multiple benefits. The state forests provide outdoor recreation ranging from camping and hiking to hunting and caving. The state forests conserve and protect all the forest resources including water, wildlife, herbaceous plants, archaeological sites, historic features, geological features, soil, and forests. Forests are managed for timber production, forest management demonstration and research areas, recreation, wildlife habitat, biodiversity, and watershed protection. These are accomplished through an integrated forestry management strategy. They serve as demonstrations of good forest stewardship for the public, and help train loggers and forest landowners in proper timber harvesting methods and other sound management practices (IDNR 2005).

1.3 Purpose of the Proposed Action

The Division of Forestry proposes to implement a timber management program designed to maintain the current dominance of oak-hickory forests and associated biodiversity while improving overall wildlife habitat and successional stage diversity through a combination of forest management treatments described below. A detailed discussion of the problem associated with perpetuation of the oak-hickory forest type is provided in the "Need for Proposed Action" section below. The proposed action will use timber harvest as a silvicultural tool with an annual harvest level of up to 8,000 acres on all state forest properties in the State of Indiana using a variety of management treatments. A description and anticipated level of use of each management treatment is provided below.

General Forest Management Goals

Under the proposed action, the DoF would implement actions for forest management congruent with the following list of landscape-level management goals. The DoF expects that adherence to these goals through integrated management actions would benefit species of concern, rare, or vulnerable species that live in the plan area.

- Maintain or develop diverse species composition
- Maintain or develop a mosaic of size classes
- Provide forest-based outdoor recreation
- Protect water quality
- Sustain growth of quality hardwood timber
- Conduct timber harvesting at adequate levels for regeneration and revenue
- Monitor habitat conditions
- Control and management of non-native invasive species

1.4 Need for the Proposed Action

Rationale and Overview of Problem

The perpetuation of the oak-hickory forest type is a primary goal of the proposed action. Oaks are the most prevalent forest type in the United States (Clark 1993) and are considered the most important aggregate of hardwoods found in North America (Harlow et al. 1996). Oaks dominate most forest communities throughout the Central Hardwood forest type, a region that includes Indiana and several other Midwestern states (Fralish 2003). In these communities oaks are the unifying component of both successional and compositionally stable (climax) woodlands and forests (Fralish 2003). As the dominant species group of these forest types, oak is an essential element to the habitat of countless species of animals and plants (Ostfeld et al. 1996, Rodewald 2003, Dickson 2004, Fralish 2004, McShea et al. 2007). As a foundation species, oaks influence energy and nutrient dynamics, food webs, hydrology, and biodiversity throughout the eastern deciduous forest (Johnson et al. 2002, McShea and Healy 2002, Ellison et al. 2005). According to recent inventories oak-hickory stands are a major component of Indiana's forests, comprising 61 percent of forestland statewide (Woodall et al. 2005) and 49 percent of state forest properties (unpublished IDNR data). Widespread losses of oak would directly and indirectly affect multitudes of species, reduce native biodiversity, and generally drive community-level shifts and alterations (Ostfeld et al. 1996, Rodewald 2003, Fralish 2004, McShea et al. 2007).

Throughout Indiana and the entire Central Hardwood region, oak-hickory forests are maturing and in many places shifting to different forest types (McCune and Cottam 1985, Schmidt et al. 2000, Abrams 2003, Aldrich et al. 2005, Woodall et al. 2005). Driving these shifts are significant reductions or even failures in oak-hickory regeneration (Lorimer 1993, Aldrich et al. 2005, Woodall et al. 2005). As maturing oaks and hickories die they often are replaced by other competing species such as sugar maple and yellow poplar, rather than young oaks or hickories. Given forest type compositional shifts and a lack of regeneration, the persistence of oak and hickory in Indiana's future forests is becoming increasingly uncertain.

According to the DoF definition of sustainability, the forest should be managed to maintain a desirable species composition within each size or age class to ensure continuity of forest products and other benefits. The DoF proposes that an expanded definition of sustainability include maintaining a desirable species composition in the future high canopy of the forest to sustain the existing level of oak-hickory dominated stands across the system, currently estimated to be 49 percent of forest acres. Proposed harvest levels, methods, timing, and understory treatments must be able to demonstrate that oaks and hickories will be sustained as a major component of the system. To assure this composition and structure is maintained, periodic inventories at the stand and system level must be taken, with management treatments applied as necessary. Adequate timber harvest levels with emphasis on methods, timing, and follow-up silvicultural treatment would assist problematic oak and hickory regeneration and, ultimately, recruitment. Placement and size of harvest openings is critical to supporting oak and hickory seedlings in concert

with sufficient understory treatment to reduce competition from other species. Due to the immediacy and severity of the problem, relying on a "hands-off" approach to oak and hickory regeneration is not likely to be successful in the long-term; some form of active management is necessary to emulate natural disturbances that favor regeneration and survival of the oak-hickory component.

The following sections offer a treatise on the problems and challenges facing forest ecologists and land managers as they design harvest and vegetation management regimes to successfully regenerate oak and hickory in the Central Hardwood region. Here in Indiana, an extensive array of research studies and programs are currently underway on state forest properties, investigating the site-specific challenges to oak and hickory regeneration (see section 1.6.4). The results of this long-term study are expected to guide future forest management activities on Indiana's state forests and provide a model for successful oak-hickory management throughout the state and region. The ecological factors that shaped today's oak-hickory forests are continually changing (Hicks, 1998), requiring forest managers to accordingly adapt their understanding of challenges and how forest development and sustainability is affected. The DoF anticipates its policies and procedures, particularly those regarding timber harvest levels and management activities, will have a positive effect on regeneration and the composition of Indiana's future forest.

Oak Ecology and Life History

Oaks, as a group, tend to be relatively inflexible morphologically and physiologically making them less competitive in many environments. In general, oaks are shade and flood intolerant, drought tolerant, and grow at rates equal to or slower than their competitors (Smith 1993, Johnson et al. 2002). Seedlings of most oak species will survive under the shade of forest canopies if competition from other species below the canopy is reduced or eliminated (Lormier 1993, Rauscher et al. 1997). Light intensity on the forest floor in these situations is often below the compensation point for oaks and seedlings eventually die (Rauscher et al. 1997); however, more shade tolerant competitors, such as sugar maple and beech can survive for much longer periods of time under shady canopy cover. Initial survival and growth of oak seedlings under low light conditions is dependent upon food reserves stored in the cotyledon leaves of acorns. Once these are depleted, light becomes a limiting factor (Rauscher et al. 1997). The regeneration strategy for oaks is to accumulate advance regeneration under a closed canopy until a disturbance event removes enough of the overstory to adequately increase light levels, encouraging shoot growth and, eventually gap capture (Johnson et al. 2002). Adaptations such as fire tolerance and resprouting have enabled oaks to survive during the accumulation stage of its strategy, particularly in regions such as the Midwest where fire and other forms of understory disturbance historically selected against less capable competitors (Crow 1988, Abrams 1992, Van Lear and Watt 1993, Abrams 2003, Van Lear 2004).

Oak seedlings emphasize root growth at a higher rate than many of their competitors (Hodges and Gardner 1993) and generally do not grow rapidly in height until they have developed a substantial root system (Sutherland et al. 2000). This has the effect of making them more fire tolerant and competitive in xeric conditions at the cost of slower shoot

growth. Seedlings resprout following repeated top kill (from factors such as fire) more readily than other tree species due to a concentration of dormant buds near the root collar (Parker 2006). Repeated dieback allows development of sufficient root mass for rapid height growth when light intensity increases on the forest floor following mortality of the canopy (Larsen and Johnson 1998).

Oaks produce acorns sporadically with most species producing a good crop of acorns every 3 to 4 years and bumper crops produced at 3- to 7-year intervals (Johnson 1994; Smith 1993). Most acorns are lost to weather or consumed by insects, birds, and mammals except in bumper crop years (Barnett 1977). Acorn production increases with tree size and generally peaks at 20 to 26 inches dbh. Dominant trees reach 24 to 28 inches on productive sites (site index of 75+) in 60 to 75 years (Sander 1977). Acorns are not viable for more than one year, so seedlings must establish the year of acorn production (Bonner and Vozzo 1987).

Historic and Current Factors Affecting Oak-Hickory Establishment and Sustainability

Oaks and hickories have been important species in Indiana and throughout the Central Hardwood region for the last several millennia (Whitehead 1997, Fralish 2004). Following the retreat of the last glaciers from the Midwest, spruce and fir forests developed across pre-historic Indiana, which gave way to pine, then hardwoods, approximately 9,500 years ago (Whitehead 1997). As the climate continued to warm and become drier, prairies expanded east through portions of present-day Indiana and Ohio bringing with them an associated increase in wildfire (Fralish 2004). During this period it is likely oaks and hickories dominated the hardwood forests of the Midwest, eventually moving into uplands as precipitation levels rose after 5,000 years before present. The eventual invasion by mesophytic hardwoods (e.g., beech, maple, ash) into bottoms and moist, rich slopes was associated with a period 5,000-6,000 years before present (Parker and Ruffner 2004, Fralish 2004). It is likely that the advance of mesophytic hardwoods was slowed into uplands due to the use of fire and land clearing by early Native American cultures (Fralish 2004). These activities, and those done more extensively and intensively by Euro-American settlers centuries later, clearly benefited the maintenance of the oak-hickory ecosystem throughout this region (Fralish 2004). Prior to European settlement, oaks were dominant throughout much of what is now the eastern United States (Abrams 2003).

Most oaks are considered early to mid-successional species and their dominance in many habitats has historically been maintained by large-scale disturbance. The use of fire by Native Americans and land use practices associated with early Euro-American settlement (e.g., conversion of forest to agriculture, cattle grazing, and frequent fires) perpetuated the oak-hickory forest complex across the Central Hardwood region by reducing or eliminating competition from less fire-tolerant, more mesophytic species. As settlements grew in population, use of woodland fire was largely limited to understory improvement burns for livestock grazing (Parker and Ruffner 2004); eventually, active suppression of wildfires effectively eliminated the periodic, landscape-scale effect of fire from many forests (Fralish 2004). Other large-scale disturbance patterns changed following settlement, including

the elimination of the passenger pigeon from Midwest woodlands through unregulated market hunting. Researchers believe the enormous roosting and nesting colonies of passenger pigeons caused significant periodic disturbance to pre-settlement forests and woodlands, creating conditions that may have benefited the development of oak forests (Ellsworth and McComb 2003). Other human-influenced changes also have taken place over the last century that affected the development and growth of oak-hickory forests, including increases in deer densities and the introduction and spread of pathogens and insect pests (Spetich 2004). Though today's forestland has developed from the remnants of pre-settlement forests, it has been shaped and influenced by very different disturbance regimes and faces very unique developmental challenges.

In the last 30 years, low levels of selective timber harvest on public lands, partial-cutting and high-grading on private lands, and a lack of fire as a periodic disturbance regime have reduced oak recruitment in Central Hardwood forests, particularly on high quality (mesic) sites (Hicks 1998, Schmidt et al. 2000, Van Lear 2004, Woodall et al. 2005). These factors create situations where oak and hickory seedlings either develop in low-light environments under full or partial canopy (selection harvesting) or where canopies were removed before the necessary advance regeneration was in place (high-grading). Without periodic understory disturbance to reduce competition from more shade-tolerant and less fire-tolerant species such as sugar maple, oaks and hickories are eventually outcompeted when openings or large gaps are created in the canopy (Lorimer 1993, Hicks 1998). Unless sufficient advance regeneration is in place when openings are made in the canopy, rapidly establishing and faster growing species such as yellow poplar will quickly overtop oak seedlings and dominate the site (Johnson et al. 2002, Loftis 2004). Eventually, successful non-oak competitors become established in forests that were once dominated by oak-hickory, shifting the species composition toward a new forest type (Abrams 1992, Van Lear 2004). While Indiana's forests are now growing faster than they have in several decades, oaks as a group are growing substantially slower than other competitors, such as yellow poplar and sugar maple (Woodall et al. 2005). Today, yellow poplar is the most common tree in Indiana by volume and has experienced a state-wide growth in volume more than 4 times that of any oak species over the last two decades (Woodall et al. 2005). In terms of sheer number, sugar maples dominate Indiana's forests, with twice as many trees as any other species. Though oak and hickory seedlings can still be found in Indiana forests, there typically are substantially more competitors, such as sugar maple, which outnumber oaks and hickories 4 to 1 statewide (Woodall et al. 2005).

On DoF lands, approximately 80 percent of the high canopy forest is currently dominated by oaks or hickories. Results of a system-wide state forest inventory in 2005 indicated that 49 percent of forest stands are typed oak-hickory. However, the composition of seedlings and saplings from this same inventory suggests the future of oak and hickory dominance may be in jeopardy on state forests. Across the state forest system, oak-hickory is the most abundant hardwood cover type by area (49 percent), followed by mixed-hardwoods (34.4 percent), and beech-maple (3.8 percent); however, mixed-hardwood seedlings and saplings occurred most often in the same inventory (64.9 percent), followed by beech-maple (17.7 percent) and oak-hickory (11.3 percent). Of the six forest proper-

ties with the highest proportion of oak-hickory stands (≥ 40 percent of total forest), five had lower densities of seedlings and saplings in the oak-hickory group than beech-maple and all properties had considerably fewer seedlings and saplings in the oak-hickory than mixed-hardwood group.

While oak seedlings can generally be found in most woodlands where oak species occur as canopy dominants, studies suggest the presence of natural regeneration alone will not necessarily guarantee oak persistence in undisturbed areas (Sander and Graney 1993, Johnson et al. 2002, Loftis 2004). Given the rapid and wide-spread shifts in overstory and seedling/sapling dominance by oak-hickory competitors, it is extremely unlikely that natural disturbance events alone can maintain current levels of oak-hickory forest throughout Indiana (e.g., Klaus et al. 2005). Timber harvest and silvicultural treatments are viewed as the ecological equivalent or more socially and economically acceptable mimic of natural disturbances that historically have maintained oaks on the drier sites across their range.

Successful Oak Recruitment through Forest Management

In general, perpetuating oaks in most habitats requires intentional management to create conditions favorable to oaks and detrimental to their competitors. Many studies have documented the failure of oak regeneration across the Central Hardwood region and have shown a causal link between insufficient understory disturbance and the expansion of mesophytic species across the region (McCune and Menges 1986; Parker et al. 1985; Crow 1988; Abrams 1992; Ruffner and Groninger 2004). Prescribed fire has been used successfully in many places to reduce competition with oak regeneration (Van Lear and Watt 1993, Loftis 2004, Groninger et al. 2005, Dickinson 2006). Other methods used alone or in various combinations also have been successful in reducing oak competitors. These include the use of mechanical removal, soil scarification, and herbicide (Spetich 2004).

Oak regeneration may be artificial or natural and usually occurs following a disturbance or harvest (Rauscher et al. 1997). Because artificial regeneration methods (seeding and planting) are costly and labor intensive, they usually are not employed to supplement natural regeneration across large forested landscapes. Natural oak regeneration may take three different reproductive forms: seedlings, seedling sprouts, and stump sprouts (McGee and Loftis 1993). Small, recently established seedlings are often out-competed by other species, and stump sprouts alone are generally not considered a reliable source of forest regeneration because larger stumps often fail to sprout and small stumps typically occur too infrequent to provide adequate regeneration on medium- and high-quality sites (Rauscher et al. 1997). The presence and development of advanced reproduction – well-established seedling sprouts and other stems – is vital for oak regeneration in the Central Hardwood region (Hicks 1998, Johnson et al. 2002, Loftis 2004). Sufficient oak reproduction in advance of canopy removal ameliorates the effect of competition with more tolerant species and will have a large effect on the future composition of the future stand.

Oak Sustainability on DoF Properties for the Term of this Assessment

Timber harvest prescriptions on state lands are designed to produce a sustainable yield

of forest products while maintaining, creating or perpetuating a desired forest condition. Future timber harvest levels outlined in the 2008-2013 DoF Strategic Plan are projected to maintain a maximum harvest level on state forestland at 60 percent of growth, or an estimated 14 million board feet (mmbf) annually. The average annual growth on state forests estimated from the 2005 system-wide inventory is 24.8 mmbf. Under the proposed action, timber harvests would be applied on an estimated 5 percent of the total state forest area annually.

This proposed action includes a greater number of harvest openings, increased recruitment efforts for oak and hickory, and better opportunity to establish new stands of shade intolerant and mid-tolerant species than previous management levels. Based on the 2005 system-wide inventory, the DoF estimates that approximately 10.8 trees per acre >15 inches dbh would be harvested on approximately 8000 acres (equating to a harvest of approximately 86,480 trees annually) under this treatment. It is important to note that this harvest level represents a maximum effort, and could be less in any one given year.

The increased forest management emphasis across DoF administered lands will provide the disturbance needed to help maintain and perpetuate the oak-hickory cover type over the long-term. While groundstory and overstory disturbance is necessary for the maintenance of this forest type, other important management needs will be addressed as well, including control of non-native invasive species. On areas not harvested, existing trees will continue to mature and the recruitment of new trees and the future composition of the forest will depend on the timing and degree of magnitude of harvesting and other forest management activities implemented by DoF.

1.5 Management Activities used in the Proposed Action

This section provides a brief description of the range of forest management treatments applied in the past and are proposed for continued use during the life of the proposed action.

1.5.1 Timber Harvest Treatments

Silvicultural Systems Used to Increase Oak Regeneration
Decisions regarding the appropriate silvicultural method to employ when working to maximize oak and hickory regeneration must take into account many factors including site conditions (edaphic factors), existing stand characteristics, and the regeneration potential of a site (relative amount of advanced reproduction) (Hicks 1998). Regeneration of forests in Indiana has used both uneven- and even-aged silvicultural systems (Mills et al. 1987) on rotations of 80 to 120 years. Such a rotation is consistent with the observed natural longevity in oaks (Johnson et al. 2002:198). Although individuals may live 400 years or longer, few live beyond 200 years, even in old-growth forests (Johnson et al. 2002:199). Uneven-aged systems (both single tree and group selection) have generally been applied to both private and state-owned forests in Indiana. The Hoosier National Forest used an even-aged system (primarily clearcutting) from the mid-1960s to the mid-1980s, but since the 1990s, has employed uneven-aged management methods.

Hardwood Single Tree Improvement and Group Selection
A hardwood single tree improvement harvest is a type of uneven-aged harvesting done alone or in conjunction with group selection openings. Individual trees are selected and removed throughout the stand approximately every 15 to 25 years. The treatments are conducted to modify or guide the development of the existing crop of trees, but not to replace it with a new one. These activities include selective removal of some vegetation to allow the expansion of remaining tree crowns and root systems. The decision to remove a single tree under this method is based on in-field evaluation of that individual stem for condition, vigor, species, and impact to neighboring existing trees.

Single tree improvements on state forests usually harvest 7 to 10 trees per acre (or about 20 percent of the sawtimber sized trees). Additional trees may be removed in follow-up timber stand improvement treatments. The remaining sawtimber trees are left as growing stock. Before the stand is re-entered for the next harvest, canopy gaps are filled in by the growth of adjacent trees. The average dbh of harvested trees is 19 to 20 inches. Historically, the most common tree species harvested on state forests have been Black oak, Chestnut oak, White oak, Yellow-poplar, Red oak, and Scarlet oak. These harvested trees are also the most commonly occurring species in sawtimber size classes.

Under the proposed action, hardwood group selection openings (each less than 10 acres in size) would occur annually on 1,400 acres and hardwood single tree improvements would be used on about 5,000 acres. Within an administrative tract, areas of less than 10 acres each would be identified for group selection openings in which all stems are removed to encourage regeneration and creation of small patches of early successional habitat. These potential group selection openings would be selected based on an evaluation of the overstory condition and regeneration potential. To ensure successful oak regeneration, these future openings may be pre-selected and pre-treated to create conditions necessary for oak seedling establishment. That is, the site may be given the necessary understory control treatment to encourage oak seedlings, with the final overstory removal to create the group opening occurring 15 to 25 years later. The remainder of the tract between openings would be treated with an improvement harvest. The improvement harvest would selectively remove some mature, damaged, or competing trees to allow remaining desirable stems the conditions to grow more vigorously.

Pine Clearcuts
A pine clearcut is an even-aged stand regeneration action. All the pines in the stand are cut and removed at the same time, and replaced with a new stand of small seedling/sapling hardwood trees on the entire area. Almost all existing pines on DoF lands are non-native and the result of plantation plantings established on abandoned farmlands to stabilize and improve soils. Pine clearcuts are implemented to replace non-native pines with native hardwoods. This method mimics hardwood regeneration that naturally occurs when openings are created.

The DoF estimates approximately 75 acres of pine clearcut harvests could be applied on the State Forest system each year.

Pine Thinning

Pine thinning is the removal of pines from pine stands or a partial cutting in even-aged aggregations of trees. Tree removal is done to improve future growth and vigor by regulating stand density. Thinning methods are of two different types: commercial thinning where some or all of the wood harvested is sold, and pre-commercial thinning where unwanted trees are cut or killed without product utilization. Most of the pine thinning on DoF properties is conducted as commercial thinning and is usually done only once, occasionally more frequently, during the life of the pine stand. A typical pine thinning prescription is 0.5 to 20 acres and approximately less than 50 percent of the trees present are removed from an even-aged stand. Without thinning, pine stands often become overcrowded, resulting in little growth, poor health and high mortality.

The DoF estimates approximately 75 acres of pine thinning could be applied on the State Forest system each year.

Hardwood Shelterwood

A Shelterwood harvest is a method of even-aged regeneration. Typically retained hardwood trees are 16 to 28 inches dbh. Trees selected for retention are well spaced, of desirable species, and have the form and condition desirable in future stands. These trees contribute seed to create the future stand and provide partial shade to protect and foster development of seedlings. Extra or undesirable trees are harvested, resulting in natural regeneration of hardwood species. Shelterwoods designed to encourage oak-hickory regeneration must allow the proper amount of sunlight to reach the forest floor to allow oaks and hickories to successfully compete with more shade tolerant species; properly applied, oaks and hickories will make up a large proportion of the regenerated stand. Harvesting the existing stand of trees is done in a series of cuttings to release the new seedling trees started under the previous stand. The essential characteristic of the shelterwood method is that the new stand is established (naturally or artificially) before the last of the previous stand is removed. The final overstory removal in shelterwood harvests usually takes place within 10 years of the initial cutting. Because the final harvest on these areas is near the time of the initial harvest, the size and age of trees in the final harvest is not vastly different from the initial harvest. In these areas large trees (16 to 28 inches dbh) are present in a more open setting for the period between harvests (approximately 10 years). In its most intensive development, shelterwood harvest may involve a series of three different kinds of cutting: (a) a preparatory cutting designed to foster the potential seed producers or speed decomposition of litter; (b) a seed cutting which is a true regeneration cutting and aimed at getting the new crop established; and (c) one or more removal cuttings to release the newly established crop or to harvest the remaining old trees.

The DoF estimates approximately 650 acres of hardwood shelterwood harvests could be applied on the State Forest system each year.

Hardwood Clearcuts > 10 acres each
A hardwood clearcut is an even-aged stand replacement action on areas 10 acres or more in size. Usually clearcuts on DoF properties are between 10 and 25 acres. On rare occasion, larger areas may require a clearcut to manage the results of unforeseen events such as damage from wildfire, insects, storms, or disease. All trees in the stand are cut at the same time and replaced with a new stand of small hardwood trees on the entire area. Hardwood clearcuts on DoF lands are most often used in areas where an entire stand has been damaged by wildfire or storms or where, as a result of past activities, the stand composition is dominated by less desirable trees, exotics, or invasive plant species. The use of clearcut harvests provides a higher probability for the successful establishment of new oak-hickory stands than uneven-aged harvests. However, clearcutting alone does not guarantee the regeneration of an oak-hickory dominated stand. On most sites a mechanical, chemical or prescribed fire pre-treatment is needed to control the understory and create conditions necessary for the development of competitive oak seedlings in the stand prior to the clearcut. Clearcuts also create conditions favorable for non-native invasive species, so pre-treatment actions must identify and control these problem species when present. Clearcuts also create openings for large continuous areas of early successional habitat.

The DoF estimates approximately 800 acres of hardwood clearcuts could be applied on the State Forest system each year.

1.5.2 Follow-up Harvest Treatments

Prescribed Fire
The DoF completes a low-intensity prescribed burn for the specific purposes of management of plant communities including hazardous fuels reduction, forest regeneration, and habitat enhancement. Low intensity prescribed fire is described as controlled ground fire that does not burn into the crowns of mature trees. These fires mostly kill very small stems and thin barked species. Specifically, this includes control of woody vegetation on grassland habitats, support for advance regeneration of fire-tolerant tree species (oaks and hickories), maintenance of unique fire-dependent natural communities, and control of fire sensitive tree regeneration in forest openings. Implementing a prescribed burn requires construction of firebreaks by hand or machine. When used to promote oak-hickory regeneration, prescribed burns usually are done prior to or in conjunction with timber harvests or timber stand improvement to establish desirable forest regeneration. Prescribed fire is an effective tool used to prepare the forest understory to favor oak regeneration by top-killing some interfering species that compete with oak seedlings. Prescribed fire also removes or thins the duff layer to facilitate germination by allowing the acorn to come into contact with mineral soil, and to recycle nutrients stored in the leaf litter. Prescribed fire has been shown to increase regeneration success when oak seedlings are more than 3 years old have developed a level of fire resistance that provides a competitive advantage over less fire-tolerant species. When used for maintenance of grassland habitats, prescribed fires may cover up to 300 acres, while the typical woodland fire is usually less than 50 acres.

The DoF estimates approximately 2,000 acres of prescribed fire could be applied on the State Forest system each year.

Timber Stand Improvement (TSI)

Timber stand improvement actions are treatments done alone or in conjunction with a timber harvest. Treatments include pruning, grapevine control, and individual stem deadening by girdling or herbicide application. The purpose of all timber stand improvement treatments is to create conditions that give existing and desirable trees a competitive advantage. A competitive advantage is created by allowing desirable trees adequate supply of light, moisture and nutrients, and by limiting vegetation that can interfere and compete with tree growth. Control of grapevines and many non-native invasive species is best accomplished with treatments prior to a timber harvest. Non-native invasive plant species will be evaluated and, if necessary, controlled in all stands prior to harvest. Release of desirable trees from other competing trees is most often completed after harvest activities.

TSI can be applied as a pre- or post-harvest treatment and may be used on the same tract but spaced within a few years of each other. Each TSI activity is viewed as a separate action and thus the same acre may be counted twice in acreage calculations if both pre- and post-harvest treatments occur. During pre-harvest TSI, grapevines in high quality trees are deadened and undesirable saplings in areas planned for openings are removed. Pre-harvest TSI is often used to remove shade tolerant mid-story and understory species to allow sufficient sunlight to encourage oak seedling development. During post-harvest TSI, most remaining stems in regenerated openings are deadened and individual crop trees are released from competition. Post-harvest TSI typically results in the deadening of three to six sawtimber size (>11 inches dbh) trees per acre. TSI not only is used to improve the quality and growth of residual trees, but also is an effective tool for creating wildlife habitat. On a specific tract, TSI can be used to improve wildlife habitat through the creation of snags in selected sizes, locations, and tree species, or through the release of individual trees with desirable characteristics for wildlife.

The DoF estimates approximately 8,000 acres of TSI could be applied on the State Forest system each year.

Soil and Water Improvement

The DoF implements soil and water improvement actions according to procedures outlined in the Best Management Practices (BMP) for Water Quality applicable to all forest management activities. Soil and water improvements are done to minimize impacts to soils and water quality and to support rehabilitation of disturbed areas. These activities must adhere to proper implementation of the BMPs which contain guiding provisions, treatments, and restrictions for forest and haul roads, recreation and skid trails, stream crossings, log landings, fuel, lubricants and trash, site preparation, tree planting and reseeding, wetlands, chemicals and weed control, riparian management zones, buffers, mechanical and hand clearing, and prescribed fire control lines. The DoF BMP document is provided on the DoF pages of the DNR web site at www.in.gov/dnr/forestry/6867.htm.

In an effort to minimize soil movement, compaction, and run-off issues which affect water quality, the DoF practices, when possible, avoidance of wet-weather or winter logging on unfrozen soil conditions. Timber harvesting contractors also are required to implement BMPs as a condition of contractual performance.
Soil and water improvement associated with the proposed action is primarily implementation of the BMPs on an estimated amount of acreage. A small amount of construction-type projects also are included in these calculations. The DoF estimates about 2 to 3 percent of the acres proposed for harvest will require soil and water improvements as a result of ground disturbance. These soil and water activities on harvest areas and trails constitute almost the entire emphasis by DoF on water quality issues.

The DoF estimates approximately 300 acres of soil and water improvement could be applied on the State Forest system each year.

Tree Planting and Natural Regeneration
After timber harvest, stands are assessed for successful reforestation. Young trees need adequate sunlight, moisture, and nutrients to develop into a forest stand. Treating this environment to support forest plantings and natural regeneration may require removal of competing vegetation with cuttings, herbicides, or other mechanical means. These methods are designed to ensure desirable regeneration has a competitive advantage over other existing vegetation at a particular site. Tree plantings include consideration of tree species that meet planting objectives and are naturally suited to the site. These methods are particularly helpful for species that are slow-growing seedlings and saplings. Prioritized areas targeted for forestation projects include previously cleared areas along streams, forested sites needing species enrichment, aesthetically sensitive areas and unproductive or potentially erosive sites slow to regenerate naturally. Wherever possible, the DoF supports and promotes natural regeneration.

The DoF estimates approximately 2,925 acres of natural regeneration could be applied on the State Forest system each year. Tree planting is estimated to be applied on an additional 100 acres each year.

1.5.3 Maintenance Activities

Recreational and Operational Facility Construction and Maintenance
Vegetation control is required as part of construction and maintenance of facilities in forested settings. These activities provide for public safety and promote a more aesthetic and satisfying recreation and work experience. These actions include tree and vegetation removal for safety, hazard reduction, facility maintenance, and site preparation for new construction that may require grading, clearing, cuttings, herbicides, prescribed fire, and use of mechanical means. Compared to other DoF activities, these actions affect a limited amount of acreage annually. DoF maintenance activities also are required to comply with regulations in Indiana Code (IC 14-21) for cultural resources.

The DoF estimates approximately 100 acres of facility maintenance and construction methods could be applied on the State Forest system each year.

Road Construction
Road construction is the development of new roadways where no road existed before. On DoF lands a small amount of new roads are developed annually. Because much of the state forestland historically was cleared and farmed prior to acquisition, there is a large preexisting system of roads and trails. New road construction is typically required for short distances and to replace existing roads with drainage or other problems difficult to resolve. Access roads needed for timber harvest operation, wildfire control, recreation, or other actions may require tree and vegetation removal, ground shaping, and the installation of geo-textile fabric and aggregate. All road construction activities adhere to guidelines specified in the DoF BMPs. DoF road construction activities also are required to comply with regulations in Section 106 (NHPA) Indiana Code (IC 14-21) for cultural resources. Road and trail construction activities have the potential to introduce non-native invasive species. The DoF will take the necessary steps to prevent introduction of new non-native invasive species into new areas. Equipment used to construct roads should be free of non-native invasive species seed or propogules. Seed mixtures used to re-vegetate roadsides should be weed free. State forest property personnel will inspect each newly constructed road during the following growing season to identify and control, as necessary, any newly introduced non-native invasive species.

The DoF estimates approximately 50 acres of road construction could be applied on the State Forest system each year.

Road Maintenance
Road maintenance is required to ensure existing roads remain usable and stable. Annual maintenance and periodic clearing is conducted on approximately 450 miles of existing service roads. Routine maintenance actions may include tree and vegetation removal, non-native invasive species control, ground shaping, and the installation of geo-textile fabric and aggregate. Typically DoF maintains a ROW (right-of-way) width of 15 feet for forest roads. Road and trail maintenance activities have the potential to introduce or increase the rate of spread of non-native invasive species. For this reason, DoF will regularly inspect roads and trails for the presence of non-native invasive species and control populations as necessary.

The DoF estimates approximately 900 acres of road maintenance activities could be applied on the State Forest system each year.

Trail Construction
Trail construction is the development of new trails where no road or trail existed before. On DoF lands a small amount of new trail is developed annually. Because much of the state forestland was historically cleared and farmed prior to acquisition, there is a large preexisting system of roads and trails. New trail construction typically is required for short distances and to replace existing trails with drainage or other problems difficult to resolve. New trail construction provides recreational opportunity for hiking, mountain biking, scenery viewing, and horseback riding. Construction of trails may require tree and vegetation removal, non-native invasive species control, ground shaping, and the

installation of geo-textile fabric and aggregate. All trail construction activities adhere to guidelines specified in the DoF BMPs. DoF maintenance activities also are required to comply with regulations in Indiana Code (IC 14-21) for cultural resources.

The DoF estimates approximately 15 acres of trail construction activities could be applied on the State Forest system each year.

Trail Maintenance
Trail maintenance is required to ensure existing trails remain usable and stable. Annual maintenance and periodic clearing is conducted on approximately 525 miles of existing recreational trails. Routine maintenance actions may include tree and vegetation removal, non-native invasive species control, ground shaping, and the installation of geo-textile fabric and aggregate. Typically DoF maintains a ROW width of 10 feet for recreational trails.

The DoF estimates approximately 635 acres of trail maintenance activities could be applied on the State Forest system each year.

1.5.4 Habitat Management

General Wildlife Habitat
These management actions include on-the-ground activities to create and maintain openings as general wildlife habitat and provide water resources that also may support fish and herpetile populations. On DoF lands these areas are often permanent openings that are maintained with herbaceous cover by controlling the incursion of woody vegetation. Water holes or small ponds are constructed and maintained at permanent openings where water availability may be a limiting factor for wildlife. Maintenance and establishment of wildlife openings and ponds is accomplished with brush hogging, edge clearing, herbicides, heavy equipment operation, hand tools, and prescribed burning. Permanent openings with herbaceous cover can be hot spots for the spread of non-native invasive species and will be monitored regularly for potential problems and control treatments applied as necessary.

These permanent openings usually are constructed and maintained initially with the establishment of haul roads used for access and log landings used as staging. These areas sometimes are developed in cooperation with the Forest Wildlife Project of the Indiana Division of Fish and Wildlife. For a haul road to be stable for traffic and resistant to soil movement it must be designed to receive enough sunlight and drainage to quickly dry after rain events. In areas where sunlight and drainage are not naturally available, a road corridor is widened to about 100 feet or less to allow for construction of water diversions and influx of sunlight. Linear corridor openings along haul roads are usually less than three acres each and are often created with at least one edge adjacent to areas of sawtimber size trees. Log landings are rectangular to semi-circular polygons usually less than 0.5 acre in size. Both types of openings are intended for re-use during subsequent harvest operations and are maintained by mowing and brush cutting every few years.

The DoF estimates approximately 300 acres of general wildlife habitat activities could be applied on the State Forest system each year.

Early Successional Habitat

After a regenerating harvest (clearcut or large group opening), the developing stand provides early successional habitat, which persists for about 10 to 20 years. Early successional habitat created from timber harvest areas left to transition through developmental stages is a contrast to creation and maintenance of permanent wildlife openings. Like permanent openings, early successional habitat following a timber harvest can introduce or increase the spread of non-native invasive species. DoF precautions described in the harvesting and TSI sections of this document will be followed to monitor and control these problem species. During the early successional stage the area will progress from very large numbers of seedling size trees with a very open appearance, to somewhat fewer sapling size trees with a "brushy" appearance, to the early stages of pole size timber with even fewer stems per acre, and the beginning appearance of a young forest. Each of these phases of early successional habitat provides food and cover for many different groups of wildlife species. As a stand transitions from early successional habitat to a closed canopy forest, new early successional habitat will need to be created to maintain diversity and supply of this important habitat type. Furthermore, regeneration in these openings is much more likely to exhibit a higher concentration of oaks, hickories and other desirable tree species. These regenerating openings interspersed within an older forest or one managed by single tree selection provide a mosaic of size classes favorable to a wide range of wildlife species.

The DoF estimates early successional forest currently constitutes < 1 percent of state forest properties; the DoF Strategic Plan for 2008-2013 identifies a goal of 10 percent early successional forest habitat, system-wide. The DoF estimates approximately 2,925 acres of early successional habitat could be applied on the State Forest each year.

Acquired Wildlife Habitat

All DoF lands provide a mosaic of wildlife habitats that satisfy multiple-use goals. As new lands are acquired and placed under DoF management, the total area of managed wildlife habitat increases. Under the DoF Strategic Plan for 2008-2013 about 35 percent of the proceeds from timber harvest will be used to acquire additional lands to be included in the state forest system. The DoF expects this level of effort for land acquisition to continue annually (beyond Strategic Plan dates) over the 20-year duration of this assessment period. Most state forestlands are available to the public for recreational wildlife viewing, hunting, and fishing.

The DoF estimates approximately 490 acres of acquired wildlife habitat could be applied on the State Forest system each year.

Agricultural Areas

The DoF land acquisition program frequently results in the addition of agricultural lands, including pasture, hay or crop fields. These open fields usually are planted with native

hardwood seedlings as time and funding permits, usually within 2 to 5 years. Until such planning and funding is in place, these fields are usually maintained as crop fields through a lease agreement with a nearby farmer. The DoF estimates approximately 300 acres of agricultural fields could be present on the State Forest system at any given time.

Non-native Invasive Plant Species Control

Invasion of non-native species is one of the most critical threats facing Indiana's forests. Invasive plants are those that grow quickly and aggressively, displacing other desirable vegetation or ecological habitats as they spread. Usually, invasive plants are non-native and sometimes referred to as exotics or noxious weeds. Of the roughly 2,300 plant species growing outside of cultivation in Indiana, 25 percent are non-native. Most non-native plants are not troublesome to the landscape. However, a few aggressive plants are responsible for degrading and destroying thousands of acres of natural plant communities in Indiana and are costing hundreds of thousands of dollars each year for control measures. Some non-native invasive plants are well established on DoF lands and are causing increased displacement of native plant communities.

One of the best ways to control non-native invasive species is to prevent the spread of problem species into new areas. Inventory and control efforts will be applied at the stand level before soil or canopy disturbance activities begin. As new populations are discovered, DoF will initiate control efforts as soon as possible before the population has a chance to reproduce. Once a seed bank is established, the non-native invasive plant species become more difficult to control. Removal of invasive plants will be done with cuttings, herbicide applications, prescribed fire, hand pulling, and other mechanical means. Two non-native invasive plant species active on DoF lands that are targeted for intensive surveys, mapping, and control measures are *Pueraria montana* (kudzu) and *Ailanthus altissima* (tree of heaven).

DoF proposes a proactive and ongoing program to control the most aggressive invasive plants. All properties began conducting extensive searches for invasive plants during 2006. The DoF will continue to work with the DNR Invasives Committee and other partners to determine effective methodology, the location of infestations, and degree of invasive incursion on state forests. To the extent possible, DoF will work with neighboring landowners to coordinate control efforts on populations that cross ownership boundaries. The continuous forest inventory (CFI) system described later (§ 1.6, Existing Monitoring and Quality Control Systems) will provide system-wide monitoring of non-native invasive plant species.

The DoF estimates approximately 1,400 acres of invasive plant species control could be applied on the State Forest system each year.

BMP Mitigation Measures

The DoF mandates proper implementation and adherence to BMPs as performed by its staff and contractors participating in planned ground disturbing activities, including timber harvest projects. A complete list of DoF BMPs is provided on the DoF pages

of the DNR web site at www.in.gov/dnr/forestry/6867.htm. A partial list of BMPs is summarized below.

Forestry Logging Operations

1. Locate and identify streams, drainages, and crossings.
2. Locate and identify critical areas subject to rutting and erosion.
3. Locate and identify buffer zones for streams and other sensitive areas.
4. Avoid steep slopes and poorly drained areas.
5. Locate and avoid poorly drained, highly erosive, or wet areas.
6. Locate and avoid open karst features.

Forest Roads

1. Lay out roads and drainage system before equipment arrives.
2. Use existing access routes if use will not aggravate erosion problems.
3. Apply Riparian Management Zone BMPs to road locations.
4. Minimize the number of stream crossings.
5. Avoid or minimize disturbance to areas of high quality trees.
6. Keep grades between 2 percent and 10 percent when possible.
7. Maintain buffers between roads, waterways, and other sensitive areas.
8. Install breaks for road grades to divert water from road surface to stable areas.
9. Avoid gullies, seeps, and other permanently wet areas.
10. Incorporate aesthetic considerations, especially in visually sensitive areas.

Constructing Forest Roads

1. Construct only as much road as necessary, minimize clearing.
2. If possible, construct, stabilize, and seed in advance.
3. Minimize earth-moving activities when soils are excessively wet or dry, and before oncoming storms.
4. Place crushed stone on highly erosive sites or when hauling during wet or muddy conditions and place geotextile stabilizing fabric under crushed stone on wet sites.
5. Construct roads to drain at all times, install culverts or other breaks at specified intervals on steep grades where inside ditches are required.
6. Drain water diverting structures and road runoff onto the undisturbed forest floor away from stream channels.
7. Minimize cut and fill work, and keep slopes at stable angles.
8. Maintain an undisturbed buffer strip between forest roads and streams. If a suf ficient buffer strip next to waterways is not possible, use temporary erosion and sediment control practices.
9. Install erosion control measures as road sections are completed.
10. At culvert drain spouts, install sufficient energy dissipaters such as brush or rip rap where necessary to prevent sediment delivery to the watercourse.
11. Do not place fill material into open sinkholes, waterways, wetlands, floodways, or other sensitive areas.
12. Do not leave felled or cleared material in major stream channels or where it may be washed into a channel during a flood event.

Road and Trail Maintenance

Road maintenance should be done regularly. Inspect and maintain erosion control and water diversions frequently. This maintenance should be done even during periods of work shut down.

1. Avoid using roads during wet periods if it will damage the road drainage features or cause excessive rutting and erosion.
2. Clean dips, culverts, and cross drains; repair ditches to prevent erosion and sedi ment delivery into waterways.
3. Clear away minor obstructions that may have accumulated in drainage structures.
4. Smooth edges that develop on road surfaces if they will trap water.

Skid Trails

1. Avoid long steep grades greater than 20 percent. Use steeper grades only for short distances and when large water bars or other diversions are installed and maintained.
2. Locate and allow skidding at an angle to the slope, not straight up and down a hill.
3. Avoid skidding through stream channels, springs, seeps, sinkholes, and other wet areas.
4. Cross streams as near to a right angle as possible. Utilize temporary bridges or install culverts where practical.
5. Remove temporary crossings as soon as use is completed.
6. Fords may be utilized where stable conditions exist and allow crossing without excessive soil movement into the stream

Closing Skid Trails

1. Smooth water channeling ruts and berms.
2. Install appropriately spaced water bars and other diversions as each harvest sec tion is completed or shut down (even temporary shutdowns).
3. Divert water off skid trails before the trail enters a Riparian Management Zone or crosses a stream.
4. Drain each diversion onto stable forest ground.
5. Seed skid trails prone to erosion or allow to regrow naturally. Mulch and fertilize seeded areas where necessary.
6. Return disturbed recreation trails to preharvest condition or better.
7. Logging debris in combination with water bars or other diversions can be placed on skid roads for erosion control. Brush and logs need to be limbed sufficiently to allow ground contact.

Stream Crossings

1. Cross at right angles at a point where the streambed is straight and uniform.
2. Minimize the use of equipment in the streambed.
3. Limit construction activity to periods of low or normal flow.
4. Minimize excavation and fill at stream crossings and other disturbances to stream banks and channels.
5. Use materials that are clean, non-erodible and non-toxic.
6. Avoid using soil as fill except when installing culverts.
7. Culverts in permanent streams should be installed with the advice of a IDNR

fishery biologist.

8. Avoid altering stream flow.
9. Divert runoff from roads and trails leading to stream crossings into undisturbed vegetation. Avoid directing runoff directly into streams, including ephemeral streams.
10. Construct bridge, culvert, or pole crossing at elevations higher than their road approach.
11. If necessary, stabilize road and trail approaches to stream crossings with aggre gate or other suitable material.
12. Stabilize exposed soil as soon as practicable.

Riparian Management Zones (RMZ)

RMZs are natural buffer areas between logging and forestry activities and waterways. A RMZ begins at the watercourse bank or sinkhole opening and extends inland. Trees may be harvested within the RMZ. The goal is to maintain a stable forest floor to filter sediment and other pollutants before runoff enters the main watercourse.

1. Make RMZs as wide as practical.
2. When harvesting trees in the RMZ, minimize disturbance of the forest floor, ex posure of mineral soil and degradation of stream banks, and leave adequate tree stocking to shade the stream.
3. Locate roads and skid trails outside RMZs except where necessary for stream crossings.
4. Minimize mechanical disturbance to the forest floor by using directional felling away from the watercourse and winching to skid trails outside an RMZ when necessary.
5. Do not pile slash, fill, or place debris within RMZs.
6. Remove felled tops and logging debris from the channels of perennial and large intermittent streams.
7. Place felled tops and debris a sufficient distance away from the watercourse to prevent flood impediments.
8. Expose no more than 10 percent bare, mineral soil, well distributed throughout the RMZ.
9. Avoid locating equipment and material storage sites, maintenance sites and log landings within the RMZ.
10. Avoid operating wheeled or tracked equipment in the RMZ and watercourses except on designated roads and stream crossings.
11. Do not locate roads or skid trails on pond dams.
12. Divert forest road and skid trail runoff onto stable areas before it enters the RMZ.
13. Stabilize all roads, skid trails, cuts, and fills in the RMZ as soon as practicable after construction and use.
14. Avoid broadcast spray of herbicides or fertilizers within the RMZ.
15. Cut few, if any, trees within 15 feet of permanent watercourses.
16. Retain at least 50 percent well-distributed canopy cover in the primary RMZ on perennial watercourses.

Log Landings

1. Well-planned and managed log landings minimize impacts to the site, protect water quality, enhance visual quality, and often increase operation efficiency and safety.
2. Keep the number and size of landings to the minimum needed to operate safely and efficiently.
3. Choose a site that will hold up under anticipated use by heavy equipment.
4. Avoid sensitive areas, such as RMZs, waterways, caves, springs, seeps, and open sinkholes.
5. Maintain an undisturbed buffer strip between log landings and sensitive areas.
6. Locate landings on slightly sloping ground where soil and site characteristics facilitate drainage and minimize erosion problems.
7. Design landings to provide safe access and visibility onto highway when next to public roads.
8. Consider aesthetics when planning log landings next to roadways and other visu ally sensitive areas.
9. Notify appropriate utility companies before locating landings near overhead and underground utilities

Fuel, Lubricants and Trash

Improper handling of fuels, paints, solvents and lubricants has the potential to cause soil and water contamination and damage water potability, recreational use, and fisheries.

Report all fuel, lubricant, and hazardous material spills exceeding one pound or pint which enter the waters of the state, including ground water, and causes a sheen or creates damage to water quality to Indiana Department of Environmental Management.

Also report: 1) spills near well heads, 2) operating fluids spills exceeding 55 gallons, 3) spills which may damage water quality, 4) spills exceeding your cleanup capabilities, and 5) any spill where there is doubt or when technical clarification or assistance is needed. Any spill not cleaned up is also reportable. (Indiana Spill Rule, 327 IAC 2-6-1 & 2). General guidelines:

1. Clearly specify and use a designated area for fueling, material storage, and main tenance. This area should be away from waterways, areas prone to runoff, or sensitive areas like caves, sinkholes, springs, seeps, and RMZs.
2. Use caution when fueling all equipment, even chainsaws, to avoid spills.

1.6 Existing Monitoring and Quality Control Systems

The Division of Forestry uses on a number of monitoring, reporting and quality control systems to assure sustainability of the forest resource on the state forest system. This section summarizes those efforts.

1.6.1 Continuous Forest Inventory

The DoF initiated a Continuous Forest Inventory (CFI) in 2007. This inventory involves the installation of permanent plots that are revisited and measured at 5-year intervals. A total of 3,750 plots will be installed on the State Forest System during the initial 5-year

period from 2008 through 2012, with approximately 750 plots measured each year. This sampling intensity is approximately one plot per 40 acres, and is sufficient to provide statistically significant results for all major forest variables at the state forest property level. The plot design follows that of the U.S. Forest Service Forest Inventory and Analysis (FIA) program, so results from the State Forest CFI can be compared accurately to statewide and regional data. The DoF will annually analyze and provide a public summary of the results, with a complete summary at the completion of each 5-year cycle.

1.6.2 Best management Practices (BMP) Audits

Each timber sale is reviewed by the supervising forester and the Division License Timber Buyer Forester for compliance with BMPs. Annual audit summaries are produced and published on the Division web site. Additionally, a random audit of 10 percent of timber sales
is completed by an independent, third-party auditor. Results of these audits are available on the DoF pages of the DNR web site at www.in.gov/dnr/forestry/13166.htm.

1.6.3 Forest Certification Audits

The State Forest System is certified by both the Sustainable Forestry Initiative (SFI) and Forest Stewardship Council (FSC). A requirement of both certifications is the completion of annual surveillance audits by an independent third-party auditor. The State Forest System was initially certified by both organizations during 2007; annual surveillance audits have been or will be conducted through 2011, with a complete recertification audit during 2012. Audit reports are made available to the public on the DoF pages of the DNR web site at www.in.gov/dnr/forestry/13166.htm.

1.6.4 Hardwood Ecosystem Experiment

The Hardwood Ecosystem Experiment (HEE) is a long-term forest ecosystem experiment being conducted by researchers from various universities on the State Forest System. The purpose of the experiment is to determine the effects of forest management treatments on multiple forest attributes (birds, amphibians, vegetation, endangered species, etc). Forest management treatments include many of the treatments described in this document, involv-ing both even-aged management and uneven-aged management systems along with non- manipulative forest management as a control. The project was initiated during 2006; initial
forest management treatments are to be applied during 2008-2009, with post-treatment effects monitoring to begin immediately thereafter. The project is designed to continue for 100 years contingent on funding availability. Monitoring results will be made public when available. Information on this project is available at www.fnr.purdue.edu/HEE/.

1.6.5 Tract Management Guide Process

The DoF State Forests are divided into individual State Forest Properties. These properties are divided further into compartments and tracts for management purposes. Division staff follows an extensive process in the review of an individual tract before any manage-

ment activities are undertaken.

The resource management process relates to individual tracts of state forestland. The Management Guide for the tract specifies the resource management activities to be applied. The Guide is developed within the context of the property Ten-Year Financial Management Plan, Five-Year Fish and Wildlife Plan, Resource Management Goals and the Division of Forestry strategic direction. Procedures and policies for all resource management activities are in the Division of Forestry Properties Section Resource Management Procedures Manual available on the DoF pages of the DNR web site at www.in.gov/dnr/forestry/5197.htm. Draft management guides are posted for public review and comment at www.in.gov/dnr/forestry/6472.htm.

This resource management process and its flowchart are designed for internal use to provide guidance in planning management activities. They are intended to describe the process and an approximate order and timeline of management events. In some cases the order and timeline are not followed exactly. In other cases, one activity cannot occur without a previous activity having occurred first.

Activity	**Description**
Preliminary Reconnaissance	Identify forest tracts to be inventoried. Tracts are identified on maps and a visual inspection of the tracts is made. Not always done in situations involving prescheduled inventories.
Forest Inventory	Consists of a statistical inventory of the tract utiliz ing on the ground point samples.
Heritage Database Review	Formal review of the Indiana Heritage Database for any animal and plant species of significant concern. Information from this review is included in the Management Guide prepared for the tract. The Division of Nature Preserves maintains the Heritage Database.
Ecological Review	Tract is reviewed for ecological resources and the presence of non-native invasive species utilizing a system developed by the Division of Forestry. Results are included in the Management Guide for the tract. Wildlife biologists from the Divisions of Forestry and Fish and Wildlife are available for consultation.
Bat Management Guidelines	Tracts are evaluated for bat habitat in accordance with the Division of Forestry Resource Manage ment Strategy for Indiana Bat. Snag counts are component of the inventory. Results are included in the Management Guide for the tract.
Draft Management Guide	A draft management guide is developed for the tract incorporating all information gathered. This draft may recommend no further management, or it may recommend further management, which may

	include such items as tree planting, wildlife habitat improvement, timber stand improvement, and timber harvesting.
Public Review	The draft Management guide is posted on the DNR web site and/or summarized at a property open house with comments solicited. Guides posted on the web site will be available for a minimum 30-day comment period.
Heritage Database Review	The Division of Nature Preserves reviews the draft Management Guide and provides comments as appropriate on all tracts proposed for management. This is a second check of the heritage information and uses that division's on-the-ground expertise.
Management Guide	The final Management Guide is prepared after review of all the information contained in the draft guide and inclusion of any edits or comments received from the public. The guide may recom mend no further management activities at this time. Duration of the Management Guide is 20 to 30 years.
Sale Layout	If the Management Guide recommends a timber harvest, the resource managers identify on the ground the loctions of access roads, log yards and main skid trails. This may include as appropriate the identification of significant riparian areas, visual enhancement areas and cultural resources. At approximately this time, adjacent neighbors are notified of the planned harvest using the Good Neighbor database.
DHPA Clearance	The proposed timber sale area is sent to the Division Archaeologist for clearance. Frequently, this requires an on-the-ground archaeological review by a certified archaeologist. Modifications in the sale layout may result from this review. Archaeological reports are submitted to the Division of Historic Preservation and Archaeology for approval.
Boundaries	Resource managers identify the boundaries of the timber sale area. Special consideration is given to exterior boundaries with neighbors.
Roads/Landings/Skid Trails	Access roads, log yards and main skid trails are constructed by Division of Forestry equip ment operators, if necessary.
Pre-Harvest TSI	If the tract requires timber stand improvement prior to the harvest, such as vine control, the activity is performed at this time. Control efforts will be directed toward any non-native invasive plant spe

	cies identified in the inventory or ecological review process. Some problem invasive plant species may require repeated treatments to reduce the population to the point that it is manageable after harvest.
Mark Harvest	Resource managers mark and measure each tree to be included in the harvest.
Pre-Sale Approval	A supervisor inspects the proposed sale for confor mance with Division policies and technical competency.
Advertise Sale	The timber sale is publicly advertised in accordance with Division of Forestry policies.
Conduct Sale	The timber sale is conducted at the property in ac cordance with Division of Forestry policies.
Harvest Evaluations	Resource managers inspect the work of the loggers during the harvesting operations. Deviations from contract requirements are corrected.
Sale Release	When harvesting is completed and all aspects of the timber sale contract are fulfilled, the buyer is released from the timber sale contract.
Post-Harvest BMP Review	The sale is reviewed by Division of Forestry staff for compliance with water quality best management practices. Any deviations are corrected.
Post-Harvest Management	Application of any post-harvest management rec ommended in the management guide. This may include such activities as timber stand improvement, tree planting, non-native invasive species inventory or control
Post-Management Evaluation	Inspection and evaluation of post-management activities.

All timber harvests are given a post-harvest BMP review as described above. This review is conducted by the Division Watershed/Timber Licensing Forester and the field forester who supervised the sale, usually accompanied by at least one additional forester. Annual summaries of these inspections are available on the DofF pages of the DNR web site at www.in.gov/dnr/forestry/13166.htm. In addition, approximately 10 percent of timber harvests are reviewed by an independent third party auditor accompanied by the DoF Watershed/Timber Licensing Forester. Results of these audits are also available on the Division web site.

An additional round of third party auditing occurs with the Certification audits (both Sustainable Forestry Initiative and Forest Stewardship Council). Independent third-party auditors select properties to visit and randomly select recent management activities (including timber harvests) to review. Results of those annual surveillance audits are posted on the DofF pages of the DNR web site at www.in.gov/dnr/forestry/13166.htm.

2.0 Alternatives Including the Proposed Action

2.1 The Proposed Action

The Division of Forestry proposes to manage the forest resource in a way that maintains the current dominance of oak-hickory forests and associated biodiversity while improving overall wildlife habitat and successional stage diversity. This action requires the use of a variety of forest management activities. As presented in Table 1, the proposed action includes the following DoF management activities expected to occur annually on the state forest system. Some of the management actions are not necessarily mutually exclusive and certain areas could receive multiple actions or treatments over time; acreage for each individual treatment is shown. The proposed action includes a timber harvest regime that is increased from historical harvesting by DoF on state lands, but still meets established goals for long-erm sustainability while maintaining the current acreage of oak-hickory dominated forests. The acreages presented in Table 1 are considered the maximum possible levels for any one year.

Table 1. DoF Management Actions

Management Activities	**Potential Acres* Affected Annually**
Timber Harvest Methods	
Hardwood and Pine Group Selection Openings (< 10 ac ea)	1,400
Hardwood Single tree Improvement	5,000
Pine Clearcuts	75
Pine Thinning	75
Hardwood Shelterwood	650
Hardwood Clearcuts (> 10 ac ea)	800
Total Acres Harvested	**8,000**
Follow-up Harvest Treatments	
Prescribed Fire	2,000
Timber Stand Improvement	8,000
Soil and Water Improvement	300
Tree Planting	100
Natural Regeneration	2,925
Total Acres Treated	**10,400**
Maintenance Activities	
Recreational and Operational Facility Construction and Maintenance	100
New Road Construction	50
Road Maintenance (447 mi x 15 ft ROW)	900
New Trail Construction	15
Trail Maintenance (521 mi x 10 ft ROW)	635

Management Activities	Potential Acres* Affected Annually
Total Acres of Maintenance Activities	**1,700**
Habitat Management	
General Wildlife Habitat	300
Early Successional Habitat (created from harvests)	2,925
Acquired Wildlife Habitat (purchased with sale proceeds)	490
Invasive Plant Species Control	1,400
Total Acres of Habitat Management	**5,115**

*Some acres may be accounted for twice for multiple treatments

2.1.1 Proposed Timber Harvest by Property

Table 2 depicts the amount of proposed annual timber harvest by state forest property as defined with the proposed action. Acres of timber harvest and estimated volume goals are commensurate with direction in the 2008-2013 Strategic Plan and are expected to occur over the life of this EA. Based on the 2005 system-wide forest inventory, the DoF estimates that approximately 11 trees per acre >15 inches dbh would be harvested on approximately 8,000 acres also equating to a harvest of approximately 86,480 trees annually. This harvest level represents a maximum effort, and could be less in any one given year. A majority of the sawtimber volume harvested would be from the oak-hickory and mixed hardwood tree species groups. Hardwood group selection openings, each less than 10 acres in size would occur on 1,400 acres and hardwood single tree improvements would be used on 5,000 acres. Harvesting also includes 150 acres of pine thinning and clearcuts, and about 1,450 acres of hardwood shelterwood and clearcuts across the system. Likewise, timber stand improvement as a follow-up treatment is proposed for approximately 8,000 acres and prescribed burning would be implemented on about 2,000 acres.

Table 2. Estimated Annual Timber Harvest by Property

State Forest Property	Size (acres)	Annual timber harvest % (acres)[1]	Available timber volume (bd. ft.)[2]	Estimated annual harvest (bd. ft)[3]
Harrison-Crawford SF	24,000	15% (1200 ac)	169,536,000	2,400,000
Greene-Sullivan SF	9,000	2% (160 ac)	30,402,000	320,000
Morgan-Monroe	24,000	21% (1680) ac	219,672,000	3,360,000
Yellowwood SF	23,000	20% (1600 ac)	207,644,000	3,200,000
Selmier SF	350	1% (80 ac)	3,883,950	160,000
Salamonie SF	900	1% (80 ac)	6,103,800	160,000

State Forest Property	Size (acres)	Annual timber harvest % (acres)[1]	Available timber volume (bd. ft.)[2]	Estimated annual harvest (bd. ft)[3]
Clark SF	25,000	8% (640 ac)	181,375,000	1,280,000
Pike SF	3,100	2% (160 ac)	28,585,100	320,000
Owen-Putnam SF	6,300	8% (640 ac)	55,011,600	1,280,000
Jackson-Washington SF	17,000	10% (800 ac)	145,996,000	1,600,000
Martin SF	8,000	8% (640 ac)	61,600,000	1,280,000
Ferdinand SF	8,000	4% (320 ac)	61,568,000	640,000
TOTAL	**148,650 acres**	**8000**	**1.17 billion Bd. ft.**	**16,000,000**

1 Basis: Estimates, based on 1994-2004 avg. annual harvest level
2 Basis: 2005 system wide inventory
3 Basis: Assumes average volume harvest of 2000 bd. ft. / acre

2.1.2 Conservation Strategy

The DoF has identified several options whereby different levels of timber harvest, silvicultural practices, timing of activities, studies and research, and use of exclusion zones and buffers could maintain the integrity of sensitive areas, biological hotspots, and specific structures and vegetative conditions in the managed forest landscape to ensure habitat to support a wide range of wildlife species of management concern. The DoF manages approximately 154,000 total acres in Indiana and these managed landscapes represent some of the larger forest blocks remaining in the state. Under the proposed action, the DoF would continue landscape-scale forest management with timber harvest, treatments, maintenance activities, and habitat management on lands it manages.

2.2 Alternatives to the Proposed Action

The DoF evaluated several alternatives to the proposed action, described in this section.

2.2.1 Alternatives Evaluated in Detail

2.2.1.1 No Action Alternative

This alternative represents the historical perspective of timber harvest and other management activities by DoF during the period from 1994 to 2004. This time period provides a basis for comparison of the alternatives.

From about 1970 until about 2000 the DoF concentrated management efforts on state forests to maximize a maturing oak-hickory value that was established by early 20th century disturbance. Management efforts focused on using single tree removal of damaged trees to promote the release of healthy trees to accelerate growth.

Under this alternative, a majority of the sawtimber volume harvested would be from the oak-hickory and mixed hardwood tree species groups. Hardwood group selection openings, each less than 10 acres in size, would occur on 65 acres and hardwood single tree improvements would be used on 1,520 acres. Likewise, timber stand improvement as a follow-up treatment is proposed for approximately 1,685 acres and prescribed burning would be implemented on about 500 acres.

This alternative was rejected because it would not maintain the oak-hickory forest component. Limited harvesting would retain many large trees. Very little early-successional habitat would be created. Without disturbance, the current ecological condition of the forest would not be maintained. The forest would move toward closed canopy of mostly shade-tolerant species with very little edge or early successional habitat. Species composition in the future overstory would shift to mixed hardwoods and eventually to beech-maple.

2.2.1.2 Current DoF Management Practices

This alternative represents the level of timber harvest on DoF land as directed by the *2005-2007 Strategic Plan.* It includes approximately 6,100 acres of annual timber harvesting and other management actions whereby current conditions and trends would persist. The acreage of timber harvest proposed with this alternative is greater than historical harvest levels on Indiana state forest lands and this alternative would minimally meet multiple-use goals as stated in DoF's *2005-2007 Strategic Plan*.

Timber management under this alternative would be uneven-aged management accomplished mostly using hardwood single tree improvement harvests on approximately 4,890 acres, and about 600 acres of group selection openings less than 10 acres each. The DoF would implement uneven-aged management on a management tract basis, with tracts generally between 40 and 150 acres in size. Initially a tract may be comprised of several different types, ages, conditions, and sizes of timber. Uneven-aged timber management methods are used to regenerate a stand by removal of one tree or a small group of trees at any one time. Within a tract, areas will be identified for group selection openings less than 10 acres each in which all stems are removed to encourage regeneration and the creation of small patches of early successional habitat. The remainder of the tract between openings is treated with an improvement harvest. The improvement harvest will selectively remove some mature, damaged, or competing trees to allow remaining desirable stems the conditions to grow more vigorously.

Based on the 2005 SWI dataset, the DoF estimates approximately 11 trees per acre >15 inches dbh would be harvested on approximately 6,100 acres equating to a harvest of approximately 65,970 trees annually under this alternative. A majority of the proposed timber harvest would likely occur at Harrison-Crawford, Clark, Morgan-Monroe, Yellowwood, and Jackson-Washington state forests. These locations are also some of the largest state forest properties.A majority of the sawtimber volume harvested would be from the oak-hickory and mixed hardwood tree species groups. Hardwood group selection openings, each less than 10 acres, would occur on 600 acres and hardwood single

tree improvements would be used on 4,890 acres. Likewise, timber stand improvement as a follow-up treatment is proposed for approximately 4,500 acres, and prescribed burning would be implemented on about 1,000 acres.
This alternative was rejected because it would not maintain the current ecological condition and will not be adequate in maintaining oak-hickory in the long term. The forest would move toward closed canopy of mostly shade-tolerant species with very little edge or early successional habitat.

2.2.1.3 Increased Oak-Hickory Management
This alternative would propose an annual harvest level of up to 9,000 acres. This alternative responds to the need for a proposed increased level of effort (timber harvesting) in order to maintain oak and hickory as a viable forest component at levels for which it currently exists on DoF lands. DoF forestry management, specifically use of cutting as a silvicultural tool to emulate natural disturbance, plays a significant role in the disturbance and synchrony required for development and maintenance of oaks and hickories in the central hardwood forest.

This alternative would provide approximately 5,000 acres annually of early successional habitat with a mixture of opening sizes, and maintains a high percentage of closed canopy forest. Timber management under this alternative still would be a combination of uneven- and even-aged management, although the overall approach contains more even-aged management than other alternatives. Hardwood single tree improvement harvests would occur on approximately 4,000 acres and about 2,400 acres of group selection openings less than 10 acres each. Uneven-aged timber management would occur in the same manner and similar magnitude as that described for the proposed action. Even-aged management would be increased, with 1,850 acres of hardwood clearcuts where each opening is generally greater than 10 acres, and shelterwood cuts on a total of about 650 acres across the system. The shelterwood harvest method would retain scattered large trees to encourage oak and hickory regeneration. This alternative includes a greater number of harvest openings and increased recruitment efforts for oak and hickory. Increased use of clearcuts as a silvicultural method would provide more opportunity to establish new stands of shade intolerant and mid-tolerant species.

Under this alternative, the desired future condition of the forest is influenced by the goal to maintain oak-hickory as a future forest component on an area equivalent to the area occupied by the oak-hickory component in 2005 system-wide inventory. Prescribed burning is increased to 5,000 acres under this alternative as an exogenous disturbance to further assist with regeneration of natural even-aged stands. This alternative defines a timber harvest regime that is much more than historical harvests on state lands, but still meets established goals for maintaining specific habitat structure at a large spatial scale to achieve conservation objectives

The proposed annual timber harvest defined with this alternative exceeds the direction in the 2005-2007 Strategic Plan. Based on the 2005 SWI dataset, the DoF estimates approximately 13 trees per acre >15 inches dbh would be harvested on approximately 9,000 acres equating to a harvest of approximately 117,000 trees annually. This pro-

posed harvest level would be a maximum effort and could be less for any one given year. Although the proposed harvest acreage is spread across the system, most of the harvest under this alternative would occur at Harrison-Crawford, Morgan-Monroe, Yellowwood, Clark and Jackson-Washington state forests. These forests have the largest amount of merchantable acres, considering topography and access, and they are also the largest state forest properties. A majority of the sawtimber volume harvested would be from the oak-hickory and mixed hardwood tree species groups. Harvesting also includes 100 acres of pine clearcuts. Timber stand improvement as a follow-up treatment is proposed for approximately 9,000 acres.

Although this has a reasonable probability of achieving the habitat goal of continued maintenance of oak-hickory in the system, it was rejected. It would involve the annual harvest of an estimated 24 million board feet, which is near 100 percent of annual growth. At this level of harvesting, it would be extremely difficult to maintain wildlife habitat features such as cavity trees or snags. It would not allow the DoF to set aside areas for recreational, ecological or aesthetic reasons that are free from timber harvests. Furthermore, implementation of this level of harvest would require undue emphasis on the timber harvest program at the expense of recreation, wildlife and aesthetic management.

2.2.2 Alternatives Given Brief Consideration and Rejected from Further Analysis

2.2.2.1 Care-taker Status

Under the "care-taker" status approach all resource management activities and developed recreation facilities would be managed at a level where DoF's primary role would be as a care-taker.

This approach is not consistent with DoF enabling legislation (IC 14-23-4-1**)** or IDNR policy. Habitat maintenance, development, and restoration, and non-native invasive species control would not occur. Public recreation opportunities would be severely curtailed. The legal responsibilities associated with ownership of the state forests would not be met. Commitments to adjacent landowners, communities, and partners would be unfulfilled.

2.2.2.2 Landscape-Scale Regeneration Openings

This concept proposes a large portion of the annual timber harvest on state forests would be conducted as a few, very large (several hundred acre), even-aged regeneration openings.

This approach and harvest method would provide a "critical mass" of early successional habitat (which is underrepresented on state forests) and opportunity for landscape-scale site preparation treatments (prescribed fire, chemical treatments, artificial regeneration) to influence species composition. It would do so at the expense of other habitat types, high quality hardwood timber production, aesthetics and other intangible benefits. Large landscape-scale harvests are not considered necessary or appropriate in the Central Hardwood region, either from a silvicultural or conservation perspective.

2.2.2.3 Maximum Fiber Production Alternative

Under this alternative, annual harvests would be increased to a level that would try to capture for timber production all of the existing volume of high value hardwood sawtimber. On DoF ownership, this alternative would require a harvest rate of 12,000 to 15,000 acres per year during the life of this Assessment. This type of harvesting is sometimes referred to as “high grading” or “diameter limit” harvesting. Under this alternative, an initial harvest would be conducted on each tract that removed all commercially valuable trees large enough to be considered sawtimber, then each tract would be re-entered about every 10 years to harvest any trees that had grown into sawtimber size since the previous harvest. This method allows for the maximum recovery of the volume and current value of pre-existing timber stands, but results in timber stands whose average diameter is reduced to sub-sawtimber size, and the species composition, genetic viability, and market value of the forest is severely compromised over time. This alternative did not receive detailed study because it was not sustainable and did not meet the DoF management goals.

3.0 Affected Environment

The Indiana State Forest System includes approximately 154,000 acres in 13 State Forest and State Recreation Areas scattered across 23 counties, primarily in the southern half of the state. This assessment applies to all forest lands managed by the Division of Forestry. Figure 1 provides a location map of the State Forests in Indiana.

3.1 Current Forest Cover

DoF conducted a system-wide inventory (SWI) of the entire state forest system during 2005 to provide a "snapshot" of forest conditions. SWI information is used to make strategic, system-wide decisions and to measure trends over time. The SWI was composed of 1,020 fixed and variable-radius plots positioned on DoF lands. Information and measurements on tree composition, canopy cover, slope, harvest history, and many other variables were recorded on each plot and added to a system-wide database for each state forest. Using the DoF's 2005 SWI, the relative proportion of habitat cover types was obtained for each state forest (Table 3). Oak-hickory and mixed-hardwoods are the most common habitat types on Indiana state forests, comprising nearly 80 percent of SWI plots. The relative proportions of cover types on all state forests are oak-hickory (49.1 percent), mixed hardwoods (34.4 percent), pine (6.7 percent), beech-maple (3.8 percent), non-forested (3.1 percent), bottomland hardwoods (2.0 percent), undefined (0.8 percent), and tree plantation (0.1 percent).

Table 3. Cover Types on 12 State Forests Based on Percentage of Sample Plots Assigned to Each Cover Type in the DOF 2005 System-Wide Inventory

State Forest	Forest Cover Type Percent [1]							
	OH	**BM**	**MH**	**BH**	**PI**	**NF**	**TP**	**UN**
Clark	66.3	1.2	24.4	0.0	5.8	0.0	0.0	2.3
Ferdinand	42.0	8.0	23.0	0.0	27.0	0.0	0.0	0.0
Greene-Sullivan	2.3	2.3	49.4	5.7	6.9	32.2	1.0	0.0
Harrison-Crawford	42.5	1.0	42.5	1.0	10.3	2.0	0.0	0.0
Jackson-Washington	56.6	7.2	24.1	2.9	4.8	4.8	0.0	0.0
Martin	34.7	5.8	48.8	6.6	2.5	1.7	0.0	0.0
Morgan-Monroe	58.8	7.0	31.8	0.0	2.3	0.0	0.0	0.0
Owen-Putnam	24.3	5.4	60.8	2.7	6.8	0.0	0.0	0.0
Pike	21.9	6.8	39.7	26.0	5.5	0.0	0.0	0.0
Salamonie	5.6	4.2	63.4	0.0	21.1	5.6	0.0	0.0
Selmier	21.7	0.0	65.0	0.0	13.3	0.0	0.0	0.0
Yellowwood	60.0	1.2	30.6	1.2	3.5	1.2	0.0	2.6
Weighted Average	**49.1**	**3.8**	**34.4**	**2.0**	**6.7**	**3.1**	**0.1**	**0.8**

[1] OH = oak-hickory, BM = beech-maple, MH = mixed hardwoods, BH = bottomland hardwoods, PI = pine and other conifer, NF = non-forested, TP = tree plantation/plantings, UN = undefined.

3.2 The Natural Features of Indiana

DoF lands cover an extensive geographical range across Indiana. To facilitate a more detailed analysis of topography/geology, hydrology, and vegetation, descriptions of indi-

vidual DoF properties below are within the context of natural or physiographic regions, as addressed in detail by Homoya et al. (1985; Figure 2). A natural region is a major landscape unit that generally describes natural features by incorporating climate, soils, glacial history, topography, exposed bedrock, presettlement and current vegetation, species composition, physiography, and flora and fauna distribution.

3.2.1 Highland Rim Natural Region

The Highland Rim Natural Region is located in southern Indiana below 40°N. Six Indiana DoF land holdings totaling about 90,000 acres lie within this region: Morgan-Monroe State Forest, Yellowwood State Forest, Starve Hollow State Recreation Area, Jackson-Washington State Forest, Clark State Forest and Deam Lake State Recreation Area. (Figure 2).

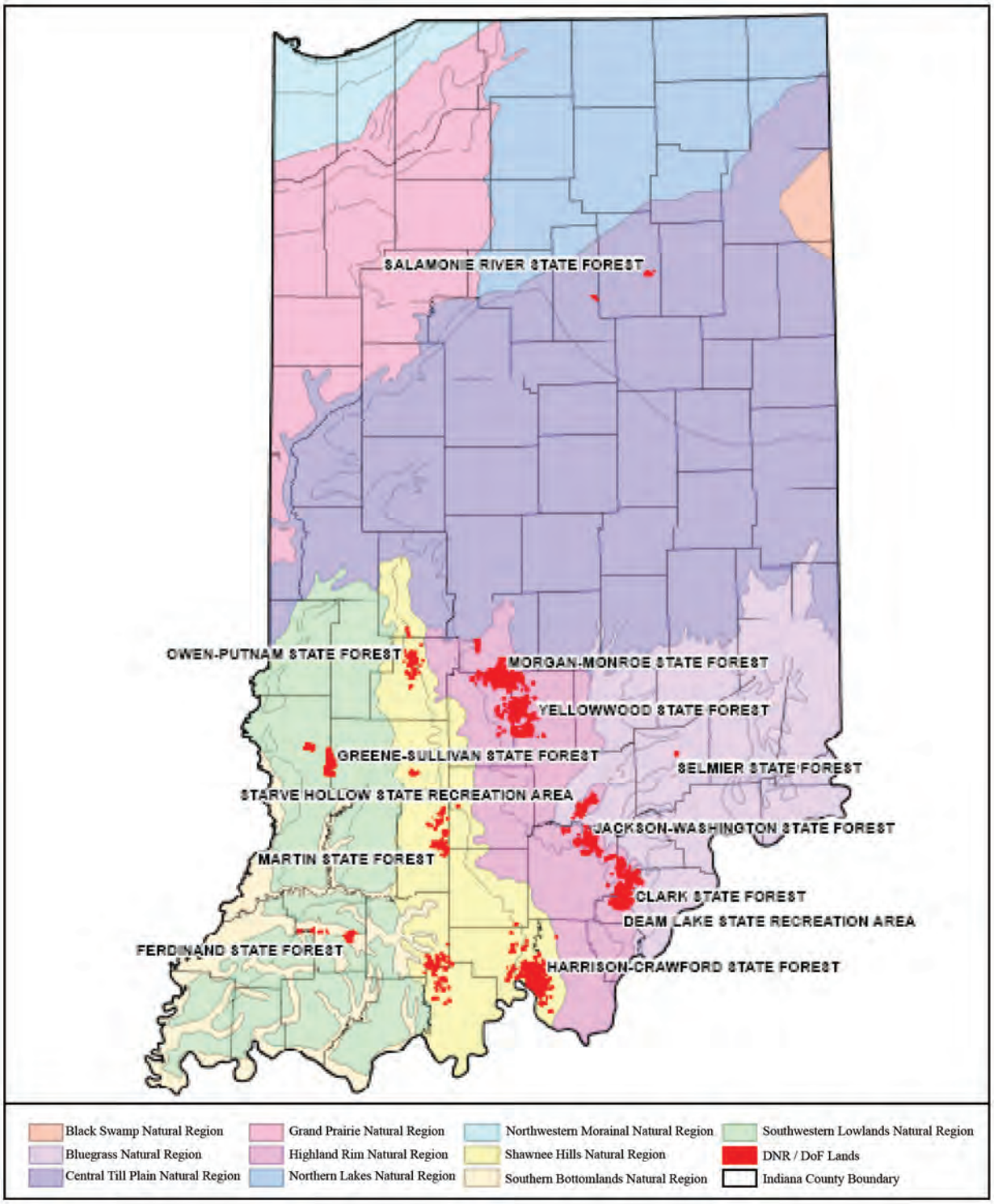
Topography and Geology

This region generally is characterized by large expanses of karst topography, occasional cliffs, rugged hills, flat-topped narrow divides, steep slopes and deep V-shaped valleys (Homoya et al. 1985; Schneider 1966). The region is relatively unglaciated, except for parts of the northern and eastern boundary. Underlying strata are mostly of Mississippian age with some Pennsylvanian-aged strata exposed in outcrops. The region is further divided into three sections: Mitchell Karst Plain Section, Brown County Hills Section, and the Knobstone Escarpment Section (Homoya et al. 1985). Most of the Mitchell Karst Plain is level, although some limestone cliffs and steep hills are present. Caves are common in this region. Karst plain soils are typically well-drained silty loams from weathered limestone. The Brown County Hills and the Knobstone Escarpment sections are characterized by deeply dissected uplands with strata composed of siltstone, shale, and sandstone. Soils are well-drained acid silt loams and bedrock is near the surface, but is rarely visible as outcrops.

Hydrology

The Highland Rim Natural Region is well drained by dendritic drainages, in which smaller tributaries have begun to develop floodplains. However, some of the larger streams have developed noticeable narrow valleys (Schneider 1966). As a result of the large amount of karst in the Mitchell Karst Plain, surface streams are uncommon and streams that do exist are typically medium to high gradient with rocky substrates. Examples of surface streams are Indian Creek, Clear Creek, Buck Creek, and upper stretches of the Blue River. Numerous small, high-gradient ephemeral streams are common throughout the Brown County Hills, and the larger streams are predominately medium to low-gradient streams, e.g. Guthrie Creek and all forks of Salt Creek. Small, high-gradient ephemeral streams characterize surface waters of the Knobstone Escarpment, including Muddy Fork, Silver Creek, and Buffalo Creek (Homoya et al. 1985).

Figure 2. DNR/DoF Lands by Physiographic Region in the State of Indiana



Vegetation
Several plant communities are associated with the Mitchell Karst Plain, including cave, sinkhole, swamp, flatwoods, limestone glades, barrens, and several upland forest types. Western mesophytic forest is the dominant forest type of the Mitchell Karst Plain, characterized by shagbark hickory, white oak, sugar maple, pignut hickory, and white ash. Upland areas of the Brown County Hills are dominated by oak-hickory forest, particularly chestnut oak. Mesic species such as beech, red oak, sugar maple, and white ash dominate ravines. Co-dominance of Virginia pine and chestnut oak differentiate upland forests of the Knobstone Escarpment Section from the Brown County Hills Section. Virginia pine is commonly found on ridges of south facing slopes. Xeric forests, typically composed of blackjack oak, chestnut oak, and scarlet oak, are located along edges of glades in the Knobstone Escarpment (Homoya et al. 1985).

3.2.2 Shawnee Hills Natural Region
A total of four Indiana DoF land holdings lie within the Shawnee Hills Natural Region. These DoF lands total approximately 46,000 acres and include Owen-Putnam State Forest, Martin State Forest, Harrison-Crawford State Forest, and Ferdinand State Forest (Figure 2).

Topography and Geology
The region consists primarily of Pennsylvanian and Mississippian bedrock, which is visible in cliffs and rockhouses. The Shawnee Hills Natural Region incorporates two sections: Crawford Upland and Escarpment Sections. The Crawford Upland is a continuous chain of rugged hills with cliffs. The Escarpment Section consists primarily of Pennsylvanian and Mississippian bedrock and lies between the Crawford Upland and Mitchell Karst Plain sections. Sandstone and Wellston-Zanesville derived soils cap the hills and limestone soils are found at lower elevations. Erosion of underlying strata has created a deeply dissected upland (Schneider 1966) and weathering of limestone bedrock is responsible for cave formation (Homoya et al. 1985).

Hydrology
This region has a well-integrated drainage system with a westward sloping plateau and an abundance of stream valleys (Schneider 1966). The majority of the level land is in the floodplains of larger valleys. Aquatic systems in the Escarpment Section are normally clear, medium and high-gradient streams, springs, and sinkhole ponds. The Blue River is an example of a major river in the Escarpment (Homoya et al. 1985).

Vegetation
The Shawnee Hills Natural Region represents pre-settlement conditions better than any region in the state because of its ruggedness and low human population density. Dominant natural communities include upland forests mixed with a few sandstone and limestone glades, gravel washes, and barrens. Forest vegetation of the Crawford Upland consists of an oak-hickory complex on upper slopes and a mesic component in ravines. Typical upper slope species include black oak, white oak, chestnut oak, post oak, and shagbark hickory. Sandstone cliffs in the Crawford Upland section contain several plant species found in Appalachian communities such as mountain laurel and umbrella magnolia. Mesic forests consist of beech, yellow-poplar, sugar maple, black walnut, and white ash. Various upland forest types exist in the Escarpment section and species composition

is similar to the Crawford Upland, although post and black oaks commonly replace chestnut oak (Homoya et al. 1985).

3.2.3 Southwestern Lowlands Natural Region

Greene-Sullivan State Forest lies within the Glaciated Section of the Southwestern Lowlands Natural Region and encompasses approximately 7,000 acres (Figure 2).

Topography and Geology

As a whole, the region is level, undissected, and poorly drained due to glaciation. However, upland areas are described as rolling plains and are well drained (Schneider 1966). The average elevation of this region is 500 feet above sea level. The Southwestern Lowlands is divided into three sections: Plainville Sand, Glaciated, and Driftless Sections. Soils of the Glaciated Section are primarily acid to neutral silt loams and low hills and broad valleys characterize the topography. Soils of the Driftless Section are acidic (Homoya et al. 1985).

Hydrology

Stream characteristics vary across the region and include medium-gradient streams in the Driftless Section and low-gradient streams in the Glaciated Section. The Eel River and Busseron Creek are examples of low-gradient streams in the Glaciated Section (Homoya et al. 1985).

Vegetation

Natural communities of the region are predominantly forests, although barrens and prairie communities once dominated some areas (Homoya et al. 1985). Flatwood communities are common in the Glaciated Section and species composition includes shagbark hickory, pin oak, hackberry, red maple, and silver maple. Oak-hickory upland forest communities dominate the Driftless Section, although flatwood communities are also present and include cherry bark oak, sweetgum, shellbark hickory, pin oak, and swamp white oak.

3.2.4 Southern Bottomlands Natural Region

Pike State Forest lies within the Southern Bottomlands Natural Region and encompasses approximately 3,000 acres. This region is a single natural unit and is not separated into sections (Homoya et al. 1985; Figure 2).

Topography and Geology

The Southern Bottomlands Natural Region in southwest Indiana consists of alluvial bottomlands along rivers, such as the Patoka River and Ohio River. Soils are mostly neutral to acid silt loams.

Hydrology

The Patoka River is exemplary of silt-bottomed, low-gradient streams characteristic of the region. Much of this region encountered frequent flooding prior to construction of flood control structures. Other typical features include large bottomland ponds along the Wabash River.

Vegetation

Swamps, ponds, sloughs, and former marshes and prairies characterize the Southern Bottomlands Natural Region. This region is distinguished from other bottomland regions in Indiana by the presence of vegetation similar to the lower Mississippi Valley and Gulf

Coast Plain (Homoya et al. 1985). Some distinctively southern bottomland tree species include bald-cypress, swamp cottonwood, water locust, pumpkin ash, and overcup oak.

3.2.5 Bluegrass Natural Region

Selmier State Forest and a small portion of Jackson-Washington State Forest lie within the Bluegrass Natural Region and total approximately 1,000 acres. This region is south of the Central Till Plain and east of the Highland Rim (Figure 2).

Topography and Geology

At one time, the Bluegrass Natural Region was covered by at least one pre-Wisconsin ice sheet, and its northern boundary is the southern-most extent of Wisconsinan glaciation (Homoya et. al.1985). This region is further divided into three sections; DoF lands are located in two: Scottsburg Lowland and Muscatatuck Flats and Canyons Sections. The third section of this region is the Switzerland Hills Section. Major topographic features of the Scottsburg Lowland Section are wide alluvial and lacustrine plains bordering major streams. Glacial drift partially filled the northern part of the section, and consequently, the lowland is not well defined. However, in the southern part of the section, the lowland becomes more defined and can be recognized as a distinct physiographic unit (Schneider 1966). Soils of the Scottsburg Lowland Section are primarily acid to neutral silt loams. Topographic features of the Muscatatuck Flats and Canyons Section include a west sloping plain with steep-walled canyons created by major streams. Upland portions of this section are broad and nearly flat to undulating, characteristic of early stages of landform development (Schneider 1966).

Hydrology

Aquatic and wetland features of the Scottsburg Lowland Section include swamps, acid seep springs, and ponds. The streams and rivers are typically low gradient with a silty substrate. In contrast, streams such as Graham Creek and Big Creek of the Muscatatuck Flats and Canyons Section are typically medium gradient with a flat limestone substrate.

Vegetation

Swamps and floodplain forest are the dominant natural communities of the Scottsburg Lowland Section. However, there are a few areas of upland forest near the border of the Muscatatuck Flats and Canyons Section. Plant communities associated with swamps are composed of swamp cottonwood, red maple, pin oak, river birch, green ash, stiff dogwood, and button bush. Floodplain forests, which are better drained than swamps, include trees such as sweetgum, swamp chestnut oak, swamp white oak, American elm, and shellbark hickory. The southern flatwoods natural community dominates the plain of the Muscatatuck Flats and Canyons Section. Southern flatwoods are dominated by beech, red maple, sweetgum, pin oak, swamp chestnut oak, and yellow-poplar. Mixed mesophytic forests dominate cliffs and slopes and non-forested communities are small limestone gravel washes and limestone glades. Numerous plant species found in the Muscatatuck Flats and Canyons Section are geographically isolated to the southern flatwoods community, such as fox grape and dwarf ginseng (Homoya et al. 1985).

3.2.6 Central Till Plain Natural Region

The Central Till Plain Natural Region is in the northern half (above 40°N) of Indiana. Salamonie River State Forest lies within the Central Till Plain Natural Region and totals

approximately 1,500 acres. This is the largest natural region in Indiana and was once a forested plain of Wisconsinan glacial till (Figure 2).

Topography and Geology
The topography across the region is relatively homogenous except for several moraines. The most prominent moraines are located in the west-central part of the state (Schneider 1966). The region is nearly flat to rolling glacial plain divided into three sections: Entrenched Valley, Tipton Till Plain, and Bluffton Till Plain sections. DoF lands in this region are found only in the Bluffton Till Plain Section. The Bluffton Till Plain is a level till plain characterized by clay-rich soils, causing much of the area to drain poorly. A series of moraines is also evident in this section.

Hydrology
Glacial activities in this region created a drainage pattern that flows in a northeast to southwest direction (Schneider 1966). Some channels created by meltwater drainage are now occupied by streams, while other channels are swampy, partially filled, and do not carry moving water. Most channels are relatively shallow, but in some locations they are deeply entrenched from late and post-glacial stream erosion (Schneider 1966).

Vegetation
The Bluffton Till Section was one of the last areas in Indiana covered by glacial ice. Intensive agriculture has largely dissected the historic beech-maple forests into small woodlots. Flatwood species composition of the Bluffton Till Plain includes red maple, pin oak, bur oak, and American elm. Species common to the drier areas include beech, sugar maple, yellow-poplar, and red elm. Other natural communities of this section include bogs, prairies, marshes, seep springs, and ponds (Homoya et al. 1985).

3.3 Soil and Water

Soils
Various soils occur on 154,000 acres of DoF lands as a result of varying parent material, topography, local hydrology, vegetation, and wind patterns. DoF lands occur in five soil regions: water-deposited materials, Illinoian glacial till, clastic bedrock, and limestone regions (Franzmeier 1997). Approximately 90 percent of DoF lands occur in the clastic bedrock and limestone classifications. These are discussed below.

South-central Indiana, where most DoF properties are located, was not glaciated and the topography was not ground down and smoothed as it was in the northern part of the state. Portions of this region rest on clastic bedrocks, such as sandstone, siltstone, and shale (Franzmeier 1997). Water does not readily penetrate the bedrock and carves an open drainage system with dendritic (branched) patterns. Most soils on less than 12 percent slopes have fragipans, illustrated by Johnsburg soil on summits and Zanesville soils on shoulders. On the backslopes, Wellston soils are on the moderate slopes, and the shallow Berks soils are on the steeper slopes.

Soils on more gentle slopes in the region are used mostly for pasture, but many are cultivated or forested. Erosion can be a serious problem where slopes are farmed and farmers are advised to protect soil by growing winter crops and leaving crop residue (Franzmeier

1997). Many of these areas came under IDNR ownership and are now under forest cover.

Soils in southern Indiana are also over limestone with a different drainage pattern than that found in other regions. Percolating water penetrates the bedrock limestone through closed depressions or sinkholes and forms an underground network of drainages. Known as the karst plain, there are very few surface streams and these streams flow only during intense rains. The soils in this region are highly erodible and most of the steeply sloping soils are forest land (Franzmeier 1997).

Streams and Rivers

Very few major rivers bisect DoF properties. Many DoF lands border or are included within the drainages of major rivers such as the Ohio, Patoka, Salamonie, Muscatatuck and White. Portions of Pike State Forest are located in the bottomlands of the Patoka River in southwest Indiana. The Ohio River forms the southern border of Harrison-Crawford State Forest. Numerous smaller streams on Harrison-Crawford State Forest empty into the Ohio River such as Indian Creek and the Blue River. Salamonie River State Forest was created as a demonstration of riverside forest for the reclamation of eroded land. There are also numerous unnamed streams in addition to the major rivers. In general, only the lower portions of key drainages are perennial streams, while upper portions and tributaries are intermittent or ephemeral and only discharge seasonally or in response to rain events.

Wetlands and Deepwater Habitats

Much of the land DoF acquired in the 1930s was heavily grazed or farmed land on steep slopes or ridges unsuitable for agriculture. Consequently, wetlands are a small portion (approximately 3 percent) of the total DoF land holdings but consist of a wide variety of aquatic habitat types. The U.S. Fish & Wildlife Service National Wetlands Inventory (NWI) has identified approximately 4,000 acres on DoF lands as wetlands and deepwater habitats. This includes large wetlands associated with over 120 lakes in Greene-Sullivan State Forest and numerous bottomland forests throughout the state forest system. Bottomland forests are the most common wetland type on DoF lands with the majority found on Pike State Forest. Aquatic beds, emergent, and scrub-shrub wetlands are least common, comprising 12 percent of all palustrine wetlands on DoF lands. Numerous smaller wetlands, not usually associated with extensive drainage systems, are sustained by local runoff and are found throughout the state forest system.

4.0 Environmental Consequences

This section provides details on the living and nonliving environmental components and the anticipated direct and indirect impact expected from the proposed action. Floral and faunal species that have been documented on DoF properties and are included on Indiana's lists of Species of Greatest Conservation Need are addressed in sections 4.1-4.6 and shown in Tables 1-6 of Appendix A. Sections pertaining to terrestrial species include habitat descriptions and reported threats to population persistence to better evaluate how these species may be affected by the proposed alternatives.

4.1 Amphibians and Reptiles

Eastern Hellbender (*Cryptobranchus alleganiensis alleganiensis*)
The eastern hellbender is listed as an endangered species in Indiana. This species is a large aquatic salamander that inhabits large, rocky, fast-flowing streams from southern New York to northern Alabama and extreme northeastern Mississippi, westward to central and southern Missouri and northern Arkansas (Petranka 1998). Historical distribution records indicate the eastern hellbender once inhabited the entire Ohio River mainstem and probably most of its larger, tributaries in southern Indiana. Today, eastern hellbenders inhabit only portions of the Blue River (Indiana Natural Heritage Database 2008).

Eastern hellbenders require cool, swift-running streams with high levels of dissolved oxygen and good water quality (Nickerson and Mays 1973, Z. Walker, IDNR, pers. comm. 2008). Large rocks and logs on a gravel substrate are important for nesting and for larval development, as is cool and well-aerated flowing water (Minton 2001). Adults spend much of their time under large rocks or cover objects at the bottom of streambeds (Conant and Collins 1998). Nests are normally found in crevices or holes in bedrock, or excavated beneath large flat rocks, in the streambed. Habitat alterations (e.g., water impoundment, siltation, and other changes in water quality) are the greatest threats to the species, followed by over-utilization and predation (Mayasich and Grandmaison 2003). In addition to these threats, there is some indication hellbender populations suffer from low genetic variability, that recruitment is limited by endocrine disruption, and that adverse effects could result from a complex of interactions associated with global climate change (Mayasich and Grandmaison 2003).

Kirtland's Snake (*Clonophis kirtlandii*)
Kirtland's snake is listed as an endangered species in Indiana. Distribution is limited to an area that includes central and eastern Illinois, all of Indiana, central and western Ohio, and the extreme southern portion of Michigan and northern Kentucky (NatureServe Explorer 2008). The Indiana Natural Heritage Database (2008) reports one individual was observed at Yellowwood State Forest in 1997. Kirkland's snake is chiefly an occupant of moist, open meadow or wet prairie habitats. Kirtland's snakes are usually found in relatively open areas, within the immediate vicinity of a water source, such as a pond, lake, or sluggish stream (Gibson and Kingsbury 2004). Another commonality among sites supporting Kirtland's snakes is the tendency for seasonal flooding and the presence

of burrowing crayfish (Gibson and Kingsbury 2004). Kirtland's snakes can be found in forested settings, but always in association with aquatic (often seasonal) habitats such as woodland pools, small streams, and bogs (Conant 1943).

Habitat loss and degradation are important factors that contribute to the decline of the Kirtland's snake. Habitat-altering activities such as urban development and agriculture have destroyed much of the native moist, open prairie habitats these snakes formerly occupied (Gibson and Kingsbury 2004). Outright habitat loss is not the only threat from development and agricultural conversion; remnant habitat can degrade through changes to local hydrology and urban and agricultural sources may contribute to the occurrence of water and soil pollution (Wilsmann and Sellers 1988). Researchers have noted an absence of Kirtland's snakes in areas of suitable habitat that had been contaminated by chemical toxins (Wilsmann and Sellers 1988).

Timber Rattlesnake (*Crotalus horridus*)

The timber rattlesnake is listed as an endangered species in Indiana. The range of the timber rattlesnake extends from southern New England to northern Florida, west to east Texas and southwestern Wisconsin (NatureServe Explorer 2008). In Indiana the majority of timber rattlesnake records occur from the Shawnee Hills and Highland Rim regions (Minton 2001). Records of timber rattlesnakes occur from Jackson-Washington, Morgan-Monroe, and Yellowwood State Forests in the Indiana Natural Heritage Database (2008). Timber rattlesnakes may use rocky ledges, cliffs, and similar areas, especially before and after hibernation, but favor dry hillsides and ridges with open deciduous woods during summer months. In Indiana, these rattlesnakes are not necessarily associated with exposed rock (Z. Walker, IDNR, pers. comm. 2008). Downed woody material is an important habitat component, as it provides hiding cover for these ambush hunters. Summer habitat often includes small openings within oak-hickory forest. Timber rattlesnakes hibernate during cold winter months and often return to the same hibernaculum each year (CRACM 2006). Although the range is large in the eastern United States, these snakes have a restricted range in south-central Indiana and occurrences are spotty. Declines are attributed to habitat loss, hunting and commercial collection, and indiscriminate persecution (Walker 2000). While small forest openings benefit this species, large-scale forest fragmentation could result in increased predation and population declines (Z. Walker, IDNR, pers. comm. 2008). Due to its relatively low reproductive output, timber rattlesnake populations are extremely fragile and susceptible to decline.

Smooth Green Snake (*Opheodrys vernalis*)

The smooth green snake is listed as an endangered species in Indiana, where it inhabits wet prairies and now is restricted primarily to prairie remnants in the northwest portion of the state (CRACM 2006). Since 1980, one record of occurrence in Yellowwood State Forest is documented in the Indiana Natural Heritage Database (2008), though it is thought this observation may represent a misidentification of a rough green snake (Z. Walker, IDNR, pers. comm. 2008). Smooth green snakes are found most frequently in meadows, lawns and weedy thickets. It is known to climb into low bushes; however, it is not as arboreal as the rough green snake. The smooth green snake is often found under loose boards and stones (Green and Pauley 1987). This species is vulnerable to careless

misuse of pesticides due to its insectivorous diet (Oldfield and Moriarty 1994). In Indiana, the loss and degradation of natural prairie habitat, as well as the direct and indirect effects of insecticides, are known threats to smooth green snake populations (CRACM 2006).

Rough Green Snake (*Opheodrys aestivus*)

The rough green snake is a species of special concern in Indiana. This species ranges from southern New Jersey to the Florida Keys, west to Kansas, Texas, and Mexico (Green and Pauley 1987). In Indiana, it ranges south of the glacial boundary from Vigo to Dearborn counties (CRACM 2006). One record of occurrence at White Oak Nature Preserve in Clark State Forest is documented in the Indiana Natural Heritage Database since 1980 (2008). The rough green snake is primarily an inhabitant of open sunny areas and roadside vegetation, such as greenbrier thickets and berry patches. This species is highly arboreal, and it is unusual to find them under rocks, logs, or other similar cover (Green and Pauley 1987). At times, it is almost semi-aquatic, freely entering shallow bodies of water. A frequently used habitat is dense vegetation overhanging streams or lake edges (Conant and Collins 1991). Clearing wooded wetlands and woody borders of aquatic habitats is thought to be a likely reason for population declines (CRACM 2006).

Eastern Box Turtle (*Terrapene carolina*)

The eastern box turtle is a species of special concern in Indiana. This species ranges from southern Maine to the Florida Keys and west to Michigan, Illinois, and Texas (NatureServe Explorer 2008). This species is found on all Indiana state forests in the southern half of the state (Z. Walker, IDNR, pers. comm. 2008). The eastern box turtle is commonly found in upland woodlands and forest but can also be found in bottomland forests, forest borders, and wet meadows (Z. Walker, IDNR, pers. comm. 2008, NatureServe Explorer 2008). Box turtles nest in loose soils and rest or take cover within natural soil depressions under leaf litter, within slash and brush piles, or within briar thickets (Luensmann 2006). Box turtles hibernate under logs and deep leaf litter or within soft soil (Z. Walker, IDNR, pers. comm. 2008, NatureServe Explorer 2008, Luensmann 2006). Major threats to this species include habitat loss and fragmentation. Habitat is often lost through deforestation and forest conversion to agriculture (Luensmann 2006). Fragmented habitat isolates populations and makes box turtles vulnerable to predators (Luensmann 2006). Other barriers to movement include roads and train tracks. Box turtle populations also are threatened by collection for the pet trade (Luensmann 2006).

Direct and Indirect Effects on Eastern Hellbender

The decline of the eastern hellbender is attributed to factors such as habitat alteration and degradation, deforestation of riparian corridors and resulting increases in silt burden, and water pollution associated with anthropogenic activities. The DoF routinely applies Best Management Practices which minimize erosion and sedimentation impacts. Additionally, in 2001 DoF established guidelines for harvesting near forested riparian corridors to better protect these important foraging areas for bats, such as the federally endangered Indiana and gray bats. The guidelines stipulate >100-foot wide limited-management buffers be established and maintained on either side of all perennial streams and rivers. Only minimal cutting is allowed inside these riparian management zones and the structural integrity

of the forested corridor is to be maintained at all times. To further protect habitat for this species, DoF will consult with the DNR Division of Fish and Wildlife prior to the establishment of stream crossings across the Blue River or across perennial tributaries at a location within 0.5 mile of the Blue River. Because harvesting is limited and carefully applied in riparian areas, and forested buffers are retained along streams, DoF anticipates the activities associated with all of the proposed alternatives will not adversely affect the eastern hellbender or its habitat.

Direct and Indirect Effects on Kirtland's and Smooth Green Snakes

The smooth green snake is typically found in open grassy habitats such as meadows, glades, or prairie remnants. The one specimen found at Yellowwood State Forest may, in fact, be rough green snake that had been misidentified (Z. Walker, IDNR, pers. comm. 2008). Given this and its preference for non-forested habitat, DoF does not anticipate any of the proposed activities will affect this species. The Kirtland's snake also inhabits grassy habitats, particularly those close to streams, pools, ponds, or wetlands; however, it also can be found in open wet woods. The proposed forest management activities typically are not practiced in the wet habitats preferred by this species, and for this reason the DoF anticipates there will be no direct effects on this species. Additionally, the DoF routinely applies Best Management Practices which limit erosion and sedimentation effects that could adversely affect Kirtland's snake habitat.

Direct and Indirect Effects on Forest Reptiles

The preferred forest management alternative will increase the number of small regeneration openings through selection harvesting, which should provide benefits for forest reptiles (Mitchell et al. 2006). Creating small regeneration openings often results in an increase in the abundance of small mammals (Healy and Brooks 1988, Yahner 1992, Fuller et al. 2004), the principal prey of timber rattlesnakes. Additionally, small recent openings provide rattlesnakes opportunities for basking, especially during gestation and ecdysis (skin shedding) (Z. Walker, IDNR, pers. comm. 2008). Recent forest openings result in dense stands of herbaceous plants and woody regeneration that would provide suitable habitat for rough green snakes. These snakes are largely arboreal and are often found among shrubs, saplings, and small trees. The high abundance of arthropods and lush growth of vegetation and fruiting plants that characterize recent openings and forest gaps would provide forage for box turtles, while slash piles and discarded logs would provide suitable cover.

While timber harvesting provides benefits to timber rattlesnakes through the creation of forest openings and gaps, these same activities could potentially affect the integrity of rattlesnake den sites. Skidding and tree-felling activities could potentially jeopardize den sites; for this reason, known den sites should be identified and protected where possible. Limiting harvests near den sites to winter months when snakes are dormant will minimize direct encounters and the possibility of harming snakes.

Prescribed fire is expected to create habitat conditions that benefit forest reptiles (Mitchell et al. 2006); however, widespread use of fire could potentially pose a threat to species such as Eastern box turtle. While many authors report prescribed burning has little

adverse effect on forest amphibians and reptiles (Ford et al. 1999, Russell et al. 1999, Renken 2005), these slow-moving species are often unable to escape advancing flames of even low-intensity burns restricted to the leaf litter (Z. Walker, IDNR, 2008, Luensmann 2006). Though box turtles are often unable to avoid burn areas, and burned individuals are reported, it is unclear how this affects turtle mortality and their populations. Under the proposed action, approximately 2,000 acres of recently harvested regeneration openings would be burned annually, approximately 1.3 percent of DoF forestland. Burns often are conducted in the late fall, winter, or early spring prior to green-up. During much of this time box turtles would most likely be hibernating beneath logs, within the soft soil of tree tip-up mounds/pits and soil depressions, and under deep forest litter. Though burns conducted while individuals are hibernating may affect those close to the ground surface or within dry litter, those that are less exposed should not be affected by the low intensity fires characteristic of forest prescribed burns. Since fire is prescribed as a follow-up treatment in and around regeneration openings and is not typically repeated periodically over the same area, it is very likely fire will rarely affect individuals or populations, particularly since box turtles are known to range over localized areas < 20 acres throughout much of their life (Luensmann 2006). For these reasons the DoF anticipates prescribed fire will minimally affect box turtles. Furthermore, any negative effects from prescribed burning should be mitigated at least partially by the habitat benefits these activities provide.

Cumulative Effects on Amphibians and Reptiles

As described in section 1.4 of this document, the oak-hickory component of DoF forestland has reached maturity system-wide and is experiencing regeneration issues that threaten the long-term stability of this essential forest type. DoF agrees with the opinion of regional experts (Abrams 2003, Dickson 2004, Fralish 2004, James 2004, McShea et al. 2007) who suggest a decline in the oak-hickory component will have catastrophic effects on this region's native forest communities, as many species depend on this component for their very existence (Dickson 2004). Mitchell et al. (2006) note that oak and hickory mast are a fundamental element in the forest floor food chain which includes many small mammals that are important prey for forest snakes like the timber rattlesnake. Dickson (2004) points out that the greatest diversity of salamanders occurs in the oak-hickory forests of the southern Appalachian region. The proposed action will create needed oak-hickory recruitment to help stabilize this declining trend and provide long-term sustainability to these forests and the communities they support. Additionally, many experts in this region note historic reforestation efforts and natural re-growth of eastern U.S. deciduous forests have produced an abundance of mature forest and a declining early-successional component that threatens many species dependent on that community type (Trani et al. 2001, Yahner 2003, Fuller and DeStefano 2003, Castrale et al. 2005). DoF suggests the proposed alternative not only will ensure long-term sustainability to its oak-hickory forests, but also in the process address these reported declines in early-successional habitats and species.

While accomplishing these goals with the proposed action, the DoF must ensure the life requirements of Indiana's species of greatest conservation need, specifically species requiring late-successional communities and mature forests, are addressed as well. Many

of the forest reptiles reviewed in this document – particularly timber rattlesnakes and box turtles – all use both early- and late-successional forest habitats, so their continued existence requires these habitats to be available on a sustained basis. The plan for long-term forest sustainability outlined in section 1.4 of this document will ensure a continuous supply of mature and maturing forest is available to herpetile species, even as early-successional habitats are created annually through harvesting. The DoF sustainability plan assures forest growth and maturation outpaces harvesting to ensure the needs of species that require both early- and late-successional habitats can be continually met. Additionally, DoF has designated Old Forest Areas on nearly all state forests, which will provide old growth forest elements, characteristics, and structure throughout the term of this plan and beyond. These areas are harvested nearly exclusively using single-tree selection, with only occasional use of group selection where appropriate. Old Forest Areas are to be managed for a condition in which the overstory canopy trees are relatively old (> 125 years on most sites) and relatively large for the species occurring on that site. The longer management cycle of these areas (>30 years) offers additional assurance they will be allowed to develop towards an old growth character with only limited disturbance.

Through the entirety of these measures – sustainable harvesting principally using selection silviculture and establishment of old forest tracts – DoF will ensure the needs of species reviewed in this document are met and their populations are not adversely affected. At the same time, DoF suggests the activities planned under the proposed alternative will improve habitat for all species dependent on oak-hickory forests and provide long-term sustainability for this essential ecological community.

4.2 Mammals

Gray Bat (*Myotis grisescens*)

Gray bat is listed as a federally endangered species and, consequently, receives the same designation in Indiana. This species is distributed from eastern Missouri to western Virginia and found as far south as southern Alabama (NatureServe Explorer 2008). In Indiana, this is an uncommon species sporadically distributed through the state, with only one known maternity colony location (S. Johnson, IDNR, pers. comm. 2008). One observation of this species exists on Harrison-Crawford State Forest in the Indiana Natural Heritage Database (2008). Historical records (pre-1980) of gray bats at Wyandotte Cave, adjacent to Harrison-Crawford State Forest, include three hibernating individuals and 11 bats captured at the entrance. More recent records include approximately 14 individuals either captured at the entrance or hibernating within Wyandotte Cave. An additional seven gray bats have been observed at Twin Domes Cave in Harrison County. DoF completed an extensive review of the environmental impact of the proposed treatments on Indiana and gray bats in the Draft Habitat Conservation Plan (HCP) for the Federally Endangered Indiana and Gray Bat (IDNR 2007). That draft was submitted to the U.S. Fish and Wildlife Service in October 2007 and will be released for public review and comment at the appropriate time. The environmental impacts on gray and Indiana bats are addressed here to the same extent as other species reviewed in this document, though a considerably more detailed analysis can be found in the DoF's HCP.

Gray bats commonly roost in caves throughout the entire year, though different caves

are often used during summer and winter (USFWS 1982, NatureServe Explorer 2008, S. Johnson, IDNR, pers. comm. 2008). Gray bats typically forage over rivers and wooded riparian corridors, and along the shores of lakes and reservoirs (USFWS 1982, NatureServe Explorer 2008, and S. Johnson, IDNR, pers. comm. 2008). Depending upon colony size and available habitat, individuals may travel up to 30 miles from cave roosts to forage (LaVal and LaVal 1980, Decher and Choate 1995). Bat activity levels in forested riparian areas are usually higher than in non-forested riparian areas, especially with regard to most Myotids (Hayes and Adam 1996).

Gray bat populations are threatened primarily by cave disturbance, both within caves and by forest clearing around entrances (NatureServe 2008, S. Johnson, IDNR, pers. comm. 2008). Additional threats include deforestation and development within riparian corridors (NatureServe 2008, S. Johnson, IDNR, pers. comm. 2008). Since gray bats are not known to forage on DoF lands, effects to their habitat from DoF management activities are expected to be minimal.

Indiana Bat (*Myotis sodalis*)

Indiana bat is listed as a federally endangered species and, consequently, receives the same designation in Indiana. Indiana bats spend much of the winter associated with caves and mines that serve as hibernacula; however, in summer they use forested areas and trees to fulfill life requisites (USFWS 2007a). Winter hibernacula extend from southern New England, through the Appalachian Mountains, west to the Ozarks, with isolated hibernacula occurring in Michigan and along the Mississippi River corridor in Illinois, Missouri, Iowa, and Wisconsin (USFWS 2007a). The summer range includes much of the area used during the winter, though it also expands into a general area extending from central New York, through Ohio, Indiana, Illinois, southern Iowa, and northern Missouri. In Indiana winter hibernacula occur in the south-central counties of the state, while summer records exist for the species throughout the entire state (USFWS 2007a). Records for this species exist at Clark, Harrison-Crawford, Jackson-Washington, Morgan-Monroe, and Yellowwood State Forests (USFWS 2007a, Indiana Natural Heritage Database 2008). DoF completed an extensive review of the environmental impact of the proposed treatments on Indiana and gray bats in the Draft Habitat Conservation Plan (HCP) for the Federally Endangered Indiana and Gray Bat (IDNR 2007). That draft was submitted to the U.S. Fish and Wildlife Service in October, 2007 and will be released for public review and comment at the appropriate time. The environmental impacts of the proposed activities on gray and Indiana bats are addressed here to the same extent as other species reviewed in this document, though a considerably more detailed analysis can be found in the DoF's HCP.

Upon leaving hibernacula, females form maternity colonies in forested or semi-forested areas on summer range (USFWS 2007a). Male Indiana bats often remain near hibernacula throughout summer, although some migrate considerable distances (Brack 1983, Whitaker and Brack 2002). Summer habitat for both genders include forested and semi-forested areas offering suitable roost trees, either live or dead. Most trees occupied by maternity colonies are dead, though individuals are occasionally found under the bark

of live trees, such as shagbark hickories (USFWS 2007a). Indiana bats roost within tree cracks, crevices, hollows, or beneath loose exfoliating bark. Roost trees occur on both upland sites and bottomlands, often along forest edges or in canopy gaps and openings where they receive abundant solar exposure (USFWS 2007a). Indiana bats typically forage along forest edges or within semi-open to closed-canopy forest, though individuals have also been observed foraging in open habitats (USFWS 2007a). Foraging habitats for this species include grazed woodlots, riparian corridors, open forest, forest openings and canopy gaps, closed-canopy forest, field-forest edges, old fields, ponds, and recently logged areas (Brack 1983, Gardner et al. 1991a, Gardner et al. 1991b, Kiser and Elliott 1996, Gumbert 2001, Menzel et al. 2001, USFWS 2007a). In Indiana, Brack (1983) found Indiana bats foraged most along forest edges and around the crowns of individual trees, an intermediate amount in openings, and least within forest interiors (USFWS 2007a). During autumn in Virginia, Brack (2006) found Indiana bats used open deciduous woodlands more frequently, and developed areas, closed forest, and mixed deciduous-conifer forest less than frequently than would be expected based on random use of available habitats. In Brack's study (2006), open woodlands included recently logged tracts with scatterings of individual trees.

Significant threats to this species includes disturbance within caves (particularly during the hibernation period) and near cave entrances (USFWS 2007a). Disturbance near entrances affects roosting habitat and airflow patterns that regulate cave temperatures. Natural catastrophes (i.e. winter flooding) can also affect large numbers of hibernating bats concentrated in caves. Possible threats to summer habitat include habitat loss due to deforestation, agricultural conversion, development, and subsequent loss of roosting or foraging sites (USFWS 2007a).

Evening Bat (*Nycticeius humeralis*)

Evening bat is listed as an endangered species in Indiana. This species can be found from South Dakota to Pennsylvania, south from Texas to Florida (NatureServe Explorer 2008). Populations are more widespread and abundant in the southern portion of its range (KBWG 2008). In Indiana this species has been found in many counties, with one observation from Jackson-Washington State Forest in 2004 (ESI 2004). Evening bats are commonly found near watercourses and prefer deciduous hardwood forests interspersed with agricultural areas (NatureServe Explorer 2008). This species also uses wooded, semi-open, wetlands (KBWG 2008). Evening bats are known to roost during the summer in tree cavities, spaces behind exfoliating bark, and within buildings and structures (NatureServe Explorer 2008). These bats typically do not use caves, mines, or other subterranean habitats (KBWG 2008, TBWG 2008). Little is known about this species' wintering habits, though fat reserves of migrating bats suggest this species prepares for either hibernation or long-distance migration (TBWG 2008). Some populations in Texas are present there throughout the year (NatureServe Explorer 2008).

The loss of forested wetlands to agriculture is believed to have contributed to this species' decline (KBWG 2008). Incompatible land management practices have resulted in a loss of roosting trees in some situations (KBWG 2008).

Eastern Woodrat (*Neotoma magister*)
The eastern woodrat is listed as an endangered species in Indiana and extant populations are restricted largely to south-facing limestone bluffs along the Ohio River, (Johnson 2002). Among all DoF properties, this species is documented only from Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Sites within Charles C. Deam Nature Preserve at Harrison-Crawford State Forest contain some of the highest woodrat densities in Indiana (S. Johnson, IDNR, pers. comm. 2008).

Eastern woodrats inhabit rocky areas such as cliffs, caves, outcrops, abandoned mines, and rocky slopes in deciduous forests of the eastern United States (Johnson 2002). Causes for this species' decline are unclear but potential factors include habitat fragmentation, increased predation, decline in oak-hickory forests, severe winter weather, infection from the parasitic raccoon round worm and decreased mast production due to gypsy moth invasion (LoGiudice 2006, S. Johnson, IDNR, pers. comm. 2008). Maintaining forest cover in species that produce hard mast (e.g., oaks and hickories) is considered important to this species (LoGiudice 2006, S. Johnson, IDNR, pers. comm. 2008).

Bobcat (*Lynx rufus*)
In July 2005, the bobcat was removed from Indiana's endangered species list and reclassified as a species of special concern. The bobcat ranges across much of the United States (except portions of the Midwest dominated by agriculture), extreme southern Canada, and Mexico (NatureServe Explorer 2008). In Indiana, the bobcat is most abundant in the south-central and southwest portions of the state (S. Johnson, IDNR, pers. comm. 2008, NatureServe Explorer 2008). Records of bobcat occur for Clark, Harrison-Crawford, Morgan-Monroe, and Yellowwood State Forests (Indiana Natural Heritage Database 2008).

Range-wide, the bobcat inhabits deciduous and coniferous forests and forest edges, swamps, deserts, mountains, and other areas with thick undergrowth. A wide-ranging predator, this species requires diverse habitats within its home range that are suitable for denning, foraging, and providing cover. Caves, rocky outcrops, and hollow trees and logs are all used as den sites. Early successional forest stands and recent forest openings and gaps provide excellent opportunities for hunting prey, such as rabbit and small mammals (Fuller and DeStefano 2003). Bobcats find cover in dense brush or secluded rocky outcrops. In general, habitat preference is dictated largely by prey availability, and management for this species should include creating and maintaining forest habitat suitable for rabbit and small mammals (S. Johnson, IDNR, pers. comm. 2008). In Indiana, illegal shooting and trapping continues to threaten the bobcat (Mumford and Whitaker 1982).

Badger *(Taxidea taxus)*
The badger is listed as a species of special concern in Indiana. This species occurs throughout much of the central and western United States, with its eastern limit north of the Ohio River and eastern portions of Texas and Oklahoma (NatureServe Explorer 2008). The badger has been observed in many counties throughout the northern two-thirds of Indiana, with a single observation occurring at Morgan-Monroe State Forest in 1983 (Indiana Natural Heritage Database 2008). This species generally prefers open

areas, such as grasslands, prairies, and cultivated areas (S. Johnson, IDNR, pers. comm. 2008, NatureServe 2008), and it generally avoids forests and woodlands, accounting for the single observation on a state forest property. The major threat to this species is habitat loss and degradation as grasslands and prairies are intensively converted to agriculture (NatureServe Explorer 2008). Additionally, badgers are routinely shot, trapped, and poisoned, leading some to suspect this persecution is related to population declines (NatureServe Explorer 2008).

Direct and Indirect Effects on Gray, Indiana, and Evening Bats

The gray bat is an uncommon resident of Indiana that typically roosts in caves throughout the entire year. Wyandotte and Twin Dome caves, where gray bats have previously been observed, are currently included within a harvest-restriction zone established by the DoF in coordination with the USFWS, Bloomington (Ind.) Field Office. Current guidelines for management within this zone include a seasonal prohibition on timber harvesting from April 1 through Nov. 15 within five miles of hibernacula given the USFWS-designation of either Priority 1 or 2. Additionally, forested buffers of 20 acres are established around all entrances of such hibernacula where there is no timber harvesting at any time of the year nor use of heavy, ground-disturbing machinery. Given such restrictions, DoF anticipates the activities associated with all of the proposed alternatives will not adversely affect the roosting habitat of this primarily cave-dwelling species.

Gray bats are known to frequently forage over waterways such as streams, rivers, and lakes (Tuttle 1976, LaVal et al. 1977, Best and Hudson 1996, Menzel et al. 2000) and may be associated more closely with aquatic habitats than any other bat of the eastern United States. Most gray bat roosts are located within 1-2 kilometers of a lake or stream and many authors have reported their preference for aquatic insects (Best et al. 1997, Lacki et al. 1995). While gray bats are not known to forage on DoF properties, forest management activities could potentially affect regional watercourses and bat foraging habitat. DoF will routinely apply – and exceed – Best Management Practices with all proposed forest management alternatives. To exceed the guidelines of the Best Management Practices, DoF routinely establishes >100-foot wide limited-management buffers on either side of all perennial streams and rivers to protect the integrity of forested riparian corridors many species of bats use for foraging. Only minimal cutting is allowed inside riparian management zones and the integrity of the forested corridor will be maintained. By continuing to practice (and exceed) Best Management Practices near perennial streams and rivers, DoF anticipates the activities associated with all of the proposed alternatives will not adversely affect gray bat foraging habitat.

Indiana bats winter in subterranean hibernacula and roost in trees in forested and semi-forested areas during the summer. Hibernacula management guidelines that were previously described for gray bats (above) also restrict harvesting activities around Indiana bat hibernacula so their populations and habitats would be protected as well. Given these measures of protection, the DoF does not anticipate any of the proposed alternatives will directly or indirectly affect hibernating Indiana bats.

The DoF expects the proposed action will create forest conditions beneficial to Indiana bats as well as evening bats, which use similar forest habitats during the summer. Open-

ings will increase foraging opportunities and improve solar exposure on roosting trees. Road, skid trail, and log yard construction and maintenance provide further foraging opportunities for these bats. Prescribed fire will also benefit Indiana and evening bat habitat. Burning leaf litter trapped within the buttressed roots of large trees creates scars that eventually accelerate butt- and heart-rot, contributing to the availability of snags for roosting. Opening the understory around potential roost trees would improve foraging conditions and remove possible obstructions for easier flight. Burning will encourage oak and hickory recruitment which provides long-term habitat suitability. Additionally, prescribed fire will encourage groundstory vegetation growth which, in turn, increases insect abundance (Jackson 2004) and foraging opportunities for forest bats. Since the DoF typically does not prescribe burns during the summer, it does not expect these activities will adversely affect roosting Indiana or evening bats.

In 2001, the DoF established a series of guidelines to ensure Indiana bat habitat is maintained on its properties. These guidelines quantitatively define the level of suitable roost tree retention on managed tracts and the establishment of riparian buffers to protect foraging areas. Additionally, these guidelines define appropriate schedules for hazard tree removal and harvesting associated with construction projects to ensure roosting individuals are unaffected by such activities. In addition to the measures already described, the DoF has completed an extensive review of the environmental impact of the proposed treatments on Indiana and gray bats in the Combined Draft Environmental Impact Statement and Habitat Conservation Plan (HCP) for the Federally Endangered Indiana and Gray Bat (IDNR 2007). Once approved by USFWS, the HCP will become the primary source of guidance for the protection of Indiana and gray bats and their habitats on DoF properties. The HCP will be designed to minimize incidental take of these federally endangered species during the same forest management activities proposed in this document. Given the protective actions described here and within the HCP, the DoF anticipates only negligible losses resulting from the proposed action (IDNR 2007), which should be mitigated by system-wide habitat improvements that will benefit maternal colonies and non-breeding individuals.

Direct and Indirect Effects on Eastern Woodrat

DoF does not anticipate any of the proposed alternatives will result in timber harvest activities in the preferred denning habitats of Eastern woodrats. This species typically dens in rock outcrops, ledges, and steep rocky slopes – areas where DoF typically does not conduct harvesting activities. However, retaining forest cover around, near, and between den sites is important to foraging individuals and dispersing juveniles. The proposed action has been designed to improve forest conditions for species like the Eastern woodrat by encouraging the regeneration of hard mast species in openings and improving the masting ability of retained oaks and hickories within tracts managed by single-tree selection. To accomplish this under the preferred harvesting alternative, the vast majority of annually harvested acreage (81 percent) will be harvested using selection methods, primarily single-tree selection (63 percent). While woodrats prefer contiguous mature forest communities near den sites (S. Johnson, IDNR, pers. comm. 2008), Castleberry et al. (2006) found clearcutting had minimal impact on Eastern woodrat movements, home range, and habitat use when sufficient intact forest was retained adjacent to known

colonies. In this study woodrats used forested and clearcut areas in proportion to their availability and exploited new sources of foods within recent clearcuts, such as vegetative growth from hardwood stump sprouts and soft mast from blackberry, grape, and blueberry (Castleberry 2000). While clearcut establishment near woodrat den sites (which currently are restricted to one localized portion of one state forest) will be unlikely under the proposed alternative, the results of this study suggest woodrats will tolerate limited harvesting. Given this species' inaccessible den habitat, the benefits it will derive from the preferred management alternative, and its tolerance to limited harvesting, the DoF does not anticipate the proposed forest management activities will adversely affect the Eastern woodrat.

Direct and Indirect Effects on Bobcat

It is assumed that direct contact with bobcat will be rare since den sites are often located in areas that are inaccessible or incompatible with forest management activities and because this secretive species is typically active at night. Since bobcats range over a variety of forest habitats in search of prey, increased diversity of forest age-classes should benefit this species. Forest openings created through group selection harvesting and, more infrequently, even-age silviculture will create habitat suitable for small mammals and other bobcat prey (Fuller and DeStefano 2003). Slash piles and discarded unmerchantable logs in and around regenerating openings provide habitat suitable for stalking and ambushing prey (S. Johnson, IDNR, pers. comm. 2008). Prescribed fire is unlikely to have any direct effect on bobcats, since they are highly mobile and should be able to avoid the slow-moving fires associated with these burns. The DoF does not anticipate the activities proposed will have adverse effects on bobcat, in fact, the proposed action should benefit this species through the creation of openings, gaps, and early-successional forest communities (Fuller and DeStefano 2003).

Direct and Indirect Effects on Badger

This species generally prefers open areas, such as grasslands, prairies, and cultivated areas (S. Johnson, IDNR, pers. comm. 2008, NatureServe 2008); it generally avoids forests and woodlands, accounting for the single observation on a state forest property. Given this, the DoF does not anticipate any of the proposed forest management activities will affect this species.

Cumulative Effects on Forest Mammals

As described in section 1.4 of this document, the oak-hickory component of DoF forestland has reached maturity system-wide and is experiencing regeneration issues that threaten the long-term stability of this essential forest type. DoF agrees with the opinion of regional experts (Abrams 2003, Dickson 2004, Fralish 2004, James 2004, McShea et al. 2007) who suggest a decline in the oak-hickory component will have catastrophic effects on this region's native forest communities, as many species depend on this component for their very existence (Dickson 2004). Dickson (2004) noted that many mammalian species rely heavily on oak and hickory mast to fulfill dietary needs. Authors report bats that roost under tree bark, such as Indiana bat, will often use – and may prefer – oak and hickory species, highlighting the need for these species in regional forests (USFWS

2007a). The proposed action will create needed oak-hickory recruitment to help stabilize this declining trend and provide long-term sustainability to these forests and the communities they support. Additionally, many experts in this region note that historic reforestation efforts and natural re-growth of eastern U.S. deciduous forests have produced an abundance of mature forest and a declining early-successional component that threatens many species dependent on that community type (Trani et al. 2001, Yahner 2003, Fuller and DeStefano 2003, Castrale et al. 2005). In their study on the importance of early-successional forest to mammals in the northeastern United States, Fuller and DeStefano (2003) report nearly all mammals in that region (56 of 60) use early-successional habitats and nearly one-third have a preference, in varying degrees, for those habitat types. DoF suggests the proposed alternative not only will ensure long-term sustainability to its oak-hickory forests, but also address these reported declines in early-successional habitats and species.

While accomplishing these goals with the proposed action, the DoF must ensure the life requirements of Indiana's species of greatest conservation need, specifically species requiring late-successional communities and mature forests, are addressed as well. Many of the mammalian species reviewed in this document – Indiana and evening bats, Eastern woodrat, and bobcat – use both early- and late-successional forest habitats, so their continued existence requires these habitats are available on a sustained basis. The plan for long-term forest sustainability outlined in section 1.4 of this document will ensure a continuous supply of mature and maturing forest is available to mammalian species, even as early-successional habitats are created annually through harvesting. The DoF sustainability plan assures forest growth and maturation outpaces harvesting to ensure that the needs of species that require both early- and late-successional habitats can be continually met. Additionally, DoF has designated Old Forest Areas on nearly all state forests, which will provide old growth forest elements, characteristics, and structure throughout the term of this plan and beyond. These areas are harvested nearly exclusively using single-tree selection, with only occasional use of group selection where appropriate. Old Forest Areas are to be managed for a condition in which the overstory canopy trees are relatively old (> 125 years on most sites) and relatively large for the species occurring on that site. The longer management cycle of these areas (>30 years) offers additional assurance they will be allowed to develop towards an old growth character with only limited disturbance. Through the entirety of these measures – sustainable harvesting principally using selection silviculture and establishment of old forest tracts – DoF will ensure the needs of species reviewed in this document are met and their populations are not adversely affected. At the same time DoF suggests the activities planned under the proposed alternative will improve habitat for all species dependent on oak-hickory forests and provide long-term sustainability for this essential ecological community.

4.3 Birds

Henslow's Sparrow (*Ammodramus henslowii*)

Henslow's sparrow is listed as an endangered species in Indiana. Records are scattered throughout northern Indiana, but are more abundant in the southern half of the state where several large populations are found (Burhans 2002, BBAE 2008, Indiana Natural

Heritage Database 2008). An estimated several thousand individuals breed in 19 reclaimed coal mine grasslands in southwestern Indiana (Burhans 2002). The Indiana Natural Heritage Database (2008) has records of Henslow's sparrow from Morgan-Monroe and Greene-Sullivan State Forests.

Henslow's sparrow is an obligate grassland species that historically bred in tallgrass prairie habitat (Burhans 2002). They also breed in other grasslands, including hayfields, pastures, and meadows (Hyde 1939, Graber 1968, Smith 1992, J. Castrale, IDNR, pers. comm. 2008). Tall and dense cover is frequently cited as a requirement for nesting habitat (Burhans 2002). Clawson (1991) and Mazur (1996) found that sparrows selected plots with a higher percentage of cover than available in random or unoccupied plots. Henslow's sparrows have very restrictive habitat requirements and show some of the most serious declines compared to other bird species of concern. Declines in the Midwest are largely due to loss of tallgrass habitat; those in the East are most likely due to reforestation and loss of livestock pastures (Burhans 2002).

Northern Harrier (*Circus cyaneus*)

The Northern harrier is listed as an endangered species in Indiana. This species breeds throughout Canada and the northern half of the United States and winters in the southern United States, Mexico, and Central America (NatureServe Explorer 2008). In Indiana, individuals have been observed during the breeding season throughout the state (BBAE 2008, Indiana Natural Heritage Database 2008), though only one observation exists for a state forest property; this sighting occurred outside the breeding season at Salamonie River State Forest in 1980. The lack of observations on state forests is due to the avoidance this species has for forested areas, preferring instead marshes, meadows, grasslands, old fields, pastures, and other open areas during the breeding season (NatureServe Explorer 2008, Nyboer et al. 2006). Nest sites typically are restricted to large, undisturbed grasslands and marshes. During migration these birds forage in a variety of open habitats (Nyboer et al. 2006). The major threat to this species is habitat loss and degradation, primarily nesting habitat, since large undisturbed grasslands, prairies, or marshlands are rare (Nyboer et al. 2006).

Cerulean Warbler (*Dendroica cerulea*)

The cerulean warbler is listed as an endangered species in Indiana. During the breeding season, this species nests in the deciduous forests of eastern North America, west of the Appalachian Mountains and east of the Ozark Mountains and western Great Lakes (CWTG 2007). Cerulean warblers have a relatively long migration to wintering grounds in the Andes Mountains of northern South America (CWTG 2007). Surveys throughout Indiana identified populations at 34 of 73 sites designated as potential cerulean warbler breeding habitat; these sites were found in the counties of Brown, Jackson, Jennings, Martin, and Monroe (Rosenberg et al. 2000). The Indiana Natural Heritage Database (2008) has records of the cerulean warbler on Ferdinand, Morgan-Monroe, Salamonie River, and Yellowwood State Forests. In Yellowwood State Forest, the species was documented in dry upland forests in the Brown County Hills. In Ferdinand State Forest, it was documented in a disturbed mesic floodplain. In Morgan-Monroe State Forest, two

cerulean warblers were documented on a dry ridge top with open areas (IDNR 2006). It is believed that preferred upland sites in Indiana include higher-elevation mesic slopes and ridge tops (J. Castrale, IDNR, pers. comm. 2008).

Nesting habitat for the cerulean warbler typically is found in large tracts of mature deciduous broadleaf hardwood forest with a diverse vertical structure (Hamel 2000). Habitats include wet bottomlands, mesic slopes, or uplands (Hamel 2000). Studies by The Cerulean Warbler Atlas Project found that mesic upland forests accounted for 72 percent of the cerulean warbler observations in Indiana (Rosenberg et al. 2000). The cerulean warbler is considered to be sensitive to patch size, for individuals avoid smaller areas of habitat; however, the threshold size is not known (Hamel 2000, CWTG 2007). Many authors report the occurrence of canopy gaps may be important to the species (Hamel 2000, J. Castrale, IDNR, pers. comm. 2008) and others report cerulean warblers do not appear to avoid forest gaps or roads (Weakland and Wood 2002). A recent study in southern Indiana found sustainable, selection silviculture practices provided suitable cerulean warbler breeding habitat (Register and Islam 2008). In this study there were no significant differences in cerulean warbler occurrence among uncut and harvested sites (Register and Islam 2008). Human activities that are believed to contribute to loss of habitat range-wide include extensive clearcutting, deforestation, strip mining, and clearing for agriculture and urban development (Hamel 2000, Weakland and Wood 2002).

Least Bittern (*Ixobrychus exilis*)

The least bittern is listed as an endangered species in Indiana. This species breeds throughout the eastern half of the United States and various locations along the west coast, and winters in southern coastal areas and Central America (NatureServe Explorer 2008). In Indiana, individuals have been observed during the breeding season at various locations throughout the state (BBAE 2008, Indiana Natural Heritage Database 2008), though only one observation exists for a state forest property; this sighting occurred at Salamonie River State Forest in 2002. The lack of observations on state forests is due to the avoidance this species has for forested areas, preferring instead freshwater marshes with dense, tall emergent vegetation, or – less often – brackish tidal marshes (NatureServe Explorer 2008, Nyboer et al. 2006). The major threat to this species is habitat loss and degradation (Nyboer et al. 2006), since large, undisturbed marshlands are rare. These wetlands also need to be protected from chemical contaminations, siltation, and eutrophication (Nyboer et al. 2006).

Yellow-crowned Night Heron (*Nyctanassa violacea*)

The yellow-crowned night heron is listed as an endangered species in Indiana. This species breeds throughout much of the central and southeastern United States, and winters in southern coastal areas and portions of Central and South America (NatureServe Explorer 2008). In Indiana, individuals have been observed during the breeding season at various locations throughout the southern half of the state (BBAE 2008, Indiana Natural Heritage Database 2008), though only one observation exists for a state forest property; this sighting occurred at Jackson-Washington State Forest in 1985. The yellow-crowned night heron nests in forested wetlands, swamps, and forested bottomlands near rivers, lakes,

and streams (NatureServe Explorer 2008, Nyboer et al. 2006). This heron forages in wooded/vegetated shallows along river, lake, and wetland margins (NatureServe Explorer 2008). The major threat to this species is habitat loss and degradation, since undisturbed bottomlands are rare (Nyboer et al. 2006). Environmental contamination of feedings areas may affect reproductive success (NatureServe Explorer 2008).

Virginia Rail (*Rallus limicola*)

The Virginia rail is listed as an endangered species in Indiana. This species breeds throughout much of the west, upper midwest, and northeastern United States and southern Canada, and winters throughout Mexico and the southwest and coastal areas of the U.S. (NatureServe Explorer 2008). In Indiana, nearly all breeding season observations have occurred in the northern half of the state, (BBAE 2008, Indiana Natural Heritage Database 2008), with only one observation existing for a state forest property; this sighting occurred at Salamonie State Forest in 2002. The Virginia rail nests in freshwater (and occasionally brackish) marshes characterized by dense stands of tall emergent vegetation, such as cattail or reeds (NatureServe Explorer 2008). This rail often forages in shallows along the interface between open water and emergent vegetation (NatureServe Explorer 2008). The major threat to this species is wetland loss and degradation (NatureServe Explorer 2008).

Red-shouldered Hawk (*Buteo lineatus*)

Red-shouldered hawk is listed as a species of special concern in Indiana. The breeding range for eastern populations is from Maine and southern Quebec, west to Minnesota and south to Florida, Texas, and central Mexico (Evers 1994, NatureServe Explorer 2008). In Indiana, where this species is a year-round resident, the red-shouldered hawk has been observed throughout the state, with its highest densities in the southern half of the state (BBAE 2008, Indiana Natural Heritage Database 2008). Red-shouldered hawks have been observed at Yellowwood State Forest and Leavenworth Barrens Nature Preserve at Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008).
Red-shouldered hawks typically inhabit mature deciduous or mixed deciduous-conifer riparian and bottomland forests and swamps (NatureServe Explorer 2008, J. Castrale, IDNR, pers. comm. 2008). This species also will nest in upland forests, though nests typically are located in close proximity to water (e.g., forested wetlands, creeks, ponds) (NatureServe Explorer 2008). Nests are built in tall trees, often the tallest in the surrounding forest. Some report red-shouldered hawks prefer to nest among dead trees, where they have an unobstructed view of the forest floor (Crocoll 1994, Woodward et al. 1931). Poisoning from insecticides and industrial pollutants, as well as loss of habitat, are major threats to this species. Deforestation and habitat fragmentation by agriculture and development are major threats to habitat suitability (NatureServe Explorer 2008). Incompatible forest management such as “high-grading” (NatureServe Explorer 2008) also presents a threat to some populations (Kirschbaum and Miller 2000).

Broad-winged Hawk (*Buteo platypterus*)

Broad-winged hawk is listed as a species of special concern in Indiana. This species breeds throughout much of eastern North America and winters in Central and northern

South America (NatureServe Explorer 2008). Historically, broad-winged hawks were common breeders in northern Indiana and less common as breeders in the southern part of the state (Butler 1897). Today, this species breeds sparsely in the north-central part of the state and most widely in the south-central portion (BBAE 2008, Indiana Natural Heritage Database 2008). The Indiana Natural Heritage Database (2008) has records of broad-winged hawks from Harrison-Crawford, Salamonie River, and Ferdinand State Forests. Broad-winged hawks nest in dense deciduous or mixed deciduous-coniferous forests. They prefer the nearby presence of water and canopy openings such as roads, trails, wetlands or meadows, where they often forage (UM 2004, NatureServe Explorer 2008, J. Castrale, IDNR, pers. comm. 2008). Ivory and Kirschbaum (1999) report broad-winged hawks avoid nesting near human dwellings. Primary causes of mortality include predation, trapping, shooting, and vehicle collisions (Goodrich et al. 1996). Population-level threats include extensive loss of forested habitat and fragmentation. Though widespread forest loss undoubtedly threatens nesting habitat, scattered openings and clearings in forested areas creates foraging opportunities (J. Castrale, IDNR, pers. comm. 2008).

Worm-eating Warbler (*Helmitheros vermivorum*)

Worm-eating warbler is listed as a species of special concern in Indiana. This species breeds from southern New York to Missouri and south from east Texas to South Carolina; wintering range extends across Caribbean islands and Central America (Indiana Natural Heritage Database 2008). In Indiana, this species occurs in its highest densities in the south-central portions of the state (BBAE 2008, Indiana Natural Heritage Database 2008). The Indiana Natural Heritage Database (2008) has records of the worm-eating warbler on Clark, Ferdinand, Harrison-Crawford, Jackson-Washington, Martin, Morgan-Monroe, and Yellowwood State Forests.

Worm-eating warblers typically nest on steep hillsides and ravines in deciduous or mixed deciduous-coniferous forests with a dense undertstory (Harrison 1978, Mumford and Keller 1984, NatureServe Explorer 2008, J. Castrale, IDNR, pers. comm. 2008). Dense patches of shrubs or saplings may be an important habitat component (Bushman and Therres 1988), and forest stands with a variety of age-classes available are often used by this species (J. Castrale, IDNR, pers. comm. 2008). As forest fragmentation increases on favorable breeding habitat, the worm-eating warbler becomes more susceptible to brown-headed cowbird parasitism and nest predation. Bushman and Therres (1988) studied the effects of forest fragmentation on nesting success and suggested the worm-eating warbler may be tolerant of various forest management practices. Nesting may occur in clearcuts greater than 7 years old that contain reserves of standing hardwood trees. Since dense groundstory and understory vegetation is necessary for suitable nesting habitat, control of deer populations and browse pressure is important to this species (J. Castrale, IDNR, pers. comm. 2008).

Bald Eagle *(Haliaeetus leucocephalus)*

The bald eagle is designated as a species of special concern in Indiana. The bald eagle was listed in 1978 as federally endangered throughout most of the United States. On Aug. 12, 1995, the USFWS down-listed the bald eagle from federally endangered to federally threatened throughout the lower 48 states due to the success of regional recovery

plans; 12 years later, in 2007, the bald eagle was removed from the list of federally threatened species.

The bald eagle breeds from central Alaska to Newfoundland and in scattered locations south to northern Mexico and Florida (USFWS 2007b). Bald eagles winter along North American coastlines and major rivers and lakes throughout the United States. (USFWS 2007b). In Indiana, bald eagles have been documented in various counties including Morgan, Brown, Monroe, Crawford, Dubois, Martin, Greene, Owen, Putnam, Jackson, and Harrison (Indiana Natural Heritage Database 2008). In Indiana, 68 active nests were known in 2006 (Castrale 2006) and an active nest was observed at Jackson-Washington State Forest in 2008 (B. Schneck, IDNR, pers. comm. 2008).

Nesting bald eagles are associated almost exclusively with lakes, rivers, or seacoasts that support an adequate food supply and have nearby forested areas (Buehler 2000, USFWS 2007b). Nests typically are located in canopy-level trees – live or dead – that are open and accessible, as well as rock ledges and promontories (USFWS 2007b). Bald eagles generally are thought to be intolerant of human activity close to nest sites during the nesting season, though some individuals nest successfully in close proximity to such activity (USFWS 2007b). Sensitivity to humans may depend on the type of activity, the nesting pair's prior experience with humans, and during which stage of breeding the activity occurs. Threats to this species continue though it has been federally delisted, including habitat loss, human disturbance and persecution (including illegal harvesting and poaching), and environmental contamination (NatureServe Explorer 2008).

Black-and-white Warbler (*Mniotilta varia*)

The black-and-white warbler is listed as a species of special concern in Indiana. This species breeds throughout the eastern United States and much of Canada, wintering along the U.S. Gulf Coast and from Mexico to northern South America (NatureServe Explorer 2008). In Indiana, these warblers nest throughout the south-central portion of the state and are known from Ferdinand, Morgan-Monroe, and Yellowwood State Forests (BBAE 2008, Indiana Natural Heritage Database 2008).

Black-and-white warblers breed in mature and second-growth deciduous and mixed deciduous-coniferous forests (NatureServe Explorer 2008, J. Castrale, IDNR, pers. comm. 2008). They generally are found in forested areas characterized by dense understory and shrub-layer development (NatureServe Explorer 2008). Black-and-white warblers are very sensitive to fragmentation of forested breeding habitat by agriculture, clearing, and deforestation (NatureServe Explorer 2008). Incompatible forest management practices, such as extensive clearcutting, may threaten local populations. Declines may be compounded by parasitism from the brown-headed cowbird, of which the black-and-white warbler is a frequent host. Since dense groundstory and understory vegetation is necessary for suitable nesting habitat, control of deer populations and browse pressure may be important to this species (NatureServe Explorer 2008). There is also evidence that pesticide use has negatively affected some populations (Dunn and Garrett 1997, Ehrlich et al. 1988, Kricher 1995). On wintering grounds, populations are threatened by deforestation, replacement of diverse native plant communities with agricultural and forested monocultures, and hunting (Arendt 1992).

Hooded Warbler (*Wilsonia citrina*)
Hooded warbler is listed as a species of special concern in Indiana. This species breeds from the southern Great Lakes region to northern Florida and west to the Ozarks (NatureServe Explorer 2008). In Indiana, this species is found in various locations but breeding populations are primarily concentrated in the south-central region of the state (BBAE 2008, Indiana Natural Heritage Database 2008). The Indiana Natural Heritage Database (2008) has records of this species on Ferdinand, Harrison-Crawford, Jackson-Washington, Morgan-Monroe, Salamonie River, and Yellowwood State Forests.

The hooded warbler is a forest-gap species that nests within a dense shrub layer in mature deciduous forests (Crawford et al. 1981, Robbins et al. 1989, Moorman et al. 2002). Preferred nesting sites often are associated with regenerating forest gaps (Gartshore 1988, J. Castrale, IDNR, pers. comm. 2008). This species is associated with large forested tracts, so extensive deforestation, clearing, and fragmentation on breeding and wintering grounds are thought to be threats (NatureServe Explorer 2008). The hooded warbler frequently is parasitized by the brown-headed cowbird (NatureServe Explorer 2008, J. Castrale, IDNR, pers. comm. 2008).

Direct and Indirect Effects on Birds of Wetlands and Grasslands
Forest management activities associated with each of the proposed alternatives are not expected to have significant direct or indirect effects – positive or negative – on wetland species, such as the least bittern and Virginia rail. These species infrequent DoF properties and use non-forested habitat that will likely be unaffected by the proposed timber harvesting activities. Additionally, Best Management Practices (sections 1.5.2 and 1.6.2) routinely applied during forest management activities are expected to minimize harmful effects of erosion and sedimentation, mitigating potentially harmful effects to the wetland habitats of these species.

Yellow-crowned night heron is likely an infrequent resident on DoF properties, and considering its reliance on wetlands and bottomland forests, it is also likely this species is rarely affected by timber harvesting activities. System-wide, bottomland hardwoods contribute approximately 2 percent of total forest cover, making it a rare community at most DoF properties. Furthermore, Best Management Practices restrict harvesting from the wetter, frequently inundated riparian areas this species typically inhabits. Considering these factors, it is unlikely any of the proposed alternatives will impact yellow-crowned night herons.

Henslow's sparrows use habitat that may be benefited by maintenance of wildlife openings (e.g., suppression of woody plants, periodic prescribed burning or mowing outside breeding season); these activities are described in Section 1.5.4. However, this species typically uses large grassy openings, which are rare on DoF properties. This is also true for the Northern harrier; though this species would be benefited by large grasslands maintained by periodic burning, mowing, and clearing activities, these habitats are rare on DoF properties. Consequently, the proposed activities are not expected to affect either of these species.

Direct and Indirect Effects on Forest Raptors

Since bald eagle nests are conspicuous and often reused, nest sites on and adjacent to DoF properties will be identified and actively monitored. The DoF will follow the appropriate guidelines published by USFWS for all forest management activities near bald eagle nests (USFWS 2007b). These guidelines specify the appropriate timing and distance at which various activities can take place near active and inactive bald eagle nests. Bald eagle foraging habitat typically is restricted to large water bodies and shorelines. Best Management Practices which are practiced routinely by DoF restrict harvesting activities from such areas and protect water quality. Therefore, strict application of Best Management Practices and USFWS (2007b) guidelines should result in negligible direct and indirect impacts on bald eagles nesting and/or foraging on DoF properties.

In the Midwest, red-shouldered hawks require relatively large tracts of medium-aged to mature bottomland forest habitat for breeding. Breeding territories are often closely associated with lentic habitats, such as backwater pools and sloughs, as well as wetland areas that are typically found at the confluence of sluggish streams (McKay et al. 2001). Timber harvesting that extensively opens the forest canopy is believed to degrade the site's suitability as nesting habitat (McKay et al. 2001); however, the effects of limited harvesting, including small clearcuts, are not well understood (McKay et al. 2001). Recent observations in the Upper Midwest and along the Mississippi River indicate red-shouldered hawks will continue to nest successfully when timber harvesting occurs on a small scale. Small clearcuts appeared to have little impact on breeding red-shouldered hawks, as long as an overall "core area" of mature forest remained intact (McKay et al. 2001). Broad-winged hawks also nest in generally mature forest landscapes, though they are more tolerant of second-growth and moderate-aged stands for nesting. Like red-shouldered hawks, this species will forage along forest edges, canopy-covered roads, and openings. Small, scattered openings like those created by selection harvesting would provide appropriate foraging opportunities for both of these species. Recent even-age openings likely will create suitable foraging habitat, though these should occur infrequently among forested tracts so as not to reduce the suitability of nesting habitat.

The preferred harvesting alternative is expected to annually affect approximately 5.3 percent of DoF managed forest acreage. The vast majority of this harvested acreage (81 percent) will be cut using selection methods, primarily single-tree selection (63 percent). DoF anticipates use of these harvesting methods will provide appropriate foraging habitat for each of these forest raptors while still preserving large areas of uncut, mature forest suitable for nesting. Under the proposed action even-age harvests will annually occur on < 1 percent of DoF acreage system-wide. Given this infrequency it is anticipated that even-age harvests would have little effect on the suitability of nesting habitat, though if encountered by either of these species, recent even-age openings would provide appropriate habitat for foraging.

Though DoF anticipates the proposed action would have only negligible effects on breeding raptors, guidelines have been established to ensure large even-age openings are designed to provide benefits for both early- and late-successional bird species. Larger openings typically provide abundant habitat for early-successional bird species, while temporarily displacing nesting late-successional species to nearby uncut areas. However,

many studies have found that retention of some mature canopy trees within large openings provides benefits to mature forest species (Annand and Thompson 1997, Rodewald and Yahner 2000, McDermott 2007). Therefore, to further mitigate potential negative effects of large (≥20 acres) even-age openings on mature forest species, DoF suggests leaving 5 percent of the harvested acreage permanently in mature forest structure. It is anticipated that islands of residual structure, each no smaller than 1/5 of an acre will provide suitable nesting and foraging habitat within regenerating openings for a variety of species as well as perching opportunities for forest raptors such as red-shouldered and broad-winged hawks.

Direct and Indirect Effects on Forest Warblers

Many forest passerines are known to benefit from the harvesting activities DoF regularly uses; for instance, the small canopy gaps created by single-tree selection favors hooded warblers (Robinson and Robinson 1999). Additionally, the small openings that result from group selection create unique patches of early successional habitat within otherwise mature forest communities, which have been found to benefit both hooded and worm-eating warblers (Annand and Thompson 1997, Gram et al. 2003, Campbell et al. 2007). Many studies report that forests managed using selection silviculture retain the mature forest's late-successional species around and between gaps and openings, while also attracting early-successional species to the nesting and/or foraging habitat created within openings (Annand and Thompson 1997, Germaine et al. 1997, Robinson and Robinson 1999, Costello et al. 2000, Gram et al. 2003, Campbell et al. 2007, Holmes and Pitt 2007). Because selection silviculture creates early-successional habitat and attracts new species while still retaining many late-successional species, many researchers report the number of forest passerine species either increased or remained unchanged in their studies following timber harvesting (Annand and Thompson 1997, Robinson and Robinson 1999, Costello et al. 2000, Campbell et al. 2007).

Even-aged silvicultural systems generally result in larger openings as they are used for stand-wide replacement. These openings create larger patches of regenerating vegetation, which provide suitable nesting habitat for early-successional bird species (e.g., indigo bunting and chestnut-sided warbler) and important foraging habitat for many species that typically nest in mature, late-successional forest (Kilgo et al. 1999, Pagen et al. 2000, Keller et al. 2003, Marshall et al. 2003, Castrale et al. 2005, Vitz and Rodewald 2006, McDermott 2007). While these larger openings typically displace nesting late-successional species to areas of uncut forest, studies have found the productivity of these same species nesting near even-age openings is often unaffected (Hanski et al. 1996, Duguay et al. 2001, Gram et al. 2003).

While each of the four forest warbler species reviewed for this document are associated with mature forests and require varying amounts of late-successional forest habitat during the breeding season, it is also true that each of these species does not necessarily avoid openings, gaps, or the presence of early successional habitat. In fact, most ornithologists and researchers conclude there are no bird species using the disturbance-dependent forests of this region that require undisturbed, old growth forest for their existence (Lorimer 1994). Given this, it is expected that even species that typically nest in large forest

tracts, such as cerulean warbler, tolerate some level of disturbance (Register and Islam 2008). Since the preferred harvesting alternative is expected to annually affect a maximum 5.3 percent of DoF managed acreage, it is anticipated there will be considerable uncut forest available for the nesting and foraging needs of these species. The vast majority of harvested acreage (81 percent) will be managed using selection methods, primarily single-tree selection (63 percent). Given the habitat requirements of the forest warblers addressed in this document, small, scattered openings of the type typically created by selection management are expected to benefit some of these species (e.g., hooded warbler) while not adversely affecting others (e.g., worm-eating warbler, cerulean warbler, and black-and-white warbler). Under the proposed action, even-age harvests will occur annually on < 1 percent of DoF acreage system-wide. Given this infrequency, it is anticipated that even-age harvests would have little effect on the ability for these forest species to find suitable nesting habitat in the remaining expanse of uncut forest.

While harvesting at the level suggested by the proposed action is not expected to have significant direct affects on the availability of habitat for these species, the indirect effects of such activities must also be examined. A major concern of Midwest bird populations is the effect forest fragmentation may have on breeding success and productivity. While habitat loss and fragmentation are often used interchangeably, habitat loss refers to the detraction of habitat available to a species, while fragmentation refers to the simultaneous effects of habitat loss and a change in the configuration of a particular habitat type (Villard et al. 1999, Villard 2002). Fragmentation concerns center on the perception that increasing the amount of edge within and around forested tracts increases the vulnerability of forest-nesting bird species to nest predators (e.g., raccoons, canids, corvids) and brood parasites (e.g., brown-headed cowbird) that frequent these edge habitats. While many studies found evidence to support these "edge effects" (King et al. 1996, Manolis et al. 2000, Manolis et al. 2002), many other studies found no such effects (Annand and Thompson 1997, Germaine et al. 1997, Hanski et al. 1996, King and DeGraaf 2000, King et al. 2001, Robinson and Robinson 2001, Moorman et al. 2002, Gram et al. 2003), and in recent years some have even suggested that concerns for widespread population declines due to habitat re-configuration may be misplaced and overestimated compared to habitat loss (Villard 2002).

While much remains to be learned about the population-level effects of fragmentation on breeding birds and other taxa, there do seem to be some consistencies among studies. Many agree edge effects are most pronounced in forest tracts and fragments situated within predominantly agricultural landscapes (Donovan et al. 1997, Rodewald and Yahner 2001) or adjacent to agricultural corridors (Ford et al. 2001). Here, at the maintained interface between forest and agricultural or developed areas, the diversity and abundance of nest predators and brood parasites appear to be higher than in forest-dominated landscapes (Rudnicky and Hunter 1993, Lorimer 1994, Hanski et al. 1996, Bayne and Hobson 1997, Rodewald and Yahner 2001, Rodewald 2002). Maintained forest edges, like those associated with developed or agricultural areas, sustain suitable edge-predator habitat over time; however, edges associated with regeneration openings that quickly transition into dense stands of early-successional forest quickly "soften" and are less suitable for edge-predators than well-defined, maintained edges. Rosenberg et al. (1999) state "[i]t is

important to distinguish between forest that is fragmented by agricultural or urban development and a forested landscape composed of a mosaic of mature and regenerating stands that result from timber harvesting", concluding that the fragmentation effects of agriculture and development are typically more damaging to forest bird populations. Many researchers report selection harvesting systems do not significantly affect the incidence of nest predation or brood parasitism on forest birds (Annand and Thompson 1997, Germaine et al. 1997, King et al. 2001, Robinson and Robinson 2001, Moorman et al. 2002, Gram et al. 2003). In studies examining the occurrence of edge effects associated with even-age openings, some studies observed edge effects (King et al. 1996, Manolis et al. 2000, Manolis et al. 2002) while others report no such effects (Hanski et al. 1996, King and DeGraaf 2000, Gram et al. 2003).

Given the lack of observed edge effects resulting from selection methods – the predominant cutting method used in the proposed action – and the inconsistencies in observing such effects in relation to even-age harvesting, a relatively minor component of the proposed action, DoF does not anticipate any significant negative indirect effects on forest birds. If indirect, or "edge", effects occur, they most likely will be from even-age openings adjacent to maintained forest edges or within areas dominated by non-forest habitat types (e.g., agriculture), and DoF expects these situations will rarely occur.

Each of the proposed alternatives includes use of prescribed fire as a follow-up treatment to harvesting. Two of the forest warblers reviewed in this document nest on the ground (worm-eating and black-and-white warblers) and potentially could be affected by such activities. However, prescribed burns typically take place well outside the breeding season of these two species. Additionally, prescribed burns would occur soon after harvesting when vegetation conditions in the regeneration opening would not offer suitable nesting habitat for either species. Prescribed burns are typically of low intensity; often only the leaf litter and, occasionally, small woody stems (< 1 inch diameter) are affected. Therefore, prescribed burning is not expected to have any appreciable effects on any of the forest warblers reviewed, whether they nest on the ground or in trees.

Cumulative Effects on Forest Birds

As described in section 1.4 of this document, the oak-hickory component of DoF forestland has reached maturity system-wide and is experiencing regeneration issues that threaten the long-term stability of this essential forest type. DoF agrees with the opinion of regional experts (Abrams 2003, Dickson 2004, Fralish 2004, James 2004, McShea et al. 2007) who suggest a decline in the oak-hickory component will have catastrophic effects on this region's native forest communities, as many species depend on this component for their very existence (Dickson 2004). The proposed action will create needed oak-hickory recruitment to help stabilize this declining trend and provide long-term sustainability to these forests and the communities they support. Additionally, many experts in this region note that historic reforestation efforts and natural re-growth of eastern U.S. deciduous forests has produced an abundance of mature forest and a declining early-successional component that threatens many species dependent on that community type (Hunter et al. 2001, Dettmers 2003, Trani et al. 2001, Murphy 2003, Castrale et al. 2005, Rich et al. 2005). Accordingly, the American Bird Conservancy (2007) lists this region's

early-successional forests as one of the nation's "top threatened bird habitats". DoF suggests the proposed alternative will not only ensure long-term sustainability to its oak-hickory forests, but in the process address these reported declines in early-successional bird habitats and species.

While accomplishing these goals with the proposed action, the DoF must ensure the life requirements of Indiana's species of greatest conservation need, specifically species requiring late-successional communities and mature forests, are addressed as well. The plan for long-term forest sustainability outlined in section 1.4 of this document will ensure that a continual supply of mature and maturing forest is available to late-succession species such as the forest raptors and warblers reviewed for this document, even as early-successional habitats are created annually through harvesting. The DoF sustainability plan assures forest growth and maturation outpaces harvesting to ensure that the needs of early-successional species are balanced with those requiring late-successional habitats. Additionally, DoF has designated Old Forest Areas on nearly all state forests, which will provide old growth forest elements, characteristics, and structure throughout the term of this plan and beyond. These areas are harvested nearly exclusively using single-tree selection, with only occasional use of group selection where appropriate. Old Forest Areas are to be managed for a condition in which the overstory canopy trees are relatively old (> 125 years on most sites) and relatively large for the species occurring on that site. The longer management cycle of these areas (>30 years) offers additional assurance that they will be allowed to develop towards an old growth character with only limited disturbance.

Through the entirety of these measures – sustainable harvesting principally using selection silviculture and establishment of old forest tracts – DoF will insure the needs of species reviewed in this document are met and their populations are not adversely affected. At the same time DoF suggests the activities planned under the proposed alternative will improve habitat for all species dependent on oak-hickory forests and provide long-term sustainability for this essential ecological community.

4.4 Fish and Freshwater Mussels

Direct and Indirect Effects

Three species of fish and two freshwater mussels that are included on Indiana's listing of species of greatest conservation need have been found on DoF properties since 1980 (Indiana Natural Heritage Database 2008). Fish species include northern cave fish (endangered), variegate darter (endangered), and spotted darter (special concern); mussels include wavyrayed lampmussel and kidneyshell, both species of special concern (Appendix A, Table 4). Since these species are restricted to aquatic habitats, DoF does not expect the proposed action to cause any direct, adverse effect on them or their populations. Four of these species (the two darters and two mussels) inhabit streams that flow through actively managed DoF properties. Additionally, one federally endangered freshwater mussel – the Eastern fanshell (*Cyprogenia stegaria*) – has been documented in the east fork of the White River, downstream of Martin State Forest (Indiana Natural Heritage Database, 2008, B. Fisher, IDNR, pers. comm. 2008). Each of these species inhabits streams or rivers that feature a gravel or cobble substrate, free of deep sediment and silt. The DoF routinely applies Best Management Practices to each timber harvest which minimizes the

effects of erosion and sedimentation. Additionally, in 2001 DoF established guidelines for harvesting near forested riparian corridors to better protect these important foraging areas for bats, such as the federally endangered Indiana and gray bats. The guidelines stipulate >100-foot wide limited-management buffers be established and maintained on either side of all perennial streams and rivers. Only minimal cutting is allowed inside these riparian management zones, and the structural integrity of the forested corridor is to be maintained at all times. Because harvesting is limited and carefully applied in riparian areas, and forested buffers are retained along streams, DoF anticipates the activities associated with the proposed action will not adversely affect the riverine habitats of these fish and mussels.

The Northern cavefish (Appendix A, Table 4) inhabits cave systems that feature streams, pools, and other deep water habitats (NatureServe 2008, B. Fisher, IDNR, pers. comm. 2008). As with the other fish reviewed for this document, the DoF does not anticipate direct effects to this species that inhabits subterranean habitats. To minimize threats to water feeding into subterranean streams, DoF applies Best Management Practices to each timber harvest. Disturbing the integrity of cave entrances and sinkholes could also affect the quality of water entering these systems and for this reason the DoF enforces a policy of minimum disturbance around such features (DoF Procedures Manual, Section S-1 1999). Given the protective measures routinely undertaken by the DoF, no adverse effects on the Northern cavefish are anticipated from any of the proposed alternatives.

Cumulative Effects on Fish and Freshwater Mussels
Given the DoF's commitment and strict adherence to measures ensuring minimal impacts to regional water quality, no cumulative adverse changes are anticipated by the proposed activities.

4.5 Invertebrates (excluding freshwater mussels)

Southeastern Wandering Spider (*Anahita punctulata*)
The southeastern wandering spider is listed as an endangered species in Indiana. This species is largely found in the southeastern part of the United States (Headstrom 1973). The Indiana Natural Heritage Database (2008) reports the most recent record for this species was at Harrison-Crawford State Forest in 1996. The southeastern wandering spider is a member of Ctenidae family known for wandering over the ground and through foliage in search of prey. This spider has been collected in mesic woods, hammocks, and woodrat nests throughout the southeastern United States (Peck 1981). Specific causes for decline are unknown.

Short-winged Panic Grass Leafhopper (*Polyamia dilata*)
The short-winged panic grass leafhopper is listed as an endangered species in Indiana. This species of leafhopper is found in the driftless areas of Wisconsin, Minnesota, Iowa and Illinois, loess hills in Iowa, and sand prairies of Indiana (WDNR 2006). The Indiana Natural Heritage Database (2008) reports one known occurrence of this species at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. The

short-winged panic grass leafhopper seems to be restricted to areas of upland dry to dry-mesic prairie. Though unknown for certain, the host plant for the species is thought to be one or several native cool-season panic grasses of the subgenus *Dicanthelium* (WDNR 2006). Specific causes for decline are unknown.

Dusted Skipper (*Atrytonopsis hianna*)

The dusted skipper is listed as a threatened species in Indiana. This skipper ranges from eastern Wyoming to New Hampshire and south from Florida to Texas. Indiana Natural Heritage Database (2008) reports this species has been observed in the counties of Lake, Newton, Starke, Jasper, Perry, Crawford, and Porter, with one known occurrence at the Leavenworth Barrens on Harrison-Crawford State Forest in 2000. Caterpillar hosts include little bluestem (*Andropogon scoparius*) and big bluestem (*A. gerardi*). Adult food includes nectar from flowers including Japanese honeysuckle, wild strawberry, blackberry, wild hyacinth, phlox, vervain, and red clover (NBII 2006).

The dusted skipper is found in grasslands, prairies, barrens, and old fields (NBII 2006). This species colonizes areas which have been burned, re-vegetated, and support its reported food plant, beardgrass (or bluestem) (Shull 1987). It is likely to inhabit open dry fields, in sandy barrens supporting scrub oak and pine (Shull 1987), and in open utility corridors (Allen 1997). Specific causes for decline are not known; however, habitat loss is the biggest threat to butterflies in general (WDNR 2005).

Sooty Azure (*Celastrina nigra*)

The sooty azure is listed as a threatened species in Indiana. It is found in the southern Appalachians, the Ohio River Valley, central Illinois, and northwest Arkansas (NBII 2006). The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in Floyd and Clark counties, with one known occurrence of this species on Clark State Forest in 1988. Males patrol along woodland edges in search of females. The only host known for the caterpillars is goat's beard (*Aruncus dioicus*) in the rose family. Adults, especially females, feed on flower nectar, including redbud (*Cercis canadensis*), wild geranium (*Geranium spp.*), toothwort (*Dentaria spp.*) and spring beauty (*Claytonia spp.*) (Allen 1997). The sooty azure seems to prefer shady and moist deciduous woods (NBII 2006) and cool, shaded woodland roads and edges (Allen 1997). It is often found in shaded northern slopes where goat's beard grows (Shull 1987). Habitats may be threatened by the spread of non-native invasive species such as garlic mustard (*Alliaria officinalis*) (NBII 2006).

Indiangrass Flexamia (*Flexamia reflexus*)

The Indiangrass flexamia is listed as a threatened species in Indiana. In the United States it is found in Arkansas, Indiana, Kentucky, and Michigan. The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in LaPorte, Lake, and Crawford counties, with one known occurrence of this species in the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Specific causes for decline are unknown.

Multicolored Huckleberry Moth (*Pangrapta decoralis*)
The multicolored huckleberry moth is listed as a threatened species in Indiana. This species occurs in most of the eastern United States (BugGuide 2006). The Indiana Natural Heritage Database (2008) reports this species has been found in Harrison and Crawford counties, with a known occurrence of this species at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. The caterpillar of the species feeds on blueberry and sourwood. The multicolored huckleberry moth prefers woodlands and shrubby areas near its host plant, blueberry (BugGuide 2006). It has been captive-reared on blueberry plants, and in Ohio larvae were commonly found on sourwood (Rings et al. 1992). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Prairie Panic Grass Leafhopper (*Polyamia herbida*)
The prairie panic grass leafhopper is listed as a threatened species in Indiana. Information regarding U.S. distribution of the prairie panic grass leafhopper is limited but is known to include Indiana and Kentucky. The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in Crawford and Porter counties, with one known occurrence of this species at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Prairie panic grass leafhoppers occur in areas of upland dry to dry-mesic prairie. The host plant for the species is thought to be one of several native cool-season *Panicum* grasses (WDNR 2006). Specific causes for decline are unknown.

Red-striped Panic Grass Moth (*Tampa dimediatella*)
The red-striped panic grass moth is listed as a threatened species in Indiana. This species ranges from the Gulf of Mexico to Missouri, with additional local populations isolated beyond the core range (NDSU 2006). The Indiana Natural Heritage Database (2008) reports this species has been found in Crawford, Porter, and Harrison counties, with one known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. There is no information available on host species (NDSU 2006). It is associated with barrens (USDA 2002). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Salt-and-pepper Skipper (*Amblyscirtes hegon*)
The salt-and-pepper skipper is listed as a rare species in Indiana. It ranges from southern Manitoba to Nova Scotia and Maine, south to northern Florida and southeastern Texas. The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in the counties of Parke, Putnam, Brown, Montgomery, Harrison, Perry, and Crawford, with one known occurrence at the Leavenworth Barrens on Harrison-Crawford State Forest in 2000. Caterpillar hosts include bluegrass (*Poa pratensis*), Indian grass (*Sorghastrum nutans* and *S. secundum*), and Indian woodoats grass (*Chasmanthium latifolia*). Adult food includes nectar from the flowers of viburnum, blackberry (*Rubus spp.*) and fleabane (*Erigeron spp.*) (NBII 2006, Allen 1997). The salt-and-pepper skipper frequently is found near streams in forest glades and edges (NBII 2006), bogs, low-lying

wet meadows, and glades at the edges of mixed or coniferous forests (Allen 1997). Adults prefer edges of forests in hilly areas. They also occur along stream banks and in hayfields usually flying rather close to the ground (Shull 1987). Specific causes for decline are not known; however, habitat loss is the biggest threat to butterflies in general (WDNR 2005).

Common Roadside-skipper (*Amblyscirtes vialis*)
The common roadside skipper is listed as a rare species in Indiana; it is the most widespread skipper in North America. This skipper occurs from British Columbia to Nova Scotia and Maine, south from northern Florida to central California (NBII 2006). The Indiana Natural Heritage Database (2008) reports individuals of this species have been collected in Porter, Harrison, and Crawford counties, with one known occurrence at the Leavenworth Barrens on Harrison-Crawford State Forest in 2000. Caterpillar hosts include, wild oats (*Avena spp.*), bent grass (*Agrostis spp.*), bluegrass (*Poa spp.*), Bermuda grass (*Cynodon dactylon*), and Indian woodoats grass (*Chasmanthium latifolia*). These skippers prefer nectar from low-growing blue flowers including *Verbena* and selfheal (*Prunella vulgaris*) (NBII 2006). The common roadside skipper prefers open areas in or near woodlands, often close to streams (NBII 2006). Adults fly from mid-May to early September, resting on exposed soil of woodland trails and paths, along railroads and wet protected places (Shull 1987). It may frequent dry grassy hillsides, shale barrens, or open utility corridors (Allen 1997). Specific causes for decline are not known; however, habitat loss is the biggest threat to butterflies in general (WDNR 2005).

West Virginia White (*Artogeia virginiensis*)
The West Virginia white is listed as a rare species in Indiana. It occurs from northern Wisconsin to western New England, south to the mountains to Georgia. The species also has scattered, localized populations near the Ohio River in Indiana and Kentucky (NatureServe Explorer 2008). The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in several counties (Floyd, Jennings, Clark, Harrison, Crawford, and Scott), with occurrences at Harrison-Crawford State Forest in 1994 and Clark State Forest as recently as 1988. This species inhabits mesic, rich deciduous woodlands and the margins of hardwood wetlands; the larvae feed exclusively on the forest herb toothwort (*Dentaria*) (NatureServe Explorer 2008). The West Virginia white is extremely sensitive to forest fragmentation, some reports suggest individuals avoid all open habitats, including un-canopied forest roads (NatureServe Explorer 2008). Besides deforestation and fragmentation, this species is threatened by the spread of invasive plants, such as garlic mustard (*Alliaria officinalis*), that can out-compete its larval host-plant.

Long-nosed Elephant Hopper (*Bruchomorpha extensa*)
The long-nosed elephant hopper is listed as a rare species in Indiana and occurs in both Indiana and Kentucky. The Indiana Natural Heritage Database (2008) reports one known occurrence of this species at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Mesic prairie is the typical habitat of the long-nosed elephant hopper (IL DNR 2008). Specific causes for decline are unknown.

Red-banded Hairstreak (*Calycopis cecrops*)
The red-banded hairstreak is listed as a rare species in Indiana. It is found from New York to Florida, west to southeast Kansas and eastern Texas. It occurs in scattered populations to eastern Nebraska, northern Illinois, and Michigan (NBII 2006). The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in Harrison and Crawford counties, with one known occurrence of this species at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Larvae are reported to feed on dead leaves and detritus in the leaf litter; however, in captivity they will also feed on living foliage and flowers. Reported host plants include wax myrtle (*Myrica cerifera*), sumacs (particularly winged sumac, *Rhus copallinum*), and oaks (UFL 2006). Adults visit a variety of plants for nectar, including sumac, dogbane, black cherry (*Prunus serotina*), blackberry, milkweeds (*Asclepias spp.*), autumn olive (*Elaeagnus umbellate*), New Jersey tea (*Ceanothus americanus*) and yarrow (*Achillea* spp.) (Allen 1997). The red-banded hairstreak can be found in dry open woods and wooded residential neighborhoods (UFL 2006), coastal hammocks, overgrown fields, and forest edges (NBII 2006). It is also found in semi-open brushy habitats including abandoned farms, hedgerows and clearings (Allen 1997). Specific causes for decline are not known; however, habitat loss is the biggest threat to butterflies in general (WDNR 2005).

Black-dashed Underwing Moth (*Catocala flebilis*)
The black-dashed underwing moth is listed as a rare species in Indiana. The species ranges from New Hampshire to Georgia and Alabama, west to Kansas, Oklahoma, and Texas (NatureServe Explorer 2008). The Indiana Natural Heritage Database (2008) reports this species has been found in Harrison and Crawford counties, with one known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. The larvae feed on the foliage of hickories (*Carya*), with preference for shagbark (*C. ovata*) and pignut (*C. glabra*) (Rings et al. 1992, OARDC 2006). Caterpillars also have been known to feed on oak (*Quercus*) and apple (*Malus*) (Klots and Klots 1972). This species inhabits forests, woodlands and gardens with trees (Farrand 1988). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Gemmed Satyr (*Cyllopsis gemma*)
The gemmed satyr is listed as a rare species in Indiana. Gemmed satyr can be found from Maryland in the east to Kansas in the west, south through Florida and Texas to northeastern Mexico (BugGuide 2006). The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in the counties of Perry, Posey, Crawford, and Harrison, with known occurrences at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 1992 and 2000. Males patrol in an erratic, bouncing flight close to the ground through woodland vegetation, perching on vegetation or dead leaves on the forest floor. Caterpillars feed on grasses including Bermuda grass (*Cynodon dactylon*) (NBII 2006). Adults do not visit flowers but are attracted to rotting or overripe fruit (NBII 2006), damp soil, dung, fungi, and tree sap (Allen 1997). The gemmed satyr is found near open, wet woodlands and grassy areas near streams and ponds (NBII 2006, Shull 1987). Specific causes for decline are not known; however, habitat loss is the biggest threat to butterflies in general (WDNR 2005).

Figured Grammia (*Grammia figurata*)
The figured grammia is listed as a rare species in Indiana. This species is known in the United States from Arkansas and Indiana and in Canada from Ontario and Quebec (NatureServe Explorer 2008). The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in Starke, Lake, Harrison, Crawford, and Porter counties, with one known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Known food plants include alfalfa and plantain (Covell 1984). The figured grammia favors sandy (or occasionally rocky), grassy habitats (NatureServe Explorer 2008). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Oithona's Grammia (*Grammia oithona*)
Oithona's grammia is listed as a rare species in Indiana. This species is known in the United States from Arkansas, Indiana, Maryland, Michigan, and Wisconsin (NatureServe Explorer 2008). The Indiana Natural Heritage Database (2008) reports this species has been found in Starke, Lagrange, Lake, Harrison, Porter, and Crawford counties, with a known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Known food plants include clover, painted-cup, and wild pea (Covell 1984, NDSU 2006). This species has been collected most often in Michigan in old fields or disturbed habitats with sandy soils and among sparse vegetation in open sandy areas. Four of the eight Ohio specimens are from the remaining open communities that are characterized by sandy soil (Metzler and Lucas 1990). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Sand Barrens Grammia (*Grammia phyllira*)
Sand barrens grammia is listed as a rare species in Indiana. The species is known across several separate ranges that include the Atlantic coast from Maine to Florida, the Great Lakes region, and from Colorado to Texas. The Indiana Natural Heritage Database (2008) reports this species has been found in Starke, Harrison, and Crawford counties, with one known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Food plants include corn, lupines, and tobacco (Covell 1984). The sand barrens grammia prefers areas of sandy soil, generally supporting barrens or disturbed old field vegetation (NatureServe Explorer 2008). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Carolina Satyr (*Hermeuptychia sosybius*)
Carolina satyr is listed as a rare species in Indiana. It can be found from southern New Jersey to southern Florida and west to southeast Kansas, central Oklahoma, central Texas, and Mexico (BugGuide 2006). The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in Harrison and Crawford counties, with a known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Caterpillar hosts include various native grasses and the exotic Japanese stilt grass *(Microstegium vimineum)* (Pippen 2005, NBII 2006). Adults have a slow, weak flight, and are usually found flying in the forest understory. Males patrol along

roads, trails or woodland openings in a slow bouncing flight close to the ground in search of females (Allen 1997). Adult Carolina satyrs usually are found in grasslands, along grassy woodland trails, and in woodland openings where there is an abundance of grass (Allen 1997, Pippen 2005). Specific causes for decline are not known; however, habitat loss is the biggest threat to butterflies in general (WDNR 2005).

No common name (*Herpetogramma thestealis*)
Herpetogramma thestealis is listed as a rare species in Indiana. Information regarding the distribution of *H. thestealis* is limited but is known to include Indiana, Arkansas, and Ontario (NatureServe Explorer 2008). The Indiana Natural Heritage Database (2008) reports one known occurrence of this species at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. The larvae feed on euonymus, hazelnut, and linden (Covell 1984). Habitat requirements for this species are not known. Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Leonard's Skipper (*Hesperia leonardus*)
The Leonard's skipper is listed as a rare species in Indiana. This skipper ranges from Minnesota to Nova Scotia and Maine, south through North Carolina, Louisiana, and Missouri (NBII 2006). The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in Lake, Crawford, Jasper, Harrison, and Porter counties, with a known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Caterpillar hosts include various perennial grasses such as little bluestem (*Andropogon scoparius*), blue grama (*Bouteloua gracilis*), and bent grass (*Agrostis spp.*) (NBII 2006). Blazing star (*Liatris punctata*) is a favorite nectar source (NBII 2006, Allen 1997). In areas lacking blazing star, other purple or pink flowers are selected for nectaring, especially ironweed (*Vernonia*), Joe-pye weed (*Eupatorium*), asters, teasel (*Dipsacus*) and thistles (*Cirsium*) (Allen 1997).
This skipper prefers open grassy areas including prairies, fields, barrens, and meadows (NBII 2006), though it may also be found in scrub oak and pine clearings and along roadsides (Shull 1987). Low-lying wet meadows with ironweed in flower are frequented by these skippers (Allen 1997). Periodic fire may be necessary to maintain this skipper's open habitat (NBII 2006).

Detracted Owlet (*Lesmone detrahens*)
The detracted owlet is listed as a rare species in Indiana. This species ranges from New York to Florida, west to Kansas and Texas (Covell 1984). The Indiana Natural Heritage Database (2008) reports this species has been found in Starke, Posey, Crawford, and Harrison counties, with a known occurrence at Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. There is no record of its preferred food plant (Covell 1984). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Unarmed Wainscot (*Leucania inermis*)
The unarmed wainscot is listed as a rare species in Indiana. It ranges from Nova Scotia to Virginia, west to Ontario and Kentucky (Covell 1984). The Indiana Natural Heritage

Database (2008) reports this species has been found in Lake, Starke, Lagrange, Steuben, Crawford, Harrison, Porter, and La Porte counties, with one known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Unarmed wainscot larvae are known to feed only on orchard grass (OARDC 2006, Covell 1984). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Fearful Barrens Locust (*Melanoplus tepidus*)
The fearful barrens locust is listed as a rare species in Indiana. Its range is poorly defined, though it has been recorded from Florida, Alabama (Capinera et al. 2001), and Indiana. The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in Crawford and Harrison counties, with known occurrences at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. The fearful barrens locust is found within the leaf litter of open woodlands and forested openings (Klots and Klots 1972). Specific causes for decline are unknown.

Barrens Paectes Moth (*Paectes abrostolella*)
The barrens paectes moth is listed as a rare species in Indiana. Its range is poorly defined though it has been recorded from New York, Virginia, Ohio, Indiana, and Arkansas (NatureServe Explorer 2008). The Indiana Natural Heritage Database (2008) reports this species has been found in Porter, Harrison, and Crawford counties, with a known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Larvae have been found feeding on sweet gum (Wagner 2005). Since adults have been found on remnant prairies in Kentucky, the connection with prairies may be significant (Rings et al. 1992), though caterpillars have been observed in woodlands and forests (Wagner 2005). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Mouse-colored Lichen Moth (*Pagara simplex*)
The mouse-colored lichen moth is listed as a rare species in Indiana. This is an uncommon species ranging from eastern Maryland to Florida, west to southern Missouri and Texas (Covell 1984). The Indiana Natural Heritage Database (2008) reports individuals of this species have been found in Newton, Harrison, and Crawford counties, with a known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Larvae have been reared in captivity on dandelion and wild lettuce (Covell 1984). No specific information on the habitat is available**.** Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Southern Purple Mint Moth (*Pyrausta laticlavia*)
The southern purple mint moth is listed as a rare species in Indiana. Its range is poorly defined, though it has been recorded from Indiana. The Indiana Natural Heritage Database (2008) reports this species has been found in Porter, Crawford, and Lake Counties, with a known occurrence in the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. This species prefers some plants in the mint family, including

purple sage. The southern purple mint moth is typically found in prairies and other grassy areas (NatureServe Explorer 2008). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Red-legged Tussock Moth (*Spilosoma latipennis*)

The red-legged tussock moth is listed as a rare species in Indiana. This species ranges from Maine and southern Ontario to Virginia, west to Nebraska and Arkansas (Covell 1984). The Indiana Natural Heritage Database (2008) reports one known occurrence of this species at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. The larvae feed on the foliage of ash (*Fraxinus*), dandelion, impatiens, and plantain (OARDC 2006; Covell 1984). This moth is found in fields, gardens, bottomlands, woodlands and forests (Wagner 2005). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Northern Cloudywing (*Thorybes pylades*)

The northern cloudywing is listed as a rare species in Indiana. It occurs throughout all of the contiguous United States and most of Canada (NatureServe Explorer 2008). The Indiana Natural Heritage Database (2008) reports this species has been found in Crawford, Harrison, Lake, and Porter counties in Indiana, with a known occurrence at the Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest in 2000. Northern cloudywing prefers open or scrubby woodland and forest edges (Neararctica 2006). The species can be found in a variety of brushy or wooded habitats where legumes are present. The larvae typically feed on legumes and mallows (NatureServe Explorer 2008). Specific causes for decline are not known; however, habitat loss is the biggest threat to moths in general (Metzler and Lucas 1990, WDNR 2005).

Direct and Indirect Effects on Invertebrates

Forty-seven invertebrate species designated as state endangered, threatened, or rare have been documented on DoF properties since 1980 (Appendix A, Table 5). Of these, 26 (55 percent) have been documented only on nature preserves associated with state forests (Table 5). Since the proposed alternatives will not affect nature preserve properties on state forests, these invertebrate species will not be considered in the proceeding analysis of direct, indirect, and cumulative effects relative to the various communities. Additionally, eight invertebrate species designated as state endangered, threatened, or rare inhabit riparian/aquatic communities on DoF properties (Appendix A, Table 5). All of these species belong to the taxanomic Order *Odonata* and are commonly known as dragonflies and darners. Since these species are restricted to aquatic habitats, DoF does not expect any of the proposed alternatives to cause any direct, adverse effects on them or their populations. The DoF routinely applies Best Management Practices to each timber harvest which minimizes the effects of erosion at and sedimentation. Additionally, in 2001 DoF established guidelines for harvesting near forested riparian corridors to better protect these important foraging areas for bats, such as the federally endangered Indiana and gray bats. The guidelines stipulate >100-foot wide limited management buffers be established

and maintained on either side of all perennial streams and rivers. Only minimal cutting is allowed inside these riparian management zones and the structural integrity of the forested corridor is to be maintained at all times. Because harvesting is limited and carefully applied in riparian areas, and forested buffers are retained along streams, DoF anticipates the activities associated with all of the proposed alternatives will not adversely affect the habitats of these invertebrates.

Direct and Indirect Effects on Invertebrates in Subterranean Habitats

Ten invertebrate species designated as state endangered, threatened, or rare inhabit subterranean areas on DoF properties (Appendix A, Table 5). Given the subterranean nature of these species, the DoF does not anticipate the proposed activities will directly affect these species. To minimize threats to water feeding into subterranean streams, DoF applies Best Management Practices to each timber harvest. Disturbing the integrity of cave entrances and sinkholes could also affect the water and airflow entering these systems and for this reason the DoF enforces a policy of minimum disturbance around such features (DoF Procedures Manual, Section S-1 1999). Given the protective measures routinely undertaken by the DoF, no adverse effects on subterranean invertebrates are anticipated from any of the proposed alternatives.

Direct and Indirect Effects on Invertebrates of Forests and Open Woods

Three invertebrate species designated as state endangered, threatened, or rare inhabit forests and woodlands on DoF properties: southeastern wandering spider, West Virginia white, and sooty azure (Appendix A, Table 5). Given each of these species' high degree of mobility, it is likely that timber harvesting activities result in only negligible direct effects under all of the proposed alternatives. The sooty azure and West Virginia white each prefer canopied woodlands and shady forests. The West Virginia white may be more intolerant of open canopy situations as the sooty azure is known to inhabit the edges of woodlands and forests. Overstory removal associated with the proposed action would likely affect individuals of each species that happened to inhabit the specific location of a group selection or even-age opening. In any given year, approximately 2 percent of DoF forestland would receive such harvests under the proposed alternative. Given this, indirect effects due to habitat alteration are expected to be quite low and have no significant population-level effect on either species. Little is known about the preferred habitat of the southeastern wandering spider and how timber harvesting would affect it. It had been reportedly found within woodrat nests, suggesting it occurs in areas typically inaccessible and incompatible with timber harvesting (e.g., talus slopes and cave entrances).

Prescribed burning following timber harvests as a follow-up treatment is unlikely to affect sooty azure or West Virginia white as they do not frequent openings such as those created by timber harvesting. Additionally, prescribed burning is typically done when each of these species are dormant. The southwestern wandering spider occurs in leaf litter which could potentially be consumed or partially consumed by fire, though it is a highly mobile species that may be able to avoid fire by retreating into damp humus or beneath rocks. Since fire is prescribed as a follow-up treatment in and around regeneration openings and is typically not periodically repeated over the same area, it is very likely that fire

will only rarely affect individuals or populations, particularly since these species range over localized areas throughout much of their life. For these reasons the DoF anticipates prescribed fire will have a negligible affect on these species.

Cumulative Effects on Invertebrates

As described in section 1.4 of this document, the oak-hickory component of DoF forestland has reached maturity system-wide and is experiencing regeneration issues that threaten the long-term stability of this essential forest type. DoF agrees with the opinion of regional experts (Abrams 2003, Dickson 2004, Fralish 2004, James 2004, McShea et al. 2007) who suggest a decline in the oak-hickory component will have catastrophic effects on this region's native forest communities, as many species depend on this component for their very existence (Dickson 2004). The proposed action will create needed oak-hickory recruitment to help stabilize this declining trend and provide long-term sustainability to these forests and the communities they support. Additionally, many experts in this region note that historic reforestation efforts and natural re-growth of eastern U.S. deciduous forests has produced an abundance of mature forest and a declining early-successional component that threatens many species dependent on that community type (Trani et al. 2001, Yahner 2003, Fuller and DeStefano 2003, Castrale et al. 2005). DoF suggests the proposed alternative not only will ensure long-term sustainability to its oak-hickory forests, but also address these reported declines in early-successional habitats and species.

While accomplishing these goals with the proposed action, the DoF must ensure the life requirements of Indiana's species of greatest conservation need, specifically species requiring late-successional communities and mature forests, are addressed as well. The plan for long-term forest sustainability outlined in section 1.4 of this document will ensure a continual supply of mature and maturing forest is available to late-succession species such as the forest arthropods reviewed for this document, even as early-successional habitats are annually created by timber harvesting. The DoF sustainability plan assures forest growth and maturation outpaces harvesting to ensure that the needs of early-successional species are balanced with those requiring late-successional habitats. Additionally, DoF has designated Old Forest Areas on nearly all state forests, which will provide old growth forest elements, characteristics, and structure throughout the term of this plan and beyond. These areas are harvested nearly exclusively using single-tree selection, with only occasional use of group selection where appropriate. Old Forest Areas are to be managed for a condition in which the overstory canopy trees are relatively old (> 125 years on most sites) and relatively large for the species occurring on that site. The longer management cycle of these areas (>30 years) offers additional assurance that they will be allowed to develop towards an old growth character with only limited disturbance.

Through the entirety of these measures – sustainable harvesting principally using selection silviculture and establishment of old forest tracts – DoF will ensure the needs of species reviewed in this document are met and their populations are not adversely affected. At the same time DoF suggests the activities planned under the proposed alternative will improve habitat for all species dependent on oak-hickory forests and provide long-term sustainability for this essential ecological community.

4.6 Plants

Bradley's Spleenwort (*Asplenium bradleyi*)
Bradley's spleenwort is listed as an endangered species in Indiana. Its range extends from New York and New Jersey, south to Georgia and Alabama, and west to Missouri, and Oklahoma (Gleason and Cronquist 1963). It is known to occur in the counties of Crawford and Dubois (Indiana Natural Heritage Database 2008). One recent record (2002) exists for Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Bradley's spleenwort is found on steep sandstone cliffs and ledges, often in crevices too small for other ferns (Jones 2005, NatureServe Explorer 2008). Typically, the plants grow tightly rooted in vertical or horizontal crevices on hard, well-weathered vertical sandstone cliffs and other highly-exposed bedrock, often near rock shelters or rock houses (Francis et al. 1993). In addition to sandstone, it also grows on granite, chert, or other acidic rocks (Lellinger 1985). The plant community surrounding the cliffs and summits it occupies is generally dry upland forest (White and Madany 1978).

Threats to the species include rock climbing, strip mining, and other disturbances to ledges and cliff faces (NatureServe Explorer 2008). Elimination of vegetative cover on bluffs above individuals may also reduce soil and nutrients. Growth of vines, such as Japanese honeysuckle and Virginia creeper onto occupied cliffs may produce too much shade for the ferns to persist. Herbicides applied at the top of cliffs could affect individuals growing below (Hill 2003b).

Black-stem Spleenwort (*Asplenium resiliens*)
Black-stem spleenwort is listed as an endangered species in Indiana. In the United States, it is widespread and has been found in 26 states (Hill 2003c). In Indiana, it is known from two counties, Clark and Harrison, and has been found on Harrison-Crawford State Forest (Indiana Natural heritage Database 2008). Black-stem spleenwort is normally found in a distinctive and somewhat limited habitat (Lellinger 1985); typically, the plants grow on moist shaded rock, particularly on limestone and dolomite or other basic rocks, boulders, cliffs, and within sinkholes. Preferred habitats are often near streams or drainages where the limestone has been exposed by erosion. Black-stem spleenwort can tolerate partial shade and it is normally not found in areas exposed to either full sun or a dense forest canopy. Its habitat is characterized by an open understory that allows ample diffused light (Hill 2003c), often within dry-mesic or mesic upland forest (White and Madany 1978).

An obvious threat to the species is quarrying or strip mining, particularly in the Cumberland Plateau region of Kentucky and Tennessee. Other threats to the species include physical damage from trampling by rock climbers, over-collecting, and from environmental degradation (Hill 2003c). It has been reported that over-collecting has eliminated at least one population of the plant in Illinois (Herkert et al. 1991). This fern is particularly vulnerable to vines such as the exotic Japanese honeysuckle and the native Virginia creeper that can create excessive shade. The growth of other understory species (particularly aggressive non-native invasive species such as shrubby honeysuckles) may also create excessively shady conditions (Hill 2003c).

Schreber Aster (*Aster schreberi*)
Schreber aster is listed as an endangered species in Indiana. This aster occurs from New Hampshire to eastern Wisconsin, south to southwestern Virginia, southeastern Kentucky, and Ohio (Gleason and Cronquist 1963). The Indiana Natural Heritage Database (2008) reports this aster occurs in Clark and Ripley counties. In 1995 two populations were found within two miles of Deam Lake at Clark State Forest. These populations grow on the lower slopes of forested ravines, not far from a small stream (IDNR 1996). Schreber aster typically inhabits dry to mesic woods (Jones 2005) and prefers semi-open conditions. In Illinois, most populations occurred on north-facing, relatively steep slopes in second-growth forests; however, no particular microhabitat features were found to be related to its growth there (Ebinger 1995). This species apparently was never common in Indiana, and current population levels are equal to or greater than historical levels (Homoya pers. comm. 2006.). There is no current evidence of population declines in Indiana; however, this species is considered rare and is therefore listed as endangered at the state level (Homoya pers. comm. 2006).

Prairie Redroot (*Ceanothus herbaceus*)
Prairie redroot is listed as an endangered species in Indiana. This species' range extends from Quebec to Manitoba in the north, south to New Mexico and Louisiana, and east to the Appalachian Mountains (NatureServe Explorer 2008). This species has been found in Lake (1903) and Harrison (2002) counties, though the Harrison County observation at Harrison-Crawford State Forest is the only modern sighting (Indiana Natural Heritage Database 2008). This species is found in dry glades and sand prairies, often in sandy, rock soil (UW 2008); also rocky, open woodland hillsides (UTA 2008). Threats to this species include land-use conversion and habitat fragmentation (NatureServe Explorer 2008).

Devil's Bit (*Chamaelirium luteum*)
Devil's bit is listed as an endangered species in Indiana. This species' range includes 24 states in the eastern United States, occurring from southern Ontario and New England to central Florida, west to Arkansas and Illinois (Allard 2003). This species has been observed in the counties of Harrison, Crawford, and Vanderburgh (Indiana Natural Heritage Database 2008). One record (1999) exists for this species at Post Oak Cedar Nature Preserve on Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Although it has a wide habitat tolerance, devil's bit typically grows on slopes of any aspect in open, mesic, rich hardwood forests, or in wet meadows. It requires partially open conditions in order to flower, but persists for years as vegetative rosettes in more shaded situations (Allard 2003). In southern Indiana, the plant seemed to prefer exposed limestone slopes and woods dominated by beech and oak (Deam 1940). Known threats to devil's bit include habitat loss, competition from non-native invasive species, shading, damage from all-terrain vehicles, and excessive deer herbivory. Collection of plants from the wild for medicinal or ornamental use is also a threat (Allard 2003).

Appalachian Bugbane (*Cimicifuga rubifolia*)
Appalachian bugbane is listed as an endangered species in Indiana. This species is found primarily in the southern Appalachian Mountains with isolated populations in Illinois,

Indiana, Kentucky, and Pennsylvania. The Indiana Natural Heritage Database (2008) reports this species has been found in Posey and Harrison counties. This species was found at Harrison-Crawford State Forest in 2001 (Indiana Natural Heritage Database 2008). Appalachian bugbane typically occupies cool, moist, north-facing slopes in relatively undisturbed mesic forests at elevations of 270 to 480 meters (occasionally up to 900 m) in areas that were never glaciated during the Pleistocene (Ramsey 1965, Cook 1993, NatureServe Explorer 2008). Although this species is typically found on slopes above floodplains, it occasionally has been found on river floodplains in Tennessee (Ramsey and Chester 1981, Miller 2000). It also may occur on limestone talus slopes, river bluffs, ravines, and coves (Small 1933, Gleason 1963, Ramsey 1965, Chester 1975, Keener 1977, Cook 1993, FNAEC 1997, Miller 2000). Only one reference indicates it may be found in open woods (Kral 1983). The species often is associated with limestone or calcareous shale, but at times it may be found on sandstone (Ramsey 1965, Ramsey and Chester 1981, Kral 1983, Medley 1993, FNAEC 1997). It often occurs on clay soils over calcareous rock (Ramsey 1965, Cook 1993), but it has been found on rich, well- drained, loamy soils (Kral 1983). In Illinois, soils typically are high in calcium and magnesium (Miller 2000).

The primary threat to Appalachian bugbane is the loss of hardwood overstory, as this species is intolerant of open, exposed situations (NatureServe Explorer 2008). Kral (1983) suggested the major threat to Appalachian bugbane is incompatible logging practices and subsequent soil erosion, especially on the highly erodable slopes this species prefers. Other threats include competition from the non-native invasive species English ivy (*Hedera helix*) in Indiana (IDNR 2003) and possibly over-harvesting for medicinal uses (NatureServe Explorer 2008).

Bluntleaf Spurge (*Euphorbia obtusata*)

Bluntleaf spurge is listed as an endangered species in Indiana. USDA PLANTS database (USDA-NRCS 2008) reports this plant occurs throughout much of the United States, excluding New England and Nevada. In Indiana, this species has been found in the counties of Posey, Allen, Wells, Greene, Parke, Fountain, Knox, Clark, and Scott (Indiana Natural Heritage Database 2008). It has been observed in Clark State Forest (Indiana Natural Heritage Database 2008). The habitat for this species includes open woods, old fields, sandy open ground, and gravel bars (Missouri Plants Database 2008). No specific threats could be found for this species.

Striped Gentian (*Gentiana villosa*)

Striped gentian is listed as an endangered species in Indiana. Its range extends from New Jersey to southern Ohio and southern Indiana, south to Florida and Louisiana (Gleason and Cronquist 1963). Records for this species in Indiana are restricted to Harrison County (Indiana Natural Heritage Database 2008). Two populations on Harrison-Crawford State Forest are the only known in the state since 1990. At these locations the species occurs in a dry post-oak woodland adjacent to an old field and small limestone glades (IDNR 1992). Striped gentian is typically associated with dry to mesic meadows and open woodlands (Jones 2005); in Ohio it inhabits dry woods and prairies (Cusick and Silberhorn

1977). It also occurs in pinelands, dry ravines, and roadsides. This species was apparently never common in Indiana, and current population levels are equal to or greater than historical levels (Homoya pers. comm. 2006). There is no current evidence of population declines in Indiana, however this species is considered rare and is therefore listed as endangered at the state level (Homoya pers. comm. 2006). In Harrison-Crawford State Forest, Japanese honeysuckle (*Lonicera japonica*) is considered a potential threat. Since this species prefers open or semi-open habitats, it may benefit from prescribed burning (IDNR 1992).

Appalachian Quillwort (*Isoetes engelmannii*)

Appalachian quillwort is listed as an endangered species in Indiana. It occurs from New Hampshire to Georgia, west to Indiana, Illinois, and Missouri (Gleason and Cronquist 1963). Records in Indiana include the counties of Clark, Lawrence, Harrison, and Orange counties (Indiana Natural Heritage Database 2008). This species has been documented at Clark State Forest and all populations were found in pools of small streams (IDNR 1996). Appalachian quillwort is an obligate wetland plant that occurs partially or completely submerged in shallow water (Jones 2005), especially in sluggish streams. It also is found in open sun in shallow bodies of water, pond margins and ditches (ODNR 2008). The primary reason for the decline of the Appalachian quillwort is loss of habitat from the draining of wetlands (Homoya pers. comm. 2006). Sudden changes in water level, water pollution, and aggressive competition by other aquatic species are also threats (ODNR 2008).

Illinois Pinweed (*Lechea racemulosa*)

Illinois pinweed is listed as an endangered species in Indiana. This species occurs from southeast New York to Ohio and Indiana, south to Georgia and Alabama (Gleason and Cronquist 1963). The Indiana Natural Heritage Database (2008) reports this species has been found in Harrison, Clark, and Lawrence counties. There are a few observations from Clark State Forest, the most recent being 1994 (Indiana Natural Heritage Database 2008). Illinois pinweed is associated with old fields, pine barrens, and open woodlands. It usually is found on dry areas with sandy soil (Jones 2005). In Indiana this plant is found in dry forests, siltstone glades, and on eroded slopes (IDNR 1996). This species was apparently never common in Indiana, and current population levels are equal to or greater than historical levels (Homoya pers. comm. 2006). There is no current evidence of population declines in Indiana, however this species is considered rare and is therefore listed as endangered at the state level (Homoya pers. comm. 2006).

Cucumber Magnolia (*Magnolia acuminata*)

The cucumber magnolia is listed as an endangered species in Indiana. This tree occurs from western New York and southern Ontario to southern Missouri and Oklahoma, south to Georgia, Alabama, and Arkansas (Gleason and Cronquist 1963). The Indiana Natural Heritage Database (2008) reports this species has been found in Hancock, Lawrence, Clark, Washington, and Jackson counties. Recent records of cucumber magnolia exist for Clark (1995) and Jackson-Washington (1996) State Forests in the Indiana Natural Heritage Database (2008). Cucumber magnolia is found in mixed mesophytic forests (Jones

2005). It prefers moist, well-drained, slightly acidic soils. Most slopes where this species is found are gentle to moderate, up to 25 percent; however, it occasionally is found on steeper slopes. Observations on the Fernow Experimental Forest in West Virginia indicate cucumber magnolia regeneration is more frequent in clearcuts than in partial cuts (NatureServe Explorer 2008). The primary cause for the decline of cucumber magnolias in Indiana is destruction of habitat through deforestation (Homoya pers. comm. 2005).

Green Adder's-mouth (*Malaxis unifolia*)

Green adder's-mouth is listed as an endangered species in Indiana. This wide-ranging species occurs from Newfoundland and Quebec to Manitoba, south to Florida and Texas (Gleason and Cronquist 1963). The Indiana Natural Heritage Database (2008) reports this species has been found in Monroe, Kosciusko, LaPorte, Elkhart, Noble, and Lake counties. The species was first discovered in Morgan-Monroe State Forest in 1989 on west-facing mossy slopes of dry mesic forested habitats (IDNR 1997). Green adder's-mouth is found in a variety of habitats from dry hilltops to moist swamps, under open sun and dense shade. It occurs in mixed and deciduous regions but all tend to be characterized by sandy and/or acidic soils (UW 2006). This species was apparently never common in Indiana, and current population levels are either equal to or greater than historical levels (Homoya pers. comm. 2006). There is no current evidence of population declines in Indiana. However this species is considered rare and is therefore listed as endangered at the state level (Homoya pers. comm. 2006).

Long-awn Hairgrass (*Muhlenbergia capillaris*)

Long-awn hairgrass is listed as an endangered species in Indiana. The distribution for this species is wide-ranging, extending from Wisconsin to Massachusetts, south along the Atlantic coast and west to Mexico (Gleason and Cronquist 1963). Records of this species within Indiana are restricted to Harrison County (Indiana Natural Heritage Database 2008). The Indiana Natural Heritage Database (2008) reports this species has been observed at Harrison-Crawford State Forest as recently as 2005. Here this grass is found in a small, remnant limestone glade (IDNR 1992). Long-awn hairgrass typically occurs in dry woods and sandy, rocky soils (Gleason and Cronquist 1963, Jones 2005). In general, it occurs at low elevations (sea level to 500 m) in open woodlands and savannas. Soils range from acidic to basic and from clay to sand in texture (NECP 2004). As with many upland grasses, it reacts favorably to fire, both in flower stalk production and in regeneration (NECP 2004). Habitat loss is the primary factor in the decline of this species in Indiana (Homoya pers. comm. 2006). Since succession and excessive shading is a potential threat to this shade intolerant species, selection silviculture and periodic burning may benefit its growth (IDNR1992).

Panic Grass (*Panicum bicknellii*)

Panicum bicknellii is listed as an endangered species in Indiana. The range of *P. bicknellii* includes Massachusetts and southern Ontario to Michigan, Missouri, and Georgia (Gleason and Cronquist 1963). The Indiana Natural Heritage Database (2008) reports this species has been found in Clark, Jackson, Brown, Lawrence, Bartholomew, and Harrison counties. The only State Forest observation since 1980 is at Post Oak-Cedar Nature

Preserve on Harrison Crawford State Forest in 1985 (Indiana Natural Heritage Database 2008). *P. bicknellii* occurs in dry rocky woods, open woodlands, fields, and along marshy shores (Hitchcock 1971, Gleason and Cronquist 1991). ODNR (2008) reports it prefers dry woods, thickets, and openings. Reasons for the decline of *P. bicknellii* are unknown (Homoya pers. comm. 2006).

Cleft Phlox (*Phlox bifida ssp. var stellaria*)

Cleft phlox is listed as an endangered species in Indiana. It occurs from southern Michigan and Wisconsin to Tennessee, northern Arkansas, and Kansas (Gleason and Cronquist 1963). Records for this species in Indiana are restricted to Harrison County (Indiana Natural Heritage Database 2008). Sporadic dense clumps of the species were found along one mile of limestone cliffs in Harrison County (Hauser et al. 1981). Additional records exist for this species at the Charles C. Deam Nature Preserve and Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Cleft phlox is found in cedar glades, limestone woods, on cliffs, and gravelly slopes (Wherry 1929, Tucker 1990, NatureServe Explorer 2008). This species colonizes bare mineral soil, holding the surface until humus accumulates (Wherry 1929). This species of phlox declines as forest succession and canopy closure progresses (Tucker 1990, Wherry 1929). Activities such as road development, herbicide use, and development continue to pose a threat to this species (NatureServe Explorer 2008). Fire suppression may result in advancing forest succession that eventually creates excessive shady conditions for this shade intolerant species (KSNPC 2008).

Prairie Parsley (*Polytaenia nuttallii*)

Prairie parsley is listed as an endangered species in Indiana. Its range range extends from Wisconsin to Nebraska, south to Mississippi, Texas, and New Mexico (Gleason and Cronquist 1963). It is presumed extirpated in Michigan and Kentucky (Olson 2002b). Deam (1940) reported this species from four counties: Jasper, La Porte, Newton, and Harrison. Several of these populations are extirpated, but additional populations have been recently located (Olson 2002b). This species has been found at the Post Oak-Cedar Nature Preserve on Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Prairie parsley typically is associated with barren and glade communities (Jones 2005). It also is found in mesic prairies, persisting in open areas that were once savannas, and in small openings or margins of dry to dry-mesic forest. Loss of habitat due to agricultural conversion of prairies, barrens, and glades has led to population declines in Indiana (Homoya pers. comm. 2005).

Purple Oat (*Schizachne purpurascens*)

Purple oat is listed as an endangered species in Indiana. This species has a wide-ranging distribution that extends from eastern Canada to Alaska and eastern Asia, south to Pennsylvania, Kentucky, and Mexico. It has been observed in Cass, Wabash, and LaGrange counties, with recent observations (1992) existing from Salamonie River State Forest (Indiana Natural Heritage Database 2008). This species was apparently never common in Indiana, and current population levels are either equal to or greater than historical levels (Homoya pers. comm. 2006). There is no current evidence of population declines in Indi-

ana; however, this species is considered rare and is therefore listed as endangered at the state level (Homoya pers. comm. 2006). Grazing has been found to be a potential threat elsewhere (ODNR 2008).

Short's Goldenrod *(Solidago shortii)*
Short's goldenrod is listed as an endangered species in Indiana and also as federally endangered throughout its limited range. This species is highly localized and is only known to occur in northern Kentucky and southern Indiana. Kentucky records are restricted to areas northeast of Lexington near the junction of Robertson, Nicholas, and Fleming counties. In Indiana, Short's goldenrod was found along the Blue River in Harrison-Crawford State Forest (IDNR 1992). Short's goldenrod is endemic to rock outcroppings, growing only in dry, shallow soils. It colonizes disturbed, early successional habitats and open glade-like areas such as utility corridors, roadside shoulders, roadside ledges, and pastures (Walck et al. 1999, Buchele et al. 1989, USFWS 1988). Although the plants are most vigorous in full sun, once they are established they can persist for a time through shading that results from woodland succession. Seedlings appear to be limited to relatively bare, dry soil in glades, roadsides and woodland edges. A historical record is known from a gravel bar of the Ohio River (NatureServe Explorer 2008). Because this species is rare and occupies a restricted range, it is vulnerable to catastrophic events such as disease and habitat loss (NatureServe Explorer 2008).

Stout-ragged Goldenrod (*Solidago squarrosa*)
The stout-ragged goldenrod is listed as an endangered species in Indiana. This plant is found from New Brunswick to southern Ontario, south to Ohio, southern Indiana, and North Carolina (Gleason and Cronquist 1963). Indiana counties with stout-ragged goldenrod records include Clark and Scott (Indiana Natural Heritage Database 2008). This species has been observed at Clark State Forest, where less than 20 individuals were encountered during the 1996 inventory (IDNR 1996). Stout-ragged goldenrod is found on dry, rocky soils along the margins of forests or in forest clearings (Nearctica 2003). In Clark State Forest, populations are found on steep, north-facing slopes near the crests of forested hillsides (IDNR 1996). This species was apparently never common in Indiana, and current population levels are equal to or greater than historical levels (Homoya pers. comm. 2006). There is no current evidence of population declines in Indiana; however, this species is considered rare and is therefore listed as endangered at the state level (Homoya pers. comm. 2006).

Large-leaf Snowbell (*Styrax grandifolius*)
Large-leaf snowbell is listed as an endangered species in Indiana. Its range extends from Illinois to Texas and east to Florida and Virginia (NatureServe Explorer 2008). Records for this species in Indiana are restricted to Harrison County, where it has been found on Harrison-Crawford State Forest in 1990 (Indiana Natural Heritage Database 2008). Large-leaf snowbell is associated with dry to mesic woodlands (Jones 2005). It is found in well-drained sandy or limy woods and thickets (ODNR 2008). This species is threatened by land development and habitat fragmentation (Southern Appalachian Species Viability Project 2002). Threats may also include incompatible forest management (ODNR 2008).

Goose-foot Corn-salad (*Valerianella chenopodiifolia*)
Goose-foot corn-salad is listed as an endangered species in Indiana. The U.S. Department of Agriculture database (USDA-NRCS 2008) reports this species is found from New York to Wisconsin, south to Maryland and Kentucky. Distribution in Indiana includes the counties of Harrison, Jefferson, LaPorte, Porter, Madison, Delaware, and St. Joseph (Indiana Natural Heritage Database 2008). This species has been found at Harrison-Crawford State Forest as recently as 2003 (Indiana Natural Heritage Database 2008). Goose-foot corn-salad is found in moist meadows, open fields, open woods, and along low ground along grassy stream banks (Hauser 1963). Non-native invasive species (e.g., Japanese honeysuckle, stilt grass, garlic mustard) can dominate sites and degrade the habitat of this species (Homoya pers. comm. 2006).

Sand Grape (*Vitis rupestris*)
Sand grape is listed as an endangered species in Indiana. It occurs from Pennsylvania to Virginia, west to Texas with some populations occurring in California (NatureServe Explorer 2008). In Indiana, this species has been found exclusively in Harrison County, with observations noted from Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Sand grape occurs on calcareous gravelly banks, dry stream bottoms and beds, washes, and gravel bars (NatureServe Explorer 2008, Missouri Plant Database 2008). This species also has been found on the margins of limestone glades and barrens (NatureServe Explorer 2008). In Indiana this species has been reported from dry chert and limestone streambeds (NatureServe Explorer 2008). Threats to this species include changes in water level that result in inundation, water pollution, and aggressive competition and succession by other species (NatureServe Explorer 2008).

Reed Bent Grass (*Calamagrostis porteri ssp. Insperata*)
Reed bent grass is listed as a threatened species in Indiana. It is restricted to the central United States, including southern Ohio, Illinois, Indiana, Kentucky, and the Ozark Plateau region of Missouri and Arkansas (KSNPC 2008). Approximately 80 occurrences are known throughout its range (Shawnee 2005). This species was first discovered in Indiana in 1994 during an inventory of Clark State Forest (IDNR 1996). Records of reed bent grass also have been reported at Jackson-Washington State Forest (Indiana Natural Heritage Database 2008). This species' habitat includes dry rocky woods usually with a north aspect or on dry limestone cliffs and sandstone outcrops (SNF 2005). It also has been found in forest openings and along edges of upland woods (Bittner and Gibson 1988). In Illinois this species has been found on cool, northwest- and northeast-facing slopes in dry-mesic forest (SNF 2005). It occurs in the leaf litter of oak-hickory forests and also in moss and lichen-dominated substrates that include sphagnum (KSNPC 2008). In Ohio, it occurs in dry upland areas in sun or partial shade where one population is in an open utility corridor and another is in an upland oak woodland (ODNR 2008). Excessive shading that results from forest succession are known threats to this species (ODNR 2008). This fire tolerant grass may benefit from prescribed fire following some canopy reduction (SNF 2005).

Yellowwood (*Cladrastis lutea*)
Yellowwood is listed as a threatened species in Indiana. It ranges from western North Carolina to Arkansas and Missouri (ISU 2006). In Indiana, this species is restricted to Brown County, where there are three populations within Yellowwood State Forest (Indiana Natural Heritage Database 2008). It grows in the rich, well-drained limestone soils of river valleys, steam margins, slopes, and ridges (Elias 1980). Primary threats to this species include forest maturation and conditions supporting shade-tolerant species; also, disease and pests (SNF 2005).

Pink Thoroughwort (*Eupatorium incarnatum*)
The pink thoroughwort is listed as a threatened species in Indiana. The range of this species extends from Virginia to Florida, west to Texas and Arizona (USDA-NRCS Plants Database 2008). Indiana has records of pink thoroughwort from Morgan, Perry, Crawford, and Harrison counties (Indiana Natural Heritage Database 2008). Records of pink thoroughwort exist from Harrison-Crawford State Forest from as recently as 2002 (Indiana Natural Heritage Database 2008). In Ohio, most individuals have been observed on well-drained acidic soils in open areas (ODNR 2008). This thoroughwort is at the northern edge of its range in Indiana, which probably accounts for its few known populations. Non-native invasive species (e.g., Japanese honeysuckle, stilt grass, garlic mustard) can dominate sites and degrade habitat (Homoya pers. comm. 2006).

Downy Gentian (*Gentiana puberulenta*)
Downy gentian is listed as a threatened species in Indiana. This species occurs throughout much of central North America, extending south from Manitoba and Saskatchewan to Arkansas and Louisiana, west to Nebraska and Kansas, and east to Ohio and Kentucky (NatureServe Explorer 2008). In eastern states, such as New York and Maryland, this species is thought to be extirpated (NatureServe Explorer 2008). Downy gentian has been reported in several counties in Indiana, and observed at Leavenworth Barrens Nature Preserve on Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Downy gentian is found on dry calcareous prairies, cedar glades, barrens, and sandy open ridges (KSNPC 2008). Habitat invasion by non-native invasive species is a major threat to this species (KSNPC 2008).

Slender Heliotrope (*Heliotropium tenellum*)
The slender heliotrope is listed as a threatened species in Indiana. It ranges from Iowa and Kansas in the west to Alabama and Texas in the south (Gleason and Cronquist 1991). This species has been found in the counties of Harrison, Crawford, and Clark and at Harrison-Crawford State Forest in 1989 (Indiana Natural Heritage Database 2008). Slender heliotrope prefers dry soil in upland woods, prairies, and barrens (Gleason and Cronquist 1991). This species is at the northern edge of its range in Indiana, which probably accounts for its few known populations. Successional changes that bring excessive shade could cause this species to decline. Also, non-native invasive species (e.g., Japanese honeysuckle, stilt grass, garlic mustard) can dominate sites and degrade habitat (Homoya pers. comm. 2005).

Smooth Veiny Pea (*Lathyrus venosus*)
Smooth veiny pea is listed as a threatened species in Indiana. It ranges from New York to Alabama, west to the Dakotas and New Mexico (USDA-NRCS 2008). The Indiana Natural Heritage Database (2008) lists several observations at Clark State Forest, with the most recent from 2004. Smooth veiny pea is found on dry to mesic slopes, especially in base-rich soils (KSNPC 2008) and dry sandy soil in open upland woods and prairies (ODNR 2008). It also can be found in moist to wet mesic prairies, woods, and stream banks (UW 2006). Threats to this species include forest succession and excessive over-shading by woody species (ODNR 2008). Additionally, this species is greatly affected by non-native invasive species (KSNPC 2008).

Three-flower Melic Grass (*Melica nitens*)
Three-flower melic grass is listed as a threatened species in Indiana. This species is found in 24 states from Minnesota south to Arizona and Virginia (USDA-NRCS 2008). This species has been found in the counties of Clark, Harrison, and Randolph (Indiana Natural Heritage Database 2008). It is found in full sun in dry clearings and dry to mesic prairies or the semi-shade of dry rocky woods (ODNR 2008). According to Jones (2005), three-flower melic grass typically is found in cliff crevices and on ledges when growing in rocky areas. The species likely is threatened from grazing since it is palatable, and from over-shading by woody species as a result of forest succession (ODNR 2008).

Thread-like Niad (*Najas gracillima*)
Thread-like niad is listed as a threatened species in Indiana. It occurs throughout eastern North America with isolated populations also reported in California (NatureServe Explorer 2008). In Indiana, this species has been found in many counties, with observations noted from Harrison-Crawford and Clark State Forests (Indiana Natural Heritage Database 2008). Thread-like niad is a submersed aquatic plant that occurs in clear water of soft-water lakes (ODNR 2008) and ponds with mud or sandy bottoms (KSNPC 2008). Threats to this species include changes in water quality such as turbidity, water pollution, and eutrophication (ODNR 2008, KSNPC 2008).

Tall Meadowrue (*Thalictrum pubescens*)
Tall meadowrue is listed as a threatened species in Indiana. This species ranges from Maine to Illinois, south to Mississippi (USDA-NRCS 2008). Indiana records of this species include the counties of Jefferson, Perry, Posey, Spencer, Porter, Clark, Crawford and Washington (Indiana Natural Heritage Database 2008). This species has been observed on Jackson-Washington (2002) and Harrison-Crawford state forests (Indiana Natural Heritage Database 2008). Tall meadowrue is found in swamps and along stream margins (CBS 2008). It grows in wet meadows, streambanks, and openings in wet to mesic woods (Gleason and Cronquist 1991). Primary causes for decline include the spread of non-native invasive species (e.g., Japanese honeysuckle, stilt grass, garlic mustard) that can dominate sites and degrade habitat of this species (Homoya pers. comm. 2006).

Mercury (*Acalypha deamii*)
Mercury is listed as a rare species in Indiana. It is a little-known species that was thought

to be restricted to four states: Arkansas, Indiana, Ohio and Tennessee (Gleason and Cronquist 1991). However, recent investigations have revealed the true range occurs from Virginia and Alabama in the southeast, west to Iowa and Kansas (Becus 2003). This species has been observed at Harrison-Crawford State Forest as recently as 2005 (Indiana Natural Heritage Database 2008). Mercury is known from a variety of moist, disturbed mesic sites in semi-shade, including stream banks, thickets, and roadsides (ODNR 2008). A possible threat to Mercury is thought to be natural succession and excessive shading; however, owing to its tolerance of moderate disturbance, recovery potential is considered good (ODNR 2008).

Wallrue Spleenwort (*Asplenium ruta-muraria*)
Wallrue spleenwort is listed as a rare species in Indiana. This species has been reported in several counties in Indiana, including Harrison, Jefferson, Crawford, Clark, and Ripley (Indiana Natural Heritage Database 2008). Wallrue spleenwort has been observed at Harrison-Crawford State Forest as recently as 2003 (Indiana Natural Heritage Database 2008). In Indiana, this fern grows exclusively on limestone cliffs and boulders (Hedge et. al 1999). Wallrue spleenwort occurs on dry to moist calcareous rock exposures, rarely in full sun (ODNR 2008). It is found in cracks and holes in dolomite and limestone bluffs (Missouri Plants Database 2006). One major threat to this species is mechanical disturbance from rock-climbing (ODNR 2008). Land-use conversion, habitat fragmentation, and incompatible forest management practices are low-level threats to this species (Southern Appalachian Species Viability Project 2002).

Aromatic Aster (*Aster oblongifolius*)
Aromatic aster is listed as a rare species in Indiana. This species has a large range in the United States, from New York and North Carolina in the east to North Dakota and New Mexico in the west (USDA-NRCS 2008). This species has been found in the Indiana counties of Jefferson, Harrison, Crawford, and Tippecanoe (Indiana Natural Heritage Database 2008). Aromatic aster has been documented at Leavenworth Barrens (1985) and Post Oak-Cedar Nature Preserves (1981) on Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). This species inhabits dry, open, often rocky areas such as bluffs, open slopes, and prairie remnants (ODNR 2008). Forest succession and excessive shading by woody species is a threat to this species (ODNR 2008).

Wild False Indigo (*Baptisia australis*)
Wild false indigo is listed as a rare species in Indiana. It occurs from New England to Georgia, west to Nebraska and Texas (NatureServe Explorer 2008). In Indiana, this species has been found in the counties of Switzerland, Ohio, Jefferson, Perry, Harrison, and Crawford, with observations noted from Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). This species occurs in rocky prairies, glades, and on open slopes (Missouri Plants Database 2008). This species also has been found in rich woods, thickets, and woodland edges (CBS 2008, UTA 2008). Threats to this species include forest succession and invasion of exotic plants (KSNPC 2008).

Ebony Sedge (*Carex eburnea*)
Ebony sedge is listed as a rare species in Indiana. This species is found from Newfoundland to Alaska south to Virginia, Alabama, Arkansas and Texas (USDA-NRCS 2008). This species has been found in the counties of Harrison, Crawford, Porter, Carroll, Clark, Lake, and Warren (Indiana Natural Heritage Database 2008). It has been found at Charles C. Deam Nature Preserve on Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Ebony sedge prefers calcareous soil (Gleason and Cronquist 1991) and typically is found on calcareous ledges, gravels or sands, rocky summits and outcrops, and non-tidal river shores (Maine DC 2004). Since this sedge occurs mostly on rock outcrops, removal of rock (e.g., rock quarrying) can destroy habitat. Also, non-native exotic species (e.g., Japanese honeysuckle, stilt grass, garlic mustard) can dominate sites and degrade habitat (Homoya pers. comm. 2006).

False Hop Sedge (*Carex lupuliformis*)
False hop sedge is listed as a rare species in Indiana. It is found throughout eastern North America, from southwestern Quebec to Wisconsin in the north, south to Louisiana (NatureServe Explorer 2008). It has been found in the Indiana counties of Daviess, Wabash, and Posey (Indiana Natural Heritage Database 2008). This species has been observed at Salamonie River State Forest (Indiana Natural Heritage Database 2008). It is found in wet woods, wooded swamps, marshes, wet meadows, and roadside ditches (SNF 2005). The effects of fire are known to have positive effects on this species (SNF 2005). Threats include river impoundments, ditching, channeling, floodplain cultivation, and interruptions to the seasonal flood cycle. Since this species prefers wetlands fed by clean spring water, it is probably sensitive to chemical-affected runoff from agricultural areas (SNF 2005).

Hairy Lipfern (*Cheilanthes lanosa*)
Hairy lipfern is listed as a rare species in Indiana. This species is found from New York to Minnesota and south to Texas and Florida (NatureServe Explorer 2008). This species has been found in the counties of Harrison, Perry, Lawrence, Martin, and Crawford (Indiana Natural Heritage Database 2008). It has been found at Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Hairy lipfern occurs on rocky slopes, ledges, and outcrops (CBS 2008). It also is found on calcareous gravelly banks (NYNHP 2008). Since this fern occurs mostly on rock outcrops, removal of rock (e.g., rock quarrying) can destroy habitat.

Carolina Thistle (*Cirsium carolinianum*)
Carolina thistle is listed as a rare species in Indiana. Its range extends from southern Ontario to southern Missouri, south to Florida and Texas (Gleason and Cronquist 1963). Carolina thistle has been found in the counties of Clark, Crawford, and Perry (Indiana Natural Heritage Database 2008). It has been observed at White Oak Nature Preserve on Clark State Forest (1988) and Harrison-Crawford State Forest (1989) (Indiana Natural Heritage Database 2008). This species inhabits dry woods, roadsides, and openings in woodlands (Jones 2005, Radford et al. 1968). Carolina thistle populations are found in clearings or areas recently disturbed by burning or timber harvesting (ODNR 2008, WNF

1992). It thrives in dry soil with moderate to full exposure to sun; typically not persisting in wet habitats or under dense canopy cover (ODNR 2008). At the Wayne National Forest in Ohio, it has been found in upland oak woodlands and under a canopy of young red maple and pine (ODNR 2008). Restricted habitat requirements make it susceptible to habitat fragmentation and land development (Southern Appalachian Species Viability Project 2002). The species also may be vulnerable to unintended consequences of attempts to control or eradicate exotic *Cirsium* species.

Northern Bush-honeysuckle (*Diervilla lonicera*)
Northern bush-honeysuckle is listed as a rare species in Indiana. This native bush-honeysuckle occurs from Newfoundland to North Carolina, west to Iowa and Saskatchewan (Fernald 1950, Radford et al. 1968). In Indiana, this species has been found in several counties, including Fountain, Montgomery, Steuben, Lake, Porter, LaPorte, St. Joseph, Jasper, and Starke (Indiana Natural Heritage Database 2008). One observation has been reported on Jackson-Washington State Forest as recently as 1999 (Indiana Natural Heritage Database 2008). This species prefers to grow on exposed, rocky sites with well-drained, dry to mesic soils. It regenerates rapidly after fire and sprouts from its rhizomes following top-kill (Rook 2002). Competition from exotic honeysuckles might be one of the reasons for the decline of the northern bush-honeysuckle (Clemants and Moore 2005).

French's Shootingstar (*Dodecatheon frenchii*)
French's shootingstar is listed as a rare species in Indiana. This species has a small geographic range that includes Arkansas, Illinois, Indiana, and Kentucky (Hauser et al. 1981). This species has been observed in Crawford and Perry counties (Indiana Natural Heritage Database 2008). A recent record (2001) exists from Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). This species is found in areas of deep shade under sandstone ledges and rock houses within mesic hardwood forests (Jones 2005). Gleason and Cronquist (1991) report this species also can be found in dry woods and prairies. It is found in close association to sandstone ledges and bluffs, preferring north and east-facing exposures (Tucker 1982, Mohlenbrock 1978). French's shooting star grows best with little competition from other plant species, often growing alone in bare soil. Some populations on the Hoosier National Forest are threatened by illegal ATV use (HNF 2005). As a result of its narrow range and relatively few known occurrences, populations are vulnerable to impacts such as excessive removal of shade-producing trees, off-road vehicle usage, and archeological digging (NatureServe Explorer 2008). Excessive deer herbivory and trampling is thought to be detrimental to the species. At present, no extant populations are known from areas extensively impacted by timber harvest (NatureServe Explorer 2008).

Yellow Gentian (*Gentiana alba*)
The yellow gentian is listed as a rare species in Indiana. The range of this species extends from Ontario south to Oklahoma and east to North Carolina and Pennsylvania (NatureServe Explorer 2008). There are 12 extant populations of yellow gentian in Crawford, Franklin, Harrison, Perry and Ripley counties in Indiana and seven extirpated populations have been documented (Olson 2002a). The most recent records for this species on Harrison-Crawford State Forest are from 1990 (Indiana Natural Heritage Database 2008).

Yellow gentian is found in mesic prairies, savannas, grassy meadows and damp woods (Andreas 1981). It has been reported from oak openings, savannas and open woodlands, wooded ravines and edges, ridges and bluffs, wet sandy prairies, utility corridors, and roadside ditches (WDNR-WIDOT 2005). Yellow gentian has been found in areas frequently disturbed by fire. It is often associated with species of tall grass prairies and has little tolerance for shade (WDNR-WIDOT 2005). The biggest threat to this species is the loss of native vegetation to exotic cool season grasses, such as tall fescue (*Festuca arundinacea*). This species is also threatened by land development, fragmentation, and incompatible forest management practices (Southern Appalachian Species Viability Project 2002). Succession and excessive shading are also threats.

Angle Pod (*Gonolobus obliquus*)

Angle pod is listed as a rare species in Indiana. This species ranges from Pennsylvania west to Missouri and south to North Carolina and Tennessee (Gleason and Cronquist 1991). This species has been observed in several Indiana counties, including Crawford, Orange, Martin, Washington, Jefferson, Gibson, and Posey (Indiana Natural Heritage Database 2008). Records exist for this species at Harrison-Crawford State Forest as recent as 1989 (Indiana Natural Heritage Database 2008). Angle pod is found in open woodlands, woodland borders, rocky slopes, and thickets, and is often associated with calcareous soils (Andreas 1981). Primary threats include succession and canopy closure and excessive trimming of wooded roadside borders and fencerows (Andreas 1981).

Crested Coralroot (*Hexalectris spicata*)

Crested coralroot is listed as a rare species in Indiana. This species ranges from Virginia to Florida in the east, to Arizona and Texas in the west, and north to the Great Lakes (NatureServe Explorer 2008). Crested coralroot has been reported from Harrison, Washington, Clark and Floyd counties in Indiana (Indiana Natural Heritage Database 2008). This species has been observed at Harrison-Crawford State Forest as recently as 1993 (Indiana Natural Heritage Database 2008). Crested coralroot typically occurs in mesic to dry soil over limestone or sandstone, in the vicinity of *Juniperus*, *Pinus*, or *Quercus* (Efloras database 2006). In Missouri, crested coralroot was found in the calcareous soil of dry forests and limestone glades, often in association with *Juniperus* (Yatskievych 1999). In Ohio, this species is found in the semi-shade of well-drained oak woodlands (ODNR 2008). Due to its relationship with symbiotic fungi, this species is sensitive to soil disturbance and compaction (ODNR 2008).

Narrowleaf Summer Bluets (*Houstonia nigricans*)

Narrowleaf summer bluets are listed as a rare species in Indiana. This species ranges from Virginia to Florida, west to Michigan, Colorado and Texas (USDA-NRCS 2008). Records of this species exist from Tippecanoe, Crawford, and Harrison counties (Natural Heritage Database 2008). This species has been found at Harrison-Crawford State Forest as recently as 1989 (Natural Heritage Database 2008). This species is often found in full sun in a variety of exposed, well-drained sites; usually on calcareous substrates (ODNR 2008). It also is found in dry exposed areas of loess hills, rocky ledges, limestone bluffs, and glades (Missouri Plants Database 2006). Primary threats to this species include soil

compaction and forest succession leading to excessive shading by woody species (ODNR 2008).

Straggling St. Johnswort (*Hypericum dolabriforme*)
Straggling St. Johnswort is listed as a rare species in Indiana. According to the USDA PLANTS database (USDA-NRCS 2008), straggling St. Johnswort ranges from southern Indiana, south through Kentucky, Tennessee, and into northern Alabama and Georgia. This species has been observed in Harrison and Crawford counties, specifically at Post Oak-Cedar Nature Preserve and Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). In Georgia, straggling St. Johnswort can be found on limestone glades and barrens (GDNR 2004). Successional changes that bring excessive shade could threaten this shade intolerant species. Also, non-native invasive species (e.g., Japanese honeysuckle, stilt grass, garlic mustard) can dominate sites and degrade habitat (Homoya pers. comm. 2006).

Canada Lily (*Lilium canadense*)
Canada lily is listed as a rare species in Indiana. This species occurs in the eastern United States and Canada, west to Nebraska and Kansas. This species has been observed in the Indiana counties of Franklin, Perry, Dearborn, Jefferson, and Crawford (Indiana Natural heritage Database 2008). One modern record (1980) exists for this species from Wyandotte Caves State Recreation Area, a property immediately adjacent to Harrison-Crawford State Forest (Indiana Natural Heritage Database 2008). Canada lily can be found in moist or wet meadows (Gleason and Cronquist 1991) and on dry wooded slopes (Yatskievych 2000). Radford et al. (1968) indicate it prefers wet meadows, bogs and balds in the southeast United States. On the Hoosier National Forest, Canada lily is characterized as a plant of mesic forests (Hedge et al. 2002) preferring forest openings and canopy gaps (Dolan 2004). Potential threats vary in different areas of the country and include deer browsing, canopy closure, and habitat loss and fragmentation (Dolan 2004). Rarity of the species may be attributed to its use of ephemeral forest openings and intolerance of woody succession. Canada lily persistence on dry sites (barrens) may be due to a slowed advance in canopy closure and competing growth (Dolan 2004).

Crow-poison (*Nothoscordum bivalve*)
Crow-poison is listed as a rare species in Indiana. This species ranges from Virginia to Florida, west to Nebraska and Texas (USDA-NRCS 2008). This species has been found in Perry, Lawrence, Greene, Posey, Martin, Warrick, Harrison, Crawford, Vigo, and Tippecanoe counties in Indiana (Indiana Natural Heritage Database 2008). This species has been observed at Harrison-Crawford State Forest as recently as 2003 (Indiana Natural Heritage Database 2008). Crow-poison inhabits a variety of moist openings, usually in rocky or sandy soil, including roadsides, fields, pastures, prairies, and open woods (ODNR 2008). Forest succession and overgrowth by woody plants is the primary cause of decline (ODNR 2008).

Limestone Adder's-tongue (*Ophioglossum engelmannii*)
Limestone adder's-tongue is listed as a rare species in Indiana. This species is abundant throughout much of its range in the southeast and south central United States (Lellinger

1985); however, populations in southern Illinois and Indiana are less secure. This species has been found in Perry, Harrison, Washington, Clark, and Crawford counties (Indiana Natural Heritage Database 2008). Limestone adder's-tongue has been observed at Harrison-Crawford State forest as recently as 2002 (Indiana Natural Heritage Database 2008). Limestone adder's-tongue prefers calcareous soils, such as those found in barrens, limestone glades, dry limestone and dolomite prairies, savannas, and glades (Baskin and Baskin 1974, Fernald 1950, FNAEC 1993, Gleason 1963, Gleason and Cronquist 1991, Mohlenbrock 1967, Nelson 1987, Small 1938, Yatskievych 1999). Threats to limestone adder's-tongue include woody encroachment and succession and competition from aggressive exotic plants (Olson 2002c).

Purple Passion-flower (*Passiflora incarnata*)

Purple passion-flower is listed as a rare species in Indiana. This species' range extends from Virginia and Florida in the east, west to Missouri and Texas (UFL 2006). This species has been observed in several Indiana counties, including Perry, Vanderburgh, Floyd, Lawrence, Knox, Cass, Spencer, Dubois, Harrison, and Clark (Indiana Natural heritage Database 2008). Records of purple passion flower at Harrison-Crawford State Forest are as recent as 2005 (Indiana Natural Heritage Database 2008). Purple passion-flower is often found in distributed sandy fields, along roadsides, railroad right-of-ways, and waste ground (ILPIN 2006). Threats to this species include forest succession and excessive over-shading (ODNR 2008).

Deam Beardtongue (*Penstemon deamii*)

Deam beardtongue is listed as a rare species in Indiana. The USDA PLANTS database (USDA-NRCS 2008) reports this plant occurs only in Indiana and Illinois. Most populations in Indiana occur in the southern knobs of Floyd, Clark, Harrison, Washington and Scott counties (Indiana Natural Heritage Database 2008). Clark State Forest is home to many populations, with the most recent observation from 1990 (Indiana Natural Heritage Database 2008). The habitat for this species includes openings in forests and along roads, trails, and clearings. This species benefits from periodic mowing, which reduces competition and increases light availability (IDNR 1996). Deam beardtongue can be affected negatively by careless use of herbicides (Homoya pers. comm. 2006).

Large-leaved Phlox (*Phlox amplifolia*)

Large-leaved phlox is listed as a rare species in Indiana. This species is found from the southern Appalachian Mountains through the interior highlands with scattered populations extending into Arkansas, Missouri, and Indiana (Wherry 1955, Medly 1993). In Indiana, populations are found in the extreme southern part of the state with the exception of one population in the west central portion of the state. Of the 10 known extant populations, six occur in the Hoosier National Forest (Heikens 2003). This species was last observed at Harrison-Crawford State Forest in 2004 (Indiana natural Heritage Database 2008).

The typical habitat for large-leaved phlox is along streams in mesic woodlands, but the species also is found in a variety of woodland situations, including rocky wooded slopes, dry open woods, thickets, sandy and rocky slopes of stream banks, sandstone ledges,

crests of mixed hardwood ridges, wooded floodplains, and alluvial woods (Small 1933, Deam 1940, Fernald 1950, Wherry 1955, Gleason 1963, Steyermark 1963, Radford et al. 1968, Gleason and Cronquist 1991, Medley 1993, Yatskievych 2000, NatureServe 2006). Most populations found in the Hoosier National Forest occur in the partial shade of mesic forests, often on north-facing slopes, but individuals have been found on all aspects. Populations within the Hoosier National Forest are along roads subject to annual mowing (Heikens 2003).

Two Indiana populations of large-leaf phlox are threatened by non-native invasive species such as Japanese stilt grass (*Microstegium vimineum*) and Japanese honeysuckle (*Lonicera japonica*) (Heikens 2003). Herbivores apparently destroyed an Indiana population through trampling, soil compaction, and plant consumption (NatureServe Explorer 2008). Another Indiana population was extirpated by careless roadside mowing (Heikens 2003). Excessive mowing is believed to be a threat to populations along roadsides and within open utility corridors (NatureServe Explorer 2008).

Resurrection Fern (*Polypodium polypodioides*)

Resurrection fern is listed as a rare species in Indiana. It is very common in the southeast and found from New York to Florida, west to Texas (SFRC-UFL 2006). In Indiana, resurrection fern has been recorded in the counties of Perry, Clark, Jefferson, Harrison, and Crawford (Indiana Natural Heritage Database 2008). This species has been observed at Harrison-Crawford State Forest as recently as 2003 (Indiana Natural Heritage Database 2008). This species is often found growing on trees, stumps, and rocks (NCSU 2002). In Florida, the fern lives on the branches of large trees such as cypresses and live oaks (SFRC-UFL 2006). In Kentucky, it is known from a few places on limestone rock, usually growing on semi-exposed limestone but also occasionally on trees (Knouse 1997). Since resurrection fern occurs mostly on rock outcrops, removal of rock (e.g., rock quarrying) can destroy its habitat (Homoya pers. comm. 2006). Also, non-native invasive species (e.g., Japanese honeysuckle, stilt grass, garlic mustard) can dominate sites and degrade habitat (Homoya pers. comm. 2006).

Rough Rattlesnake-root (*Prenanthes aspera)*

Rough rattlesnake-root is listed as a rare species in Indiana. This species ranges from Pennsylvania in the east to South Dakota and Minnesota in the west to Louisiana and Mississippi in the south (USDA-NRCS 2008). Records include the Indiana counties of Perry, Harrison, Washington, Knox, Lake, Newton, Benton, Jasper, White, LaPorte, and LaGrange (Indiana Natural Heritage Database 2008). Records of this species at Harrison-Crawford State Forest are as recent as 1990 (Indiana Natural Heritage Database 2008). Rough rattlesnake-root prefers dry, open to semi-open situations, usually in acid, sandy or rocky soil, including open rocky woods, prairie remnants, barrens, and along roadsides and railroad right-of-ways (ODNR 2008, KSNPC 2008). Threats to this species include forest succession and excessive over-shading (ODNR 2008). Invasion by exotic plants are also a threat to this species (KSNPC 2008).

Small's Snakeroot (*Sanicula smallii*)

Small's snakeroot is listed as a rare species in Indiana. This species is distributed through-

out 16 states, from Virginia to Florida and west to Texas (USDA-NRCS 2008). The Indiana Natural Heritage Database (2008) reports this species has been found in Crawford, Perry, and Harrison counties. This species has been documented on Harrison-Crawford State Forest as recently as 1990 (Indiana Natural Heritage Database 2008). Small's snakeroot can be found in rich, mesic woods (Jones 2005, Missouri Plants Database 2006). Primary cause for decline is non-native invasive species (e.g., Japanese honeysuckle, stilt grass, garlic mustard) that can dominate sites and degrade habitat of this species (Homoya pers. comm. 2006).

Weakstalk Bulrush (*Scirpus purshianus*)

Weakstalk bulrush is listed as a rare species in Indiana. It is distributed across eastern North America, from Quebec to Georgia and west to Mississippi (NatureServe Explorer 2008). In Indiana, this species has been found in scattered populations throughout many counties, with observations noted from Clark State Forest (Indiana Natural Heritage Database 2008). This species occurs on wet shores, lake margins, beaches, and mudflats (ODNR 2008). Threats to this species include changes in water level that result in inundation, mechanical shoreline disturbance (ODNR 2008).

Allegheny Stonecrop (*Sedum telephioides*)

Allegheny stonecrop is listed as a rare species in Indiana. It occurs from western New York to Georgia and west to Illinois (NatureServe Explorer 2008). In Indiana, records exist for Clark, Crawford, Harrison, and Perry counties (Indiana Natural Heritage Database 2008). Allegheny stonecrop has been observed at Harrison-Crawford State Forest as recently as 2000 (Indiana Natural Heritage Database 2008). This species typically is found in dry rocky areas, including cliffs, ledges, and bare rock outcrops. It frequently is found in association with high elevation barrens plant communities (USFWS 2005, KSNPC 2008, VDCR 2006). Off-road vehicles, incompatible forest management, or any activity that results in increased erosion and weed invasion are detrimental to Allegheny stonecrop (KSNPC 2008).

Barren Strawberry (*Waldsteinia fragarioides*)

Barren strawberry is listed as a rare species in Indiana. It is found from Maine to Minnesota, south to Georgia and Arkansas (NatureServe Explorer 2008). Currently, there are fewer than 20 extant occurrences known in Indiana (Hill 2003a). Indiana records include the counties of Crawford, Greene, Wayne, Harrison, Jennings, Wabash, and Washington (Indiana Natural Heritage Database 2008). This species has been found at Leavenworth Barrens Nature Preserve at Harrison-Crawford State Forest and Salamonie River State Forest (Indiana Natural Heritage Database 2008). Barren strawberry typically inhabits mesic woodlands (Jones 2005). It has been found to grow best in rich, moist woods, and has been observed in dry upland forests and occasionally in thickets and clearings (Fernald 1950; Gleason and Cronquist 1991). It also has been reported to grow on sandstone ledges and rocky wooded slopes (Hill 2003a). In Indiana, this species typically grows in thin, often rocky soil where the steep forested slope approaches its crest. Such sites usually possess a limestone substrate, but a few populations exist over sandstone. Deam (1940) described the plant in Indiana as consistently growing in talus at the base of cliffs or on rocky ledges (often limestone) and on slopes along creeks.

Isolated populations and those on the edges of the species' range have been impacted by land development, rockslides, and incompatible forest management (NatureServe Explorer 2008). Potential threats include natural catastrophe, competition from non-native invasive species, and long-term climate change. It is possible, but less likely, that overcollection is a current threat to the species. Additional threats to the plant and its habitat include flooding by impoundment, construction, and quarrying (Hill 2003a).

Kentucky Wisteria (*Wisteria macrostachya*)

Kentucky wisteria is listed as a rare species in Indiana. This species is found from Virginia to Florida, west to Missouri and Louisiana (PFAF 2006). The Indiana Natural Heritage Database (2008) reports this species has been found in Crawford, Perry, Delaware, Jefferson, Posey, Clarke, Pike, and Harrison counties. This species has been documented at Charles C. Deam Nature Preserve on Harrison-Crawford State Forest as recently as 1991 (Indiana Natural Heritage Database 2008). Kentucky wisteria prefers moist soils and is often found in wet forests and along stream banks. It is considered shade tolerant, but will flower only when exposed to partial or full sun (PFAF 2006). The primary cause for decline is non-native invasive species (e.g., Japanese honeysuckle, stilt grass, garlic mustard) which can dominate sites and degrade the habitat of this species (Homoya pers. comm. 2006).

Golden Alexanders (*Zizia aptera*)

Golden alexanders is listed as a rare species in Indiana. This species has a very broad geographic distribution, encompassing 37 states and seven Canadian provinces, from northeast Canada to subtropical Florida, west to the Pacific Northwest (Farnsworth 2003). This species has been found at Harrison-Crawford State Forest as recently as 2004 (Indiana Natural Heritage Database 2008). In the heart of its range, golden alexanders inhabits prairies maintained in a semi-open condition by disturbance events, including fire (Hemingson 1990). It also can be found in mid-successional fields, along river shores, and in glades with moist to dry soils principally derived from calcareous bedrock. The species is not classified as an obligate wetland inhabitant, although it is described from the margins of streams and rivers and from mesic to dry habitats, indicating a wide tolerance for a variety of moisture conditions (Farnsworth 2003). Primary threats to golden alexanders include forest succession and competition from non-native invasive species. Stressors operating at existing sites include trampling, drought (and salt stress), and herbivory (Farnsworth 2003).

Direct and Indirect Effects on Plants

Sixty plant species designated as state endangered, threatened, or rare have been documented on DoF properties since 1980 (Appendix A, Table 6). Of these, seven have been documented only on nature preserves associated with state forests (Appendix A, Table 6). Since the proposed alternatives will not affect nature preserve properties on state forests, these plant species will not be considered in the proceeding analysis of direct, indirect, and cumulative effects relative to the various communities. Additionally, eight plant species designated as state endangered, threatened, or rare inhabit riparian/aquatic communities on DoF properties (Appendix A, Table 6). Since these species are restricted to

aquatic habitats, DoF does not expect any of the proposed alternatives to cause any direct, adverse effect to them or their populations. The DoF routinely applies Best Management Practices to each timber harvest, which minimizes the effects of erosion and sedimentation. Additionally, in 2001 DoF established guidelines for harvesting near forested riparian corridors to better protect these important foraging areas for bats, such as the federally endangered Indiana and gray bats. The guidelines stipulate >100-foot wide limited management buffers be established and maintained on either side of all perennial streams and rivers. Only minimal cutting is allowed inside these riparian management zones and the structural integrity of the forested corridor is to be maintained at all times. Because harvesting is limited and carefully applied in riparian areas and forested buffers are retained along streams, DoF anticipates the activities associated with all of the proposed alternatives will not adversely affect the habitats of these plants.

Direct and Indirect Effects on Plants of Cliffs, Ledges, and Outcrops

Eleven plant species designated as state endangered, threatened, or rare occur in habitats that feature rock outcrops, cliff faces, and ledges (Appendix A, Table 6). A review of reported threats to these species include trampling from rock-climbers and hikers, quarrying, excessive shading due to forest succession, fire suppression, and competition from non-native invasive species. Species threatened by shading and competition from exotics would potentially benefit from the preferred management alternative which includes 1,400 acres of annual non-native invasive species control, 2,000 acres of prescribed fire, and canopy reductions due to harvesting. Potential harm could result from harvesting activities that result in scouring rock faces, such as skidding or felling trees. However, DoF rarely works in such inaccessible areas that are inhospitable to timber harvesting. Furthermore, a location-specific search of the Indiana Natural Heritage Database is made well in advance of each timber harvest (section 1.6.5 of this document), and forest managers avoid incompatible management activities in the presence of such species. For these reasons, it is unlikely the proposed action will adversely affect these species. However, as noted, many species would benefit by canopy reduction, prescribed fire, and non-native invasive species control.

Direct and Indirect Effects on Plants of Glades and Barrens

Nine plant species designated as state endangered, threatened, or rare occur in habitats characteristic of glades and barrens (Appendix A, Table 6). A review of reported threats to these species includes fire suppression and forest succession, land-use conversion, and competition from non-native invasive species. Areas characterized as open glades and barrens are rarely affected by forest management activities, so it is unlikely any of the proposed alternatives will adversely affect species occurring in these communities. Furthermore, a location-specific search of the Indiana Natural Heritage Database is made well in advance of each timber harvest (section 1.6.5 of this document), and forest managers avoid incompatible management activities in the presence of such species. However, as noted, many species would benefit from canopy reduction, prescribed fire, and non-native invasive species control and may warrant management actions done outside the scope of the proposed alternatives to improve their habitat conditions.

Direct and Indirect Effects on Plants of Forests and Open Woodlands
Twenty-five plant species designated as state endangered, threatened, or rare occur in forests or open woodlands (Appendix A, Table 6). A review of each species' habitat preferences and tolerances reveals the overwhelming majority of these species (20 of the 25) prefer open woods and/or forest edges. Threats to these species typically include excessive shading due to canopy closure, fire suppression, and competition from non-native invasive species. Species that are threatened by shading and competition from exotics would potentially benefit from the preferred management alternative, which includes 1,400 acres of annual non-native invasive species control, 2,000 acres of prescribed fire, and canopy reductions due to harvesting. Five species were reviewed that reportedly preferred closed-canopy forested habitats, and threats to these species included excessive loss of tree canopy, deforestation, and competition from non-native invasive species. Since a location-specific search of the Indiana Natural Heritage Database is made well in advance of each timber harvest (section 1.6.5 of this document), forest managers would know species occur in the proposed management area that may be sensitive to harvesting and can avoid incompatible activities in the presence of such species. Species threatened by competition from invasive and fire intolerant species would benefit from the non-native invasive species control and prescribed burning that is included in the proposed action. For these reasons, it is unlikely the proposed action will adversely affect forest inhabiting plant species. However, as noted, many species, particularly those preferring open forests and woodlands, would benefit by canopy reduction, prescribed fire, and non-native invasive species control.

Cumulative Effects on Forest Plants
As described in section 1.4 of this document, the oak-hickory component of DoF forestland has reached maturity system-wide and is experiencing regeneration issues that threaten the long-term stability of this essential forest type. DoF agrees with the opinion of regional experts (Abrams 2003, Dickson 2004, Fralish 2004, James 2004, McShea et al. 2007) who suggest a decline in the oak-hickory component will have catastrophic effects on this region's native forest communities, as many species depend on this component for their very existence (Dickson 2004). The proposed action will create needed oak-hickory recruitment to help stabilize this declining trend and provide long-term sustainability to these forests and the communities they support. Additionally, many experts in this region note that historic reforestation efforts and natural re-growth of eastern U.S. deciduous forests has produced an abundance of mature forest and a declining early-successional component that threatens many species dependent on that community type (Trani et al. 2001, Yahner 2003, Fuller and DeStefano 2003, Castrale et al. 2005). DoF suggests the proposed action not only will ensure long-term sustainability of its oak-hickory forests but also address these reported declines in early-successional habitats and species.

While accomplishing these goals with the proposed action, the DoF must ensure the life requirements of Indiana's species of greatest conservation need, specifically species requiring late-successional communities and mature forests, are addressed as well. The plan for long-term forest sustainability outlined in section 1.4 of this document will ensure

a continual supply of maturing and mature forest is available to late-succession species such as those requiring closed-canopy habitats, even as early-successional habitats are annually created by timber harvesting. The DoF sustainability plan assures forest growth and maturation outpaces harvesting to ensure the needs of early-successional species are balanced with those requiring late-successional habitats. Additionally, DoF has designated Old Forest Areas on nearly all state forests, which will provide old growth forest elements, characteristics, and structure throughout the term of this plan and beyond. These areas are harvested nearly exclusively using single-tree selection, with only occasional use of group selection where appropriate. Old Forest Areas are to be managed for a condition in which the overstory canopy trees are relatively old (> 125 years on most sites) and relatively large for the species occurring on that site. The longer management cycle of these areas (>30 years) offers additional assurance they will be allowed to develop towards an old growth character with only limited disturbance.
Through the entirety of these measures – sustainable harvesting principally using selection silviculture and establishment of old forest tracts – DoF will ensure the needs of species reviewed in this document are met and their populations are not adversely affected. At the same time, DoF suggests the activities planned under the proposed action will improve habitat for all species dependent on oak-hickory forests and provide long-term sustainability for this essential ecological community.

4.7 Environmental Impacts on the Nonliving Environment

Carbon Sequestration and Global Climate Change
All aspects of forests and land management contain or affect carbon. Live trees (both aboveground and roots), standing dead trees (including roots), down dead wood, forest floor carbon, and soil contain carbon. Harvesting releases carbon, and, also transfers carbon in wood to products or landfills. Wood burned for energy in place of fossil fuels helps mitigate carbon in the atmosphere because it provides energy, and then the trees regrow and take up the released carbon again. Fires release carbon and may also convert wood to charcoal, which keeps carbon captured for a long time. Land use change and other disturbances also release carbon. Even urban forests play a role in the carbon cycle, either through sequestration by trees or by thoughtful placement around buildings for summer shading that reduces the need for cooling, resulting in decreased emissions. (USFS 2008)

Based on the most recent data (2008) from the U.S. Forest Service's NE Research Station, Indiana forestland has carbon stocks of approximately 72 metric tonnes per acre and is annually sequestering 4 tonnes per acre per year. Applying these metrics to the approximately 149,445 acres of Indiana State Forests, annual carbon sequestration is 600,746 metric tonnes CO_2, and there are existing carbon stocks totaling 10,771,658 metric tonnes CO_2. (C. Gonso, IDNR, pers. comm. 2008)

The Division of Forestry is currently in the process of collecting more specific inventory information through a Continuous Forest Inventory system described earlier in this document that is consistent with the U.S. Forest Service standards that will provide a more accurate estimate of the carbon stocks and sequestration rates on State Forest lands.

Scientific evidence exists that rates of sequestration in Morgan-Monroe State Forest are higher than the 4 tonne estimate detailed above. Indiana University's Center for Energy and the Environment has been studying ecosystem carbon flux for 10 years at this fairly representative State Forest site. The IU Center's results show the cumulative Net Ecosystem Exchange (NEE) at the Morgan-Monroe State Forest AmeriFlux site where carbon is being taken out of the atmosphere and incorporated into the vegetation at an annual total carbon sequestration rate during the last nine years of about 30 metric tons of carbon per hectare. This equates to about 4.95 metric tonnes of CO2 per acre per year. (C. Gonso, IDNR, pers. comm. 2008) This sequestration rate of 4 to 4.95 metric tones per acre per year is above the current rate of timber harvesting. Per acre sequestration rates likely would be higher without any harvesting, and likely would be reduced if harvesting equals growth.

Direct and Indirect Effects on Carbon Sequestration and Global Climate Change

The increased level of harvest described in the proposed action can be expected to reduce the net carbon sequestration rate. Each 1,000 board feet of timber harvested contains 13.3 metric tonnes of carbon dioxide; the harvest level in the proposed action would reduce the carbon dioxide sequestration rate of the forests by approximately 160,000 metric tonnes of carbon dioxide annually. This would reduce the net sequestration from 600,000 metric tones to 440,000 metric tonnes annually.

The process to identify, mark, cut, skid and haul the volume designated in the proposed action would consume an estimated 250,000 gallons of fuel. Most of this fuel is consumed in the skidding and hauling, estimated to be 20.5 gallons per thousand board feet harvested. (J. Settle, IDNR, pers. comm. 2008) Consumption of 250,000 gallons of fuel will return an estimated 2,500 metric tonnes of carbon dioxide to the atmosphere annually. This reduces the net sequestration rate to an estimated 437,500 metric tonnes annually.

The Division of Forestry is interested in developing and participating in markets for ecosystem services and specifically exploring opportunities to sequester additional carbon through change in forest management practices that increase sequestration. Third party verification of these forest carbon offsets according to an established and recognized standard will be important to ensure to the public and potential offset buyers that they are real, additional, measurable, permanent and unique.

The state forests will continue to sequester carbon and contribute to amelioration of global climate change with the increased level of harvest associated with the proposed action.

Air Quality

Forest management activities, including timber harvest and road, trail, and facility construction and maintenance, have potential to contribute to air pollution. Timber harvest activities are not expected to contribute significant amounts of dust and will be short term in duration. Prescribed burning is used on DoF lands to control non-native plants, improve stand regeneration, and maintain wildlife habitat. Prescribed burning can temporarily lower air quality in the immediate vicinity of the burn, but is short in duration. Smoke created from burning results from typical woody vegetation and not toxic pollutants from

man-made materials. Indiana Administrative Code 326 IAC 4-1-4, Emergency burning (Article 4), states that certain types of open burning are exempt from burning permits, including "DNR burning to facilitate wildlife habitat maintenance, forestry purposes, natural area management, and fire-fighting or prevention." Prescribed burning associated with the proposed action would be exempt and subject to the following requirements:

1. Fires must be attended at all times and until completely extinguished.
2. If at any time a fire creates a pollution problem, a threat to public health, a nui sance, or a fire hazard, it shall be extinguished.
3. No burning shall be conducted during unfavorable meteorological conditions such as high winds, temperature inversions, or air stagnation or when a pollution alert or ozone action day has been declared.
4. All burning shall comply with other Federal, State, and local laws, rules, and ordinances.
5. Adequate firefighting equipment shall be on-site for extinguishing purposes dur ing burning times.

Smoke from prescribed burning consists of small particles (particulate) of ash, partly consumed fuel and liquid droplets, and is the major air pollutant of concern resulting from the fire. Carbon dioxide and water vapor make up over 90 percent of the mass emitted (USDA 1976). Other combustion products include invisible gases such as carbon monoxide (CO), hydrocarbons (HC), and small quantities of nitrogen oxides (NO_x). The latter usually are produced at temperatures only reached in piled or windrowed slash or in very intense wildfires. In general, prescribed fires produce inconsequential amounts of nitrogen oxides, and studies have shown concentrations far exceeding those expected of a forest fire are required for direct effects on humans (USDA 1976). Except for organic soils (which are not generally consumed in prescribed burns), forests fuels contain very little sulfur, so oxides of sulfur are not a problem either (Wade and Lunsford 1988). Particulate matter (PM), however, is of special concern. Particulate matter quantities released into the air depend on the amount and type of fuel consumed, fuel moisture content, and rate of fire spread determined by timing and type of firing technique used. Rate of smoke dispersal is mainly contingent on atmospheric stability and wind speed (Wade and Lunsford 1988). Particulate matter remains suspended in the atmosphere for periods of a few seconds to several months. Suspended particulate matter (SPM) is the portion that, because of its small size (5 to 10 microns in diameter), is transported long distances in the atmosphere and has the greatest potential for environmental impact. Suspended particles are of greatest concern in smoke management (USDA 1976). The most obvious environmental effect of smoke from prescribed forest fires is a temporary reduction in visibility. This effect is caused by the particles that absorb and scatter light, washing out the contrast that exists between the source and its background. A temporary reduction in visibility can hinder safe operation of aircraft and automobiles or the enjoyment of scenic vistas (SFSGM 1976).

Temporary haul road construction and equipment traffic associated with the proposed action would result in air emissions containing PM. However, the amount of dust created by equipment would be minimal. Dust would be suspended in the air, settle to the ground quickly, and would not cause pollution.

Direct and Indirect Effects on Air Quality

Activities under the proposed action that have the potential to produce air pollutants involve prescribed burning and haul road construction. Approximately 2,000 acres annually will undergo prescribed burning. A total of 1,700 acres is proposed to be disturbed for maintenance activities including road and trail construction. The fires will be used largely to kill very small stems and thin barked species. Specifically, this includes control of woody vegetation on grassland habitats, support for advanced regeneration of fire tolerant tree species (oaks and hickories), maintenance of fire-dependent natural communities, and control of non-fire tolerant tree regeneration in forest openings. Air pollutants emitted during burning would affect local air quality on the days burning occurred. Burning activities would be limited to days when weather conditions forecast by the National Weather Service indicate the presence of sufficient lifting and mixing to maximize atmospheric dispersion. Atmospheric data including mixing heights, wind speed, and wind direction would be monitored and evaluated by DoF or its contractors prior to initiating burning activities to ensure dispersion conditions are favorable. Adherence to these guidelines would reduce impacts on local air quality.

Air pollutant emissions created during haul road construction would result in temporary, localized air quality impacts near the construction site. Impacts from construction activities would be reduced by precipitation and would also be controlled inherently by the high moisture content of soils within state forests, which would reduce windblown dust from disturbed areas.

No violations of applicable state or Federal air quality regulations or standards would be expected to occur as a result of direct or indirect air pollutant emissions from the burning and road construction associated with the proposed action.

Cumulative Effects on Air Quality

Smoke, dust, or vehicle emissions that result from the proposed action could combine with air pollutants from other projects, including timber sale activities, prescribed fires, recreation use, and other vegetation maintenance activities to produce cumulative effects. Each of these events is largely driven by seasonal opportunities or requirements of similar parameters on resource managers, landowners, or users who may conduct their activities simultaneously. Although the potential effects of these unscheduled activities are largely temporary, of short duration, and widely spaced over a vast terrain, a cumulative short-term degradation of air quality could occur at localized sites. Approximately 3,184 acres of forests on federal lands and an estimated 150,000 acres of forests on private land in the Project Area are estimated to be harvested annually. Private harvesting could increase dust locally and contribute to cumulative effects of all activities. Other land management agencies within or near the project area might burn some existing grasslands, but at a level that would contribute negligibly to emissions. Emissions from road construction and prescribed burning activities are not expected to contribute to cumulative effects to air quality within the Project Area. The effects would remain at a level that would be minor, localized, and would not have a measurable long-term effect on the air resource.

Noise
Generally, noise from timber harvesting occurs for a short duration and often in remote forest locations.

Noise often is described as unwanted sound. Noise impacts may occur because of timber harvesting, log hauling, and road construction and maintenance. The proposed action would result in some level of noise from logging equipment used at harvest sites and logging trucks on the roads. Noise would last only as long as the harvest operation is in progress.

Noise from a point source attenuates or diminishes as it travels outward from the source. Absorption of sound waves by air and the ground surface will further attenuate sound levels. The rate at which these factors attenuate the sound depends on sound frequencies, air temperature, humidity, terrain, and the type of ground cover. When harvesting activities occur in remote areas the surrounding trees help attenuate the noise. However, because of the lower ambient sound levels existing in rural areas, some sound levels that would not be noticed in urban areas may be annoying to rural residents or people recreating. The largest impact areas for noise resulting from these activities may be in recreational areas near harvesting sites. In addition to effects on human beings, increased noise from timber harvesting could temporarily displace birds and animals. However, since these noises are short term, the effects are temporary. Long-term noise effects can damage hearing in a chainsaw operator or equipment operator, but there is no evidence of "second-hand" noise damage to observers. DoF policy is to close an active timber sale area to other users, preventing observers from entering unsafe sites.

Recreation and Visual Aesthetics
Indiana's state forests and recreation areas provide a variety of recreational opportunities for the public. The annual number of visitors to DoF properties is unknown but DoF estimates total visitor days to be between 1 and 2 million annually. There are 521 miles of hiking, mountain bike, and horse trails on DoF. Approximately 1,840 recreation sites (campsites, picnic areas, boat ramps, parking units, etc.) are found on DoF properties. Approximately 2,560 acres of DoF properties are lakes, and another 1,000 acres of DoF properties are identified as developed recreation areas. Recreational activities involving wildlife are major attractions to Indiana state forests.

Sightseeing and enjoyment of aesthetic scenery are primary uses of Indiana state forests and recreation areas. It is the policy of state forests to identify a Visual Enhancement Area (VEA) within 200 feet of public roads, high-use recreational facilities and trails. Timber harvest within a VEA consists of removal of dead or hazard trees or select removal of trees at high risk of death or loss of value during the next cutting cycle. However, placement of a 200-foot visual buffer does not imply the aesthetics of an area will not be impacted from DoF management actions. Activities within and beyond a VEA are impacted by topography, timber (timber type, number of trees, density), and season.

In addition to timber harvesting, proposed activities include trail construction and main-

tenance. On DoF lands, a small amount of new trail is developed annually. Because much of the state forestland was historically cleared and farmed prior to acquisition, there is a large preexisting system of roads and trails. New trail construction typically is required for short distances and for replacing existing trails exhibiting drainage problems or other difficulties. New trail construction provides recreational opportunity for hiking, mountain biking, scenery viewing, and horseback riding. Trail construction may require tree and vegetation removal, ground shaping, and geo-textile fabric and aggregate installation. All trail construction activities adhere to guidelines specified in the DoF BMPs.

Developed recreational or operational facilities will have limited or no harvest. Timber harvest will occur in these areas only to salvage timber, provide timber harvest management demonstrations, or in preparation for construction activities. Salvage activities will be directed toward trees that are diseased or damaged and cause a potential safety hazard or obstruct traffic, or to improve aesthetics. The major recreational areas on DoF lands that potentially may be impacted include Starve Hollow State Recreation Area and Deam Lake State Recreation Area**.** Some of the stands identified for treatment may be visible from roads or trails. Minimizing negative effects to the scenery especially around recreation areas will consistently be treated as a high priority. Portions of the treatment area would initially appear as a disturbed landscape, but would blend in during subsequent growing seasons.

Proposed actions would create some inconvenience and short-term disruption to customary recreational activities. Until treatments were completed, temporary road or area closures would displace recreational use to other areas. The indirect effects (dust, smoke, noise, trucks) of these activities would have short-term negative effects on recreational and travel experiences. Visible landings and skid trails would be restored to characteristic contours and re-vegetated as required after project completion. In one to three years the stands should appear less disturbed as regeneration proceeds. Eventually, woody debris and stumps would diminish as shrubs, hardwood trees, grass, and forbs increase in numbers.

The scale and intensity of the prescribed burn areas would dominate the scenery and may persist longer in areas that burn the hottest and where rehabilitation treatments may not have been effective. Smoke would be visible in the short-term during prescribed burns. A vegetative pattern, including many green sprouts and seedlings, would emerge in the next growing season after the prescribed burn. In one year the evidence of burning would be concealed by a flush of herbaceous plants.

Direct and Indirect Effects on Recreation and Aesthetics

The proposed action likely will reduce visual quality. Since a majority of the harvest with the proposed action is under single tree or group selection, effects on visual aesthetics would be lessened. Clearcutting and prescribed burning likely will have short-term impacts on nearby recreation areas. Properly designed harvest areas can have positive impacts on visual quality by opening views and creating vistas in an otherwise heavily forested landscape. Because the majority of the harvesting activities would occur away from public access areas, impacts on recreation and visual aesthetics would be minimized.

Cumulative Effects on Recreation and Aesthetics
Individually, each component of forest management activities contributes only a small portion to cumulative effects; however, the combination with all other reasonably foreseeable activities might result in a slight decrease in aesthetic value of the landscape. Repeated treatments over time will have no cumulative effect on recreation and aesthetics, because of the rapid regrowth following forest stand treatments.

There is potential for management activities conducted within the Project Area to combine with activities conducted beyond the borders of DoF lands to produce cumulative aesthetic effects. In addition, changes to the environment as a result of natural causes (wildfire, wind events such as tornadoes, insect and disease outbreaks, and landslides) may cause substantial changes in aesthetics but are not a result of implementing the alternatives.

Overall, the proposed action, in combination with other past, present, and reasonably foreseeable future actions, should not contribute greatly to adverse cumulative effects on recreation and aesthetics. Forest management under the proposed action could have long-term positive effects on aesthetic quality as forests maintain healthy, vigorous growth while maintaining existing species diversity.

4.8 Cultural and Unique Resources

Management of cultural resources on the system will not change with the implementation of the proposed action. All DoF management actions will continue to be referred to the DoF Historic Preservation Officer (HPO) for review. The HPO will determine if DoF management actions will affect known and unknown historic properties. All cultural heritage resources and unique ecological resources will be protected under applicable state and federal statutes. The DoF avoids impacts to all known significant sites. DoF will continue to comply with regulations in Indiana Code (IC 14-21) for cultural resources.

Direct and Indirect Effects on Cultural and Unique Resources
The DoF anticipates that any impacts to significant historic or unique resources will be avoided with implementation of the proposed action.

Cumulative Effects on Cultural and Unique Resources
No cumulative effects to significant historic or unique resources are expected with implementation of any of the alternatives.

4.9 Socioeconomic Environment

Demographics
The population of the State of Indiana in 2004 was 6,237,569, a 2.3 percent increase from population estimates in 2000 (IBRC 2005). Indiana's population growth has averaged 0.6 percent over the past five years as compared to the national level of 1 percent. The high-

est population growth occurred in Marion County. Nine of 92 counties in Indiana make up nearly 45 percent of the state's population.

Jobs and Income

In 2004, the per capita income (PCPI) in Indiana was $30,070, which ranked 34th in the nation and represented a 4.2 percent increase from 2003. The average annual growth rate of PCPI between 1990 and 2000 was 4.3 percent compared to 4.2 for the national average (U.S. Dept. of Commerce, Bureau of Economic Analysis 2004). The average job in Indiana gained $1,862 in 2003, $287 (18 percent) more than in the United States as a whole. Indiana has experienced an 8.7 percent increase in employment in the forestry sector (InContext 2005a). The Gross State Product (GSP) in 2004 was $208.4 billion, ranking the state 15th in the nation for total output, a position Indiana has held steadily for several years (InContext 2005b).

Agriculture and Manufacturing

Approximately three-quarters of the land in Indiana is used for agriculture. Agriculture and food processing are intrinsic parts of the state's economy, contributing $17 million annually and supporting 500,000 jobs (Indiana Land Resources Council 2003). Indiana ranks 9th overall in the nation for crop production. Corn and soybeans were the leading source of income for Indiana farmers in 2004 and amounted to $3.42 billion. Corn, soybeans, livestock production, dairy, and eggs accounted for over 90 percent of cash receipts in Indiana in 2004 (Indiana Agricultural Statistics Service 2005).

Heavy industry, also prominent in Indiana, is centered in larger cities, including Indianapolis, Evansville, Fort Wayne, Gary, Kokomo, South Bend, and Terre Haute. Indiana's leading manufacturing production includes iron and steel, electrical and transportation equipment, chemicals, and fabricated metals. Much of the limestone used in buildings throughout the United States is quarried in Indiana. Other mineral commodities include crushed stone, cement, sand, and gravel.

Forestry Products

Approximately 20 percent of Indiana is forested. Of Indiana's nearly 23 million acres, 4.5 million are forested. Most forests are located in the southern half of the state, south of Indianapolis. Approximately 537,000 acres of Indiana forest land are publicly owned: 196,000 acres are held in national forests; 150,000 are in state forests and 191,000 are in other public ownerships, including military bases, fish and wildlife areas and state parks (Petersen 1998). For monitoring purposes, state and federal agencies group Indiana's forests into four Survey Units: Knobs, Northern, Lower Wabash and Upland Flats. Perry, Harrison, Brown and Orange counties (Knobs Unit); and Martin County (Lower Wabash Unit), are the state's most heavily forested counties. Each is more than 50 percent forested. At 1.7 million acres, the Knobs Unit is the largest, and it holds 45 percent of all growing stock volume in the state. Together, the Knobs Unit, the 900,000-acre Lower Wabash Unit and the 600,000-acre Upland Flats Unit contain 74 percent of the state's timberland (Petersen 1998).

Indiana forest products industry is the 6th largest employer in Indiana (Purdue University through data from Census of Manufacturers). Indiana forest products industries employ more than 56,000 people, with most of the industry concentrated in the southern half of the state (Petersen 1998). Forest products manufacturing is a $2.55 billion a year industry in Indiana (Petersen 1998). Of 56,000 people working in Indiana's timber industry, almost 86 percent work for secondary manufacturers, including furniture and cabinet makers and companies that manufacture flooring, doors, window frames, millwork, pallets and hundreds of other structural and decorative products made from hardwood. Indiana ranks 18th nationally in value added for all forest-based manufacturing industries and 1st nationally in value-added manufacturing for both wood products and manufactured office furniture. Indiana's economy is diverse and growing rapidly, but many southern counties are more than 50 percent dependent on revenues and wages generated by forest products manufacturers (Petersen 1998). The 1997 Economic Census data determined there were 205 primary mills and 926 secondary manufacturing facilities in Indiana. Primary mills are those mills that use logs as their primary raw material to produce various forest products. Secondary manufacturing refers to the drying, cutting, and assembly of lumber and other wood-based primary products into parts and finished products.

State Forests

The state forests initially were created to restore eroded, worn-out land after small subsistence farms were abandoned early in the century. Early state forest management focused on reforesting eroded areas, creating wildlife habitat, demonstrating good forest land management, providing public recreation, and conserving forest resources. Today, the state forests are managed for multiple uses and benefits. Income from timber sales on state forest lands represents a small but growing portion of annual revenues for the Division of Forestry. From 2003 to 2004, nearly 2,500 acres of forest were harvested with over 3.4 million board feet sold, generating revenue of $897,313 (IDNR 2005). In 2005 (the last year before implementation of the 2005-2007 Strategic Plan), total sales were 3.6 million board feet generating $975,388. Fifteen percent of state forest timber sale revenue is returned to the counties in which the harvest occurred. The DoF Strategic Plan 2005-2007 proposed to increase revenue from state forest timber sales to $3 million to $5 million annually by increasing harvest on state forest lands to 10 to 17 million board feet (IDNR 2005). Volume sold and revenue received since implementation of the 2005-2007 strategic plan have increased. In 2005-06 (first year following implementation of the plan) the volume sold was 7.7 million board feet generating $1,979,459; the 2006-07 volume sold was 10.3 million board feet generating $2,669,179. The goals for 2007-08 call for a volume sold of 12 million board feet which is expected to generate $3.2 million in total revenue. The average annual growth on state forests is 24,788,950 board feet, so harvest levels specified in the 2005-2007 Strategic Plan represented an annual harvest of about 40 – 69 percent of annual growth. Seventeen percent of the revenue from the increased timber sales goes into a cost-share assistance program to enhance the management of private forest lands, 15 percent to the counties, and the remaining 68 percent is used for reinvestment, research, acquisition of land and improvement of state forests and preserves (IDNR 2005).

The 2005-2007 Division of Forestry Strategic Plan was replaced by the IDNR Division of Forestry Strategic Plan 2008-2013, which was released April 1, 2008, and is available on the DoF pages of the DNR web site at www.in.gov/dnr/files/fo-Forestry-Strategic-Plan-2008-2013.Final.pdf. This plan calls for an annual harvest limit of 60 percent of growth which is estimated to be 14 million board feet. This volume harvested is expected to generate $3.6 million in total annual revenue.

Table 4 shows the estimated timber value on each state forest. Combined, Morgan-Monroe and Yellowwood have the highest property value, comprising 40 percent of the total value. Harrison-Crawford, Clark and Jackson- Washington State Forest contribute another 35 percent.

Table 4. Estimated Sawtimber and Veneer Value by DNR/DoF Property (System-Wide Inventory 2005).

State Forest	Average $/BdFt*	Total Value
Harrison-Crawford	$0.19	$31,703,280
Greene-Sullivan	$0.10	$2,923,380
Morgan-Monroe	$0.21	$45,960,240
Yellowwood	$0.19	$45,380,450
Selmier	$0.16	$620,350
Salamonie	$0.19	$1,183,599
Clark	$0.19	$34,197,500
Pike	$0.24	$6,892,726
Owen-Putnam	$0.18	$9,696,078
Jackson-Washington	$0.17	$24,734,320
Martin	$0.21	$12,754,480
Ferdinand	$0.15	$9,293,360
	TOTAL	**$225,339,763**

*Average $/BdFt for each property was calculated using Hoover's 2004 survey of average stumpage prices per species, multiplied by the total sawtimber and veneer volume/acre by each species, then summed the total per acre value of all species and divided by total sawtimber and veneer volume/acre/property. (Note: This value/BdFt is significantly lower than the average bid price received for timber marked for harvest because it includes all species and all trees > 11" DBH)

The average revenue generated by sale of timber between 1994 and 2004 was $736,372 per year. The DNR increased timber sale volume on state forests by 50 percent in 2006, 150 percent in 2007, and a proposed 300 percent in 2008. Every dollar of timber value sold generates approximately $10.25 in additional direct revenue into the Indiana economy. Before 2005, DoF sold approximately $1,000,000 of standing timber. Increasing that to $4,000,000 added an additional $30,750,000 annually into Indiana's economy (IDNR 2005).

Direct and Indirect Effects on the Socioeconomic Environment
The DoF anticipates no negative impacts to Indiana's economic environment will occur as a result of this proposed action. Maintaining a sustainable, healthy forest will have a long-term positive impact on the state's economy.

Cumulative Effects on the Economic Environment
Maintenance of a sustainable flow of timber products will have a positive impact on the wood-using industry. The continuance of a healthy wood-using industry is expected to have a positive impact on the economics of private land forest management. The maintenance of oak-hickory dominated forests will have a long-term positive impact on the economic environment.

4.10 Adverse Environmental Effects Which Cannot Be Avoided

Soil and Water Quality
Some loss of productive soil could occur with the proposed action, but long-term productivity will not be affected. Design features associated with road construction and reconstruction, timber harvest, and burning activities would minimize accelerated erosion and other detrimental effects. Implementation of BMPs would minimize impacts to soils. Some direct, immeasurable input of sediment into streams would be expected and unavoidable in the short term, but sediment entering streams is expected to be extremely small and should not be noticed.

Wildlife
The proposed action potentially could result in adverse impacts on individual animals within the Project Area. Even though these alternatives would provide potential positive impacts to numerous species, some individuals could experience negative impacts, but not enough to affect populations. The proposed action is not expected to contribute to a trend towards federal listing or loss of viability to any population or species.

Vegetation
Although the proposed action overall would have potential positive impacts to species of concern, some individuals could experience negative impacts, but not enough to affect populations. The proposed action is not expected to contribute to a trend toward federal listing or loss of viability to any population or species. The proposed action may result in an increased risk of establishment and spread of non-native invasive species. Implementation of BMPs and mitigation measures would however minimize this impact.

The primary objective of this treatment is to sustain oak and hickory forest in the long term. It is possible oak and hickory will not regenerate at the expected level.

Air Quality
With the proposed action, smoke from prescribed burning of activity-created fuels, dust, and vehicle emissions temporarily would degrade air quality in the Project Area. It is, however, unlikely these activities would create any health or safety concerns. Emission levels would be below EPA-established standards.

4.11 Irreversible and Irretrievable Commitments of Resources

Irreversible effects are defined as those effects resulting from a proposed activity that cannot be reversed or regained within a reasonable period of time as perceived from a human time scale. Irretrievable effects are those effects caused by proposed activities that change outputs, benefits, or commodities. Irretrievable commitment represents trade-offs (opportunities foregone) in the use and management of forest resources. Irretrievable commitment of resources can include the expenditure of funds, loss of production, or restrictions on resource use.

Soil productivity would experience temporary irretrievable effects as a result of timber harvest (construction and use of temporary roads and log landings) applied to the DoF system. Aesthetics on state forest properties would also experience temporary irretrievable effects as a result of timber harvest activities.

There would be no irreversible effects or irretrievable commitment resulting from implementation of the proposed action.

5.0 List of Preparers

This document was prepared by the following staff of the Division of Forestry:

Name	Title	Educational Background	Years of Experience
Carl Hauser	Property Program Specialist	BS Forest Management MS Biology Certified Forester	35
Scott Haulton	Forest Wildlife Specialist	BS Forest and Environmental Biology MS Wildlife Science	12

Portions of the text of this document were taken from the *Draft Environmental Impact Statement and Habitat Conservation Plan for the Federally Endangered Indiana and Gray Bat*. That document was prepared by Environmental Solutions and Innovations, Inc under contract with the Division of Forestry.

6.0 Consultation and Coordination with the Public and Others

This document was prepared by IDNR Division of Forestry staff. Drafts were reviewed by staff from the following agencies:

IDNR Administration
IDNR Division of Fish and Wildlife
IDNR Division of Nature Preserves
INDR Division of Water
IDNR Division of Historic Protection and Archaeology
Indiana Department of Environmental Management (IDEM)

Following review and consultation with the above agencies, the document was edited as necessary before posting for public review and comment on the DNR web site. The document was posted on May 8, 2008 with a comment period extended through July 15, 2008. The availability of the review draft was announced via statewide news release and approximately 90 key stakeholders were notified by direct mail or email.

7.0 Public Comments and Responses

A total of 75 respondents provided comment on the DoF Draft Environmental Assessment; additionally, 160 copies of a single form letter were received. DoF staff reviewed each comment and incorporated those comments into the final draft to the extent possible. A copy of each comment is on file in the Division of Forestry. Comments were categorized by topic and summarized in Table 5 below. A list of respondents is shown in Table 6.

Table 5. Comments received and DoF response

Topic/Comment	Respondents	DoF Response
General		
I'm concerned about forest health, productivity, integrity; I believe in good forest stewardship	1,5,6,12,15, 22,27,52,72	We agree. A central tenet of forest stewardship is concern for forest health and productivity. We believe the certification we've received from Sustainable Forest Initiative (SFI) and Forest Stewardship Council (FSC) reflects our ongoing commitment to these principles and exemplary professionalism.
Proper forest management vital to forest health	72	
Forest management should be done by trained professionals not special interest extremists	8,14,56,66	
DoF should be commended for seeking SFI/FSC certification	67	
Consider more public education regarding vegetation/habitat management; more outreach/education	45,54	Although a detailed analysis of our education/outreach program is beyond the scope of the current environmental assessment, we recognize the state forests have a valuable role in demonstrating good forest stewardship and best management practices to the public. We will continue to seek opportunities to improve outreach as much as available resources allow.
Miscellaneous technical comment; typographical error	40,58,67,68,71	These were addressed appropriately throughout the text of the final draft.

General EA Structure/Content; DoF Categorical Exemption		
The DoF EA is based on sustainability; DoF should continue sustainable forestry	1,27, 63,64,67	The purpose of the EA is to identify and evaluate potential environmental impacts from the DoF timber management program on state forests. A fundamental question in this assessment is how the proposed program and activities would impact forest sustainability. We believe we have thoroughly addressed this concern throughout the entirety of the assessment, though most directly in Section 1.4.
The DoF EA represents sound forest stewardship	1,12,14	
The DoF EA rightly uses science-based forest management; science/research important	4,9,12, 55,63,67,70	
Activities described in EA are not sustainable and do not support healthy forests; long-term effects inevitable	11,36,37	
Environmental impact statement needed on proposed harvest levels	11,21,31, 44,47,73	IC 13-12-4 addresses policy relating to the need for an environmental impact statement. The DoF is exempt from the requirements of IC 13-12-4 by IC 14-23-4-1(b); however, the current assessment was developed voluntarily in a good faith effort to understand any potential environmental impacts of the proposed timber management program.
"Industrial forestry" should not be exempt from environmental laws; no categorical exemption	20,21,22	
DoF's categorical exemption is "shameful"	22	
DoF should abide by Indiana Environmental Policy Act	43,44,47,73	
Plan represents reversal of DoF's conservation policies; keep logging at current levels	28,29,74	This environmental assessment itself is not a plan, rather it evaluates the DoF timber program outlined in its most recent Strategic Plan.
Change management alternative to "caretaker status"	20,46,68,71	We believe this has been addressed adequately in section 2.2.2.1 of the final EA.
Does DoF's categorical exemption cover agricultural activity, too?	40	Agricultural land management is addressed briefly in the EA. We are unaware of any applicable exemption.
Thanks for providing opportunity for public comment; public review opportunity is commendable	45,32,20,1, 46,55,54,58	Public review and comment is an integral part of this process; we appreciate the input we received and the interest shown.

Multiple-use and Ecosystem Services (carbon sequestration, water, soil, air, etc.)		
The DoF's EA demonstrates delivery of multiple ecosystem services; multiple-use	1	The DoF addressed multiple use (timber, recreation, wildlife habitat, endangered species, cultural resources), water quality, soils, carbon sequestration, effect on global climate change in this assessment. All state forest timber harvests are evaluated for BMP implementation and effectiveness. We realize that forests provide ecosystem services (clean air, water); the EA addresses the effects on these services.
Forest management has negative effects on water quality	11,38	
State forests should be managed for multiple-use	11,18,20,22	
Logging on state forests reduces/eliminates ecosystem services	17,18,20, 22,4, 68,71	
Logging equipment impacts soils; impairs water quality	18,3, 68,71	
DoF is not planning for multiple-use, just oak-hickory harvests to create "oak farms"	20,21,46,73	
Forests are needed to cleanse air/water; forests provide ecosystem services	34,20,47, 50, 6, 68, 71	
Need to consider monitoring BMP's for effectiveness	45,68, 71	
Consider carbon sequestration	68, 71	
Non-Native Invasive Species		
I'm concerned about invasive species – can these be adequately addressed by DoF?	1,25,68,71	Non-native invasive species constitute one of the greatest (arguably the greatest) threat to Indiana forests. DoF routinely inventories these species before canopy removal and control efforts are initiated as needed. The current draft EA summarizes the DoF level of concern and management of non-native invasive species. Ash trees are under the threat of Emerald ash borer, a non-native invasive insect species. This is a major concern but beyond the scope of this document.
Invasive species are not adequately considered; improve section describing invasive species control	18,20,21,31, 37,44,47,58, 68,71,73	
Logging roads and openings can create corridors for invasive species	18,30, 58,68,71	
No mention of the "impending danger to the ash trees"	22	
Inventory and manage invasive species before canopy removal	32	
Managing for invasive species is important	45,58,68,71	
Cultural		
Please advise Prairie Band Potawatomi Nation on the discovery of historic cultural resources	2	The DoF will continue to consult with the Prairie Band Potawatomi Nation as well as other interested Native American Nations
Recreation		
Forest management has negative effects on recreation	11,68,71	True, any land management activity has both positive and negative effect on a number of values and potential uses. The EA addresses those negative effects.

Global Warming/Climate Change		
No discussion on climate change/global warming	20,22,30, 31,46,68,71	Text was added to the EA to summarize the effect of the proposed treatment on carbon sequestration rates and climate change and the monitoring efforts underway to increase our understanding of carbon flux. No action suggested in this EA is expected to reduce habitat connectivity or plants' ability to migrate.
Should not harvest forests before understanding climate change; monitor climate change	31	
Provide for migration of plants due to global warming	48	
Wildlife Habitat, Biodiversity, Endangered Species		
Suitable habitat should be available for all forest species; biodiversity important	3,4,5,8,12,13, 22,27,52, 54,55,56, 64,67,69,70	Hundreds of wildlife species use Indiana's state forests, and each has unique habitat requirements. The DoF seeks to promote native faunal biodiversity and suitable forest habitat conditions throughout the state forest system. Habitat management occurs primarily (though not exclusively) through the careful employment of various timber harvesting methods and related activities. The 2008-2013 DoF Strategic Plan identifies the goal of "work[ing] toward a long term balance in forest stand ages and structure with 10 percent of forest acreage in or developing older forest conditions (nature preserves and high conservation forests) as well as 10 percent in early successional forests (0-20 years old). We believe this environmental assessment adequately addresses the impacts of the program goals described in the Strategic Plan.
Need more ruffed grouse habitat; habitat for early-successional wildlife	3,54,63,64,69	
Wildlife depend on old growth; forests provide wildlife habitat	33,34	
DoF's EA rightly considers need for early successional habitat and wildlife	3,5,8,10,39,54, 58,63,67,69	
Amount of early successional forest adequate, need more old forest	68,71	
Use a variety of harvest methods to address variety of habitat needs	54,55,70	
Forest management can be good for wildlife; can improve forest health; important to wildlife	6,7,10,15, 27,30,35,39,54, 55,63,64,65,67, 68,70,71,75	The EA details possible threats and benefits to wildlife and plant species relative to forest management. Additionally, an assessment of long- and short-term impacts has been made for these species, based on available expert information and published literature. While the DoF believes there is adequate information available on which to base our current assessment, additional research and information will be evaluated continually and integrated into the forest management program where appropriate. Please refer to section 1.6 for more information on DoF commitment to monitoring and research.
Forest management has/can have negative effects on wildlife	11,38,68,71	
More research is needed on the effects of forest management on wildlife	36	

Forest fragmentation is bad for wildlife; EA fails to consider further forest fragmentation	36,41,71	The DoF agrees that habitat fragmentation and loss through forest conversion to non-forest uses are among the primary threats facing forest habitats and the species that depend on them. Recognizing this, these issues are reviewed and addressed throughout Section 4.0 of the EA, though most extensively in Section 4.3. The DoF seeks to improve the availability and continuity of forest cover throughout Indiana by supporting an aggressive land acquisition program. We agree with experts who say the best way to combat forest fragmentation and wholesale deforestation is through a long-term commitment to the avoidance of forest conversion to non-forest uses. Though the DoF believes its practices do not significantly contribute to the overall fragmentation issue, we will continue to regularly evaluate our forest management program and work to minimize habitat fragmentation threats that may occur.
Forest openings increase brood parasitism and forest fragmentation; too much fragmentation already	30	
Forest conversion to other uses biggest threat, support land acquisition	67	
Deforestation/timber extraction is among top threats listed in nation-wide American Bird Conservancy assessment	36	
Can more than 300 acres of wildlife opening management occur annually statewide?	40	Permanent wildlife habitat openings are maintained by the Division of Fish and Wildlife, and the level of management is dependent on resource availability in any given year. Based on past levels of management, this level seemed an appropriate annual approximation over the next 20 years.
Consider reintroduction of cougars and gray wolves	58,67	The Division of Fish and Wildlife is responsible for the regulation of wildlife populations, and the Division of Nature Preserves is responsible for documenting ecologically unique areas and rare species. Whenever possible, the DoF cooperates with DFW and DNP in the facilitation of surveys, natural area designation, hunter access opportunities, and habitat management. DoF personnel regularly submit observations of listed species to Division of Nature Preserves for inclusion in Indiana's Natural Heritage Database. These data are an essential part of our tract-level review prior to each management decision (see EA Section 1.6.5 for more information).
Consider deer management	68,71	
Surveys for endangered species inadequate; listed species occur on more than just Nature Preserves	20,37,68,71	

Logging practices should not hurt endangered species	3,11,71	As a responsible forest steward, the DoF takes conservation of endangered, threatened, rare, and otherwise "special concern" species seriously. To identify potential habitat for listed species, a review of the state's Natural Heritage Database is made well in advance of each timber harvest. Though historic observations do not necessarily reflect current habitat suitability, DoF personnel err on the side of caution and design appropriate management activities that assume the species and/or habitat still exists at the site. The DoF is unaware of specific "state permits" or "HCPs" it is in need of submitting, though presently we are voluntarily developing a Habitat Conservation Plan (HCP) and Draft Environmental Impact Statement with the U.S. Fish and Wildlife Service for the federally endangered Indiana and gray bats (see EA Section 4.2 for more information).
Why put special regulations in place to protect listed species when they're not "known" to exist there?	40	
DoF is not conforming to Indiana's state endangered species act; DoF needs state permits and HCPs	17,20,21, 31,47,71	
The Indiana bat and migratory birds need intact forests; large intact forests are rare	11,18, 28,36, 38,48,68,71	Large, intact forests are indeed important to many species. The DoF focuses land acquisition on parcels that will increase forest continuity and overall forest block size. The Indiana bat is a forest species that often uses open areas and edges for foraging – see a review of this species and associated supporting literature citations in section 4.2. As described in that section, the DoF currently has guidelines in place that address Indiana bat habitat conservation and is working with the U.S. Fish and Wildlife Service to develop an appropriate Habitat Conservation Plan for this species.
Indiana bat habitat not adequately protected; how will harvesting affect it (and other bats)?; logging will remove trees needed for roosting	21,30,31, 37,47,71,73	
No scientific basis for claim of no-effect on endangered/listed species; short- or long-term effects seem inevitable	20,21, 24,40,71	Sections pertaining to listed species and potential impacts (i.e. Section 4.0) include scores of citations that refer to the information sources listed in the "Literature Cited" portion of the EA. Much of this information was obtained from professional science journals that require rigorous peer-review of article submissions. Other sources include personal communication from appropriate experts and specialists in their field who are also familiar with local conditions. We believe the accumulated documentation supports the inferences and conclusions that have been drawn.

Indiana bat not adequately managed because no HCP in place; no studies of cumulative effect	20,44,71	The DoF is presently working with the U.S. Fish and Wildlife Service (USFWS), the agency responsible for federally endangered species, on the development of a Habitat Conservation Plan (HCP) for the Indiana bat. In addition to this plan, the DoF has had guidelines in place for the conservation of the Indiana bat and its habitat, including some that have been developed in cooperation with USFWS. As detailed in Section 4.2, impact assessment for the Indiana bat was based on an integration of current guidelines and aspects of the present management strategy, as well as the anticipated additional benefits provided by the HCP, when it is completed. Monitoring and adaptive management procedures will be developed with guidance from USFWS and incorporated into the HCP to effectively and appropriately evaluate cumulative effects.
Is Indiana bat assessment based on current "interim" guidelines/strategy or what DoF thinks the HCP will require?	40	
'White-nose syndrome' not discussed for Indiana bat	20	Presently "white-nose syndrome" is confined to bat hibernacula found throughout the northeastern United States. To date, no cases have been detected in Indiana or surrounding states. Present understanding of the syndrome is that it affects bats while in hibernacula. The USFWS is responsible for management of the Indiana bat and will develop guidance relating to the syndrome when it deems necessary.
Logging only during winter to protect summer Indiana bat habitat near hibernacula increases soil/BMP problems	40	Current interim guidelines effective for some portions of state forest restrict timber harvesting to the period when Indiana bats are not active outside hibernacula. In areas affected by the guidelines, DoF also adheres to the same rigorous BMP standards that are practiced on unaffected state forest property, and as such soil and water related problems should be effectively minimized and/or mitigated if they occur. The DoF believes both Indiana bat habitat conservation and BMP standards can be achieved simultaneously under the current forest management guidelines. We have forwarded this comment to the DoF BMP specialist and will address specific BMP-related issues if they occur.
Is Division of Fish and Wildlife consultation necessary for stream crossings where hellbenders may occur?	40	Hellbenders are endangered in Indiana with an extremely limited and localized distribution in the state. DFW closely monitors hellbender populations and consequently has a unique understanding of its local population distribution and site occupancy. It is anticipated this unique consultation agreement will result in a coordinated effort to develop effective stream crossings that are not detrimental to local hellbender populations.

Why “no” on EA form question 2…aren’t rare species “unique”?	40	The form provided to the DoF to complete defines”unique” as “not found in another parts [sic] of the state or nation.” As indicated in the DoF’s written response to that question on the form, species that occur on state forests also occur at other locations outside of the state forests. This is true even for species that are rare.
Economics		
Money from logging should support forest management, not profit; increased harvest is based on greed	3,27,37,43	The 2008-2013 Division of Forestry Strategic Plan summarizes the use of funds from timber harvests.
Public lands should be managed for the greatest good, not logging to “maximize profits for timber industry”	18,20,21,22, 31,36,42,44,46, 47,49,50,68,71	The alternative to maximize profits and/or liquidate forests was rejected, see section 2.0 for more information. The proposed action will sustain current forest acreage and allow for increased volume in future stands.
We shouldn’t liquidate forests when timber prices are low	19	
Discussion of economics/ecosystem services not adequate	20,22,68,71	The EA details possible threats and benefits to wildlife and plant species relative to forest management. Additionally, an assessment of long- and short-term impacts has been made for these species, based on available expert information and published literature. Given the intended focus of this document, the DoF believes the topics of economics and ecosystem services have been covered adequately and appropriately in sections 4.6 and 4.8 of the final version of the EA.
No citation for the claim that timber sales provide $30,750,000 to the Indiana economy	20	The citation “(IDNR 2005)” refers to “(IDNR) Indiana Department of Natural Resources, Division of Forestry. 2005. IDNR, Division of Forestry Strategic Plan 2005-07. Available: www.in.gov/dnr/2005ForestryPlan.html. Accessed 31 May 2006.”
DoF activities benefit timber industry, harvesting oaks for maximum value/revenue	22,24,31	True, timber is sold to members of the timber industry, selected by the highest qualified bid.
The average $270 MBF received for bid sale appears to be below market; timber sales operating at net loss?	25,68,71	DoF keeps accurate cost records for each timber sale. Sales rarely result in a net loss. The average bid for state forest timber may be below statewide average for a number of reasons described in the EA (require BMP mitigation, rigorous oversight, contract and payment requirements, to name a few.)

Could more timber revenue money go to TSI or invasive species management?	45	These issues are addressed in the DoF strategic plan.
Natural resource management important; needed for construction material and alternative fuel source	63,65	We agree.
Plan will not create jobs	73	The level of timber harvesting, TSI, monitoring, non-native invasive species control suggested in this EA will create jobs. The volume sold from state forests contributes only 3 percent of the statewide timber volume and should have little effect statewide.
State forest logging drives down prices for lumber from privately-owned forests	73	
Oak-Hickory Management and Regeneration		
Research inconclusive on oak-hickory regeneration; data “cherry-picked”; no scientific basis	11,17,20,22,31	Section 1.4 has been expanded in the final EA to provide a more detailed description of the justification for the proposed action. This expanded section includes more published expert opinion on regional oak regeneration failure and the challenges facing the perpetuation of the oak-hickory forest type. This section also includes more information specific to Indiana and our state forests on the historic aspect of oak-hickory and justification for our concern that this forest type is unsustainable without management. An extensive amount of research and published expert opinion has been cited, much of it based on articles reported in widely accepted professional journals that require peer-review of submissions. While DoF believes there is adequate information available on which to base our justification for the proposed action and management activities, additional research and information will be evaluated continually and integrated into the forest management program where appropriate. See section 1.6 for more information on the DoF commitment to monitoring and research.
More research is needed on regeneration	11	
Clearcutting does not mimic natural disturbance	20,40,71	
If there’s an oak decline, why is oak-hickory volume/forests increasing in Indiana?	20,37	
Burning and clearcutting will not help oak-hickory regeneration; makes no sense; unjustified	20,21,24,26, 37,43,47,68,71	
More prescribed burning/understory management needed for oak-hickory regeneration; pre-treatment important to encourage regeneration	32,40,58,67	
Oak-hickory is not climax forest - why maintain?	68,71	
Thin out maple trees to cultivate more oak; more beech-maple understory management needed	22,25,40,52	
I/we support management for sustainable oak-hickory communities; perpetuating OH is important	25,45, 55,58,67	

Why not maintain or increase OH levels at/above 49 percent?	32	The best available information is that 49 percent of state forest acres are oak-hickory forest type. A long term objective in the 2008-2013 strategic plan is to keep the current level of oak hickory dominated forests, plus or minus 10 percent.
More details are needed on salvage harvesting	68,71	Salvage harvesting will be directed toward diseased or damaged trees; the specific treatment used to address salvage needs will follow the treatments described in Section 1.5.1. Acreage of salvage treatment are included.
Prescribed Burning		
Burning forests has a major effect on the health of people and wildlife	20,21,37,44, 47,68,71,73	These issues were addressed in the final draft.
Burning sends CO_2 into atmosphere; cutting down forests releases greenhouse gases	20,31,61	
Provide more information on how fire prepares/improves understory for oak regeneration	58	
Forest Preservation vs. Management		
State forests should be preserved to balance historic deforestation; support preservation	11,22,30,61	Other divisions within DNR manage land without the use of timber harvests; DoF is the only division that routinely uses timber harvests to achieve objectives. DNR recognizes the wide range of opinions about forest management among Indiana's residents.
There should be no logging on public lands; stop logging	16,17,30,31, 46,48,61	
The public is against logging	17,41,47,59	
Logging SF is not sound forest stewardship	17	
I am opposed to/concerned about increased logging, clearcutting, and burning	21,23,30,51,52, 57,59,60,62,68,71	
The DoF should protect forest; large old forest tracts are important; public land scarce; "public land is for the public"; more old growth	23,27,29,31,33, 36,47,68,71,73	
Forest management on public lands is important; long-term planning and commitment is important	63	

No need to manage forests with timber harvesting, natural disturbances make early-successional habitat	68,71	While some major natural disturbance events are still effective in creating early successional forest patches (e.g., wind), other major landscape-scale disturbances are now regularly suppressed, such as fire and pest outbreaks. These lost historic disturbance regimes were instrumental in the regeneration of oak-hickory forests. Reduction or elimination of major, landscape-scale disturbance regimes has subsequently affected the development of suitable early successional forest patches and openings within larger mature forest blocks. While the proposed management activities won't fully replace landscape scale fires or insect outbreaks as disturbance agents, they are effective in creating the early successional conditions necessary for oak-hickory regeneration and suitable habitat for disturbance-dependant wildlife species. Please refer to section 1.4 for more information on the role of disturbance in oak-hickory forests.
Plan inconsistent with DNR policy to leave forests for future generations	73	We believe the plan adequately addresses the sustainability of state forests, and details the actions needed to sustain the current distribution of forest types and creating a sustainable size/age class distribution.

Table 6. List of Respondents

Respondent #	First Name	Last Name	Stated Affiliation
1	Ray	Chattin	IASWCD
2	Linda	Yazzie	Prairie Band Potawatomi Nation
3	Jerry D.	Coats	
4	Kris	Kehoe	
5	Jim	Huxford	
6	Anthony	Oliver	
7	Trent	Marsh	
8	Greg	Spurgeon	
9	Keith	Snyder	
10	Andrew	Hauke	
11	Mary Kay	Rothert	
12	Keith A.	Dutton	
13	Art	Spancake	
14	Chad	Dunscombe	
15	Mac	Moulden	
16	David	Stewart	
17	Samuel	Klawitter	
18	Lucille	Bertuccio	
19	Kent	Wilson	
20	Kristi	Hanson	
21	Rock	Emmert	
22	David	Haberman	
23	Linda	Greene	
24	Donna	Thiele	
25	Jennifer L.	Boyle	IASWCD
26	Mary	Clinton	
27	Alan	Smock	
28	Lana	Eisenberg	
29	Charles	Eisenberg	
30	Gillian	Harris	
31	Thomas R.	Tokarski	
32	Dan	McGukin	Indiana Chapter of The Wildlife Society
33	C. J.	Penhorwood	
34	Iris	Wood	
35	Rodney	Deroo	
36	Dawn	Hewitt	
37	Terrie	Usrey	
38	Susan	Bassett	

39	Greg	Russell	
40	Wayne	Werne	
41	Andy/Linda	Mahler/Lee	
42	Magie	Read	
43	Carol	Beauregard	
44	Marian	Cooley	
45	Kenneth G.	Day	Hoosier National Forest
46	Cynthia	Bretheim	
47	William A.	Boyd	
48	Nathan	Pate	
49	Allison	Strang	
50	Cyndthi R.	Hall	
51	Tonya	McCray	
52	Barbara	Tuley	
53	Amy		
54	Dan	Dessecker	Ruffed Grouse Society
55	Randy/Steve	Showalter/Gage	National Wild Turkey Federation
56	Tonya & Chris	Cobb	
57	Don	Scheiber	
58	Alan	Pursell	The Nature Conservancy, Indiana
59	Clarke & Mary	Brennan-Miller	
61	Jeanne	Melchoir	
62	Katherine	Hicks	
63	Lenny D.	Farlee	
64	Matt	Senesac	
65	Dan	Felix	
66	Dennis	Wendel	
67	Rob	Swihart	
68	Forest	Gras	
69	John	Goss	Indiana Wildlife Federation
70	Brian	MacGowan	
71	Christine	Glaser	Indiana Forest Alliance
72	Kevin	Ailes	
73	James	Todd	
74	Michael	Hendrix	
75	Rick		

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APPENDIX A: Floral and faunal species that have been documented on DoF properties and are included on Indiana's lists of Species of Greatest Conservation Need are shown in the following tables, 1-6.

TABLE 1. Amphibians and reptiles of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties	Communities	Habitat	Major Threats
SE	Hellbender	Cryptobranchus alleganiensis alleganiensis	Harrison-Crawford SF	riverine	rocky, cool, fast-moving streams and rivers; submerged logs	habitat degradation/destruction; environmental contamination; illegal collection
SE	Kirtland's Snake	Clonophis kirtlandii	Yellowwood SF	grasslands, open land, palustrine	wet meadows, sparsely wooded grasslands and associated open woodlands, seasonal marshes; areas with abundant cover objects and ground debris	habitat loss and degradation (development, prairie and grassland conversion to agriculture, succession)
SE	Timber Rattlesnake	Crotalus horridus	Yellowwood SF, Jackson-Washington SF, Morgan-Monroe SF	forest	dry forest and woodlands, rocky hillsides, upland ledges, and ridges	habitat loss and degradation, especially development; collecting and unregulated harvesting; incompatible forest management
SE	Smooth Green Snake	Opheodrys vernalis	Yellowwood SF	open land, palustrine	wet meadows, grassy marshes, wet grassy forest edges	habitat loss and degradation, succession
SSC	Rough Green Snake	Opheodrys aestivus	Clark SF	open land, palustrine, forest	dense vegetation near water, forest edges or open forest, thickets, old field, wet meadow or prairie	habitat loss and degradation (deforestation); environmental contaminants
SSC	Eastern box turtle	Terrapene carolina	All SF (Z. Walker, IDNR pers. comm. 2008)	forest, open land	upland woodlands and forests, forest edges, wet meadows	habitat loss and degradation (deforestation); fragmentation; collection for pet trade

[a] Indiana Designation: SE = endangered, SSC = special concern; Federal Designation: FE = endangered

TABLE 2. Mammals of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties	Communities	Habitat	Major Threats
SE,FE	Gray Bat	Myotis grisescens	Harrison-Crawford SF	subterranean, forest	caves, mines; females and young often use forested areas near cave entrances during summer	human disturbance in subterranean habitats
SE,FE	Indiana Bat	Myotis sodalis	Clark SF, Harrison-Crawford SF, Jackson-Washington SF, Morgan-Monroe SF, Yellowwood SF	subterranean, forest	winters in caves, mines, or similar areas; in summer roosts in hollow trees or under loose bark in open forest situations or near edges; during fall males use forested areas near caves for roosting	human disturbance in subterranean habitats; loss and degradation of summer habitat (development, deforestation, incompatible forest management, stream impoundment and channelization)
SE	Eastern Woodrat	Neotoma magister	Harrison-Crawford SF	cliffs, talus/scree, subterranean, forest	rock crags and outcrops, talus slopes, steep forested slopes, cave or mine entrances	habitat loss and degradation (conversion of hardwoods to pine plantations, development, fire suppression); predation and parasites
SE	Evening Bat	Nycticeius humeralis	Jackson-Washington SF	forest	Roosts in hollow trees or under loose bark in open upland and floodplain forests, rarely uses subterranean habitat	habitat loss and degradation (loss of forested wetlands to agriculture)
SSC	Bobcat	Lynx rufus	Yellowwood SF, Clark SF, Harrison-Crawford SF, Morgan-Monroe SF	forest	large tracts or deciduous, coniferous, or mixed woodlands and forests, bottomland forest, forest-wetland edges; dens in rock shelter, hollow logs, or under large fallen tree	excessive harvesting; development and forest conversion to agriculture
SSC	American Badger	Taxidea taxus	Morgan-Monroe SF	open areas	grassland and cropland hedgerows, old field with scattered woody cover	cultivation of grasslands, agriculture intensification; excessive trapping or poisoning

[a] Indiana Designation: SE = endangered, SSC = special concern; Federal Designation: FE = endangered

TABLE 3. Birds of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties	Communities	Habitat	Major Threats
SE	Henslow's Sparrow	Ammodramus henslowii	Morgan-Monroe SF, Greene-Sullivan SF	grasslands, open lands	dense grasslands with little or no woody vegetation	Habitat degradation/destruction due to siltation, impoundment
SE	Northern Harrier	Circus cyaneus	Salamonie River SF	grassland, open land	marshes, grasslands, old fields	Habitat degradation/destruction due to reforestation, development, wetland loss
SE	Cerulean Warbler	Dendroica cerulea	Yellowwood SF, Ferdinand SF, Morgan-Monroe SF, Salamonie River SF	forest	mature, open and semi-open hardwood forest, with or without canopy gaps; upland and bottomland forest	Loss of wintering and breeding habitat (deforestation); cowbird brood parasitism
SE	Least Bittern	Ixobrychus exilis	Salamonie River SF	palustrine	marsh, wetlands and open water edges with tall emergent vegetation	Habitat loss and degradation (marsh loss, filling, or draining); environmental contaminants
SE	Yellow-crowned Night-heron	Nyctanassa violacea	Jackson-Washington SF	bottomland, palustrine, riverine	open water edge, bottomland forest, wetlands	Habitat loss, degradation, disturbance; environmental contamination
SE	Virginia Rail	Rallus limicola	Salamonie River SF	palustrine	marsh, shallow water with dense emergent vegetation	Habitat loss, degradation, and disturbance
SSC	Red-shouldered Hawk	Buteo lineatus	Yellowwood SF, Harrison-Crawford SF	forest	open bottomland or upland forest near open water or wetland	Habitat reduced, modified, or lost, especially due to deforestation and intense timber harvesting
SSC	Broad-winged Hawk	Buteo platypterus	Harrison-Crawford SF, Ferdinand SF, Salamonie SF	forest	nests: closed-canopy deciduous or mixed forest near openings, foraging: open areas and forested edges	Habitat loss, degradation, and disturbance
SSC	Worm-eating Warbler	Helmitheros vermivorus	Yellowwood SF, Harrison-Crawford SF, Ferdinand SF, Martin SF, Morgan-Monroe SF, Clark SF, Jackson-Washington SF	forest	deciduous upland forest with dense understory, shrubby forest openings, ravines and hillsides	Loss of wintering and breeding habitat (deforestation)

[a] Indiana Designation: SE = endangered, SSC = special concern; Federal Designation: FE = endangered

TABLE 3. (continued) Birds of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties	Communities	Habitat	Major Threats
SSC	Bald Eagle	Haliaeetus leucocephalus	Yellowwood SF, Jackson-Washington SF	forest, lacustrine, riverine, palustrine	forest near water; shore of large river, lakes, bays, reservoirs; mature roost/nest trees	Environmental contaminants and excessive habitat disturbance; illegal hunting
SSC	Black-and-white Warbler	Mniotilta varia	Yellowwood SF, Ferdinand SF, Morgan-Monroe SF	deciduous or mixed forest	young and old forest, moderate understory growth, open canopy	Habitat loss (extensive forest canopy removal); cowbird brood parasitism; environmental contaminants; nest predation
SSC	Hooded Warbler	Wilsonia citrina	Yellowwood SF, Harrison-Crawford SF, Ferdinand SF, Morgan-Monroe SF, Salamonie River SF, Jackson-Washington SF	forest	young and old forest with moderate or heavy understory growth, shrubby forest openings	Habitat loss (extensive forest canopy removal); cowbird brood parasitism

[a] Indiana Designation: SE = endangered, SSC = special concern; Federal Designation: FE = endangered

TABLE 4. Fish and freshwater mussels of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties	Communities	Habitat	Major Threats
SE	Northern Cavefish	Amblyopsis spelaea	Harrison-Crawford SF	subterranean, streams	cave streams, springs and/or spring basins	restricted habitat; ground water contamination, sedimentation, impoundment
SE	Variegate Darter	Etheostoma variatum	Harrison-Crawford SF	riverine	rubble-boulder-gravel riffles with some sand in small to medium rivers	siltation; domestic, industrial, and agricultural pollution
SSC	Spotted Darter	Etheostoma maculatum	Harrison-Crawford SF	riverine	small to medium clear rivers with swift riffles, large rubble or boulders	siltation; domestic, industrial, and agricultural pollution
SSC	Wavyrayed Lampmussel	Lampsilis fasciola	Harrison-Crawford SF	riverine	small to medium rivers, riffles over firm-packed coarse sand or gravel	siltation; domestic, industrial, and agricultural pollution
SSC	Kidneyshell	Ptychobranchus fasciolaris	Harrison-Crawford SF	riverine	small to medium rivers, riffles over firm-packed coarse gravel	siltation; domestic, industrial, and agricultural pollution

[a] Indiana Designation: SE = endangered, SSC = special concern; Federal Designation: FE = endangered

TABLE 5. Invertebrates (excluding mussels) of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties[b]	Communities	Habitat	Major Threats
SE	Southeastern Wandering Spider	Anahita punctulata	Harrison-Crawford SF	forest	mesic woods	unknown, habitat loss
SE	Jordan's groundwater isopod	Caecidotea jordani	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
SE	Hidden Springs Snail	Fontigens cryptica	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
SE	Cocoa Clubtail	Gomphus hybridus	Ferdinand SF	riverine/riparian	medium to large river with silt/sand bottoms	habitat loss, disturbance
SE	Truncated Springtail	Isotoma truncata	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
SE	Packard's Cave Pseudoscorpion	Kleptochthonius packardi	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
SE	Donaldson's Cave Copepod	Megacyclops donnaldsoni	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
SE	Smoky Shadowdragon	Neurocordulia molesta	Harrison-Crawford SF	riverine/riparian	large rivers with rock, boulders, and logs	habitat loss, disturbance
SE	Short-winged Panic Grass Leafhopper	Polyamia dilata	Harrison-Crawford SF*	open glades and barrens	barrens, open bluffs, upland prairies	unknown, habitat loss
SE	Cave Beetle	Pseudanophthalmus eremita	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
SE	TNC Cave Milliped	Pseudotremia conservata	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
SE	Ancestral Springtail	Sinella avita	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
SE	Elusive Clubtail Dragonfly	Stylurus notatus	Harrison-Crawford SF	riverine/riparian	clean rivers with moderate current, gravelly/sandy bottoms	habitat loss, disturbance

[a] Indiana Designation: SE = endangered, ST = threatened, SR = rare; Federal Designation: FE = endangered

[b] Properties designated by an asterisk (*) report observations only from areas designated as nature preserves

TABLE 5. (continued) Invertebrates (excluding mussels) of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties[b]	Communities	Habitat	Major Threats
ST	Spatterdock Darner	Aeshna mutata	Harrison-Crawford SF, Morgan-Monroe SF	lacustrine, palustrine	small lakes, sinkhole ponds, fishless ponds and bogs	habitat loss, disturbance
ST	Lewis' Cave Springtail	Arrhopalites lewisi	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
ST	Dusted Skipper	Atrytonopsis hianna	Harrison-Crawford SF*	open glades and barrens	prairies, glades, barrens, fields	habitat loss
ST	Sooty Azure	Celastrina nigra	Clark SF	open woods	wooded roadsides and edges	habitat loss, degradation through spread of invasive plants
ST	Golden Cave Harvestman	Erebomaster flavescens	Harrison-Crawford SF	subterranean	subterranean	habitat loss, disturbance
ST	Indiangrass Flexamia	Flexamia reflexus	Harrison-Crawford SF*	open glades and barrens	grassy openings	unknown, habitat loss
ST	Handsome Clubtail	Gomphus crassus	Harrison-Crawford SF	riverine/riparian	small to medium rivers with rapid current and gravel bottom	habitat loss, disturbance
ST	Green-faced Clubtail	Gomphus viridifrons	Harrison-Crawford SF	riverine/riparian	rocky, highly oxygenated streams	habitat loss, disturbance
ST	Stygian Shadowfly	Neurocordulia yamaskan-ensis	Harrison-Crawford SF	riverine/riparian	fast-moving water	habitat loss, disturbance
ST	Multicolored Huckleberry Moth	Pangrapta decoralis	Harrison-Crawford SF*	open woods	open woods and edges	unknown, habitat loss
ST	Prairie Panic Grass Leaf-hopper	Polyamia herbida	Harrison-Crawford SF*	open glades and barrens	upland prairie, barrens	unknown, habitat loss
ST	Riverine Clubtail	Stylurus amnicola	Harrison-Crawford SF	riverine/riparian	clear rivers with moderate current	habitat loss, disturbance
ST	Red-striped Panic Grass Moth	Tampa dimediatella	Harrison-Crawford SF*	open glades and barrens	barrens	unknown, habitat loss
SR	Salt-and-pepper Skipper	Amblyscirtes hegon	Harrison-Crawford SF*	open glades and barrens	glades, wet meadows, grassy wood-land edges	unknown, habitat loss

[a] Indiana Designation: SE = endangered, ST = threatened, SR = rare; Federal Designation: FE = endangered

[b] Properties designated by an asterisk (*) report observations only from areas designated as nature preserves

TABLE 5. (continued) Invertebrates (excluding mussels) of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties[b]	Communities	Habitat	Major Threats
SR	Common Roadside-skipper	Amblyscirtes vialis	Harrison-Crawford SF*	open glades and barrens	glades, meadows, grassy woodland edges	unknown, habitat loss
SR	West Virginia White	Artogeia virginiensis	Clark SF, Harrison-Crawford SF	forest	hardwood forests and hardwood swamps	habitat loss, excessive deforestation
SR	Long-nosed Elephant Hopper	Bruchomorpha extensa	Harrison-Crawford SF	prairie	mesic prairie	unknown, habitat loss
SR	Red-banded Hairstreak	Calycopis cecrops	Harrison-Crawford SF*	open woods	dry open woods, forest edges, old fields	unknown, habitat loss
SR	Black-dashed Under-wing Moth	Catocala flebilis	Harrison-Crawford SF*	forest	forest, woodlands, garden trees	unknown, habitat loss
SR	Gemmed Satyr	Cyllopsis gemma	Harrison-Crawford SF*	open woods; riparian	open wet woodlands, grassy areas near water, stream margins	unknown, habitat loss
SR	Figured Grammia	Grammia figurata	Harrison-Crawford SF*	open glades and barrens	open sandy or grassy areas	unknown, habitat loss
SR	Oithona's Grammia	Grammia oithona	Harrison-Crawford SF*	open glades and barrens	open sandy or grassy areas, old fields	unknown, habitat loss
SR	Sand Barrens Grammia	Grammia phyllira	Harrison-Crawford SF*	open glades and barrens	open sandy or grassy areas, old fields	unknown, habitat loss
SR	Carolina Satyr	Hermeuptychia sosybius	Harrison-Crawford SF*	open woods	open woodlands, forest openings	unknown, habitat loss
SR		Herpetogramma thestealis	Harrison-Crawford SF*	open glades and barrens	unknown	unknown, habitat loss
SR	Leonard's Skipper	Hesperia leonardus	Harrison-Crawford SF*	open glades and barrens	fields, barrens, old field	habitat loss, forest succession
SR	Detracted Owlet	Lesmone detrahens	Harrison-Crawford SF*	open glades and barrens	unknown	unknown, habitat loss

[a] Indiana Designation: SE = endangered, ST = threatened, SR = rare; Federal Designation: FE = endangered

[b] Properties designated by an asterisk (*) report observations only from areas designated as nature preserves

TABLE 5. (continued) Invertebrates (excluding mussels) of greatest conservation need documented on DoF properties since 1980.						
Protection Status[a]	**Common Name**	**Species Name**	**DoF Properties[b]**	**Communities**	**Habitat**	**Major Threats**
SR	Unarmed Wainscot	Leucania inermis	Harrison-Crawford SF*	open glades and barrens	grassy openings	unknown, habitat loss
SR	Fearful Barrens Locust	Melanoplus tepidus	Harrison-Crawford SF*	open woods	woods and edges	unknown, habitat loss
SR	Barrens Paectes Moth	Paectes abrostolella	Harrison-Crawford SF*	prairies	prairies	unknown, habitat loss
SR	Mouse-colored Lichen Moth	Pagara simplex	Harrison-Crawford SF*	open glades and barrens	open grassy areas	unknown, habitat loss
SR	Southern Purple Mint Moth	Pyrausta laticlavia	Harrison-Crawford SF*	prairie	prairies	unknown, habitat loss
SR	Red-legged Tussock Moth	Spilosoma latipennis	Harrison-Crawford SF*	open woods	woodlands and forest, fields and edges	unknown, habitat loss
SR	Northern Cloudywing	Thorybes pylades	Harrison-Crawford SF*	open woods	woods and edges	unknown, habitat loss

[a] Indiana Designation: SE = endangered, ST = threatened, SR = rare; Federal Designation: FE = endangered

[b] Properties designated by an asterisk (*) report observations only from areas designated as nature preserves

TABLE 6. Plants of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties[b]	Communities	Habitat	Major Threats
SE	Bradley's Spleen-wort	Asplenium brad-leyi	Harrison-Crawford SF	cliffs and rock outcrops	crevices of steep cliffs and ledges	human disturbance (rock climbing, strip mining, incompatible forest management)
SE	Black-stem Spleenwort	Asplenium resil-iens	Harrison-Crawford SF	cliffs and rock outcrops	shaded limestone or dolomite cliffs, ledges, or sinkholes	quarrying, trampling, collecting, non-native invasive species
SE	Schreber Aster	Aster schreberi	Clark SF	open forests	dry to mesic open woods, slopes and ravines	historically uncommon, no specific threats
SE	Prairie Redroot	Ceanothus herba-ceus	Harrison-Crawford SF	open glades and barrens	dry rocky or sand prairies	Land-use conversion and habitat fragmentation
SE	Devil's-bit	Chamaelirium luteum	Harrison-Crawford SF*	open forests	open mesic, rich woodlands, forest, savanna	succession; competition from invasives/exotics; human disturbance (e.g., all-terrain vehicles); excessive deer herbivory
SE	Appalachian Bugbane	Cimicifuga rubi-folia	Harrison-Crawford SF	closed canopy forest	cool, moist forests; rocky soils or talus slopes	excessive loss of tree canopy, incompatible forest man-agement; competition from invasives/exotics
SE	Bluntleaf Spurge	Euphorbia obtusata	Clark SF	open forests	open woods, thickets, old fields; sandy, rocky soils	unknown, habitat loss
SE	Striped Gentian	Gentiana villosa	Harrison-Crawford SF	open forests	dry open woods and edges, glades	historically uncommon; competition from invasives/ exotics
SE	Appalachian Quillwort	Isoetes engelman-nii	Clark SF	aquatic/riparian	wet meadows, temporary pools, marshes, and stream margins	habitat loss and degradation (wetland draining and filling); environmental contaminants; competition from invasives/exotics

[a] Indiana Designation: SE = endangered, ST = threatened, SR = rare; Federal Designation: FE = endangered

[b] Properties designated by an asterisk (*) report observations only from areas designated as nature preserves

TABLE 6. (continued) Plants of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties[b]	Communities	Habitat	Major Threats
SE	Illinois Pinweed	Lechea racemulosa	Clark SF	open forests	dry sandy or rocky fields, open woodlands	historically uncommon, no specific threats
SE	Cucumber Magnolia	Magnolia acuminata	Clark SF, Jackson-Washington SF	closed canopy forest	mixed mesophytic forests with moist, well-drained acidic soils; bottoms and slopes	deforestation, incompatible forest management
SE	Green Adder's-mouth	Malaxis unifolia	Morgan-Monroe	closed canopy forest	bogs, sand barrens, dry woods	historically uncommon, no specific threats
SE	Long-awn Hairgrass	Muhlenbergia capillaris	Harrison-Crawford SF	open forests	dry woods with rocky, sandy soil	succession and excessive shading
SE	A Panic-grass	Panicum bicknellii	Harrison-Crawford SF*	open forests	dry woods, thickets, forest openings	possibly grazing, overgrowth by woody species through succession
SE	Cleft Phlox	Phlox bifida ssp. stellaria	Harrison-Crawford SF	cliffs and rock outcrops	cedar glades, limestone woods, cliffs and rocky slopes	development; fires suppression and forest succession (excessive shading)
SE	Prairie Parsley	Polytaenia nuttallii	Harrison-Crawford SF*	open glades and barrens	priairies, glades, margins of dry woods	habitat loss (conversion of prairies and barrens)
SE	Purple Oat	Schizachne purpurascens	Salamonie River SF	open forests	sandy, rocky openings; dry outcrops along limestone river bluffs	historically uncommon; grazing
SE, FE	Short's Goldenrod	Solidago shortii	Harrison-Crawford SF	open glades and barrens	shallow-soil glades, forest openings, open rocky forest edges, rock outcrops and ledges	restricted range; habitat loss
SE	Stout-ragged Goldenrod	Solidago squarrosa	Clark SF	open forests	dry, rocky open forests; forest margins and openings	historically uncommon, no specific threats
SE	Large-leaf Snowbell	Styrax grandifolius	Harrison-Crawford SF	closed canopy forest	mesic to dry woods; well-drained, sandy woods and thickets	land development, fragmentation, incompatible forest management

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[b] Properties designated by an asterisk (*) report observations only from areas designated as nature preserves

TABLE 6. (continued) Plants of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties[b]	Communities	Habitat	Major Threats
SE	Goose-foot Corn-salad	Valerianella chenopodiifolia	Harrison-Crawford SF	aquatic/riparian	wet meadows, stream banks	competition from invasives and exotics
SE	Sand Grape	Vitis rupestris	Harrison-Crawford SF	aquatic/riparian	calcareous or gravelly banks, stream beds and river bottoms; edges of glades or barrens	hydrologic changes; forest succession (excessive shading)
ST	Reed Bent Grass	Calamagrostis porteri ssp. insperata	Clark SF, Jackson-Washington SF	cliffs and rock outcrops	dry sandstone and limestone cliffs, outcrops ; forest openings, dry open woods	succession and fire suppression; incompatible forest management
ST	Yellowwood	Cladrastis lutea	Yellowwood SF	aquatic/riparian	rich, well-drained limestone soils; river valleys, stream boarders, slopes and ridges	forest succession (excessive shading); disease and pests
ST	Pink Thoroughwort	Eupatorium incarnatum	Harrison-Crawford SF	open forests	open woodlands with well-drained soils	edge of range in IN; competition from invasives/exotics
ST	Downy Gentian	Gentiana puberulenta	Harrison-Crawford SF*	open glades and barrens	dry calcareous prairies, cedar glades, barrens	forest succession (excessive shading); competition from invasives/exotics
ST	Slender Heliotrope	Heliotropium tenellum	Harrison-Crawford SF	open glades and barrens	dry, upland woodlands, prairies, and barrens	historically uncommon; competition from invasives/exotics
ST	Smooth Veiny Pea	Lathyrus venosus	Clark SF	open forests	dry, sandy open woods and prairies; also moderate to wet mesic woods and prairies	forest succession (excessive shading); competition from invasives/exotics
ST	Three-flower Melic Grass	Melica nitens	Harrison-Crawford SF	cliffs and rock outcrops	full sun or semi-shade of dry, rocky woodland and openings, crevices of rock ledges	grazing and forest succession (excessive shading)
ST	Thread-like Naiad	Najas gracillima	Clark SF, Harrison-Crawford SF	aquatic/riparian	clear, softwater lakes and streams with muddy, sandy, or peaty substrates	environmental contamination; siltation and turbidity; competition from invasives/exotics

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[b] Properties designated by an asterisk (*) report observations only from areas designated as nature preserves

TABLE 6. (continued) Plants of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties[b]	Communities	Habitat	Major Threats
ST	Tall Meadowrue	Thalictrum pubescens	Jackson-Washington SF, Harrison-Crawford SF	open forests	calcareous meadows, mesic to wet woodlands, grassy swamps and stream sides	competition from invasives/exotics
SR	Mercury	Acalypha deamii	Harrison-Crawford SF	aquatic/riparian	stream banks, roadsides, thickets	Succession
SR	Wallrue Spleen-wort	Asplenium ruta-muraria	Harrison-Crawford SF	cliffs and rock outcrops	calcareous rock outcrops, dolo-mite and limestone bluffs	human disturbance (e.g., rock climbing)
SR	Aromatic Aster	Aster oblongifolius	Harrison-Crawford SF*	cliffs and rock outcrops	dry, rocky, open slopes, bluffs and prairie remnants	Succession
SR	Wild False Indigo	Baptisia australis	Harrison-Crawford SF	open glades and barrens; open forests	moist rich woods and thickets; rocky, gravelly soils	forest succession and competition from invasives and exotics
SR	Ebony Sedge	Carex eburnea	Harrison-Crawford SF*	cliffs and rock outcrops	calcareous rock outcrops, rocky ledges	habitat loss (quarrying, strip mining); com-petition from invasives and exotics
SR	False Hop Sedge	Carex lupuliformis	Salamonie River SF	aquatic/riparian	open, sunny shores and wetlands	changes in water levels and hydroperiod; innundation, impoundment, ditching, chan-neling
SR	Hairy Lipfern	Cheilanthes lanosa	Harrison-Crawford SF	cliffs and rock outcrops	cliffs and shale outcrops	quarrying, trampling, collecting, non-native invasive species
SR	Carolina Thistle	Cirsium carolinianum	Clark SF, Harrison-Crawford SF*	open forests	dry open woods and edges, roadsides, openings	habitat fragmentation and land development
SR	Northern Bush-honeysuckle	Diervilla lonicera	Jackson-Washington	open forests	open woods; rocky, well-drained soils	competition from invasives and exotics
SR	French's Shoot-ingstar	Dodecatheon frenchii	Harrison-Crawford SF	cliffs and rock outcrops	under shady sandstone ledges within mesic forests	human disturbance (off-road vehicles, archeological digging)

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TABLE 6. (continued) Plants of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties[b]	Communities	Habitat	Major Threats
SR	Yellow Gentian	Gentiana alba	Harrison-Crawford SF	open forests	damp open woods and mesic prairies and savannas, edges	competition from invasives/exotics; succession, fire suppression; development; incompatible forest management practices
SR	Angle Pod	Gonolobus obliquus	Harrison-Crawford SF	open forests	open woodlands, and borders	succession and excessive shading
SR	Crested Coralroot	Hexalectris spicata	Harrison-Crawford SF	open glades and barrens	dry open woodlands with calcareous soil, limestone glades	soil disturbance and compaction; possibly fire suppression
SR	Narrowleaf Summer Bluets	Houstonia nigricans	Harrison-Crawford SF	open glades and barrens	dry, rocky ledges, bluffs, and glades; calcareous substrates	forest succession (excessive shading); soil compaction
SR	Straggling St. John's-wort	Hypericum dolabriforme	Harrison-Crawford SF	open glades and barrens	limestone glades and barrens	forest succession (excessive shading); competition from invasives/exotics
SR	Canada lily	Lilium canadense	Harrison-Crawford SF	open forests	openings in mesic forests, wet meadows, glades, bogs, grassy riparian areas	forest succession, excessive shading
SR	Crow-poison	Nothoscordum bivalve	Harrison-Crawford SF	open glades and barrens	open woods, prairies, barrens; moist soil	forest succession, excessive shading
SR	Limestone Adder's-tongue	Ophioglossum engelmannii	Harrison-Crawford SF	open glades and barrens	limestone glades, dolomite prairies; dry, rocky woods and barrens, calcareous soils	forest succession of barrens; competition from invasives/exotics
SR	Purple Passion-flower	Passiflora incarnata	Harrison-Crawford SF	open forests	disturbed sandy fields, roadsides	forest succession, excessive shading
SR	Deam Beard-tongue	Penstemon deamii	Clark SF	open forests	forest openings and clearings	careless use of herbicides
SR	Large-leaved Phlox	Phlox amplifolia	Harrison-Crawford SF	open forests	mesic forests, open rocky woodled slopes, stream banks	competition from invasives/exotics; grazing and mowing

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TABLE 6. (continued) Plants of greatest conservation need documented on DoF properties since 1980.

Protection Status[a]	Common Name	Species Name	DoF Properties[b]	Communities	Habitat	Major Threats
SR	Resurrection Fern	Polypodium polypodioides	Harrison-Crawford SF	cliffs and rock outcrops	found on trees, stumps, rocks; semi-exposed limestone rock outcrops	habitat loss (quarrying, strip mining); competition from invasives and exotics
SR	Rough Rattlesnake-root	Prenanthes aspera	Harrison-Crawford SF	open forests	dry, open rocky woodlands; prairie remnants, barrens	forest succession (excessive overshading); competition from invasives/exotics
SR	Small's Snakeroot	Sanicula smallii	Harrison-Crawford SF	closed canopy forest	mesic, rich woods	competition from invasives/exotics
SR	Weakstalk Bulrush	Scirpus purshianus	Clark SF	aquatic/riparian	wet shores	inundation, mechanical shoreline disturbance
SR	Allegheny Stonecrop	Sedum telephioides	Harrison-Crawford SF	cliffs and rock outcrops	dry, rocky outcrops, knobs, ledges	excessive erosion and invasion of exotic plants
SR	Barren Strawberry	Waldsteinia fragarioides	Harrison-Crawford SF*, Salamonie River SF	cliffs and rock outcrops	forested talus slopes, rocky ravines and ledges	where locally bundant, no specific threats; at disjunct sites where rare threatened by development, incompatible forest management, rock slides, and competition from invasives/exotics
SR	Kentucky Wisteria	Wisteria macrostachya	Harrison-Crawford SF*	closed canopy forest	wet forests and stream banks	competition from invasives/exotics
SR	Golden Alexanders	Zizia aptera	Harrison-Crawford SF	open glades and barrens	prairies, glades derived from calcareous bedrock, river shores	grazing and herbivory; drought; succession

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[b] Properties designated by an asterisk (*) report observations only from areas designated as nature preserves

APPENDIX B: Completed Environmental Assessment form

ENVIRONMENTAL ASSESSMENT FORM

Agency Indiana Department of Natural Resources, Division of Forestry

Address 402 W. Washington Street, Room W296, Indianapolis, IN 46204

Action Identification Forest Resources Management

Predicted Dates:

Commencement ongoing

Completion ongoing

Projected Cost _____

Preparing Body Indiana Department of Natural Resources, Division of Forestry

I. Background Information

1. *Give a brief description of the proposed action(s) and describe how your agency is involved in the action.*

Forest resources management involves a variety of activities de signed to enhance the natural and cultural resources on state forest lands.

Traditional forestry activities to manipulate vegetation structure and composition are used including timber thinnings, timber stand improvement, and reforestation. One of the tools used to perform the manipulation is commercial timber harvesting.

Many activities are specifically designed to manipulate and improve habitat for fish and wildlife species. Other activities provide an overall diversity of habitat structure. Activities also include introduction of species and management of species populations.

Fire/access road maintenance enhances the network of farm and CCC-era roads. These roads are now important for recreational access, management access, emergency access, and wildfire barriers.

Protection and management of areas or features of biological significance is a major program. Other activities involve the reduction or elimination of aggressive, non-native species.

Protection and management of areas or features of cultural significance is another major program.

Prescribed burning is an increasingly important tool used in many of the activities above. It is particularly important for management of many biologically significant areas, and for general forest structure/composition management.

Demonstration and research activities often involve atypical

activities that can only be described or predicted at the time the project is proposed. A recent example is the erection of a tower for climate research in a forested setting by Indiana University.

Land acquisition is the most significant action our agency does in terms of the effect on the environment. Land acquisition is often targeted to eliminate inholdings within existing blocks. This eliminates development potential, and allows conversion to the predominant habitat (usually forest), thereby reducing forest fragmentation. Also, areas that have biological or cultural significance that require protection are primary acquisition goals.

The State Forest Resources Procedure Manual, Recreation Procedures Manual, and Five-Year Fish and Wildlife Operational Guides provide guidance for most resource management activities. The Logging and Forestry BMP's for Water Quality in Indiana Field Guide, which was developed jointly with the Indiana Department of Environmental Management, provides the guidelines for carrying out many activities on the state forests.

2. *Describe the geographical area or areas which will be affected by the action(s), including distinguishing natural and man-made characteristics and a brief description of the present use of the area or areas.*

Thirteen state forests containing approximately 150,000 acres. The vast majority is located in the southern half of the state. Specifically, the land is located in the following counties: Brown, Clark, Crawford, Dubois, Gibson, Greene, Harrison, Jackson, Jennings, Knox, Lawrence, Martin, Miami, Monroe, Morgan, Orange, Owen, Perry, Pike, Putnam, Scott, Sullivan, Wabash, and Washington.

Most state forest land is forested, with some areas of grassland/herbaceous composition that provide particular wildlife habitat or have other biological significance. State forest land presently is used for a variety of things and managed under a multiple-use/multiple-benefits scheme. Among the uses are outdoor recreation, wildlife habitat, edibles gathering, timber management, watershed protection, research, demonstration/interpretation, and protection of significant cultural and biological resources.

II. Assessment of Environmental Impact

Answer the following questions by placing a check in the appropriate space, consider both short and long term impact. Wherever "Yes" is checked, indicate on the lines below the question the nature of the effect.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
1. *Could the action(s) adversely affect the use of a recreational area or area of important aesthetic value?*	x	_	_	x

Any number of the activities could adversely impact recreational or aesthetic values in any number of ways in the short term. But the long-term goal would be the enhancement of either the recreational/aesthetic values or the other values state forests provide. Emphasis is placed on weighing the effects of activities on the many values and benefits state forests provide. Often there is a tradeoff in which an activity may increase one value but decrease another. There is an attempt to maintain some balance of the many values state forests provide. One example would be the closing of a road to public hiking while road work occurs. While a short term recreation activity is diminished, in the long term the road may be better for all-weather hiking and watershed values enhanced because erosion is better controlled. Another example is the creation of a wildlife opening that some may consider negative to aesthetics. Others may view the wildflower/forb content and structure change aesthetically pleasing, along with enhanced wildlife viewing opportunities. Also, value for some rare species such as bobcat and rattlesnake will be enhanced. Attached is a copy of guidelines for aesthetics governing timber management activities.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
2. *Are any of the natural or man-made features which may be affected in the area(s) unique, that is, not found in another parts of the state or nation?*	_	x	_	x

The state forests do not contain natural or man-made features that are unique. Features and species found on state forests are found in other parts of the state or nation. That is not to diminish the importance of state forests for the protection of particular features or the contribution to biological diversity state forests contain some natural features that are extremely uncommon. For example, the federally endangered Short's Goldenrod is known in Indiana only from the site at Harrison-Crawford State Forest and a few sites in Kentucky, and nowhere else in the world. Also, Deam's Penstemon is known only from a few sites at Clark State Forest and in Illinois and nowhere else in the world.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
3. *Could the action(s) adversely affect a historical or archaeological structure or site?*	x			x

Activities that could potentially affect a historical or archaeological structure or site are reviewed for clearance by the Division of Historic Preservation and Archaeology (DHPA). Under the guidance of DHPA and the State Historic Preservation Officer, sites or structures identified as significant are avoided and protected. Short term activities such as alteration of historic structures for disabled access may have adverse effects, but these are cleared by DHPA. Attached are copies of forms from the procedure manual. One is a clearance form, and the other is an inventory form. The Division of Forestry's emphasis on cultural resource protection was recognized in 1993 with an award for archaeological protection from DHPA.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
4. *Could the action(s) adversely affect fish, wildlife, or plant life?*	x			x

The activities could adversely affect animal or plant life in the short term, but the long term goal is maintenance and enhancement of biodiversity. The Fish and Wildlife Operational Guides are developed in conjunction with the Division of Fish and Wildlife.

Manipulations to habitats result in trade-offs between species that favor particular habitats. An attempt is made to strike a balance between species needs in order to maintain biodiversity. For example, a habitat project that provides openings that benefit the reintroduction of the wild turkey may also benefit the rare bobcat, but may have a negative impact on the wood thrush.

Another example is the prescribed burning of a brushy barrens area that is naturally reforesting. The burning will eliminate habitat for the yellow-breasted chat, but improve the habitat for a number of barrens grasses, forbs and associated fauna. Timber management activities will remove individual trees, but also stimulate health and vigor of the remaining trees and regeneration of the forest.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
5. *Have any fish, mammals or plant species on the rare or endangered list been sited in the affected area(s)?*	x		x	

The state forests are havens to a number of rare and endangered species. In cooperation with the Division of Nature Preserves, all state forests are inventoried for rare species or communities. When found these areas are either protected as nature preserves or may have a particular management scheme (such as prescribed burning) recommended. State forests also work closely with the Non-game Section of the Division of Fish and Wildlife regarding rare animals. The management goal is for state forests to remain havens in the future.

	Short Term		**Long Term**	
	Yes	**No**	**Yes**	No
Will those sighted be adversely affected?	__	x	__	x

The Fish and Wildlife Operational Guides developed in conjunction with the Division of Fish and Wildlife covers many wildlife management activities and concerns. One example of a species specific activity is the installation of bat gates at hibernation sites of Indiana bats. Another is burning to eliminate hardwood succession from a grassland that contains a large portion of the global Henslow's Sparrow population.

Many nature preserves are created to protect individual species or groups of species.

	Short Term		**Long Term**	
	Yes	**No**	**Yes**	**No**
6. *Could the action(s) change existing features of any of the state's fresh waters or wetlands?*	__	x	__	x

State forests traditionally have few wetlands because they were created from dry, rocky land that was too shallow or steep to properly farm. However, there has been some emphasis to purchase wetland areas near but outside the traditional "forest boundary" in order to protect the wetlands, enhance river otter habitat, and protect a forest type (bottomland) that is underrepresented in the state forest system. Pike and Salamonie State Forests contain a fairly significant amount of river frontage and examples of wet and wet-mesic floodplain forest.

Also, state forests work with the Division of Water to maintain the stability of major streams.

For example, the Division of Water does not require a construction in a floodway permit for the placement and use of temporary stream crossings for logging operations that conform to the Division of Forestyr's Best Management Practices.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
7. *Could the action(s) change existing features of any of the state's beaches?*	__	x	__	x

The state forests contain no natural beaches. Several recreation areas do have man-made beaches that are maintained with the use of aquatic herbicides to control weeds.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
8. *Could the action(s) result in the elimination of significant acreage of land presently utilized for agricultural or forestry purposes?*	__	x	__	x

It is planned for the state forests to remain as forests in perpetuity. The goal of land acquisition will ensure that most additional acres purchased remain or are converted to forestland, rather than being available for residential development.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
9. *Will the action(s) require certification, authorization or issuance of a permit by any local, state or federal environmental control agency?*	x	__	__	x

In general, most activities do not require a permit. It is possible that some activities may require permits.

The most probable permit the activities would require is a floodway con struction permit from the Division of Water. This is needed in the construction or reconstruction of a stream crossing on a road to be left in place permanently or when proposed logging operations within the floodway are to be conducted out side the framework of the Division of Froestry's Best Management Practices.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
10. *Will the action(s) involve the application, use or disposal of potentially hazardous materials?*	x	__	__	x

Properties with major pesticide use have staff members trained and licensed for pesticide application. Pesticides may be used to control damaging insect outbreaks, such as gypsy moth. Herbicides are used in a number of activities. They are used to control weeds for planting seedlings on old field sites. Herbicides are used to control aquatic weeds in lakes. They are used to control brush growth along roads and trails. Herbicides are used to deaden selected trees in timber management work. Most importantly, they are used to control or eradicate aggressive, non-native plants. Also, the vehicle travel required to perform the activities require substantial amounts of fuel and other fluids to operate and maintain the vehicles.

	Short Term		Long Term	
	Yes	**No**	**Yes**	**No**
11. *Will the action(s) involve construction of facilities in a flood plain?*	__	x	__	x

Except for the occasional reconstruction of a stream crossing for a road, there is no facility construction in a flood plain.

	Short Term		Long Term	
	Yes	**No**	**Yes**	**No**
12. *Could the action(s) result in the generation of a significant level of noise?*	x	__	__	x

The use of heavy equipment or the operation of high speed motors does result in short-term noise in localized areas.

	Short Term		Long Term	
	Yes	**No**	**Yes**	**No**
13. *Could the action(s) result in the generation of significant amounts of dust?*	__	x	__	x

The activities will generally not produce a significant amount of dust.

	Short Term		Long Term	
	Yes	**No**	**Yes**	**No**
14. *Could the action(s) result in a deleterious effect on the quality of the air?*	x	__	__	x

The use of prescribed burning can lower the quality of air in the immediate vicinity. This generally occurs for a short period. The smoke created from the burning is typical wood/vegetation debris smoke, with little chance of the toxic pollutants from the burning of man-made materials.

	Short Term		Long Term	
	Yes	**No**	**Yes**	**No**
15. *Could the action(s) result in deleterious effect on the quality or quantity of any portion of the state's water resources? (If yes, indicate whether surface, groundwater, offshore.)*	x			x

Some activities could affect surface water. Access roads and trails can result in sediment-bearing runoff, especially during maintenance and heavy use. The Logging and Forestry BMP's for Water Quality in Indiana Field Guide provides guidelines for maintaining water quality standards during activities. This was developed with the assistance of the Indiana Department of Environmental Management.

	Short Term		Long Term	
	Yes	**No**	**Yes**	**No**
16. *Could the action(s) affect an area of important scenic value?*	x			x

Many of the activities performed have an effect on scenic values, all of which are short term. How scenic value is affected depends on the activity, the result, and the perception of the viewer. Some effects will be negative, and some will be positive. A timber harvest can leave a jumble of tops that is not at all scenic, or it can create a breathtaking vista. A prescribed burn can create a charred landscape, or a profusion of wildflowers. In the long term, any activity will be ameliorated by the resiliency of the central hardwood forest, unless the activity outlasts the forest. A copy of the visual enhancement guidelines from the procedures manual is attached.

	Short Term		Long Term	
	Yes	**No**	**Yes**	**No**
17. *Could the action(s) result in increased congestion and/or traffic in an already congested area or an area incapable of absorbing increase?*		x		x

The activities are in areas that are rural. Also the traffic resulting from the activities tends to be dispersed.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
18. *Could the action(s) require a variance from or result in a violation of any statute, ordinance, by-law, regulation or standard, the major purpose of which is to prevent or minimize damage to the environment?*	__	x	__	x

The goal of all activities is to comply with statutes and regulations.

	Short Term Yes	Short Term No	Long Term Yes	Long Term No
19. *Could the action(s) result in any form of adverse environmental impact not included in the above questions? (If yes, identify the impacted resource or area.)*	__	x	__	x

There are no impacts that were not included in the above questions.

III. Statement of No Significant Environmental Effects

A "Yes" answer in the "Long Term" column in section II indicates the action may cause significant environmental impact, and that an EIS will probably be required. If you have answered "Yes" to any of the questions, the effect of which is not clearly beneficial, but still think the action will cause no significant adverse environmental impact indicate your reasons below.

The response for Question # 5 regarding the sighting of rare or endangered species indicated a positive response for the long term. The state forests provide and will continue to provide an important area for conservation of rare species. As pressure continues on private lands, state forests could become the final haven in the state for many rare plants. State forests, however, do not contain sufficient area to, on their own, provide habitat for most rare animals. Animals are more mobile and scattered in their habits than plants. Rare animal populations will be maintained only through a cooperative effort among private and public landowners. State forests can provide an important, stable habitat base for many animal species.

IV. Conclusions

Place a check in the appropriate box.

1. (x) It has been determined that the action will not cause a significant adverse environmental impact. No EIS will be prepared.

2. ( ) It has been determined that the action may cause a significant adverse environmental impact. An EIS will be prepared by _____
(approximate date)

Signature of Preparing Officer: John M. Friedrich

Title: Property Specialist

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2008 - 2027

Forestry

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