Watershed Resources Working Paper
NNIS Project
Shawnee National Forest

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Introduction

Background

The Shawnee National Forest (Forest) has numerous and abundant non-native invasive plant species populations that pose a serious threat to plant and animal community health and diversity. Since invasive species have been transplanted outside their original range they often lack natural controls (e.g. disease, predators, parasites or climate). They tend to out-compete and eventually replace native species. Not only do invasive species compete with native species for resources, they also:

- cause loss of habitat and food for wildlife,
- alter soil structure and chemistry,
- modify fire regimes,
- alter plant succession,
- serve as reservoirs for pathogens,
- hybridize with natives to compromise local genetic diversity, and
- can replace and possibly lead to local extinction of native plant species, including threatened, endangered, and sensitive species.

Purpose of and Need for Action

The purpose of this project is to protect and restore native ecosystems on the Forest by controlling or eliminating populations of invasive plant species. Taking action at this time is needed because invasive plants are degrading native plant communities and will only get worse if left untreated. Past control efforts have primarily been limited to manual methods that are labor-intensive and have been focused on small-localized individual sites. Control of invasive species is needed to prevent a more widespread and costly problem in the future and to protect threatened natural ecosystems. Without treatment, the current infestations will continue to expand and jeopardize the local native plant and animal communities.

Action is also necessary to meet direction in the Forest's 2006 Land and Resource Management Plan (Forest Plan), which states: *The risk and damage from existing non-native invasive species should be reduced through integrated pest management. Invasion prevention measures should be implemented to maintain native ecosystems. Existing populations of non-native invasive species should be eradicated, controlled and/or reduced. Effects of management activities on the invasion and spread of non-native invasive species should be considered and mitigated, if needed. Natural areas and lands adjacent to natural areas have the highest priority for the prevention and control of non-native invasive species.*

Purpose of This Assessment -

This assessment analyzes the potential effects of the proposed project on soil and associated watershed resources occurring within the boundaries of the Forest. The primary purpose of this assessment is to determine whether the likely effects would result in a degradation of watershed resources in the project area.

Formal objectives of the assessment include:

1) identify watershed resources that would be affected by the proposed project,
2) ensure that Forest Service actions do not result in degradation of soil quality, water quality or air quality,
3) provide a process and standard that ensures that watershed resources receive full consideration,
4) make certain that best management practices, as per the Shawnee National Forest Amended Land and Resource Management Plan (USDA 2006) and the Region 9 Soil Quality Standards, are followed,

5) to maintain a case file on actions regulated under environmental policy and procedures.

Current Management Direction

Current policy as stated in the Forest Service, Region 9 Soil Quality Standards includes the following: Temporary roads used for vegetation management are included as areas evaluated for soil quality. System road and trails, on the other hand, and other administrative facilities within or adjacent to the activity area, are dedicated land uses and not considered detrimental soil conditions (USDA Forest Service 2005). However, changes to the existing condition on the trails as a result of activities associated with the project need to be addressed. Detrimental soil disturbance will be minimized to the extent possible. Adhere to soil quality standards identified in land management plan direction (USDA Forest Service 2006).

The management direction specified by the Forest Land and Resource Management Plan (Forest Plan; USDA 2006) is to conserve soil, water, and air resources and ensure the protection of streams, streambanks, lakes, wetlands and other bodies of water in accordance with applicable laws and regulations. Activities will be guided by the Illinois Forestry Best Management Practices (in cooperation with the Illinois Department of Natural Resources, Illinois Forestry Development Council, Southern Illinois University and University of Illinois) and may include streambank restoration and/or stabilization and management of large, woody debris.

Issues

Issues are points of debate, disagreement, or dispute about the environmental effects of a proposed action. Following our scoping of the public and other agencies, the interdisciplinary team identified the issues related to the invasive species control proposal and divided them into two groups, key and non-key. Key issues are those directly or indirectly caused by implementing the proposed action or alternatives. (Non-key issues are listed and explained in the project record.) The list of issues was reviewed and approved by the responsible official.

Key Issues and Indicators:

- ❖ The application of herbicides may affect humans.
  - Human Health Indicator: We will discuss the response of the general public in terms of the effects that the approved and properly applied herbicides could have on public health and employees/applicators.
- ❖ The establishment and spread of invasive species may affect natural areas and ecosystems, including plants and wildlife.
  - Plant Community Indicator: We will discuss the response of the plant community in terms of acres of invasive species reduced and native species restored/protected.
  - Wildlife Community Indicator: We will discuss the response of federally listed species in terms of potential changes in their habitat.
- ❖ The application of prescribed fire and mechanical treatments may affect designated natural areas and ecosystems, including soil, water, plants and wildlife.
  - Soil and Water-Quality Indicator: We will discuss the predicted amount of soil erosion in terms of tons/acre/year.
  - Plant Community Indicator: We will discuss the response of the plant community in terms of potential changes in the number and frequency of invasive and native plant species.
  - Wildlife Community Indicator: We will discuss the response of Regional Forester Sensitive Species and species with viability concern in terms of potential changes in the habitat.
- ❖ The application of herbicides may affect designated natural areas and ecosystems, including soil, water, plants and wildlife.
  - Soil and Water Quality Indicator: We will discuss the potential persistence of the proposed herbicides in the environment.

- Plant Community Indicator: We will discuss the response of plant communities in terms of the potential effects on natural areas' significant and exceptional features.
- Wildlife Community Indicator: We will discuss the response of the wildlife community to the proposed action in terms of potential changes in the habitat of management indicator species.

Effects of Alternatives

Affected Environment – The project area is 1,525 acres and 23 natural areas as well as selected other areas.

Soil – The soils in the project area are nearly all silt loams which have low rock content. Many of these soils developed in a layer of loess, or silt-sized particles transported by wind. In some places, this loess layer is thin and the soils developed in both loess and the underlying sandstone or shale bedrock. Many of the bottomland and floodplain soils were developed in alluvial, or water-transported, material. Those soils with high fertility are classified as prime timberland. Those soils not designated as prime timberland are nonetheless productive timber land. Some of the soils are upland soils and erosion ranges from slight at gentler slopes (less than five percent) to high at steeper slopes (above 18 percent). Some of the bottomland soils are classified as floodplain soils and some are rated as prime timberland soils. Some of the bottomland soils are identified as hydric soils. Nearly all the soil mapping units have a high potential for compaction. Most of the soils have a slight to moderate limitations for prescribed burning (NRCS ratings).

Soils information is found in tables in the appendices of the working paper. One table lists the soils by priority natural area and details the soil mapping unit by hydric soils designation, riparian soils designation, soil erosion potential, soil compaction potential, and potential for damage to soils from fire. The second table details the soil mapping unit by properties important for determination of pesticide leaching potential and pesticide runoff potential.

Water – Water quality information is given in tables in the appendices of the working paper and in the project record. This information is from the EPA water quality report (Illinois Environmental Protection Agency. 2012 draft, Illinois 2010 Water Quality Report (Stream and Lake Assessments), information online at: http://www.epa.state.il.us/water/tmdl/303-appendix/2012/appendix-b2.pdf.) Water quality is evaluated according to five beneficial uses and rated as fully supporting, non-support, or not assessed (unknown). For any stream and lake reach receiving a less than full support designation, source and causes of non-attainment are listed. Lakes (public and private) evaluated by the Illinois EPA are also given. Runoff from forest, grassland, parkland, loss of riparian habitat and streambank modification are the sources occurring on areas near project areas and this would most likely occur on private lands.

Air – The Illinois EPA air quality report was consulted on air quality (Illinois EPA. 2011. Illinois Annual Air Quality Report – 2008. Found online at: http://www.epa.state.il.us/air/air-quality-report/2010/air-quality-report-2010.pdf.) The air quality data from the monitoring stations in the airsheds in which the project area is located are given in the appendices in the working paper and are part of the project file. Hardin County has the lowest estimated levels of five pollutants (carbon monoxide, nitrogen oxides, particulate matter, sulfur dioxide, and volatile organic matter) of the counties in which the project areas are located. None of the counties in which the forest is located is found in non-attainment by the EPA (Kaleel (IEPA) personal communication. 2010).

Atmospheric deposition is not considered to be an air quality concern in southern Illinois. There were two monitoring stations in the National Atmospheric Deposition network (Carbondale and Dixon Springs) with the Dixon Springs station still in operation. Overall, atmospheric deposition has been becoming less acidic over the past few decades. Sulfates have decreased over the long term while nitrate and ammonia levels have fluctuated. None of these changes are attributed to Forest management. Overall, air quality across the Forest is good. Graphs of trend plots are given in the working paper appendices and are part of the project record (National Atmospheric Deposition Program (NADP). 2008. NADP / MTN Sites IL63& IL35. Found online at: http://nadp.sws.uiuc.edu/sites/siteinfo.asp?net=NTN&id=IL35 and http://nadp.sws.uiuc.edu/sites/siteinfo.asp?net=NTN&id=IL63.) Precipitation passing through a forest canopy can also serve as nutrient pathways and influence pH (Weaver and Brown 1978, Weaver and Jones 1981).

llinois EPA has developed a statewide Smoke Management Plan (SMP) to address smoke from prescriptive fires (prairie and forest) used to achieve resource benefits. The goals of the SMP are to coordinate with land managers to develop a basic framework of procedures and requirements for managing smoke from prescribed fires; to avoid significant deterioration of air quality and potential NAAQS violations; to mitigate the nuisance and public safety hazards posed by smoke intrusions into populated areas; and to avoid visibility impacts in Federal Class I Areas (Illinois EPA Bureau of Air found online: www.epa.state.il.us/air). Prescribed fires on the Forest are in line with this plan and the Forest Plan. These treatments follow a detailed burn plan and strict prescription standards. Prescribed burns also are evaluated using smoke management models (V-Smoke and/or SASEM). Recent burns associated with the Blowdown project, One Horse Gap, and other burns have not raised major issues and these burns were in compliance with the Forest Plan and followed the burn plan and prescription.

Boundaries of the Analysis

Spatial Boundary: The cumulative effects boundary for soil and water consists of the sixth field watersheds in which the project areas are located. Some basic information is given below. Watershed-based cumulative effects (water quality, soils, etc.) are best addressed from analyses based on watershed areas. The area considered for air quality cumulative effects is the IEPA Airshed Region 70 & 74.

Temporal Boundary: The time-frame is fifteen years for the following reasons:

1. Fifteen-year time frames provide a significant basis for measuring change in soil disturbance due to soil erosion and soil compaction.
2. Increases in soil erosion from project and associated activities usually return to pre-project levels within three to five years.

Soil compaction effects are variable and there is no information as to the time length for compacted soil to return to pre-project conditions in Illinois or in the Shawnee Hills. Some information from the southeast U.S. indicates 10 - 15 years is the average time for restoration of compacted areas through natural processes. The source of this information is from a technical bulletin on the effect of heavy equipment on the physical properties of soils and long-term productivity done under the auspices of the National Council for Air and Stream Improvement (NCASI, Miller, Colbert, & Morris 2004).

Alternative 1: No Action

Under this alternative, we would continue to implement current strategies of invasive species management: Pulling and torching about 50 acres of invasives annually, inventorying and mapping infestations and applying prescribed fire to about 6,000 acres per year, up to 10,000 acres over time, including in some designated natural areas; openlands management would continue, including mowing, disking and bush-hogging on about 150 acres per year; application of herbicides in campgrounds and at administrative sites (about 50-100 acres per year) would continue, contributing to invasive species control in those areas. No ground-disturbing mechanical treatments could be done in the proposed treatment locations, nor could herbicide be applied outside of administrative sites and campgrounds.

Direct Effects

No more of the proposed activities would take place, nor any associated activities with the proposed action. Therefore, no management related appreciable changes in productivity of the land would occur. Soils would be impacted by regular maintenance and use of roads as well as planned and ongoing natural resource management activities. In the absence of wildfire, current runoff and erosion pattern would be maintained. An upland erosion rate of less than one ton per acre per year is predicted by FSWEPP for stands on steep slopes in the absence of fire. Natural processes and functions would continue to occur as dead material decomposes. Actual soil organic matter may increase with an accompanying increase in microorganisms and fungi. Since there is no management activity, dead and dying trees would decay with carbon released to the atmosphere. Management activities in and adjacent to the project areas already planned would be carried out. Natural functions may also include pathogens and insects contributing to oak decline leading to dead and down trees. Salvage operations would not take place under this alternative. Dead and down trees would increase fuel levels leading to increased wildfire danger. In the absence of wildfire, dead and down trees would decompose over time leading to increased macro and micro-organism populations carrying out the decomposition process. As decomposition proceeds, dead and down material would eventually be incorporated into the organic horizon and surface horizons leading to increased soil nutrient capital.

Cumulative Effects

No ecological restoration or vegetation management will occur under this alternative. There would be no direct or indirect effects to soil or water from management activities. See the environmental assessment at the beginning of Chapter 3 for a list of the list of the past, present, and reasonably foreseeable future actions. Soil quality and productivity would be increased in the long-term as organic matter decomposes. Water quality would be maintained at current levels considering anticipated future actions and assuming the inputs from private land remain stable. Some geologic erosion could be expected to continue and some of this sediment could be expected to enter the streams. This alternative would likely result in less soil erosion, compaction, sediment load, and percentage of bare ground than the other alternatives. Implementation of this alternative is not anticipated to result in measurable changes to water quality.

Alternative 2: Proposed Action

Under this alternative, we would treat invasive plant infestations using an integrated combination of prescribed fire and manual, mechanical and/or chemical methods. As we said at the outset, our employment of integrated pest-management principles for the prevention/eradication/control of invasive species has lacked all the tools available for responsible control. Prevention measures have been inadequate to stop the spread of the most aggressive invasive species. We have tried mechanical and manual control methods with varying degrees of minimal success. We will continue to use public information and education to increase awareness of invasive species issues. Under our proposal, we would treat specified areas of the Forest (see maps) given available time and resources. Post-treatment monitoring would evaluate effectiveness and success, which we would disclose in our annual monitoring reports. Our proposal is a dual approach to treating invasive species:

1. Treatment Forest-wide of all known sites with four highly invasive species:

The project interdisciplinary team reviewed the many invasive species on the Forest and identified four as priorities to be targeted across the Forest:

- *Amur honeysuckle (Lonicera maackii) infesting about 70 acres at 5 sites in natural area treatment zones and 630 acres at 11 sites outside the natural area treatment zones,*
- *Chinese yam (Dioscorea oppositifolia*) infesting about 2 acres at 5 sites *in natural area treatment zones and* 340 acres at 19 sites outside the *natural area treatment zones,*
- Garlic mustard (*Alliaria petiolata) infesting about 75 acres at 6 sites in natural area treatment zones and 500 acres at 23 sites outside natural area treatment zones, and*
- Kudzu (*Pueraria montana) infesting about 4 acres at 1 site in a natural area treatment zone and 20 acres at 6 sites* outside the *natural area treatment zone (*see maps for locations*).*

2. Management of 23 designated natural areas and their treatment zones:

The interdisciplinary team reviewed the information on invasive species in natural areas and identified those most threatened with vigorous infestations or with the most vulnerable natural communities. Based on these factors, the team selected 23 high-priority natural areas for analysis (Table 1). To enable maximum protection of the selected natural areas, the team configured "treatment zones"—along streams, roads and trails, the main pathways of invasive species infestation—adjacent to and generally upstream of the areas. As detailed in Table 3 and Appendix A, we would target all invasive species in the natural areas and their treatment zones, following the published guidance of the Illinois Nature Preserves Commission (INPC 1990**).**

Management would include the application of prescribed fire in the natural areas and their treatment zones, about 11,220 acres. Existing fire-breaks, such as roads, trails, streams and other natural features, would be used as firelines where possible; but mechanically constructed firelines would be used where necessary. We expect to install about 14 miles of lines by hand, using leaf-blowers that cause no earth-disturbance, and 6 miles mechanically, which would be earth-disturbing. These lines would be restored promptly in accordance with the Forest Plan guidelines in Appendix F and Illinois Forestry Best Management Practices (see Table 5).

The treatment zones would be burned at intervals of 1-3 years, depending on fuel availability and the monitoring and assessment of effects to determine the need for additional fire. The fire would help restore native vegetation and set back the progression of invasive species. Further burns would be done as needed to maintain the areas' ecological integrity once invasive vegetation has been suppressed.

Herbicides could be applied to control invasive species either before or after the burns, in about 675 acres of the treatment zones, depending on the species present (see Table 3 and Appendix A). Some species, such as grasses, grow well in response to fire and would be targeted before the burns or following, when new growth appears. Other species, such as Japanese honeysuckle and multiflora rose, are generally set back by fire, so burning them off before applying herbicides would limit the amount of herbicide required for control or eradication. We would apply herbicides as needed until infestations are controlled or eliminated.

The proposal includes thin-line application, basal-bark treatment and "hack-and-squirt" (cutting into a tree's cambium and applying herbicide), as well as the cutting and stump-spraying and/or girdling of some native trees and shrubs on about 275 acres of barrens, glades and seep-springs to improve growing conditions for the natural communities. Barrens and glades are unique native plant communities that traditionally have sparse vegetation. With the exclusion of fire, some of these areas have grown up in shrubs and trees that shade out native and sensitive plant species, limiting the diversity of the plant community. Thinning the barrens and glades helps to restore their naturally dry condition and the species adapted to it. Similarly, we would control the trees and shrubs that are encroaching on seep-spring areas and de-watering their rare plant communities.

The high-priority natural areas for prescribed fire and herbicide treatment are those with acid seep-springs: Cretaceous Hills, Dean Cemetery West, Kickasola Cemetery, Massac Tower Springs and Snow Springs. These are the most threatened by invasive species and changes. The encroachment of aggressive invasive species into these areas threatens to dry up the springs and dramatically degrade the plant community, destroying the spring habitat. Rare plant resources rely on this habitat type, including Regional Forester Sensitive Species, such as twining screwstem (*Bartonia paniculata*), purple five-leaf orchid (*Isotria verticillata*), longbeak arrowhead (*Sagittaria australis*) and New York fern (*Thelypteris noveboracensis*). Additional plant species of this community-type, including several listed as threatened or endangered by the State of Illinois, are also vulnerable to local extirpation without immediate management.

Of the remaining 18 natural areas, 11 have Regional Forester Sensitive Species and numerous other rare plant resources: Double Branch Hole, LaRue-Pine Hills, Poco Cemetery East, Poco Cemetery North, Bulge Hole, Fink Sandstone Barrens, Bell Smith Springs, Hayes Creek-Fox Den, Panther Hollow, Jackson Hole and Barker Bluff. Streams run through, or are adjacent to, all these areas, providing a corridor for invasive plant species, especially Nepalese browntop. These areas would be the second priority for invasives treatments.

The remaining seven natural areas, Fountain Bluff, Ava, Keeling Hill North, Keeling Hill South, Odum Tract, Russell Cemetery and Reid's Chapel, contain dry to dry-mesic barren-communities, which provide a unique assemblage of rare plant resources. These areas would be our third priority for treatment. The other 57 natural areas also contain invasive species; however, in order for us to systematically control and eradicate invasives, it is imperative that we prioritize the natural areas that require immediate attention to preserve their integrity.

Herbicide Treatments

We have analyzed the treatment of about 2,500 acres of invasive species infestation across the Forest annually (see totals at Appendix A). We would limit our chemical treatment of invasive species to five herbicides: triclopyr, clopyralid, glyphosate, sethoxydim and picloram (Table 2). We selected the herbicides in consultation with the IDNR and the CWMA, both of which have extensive experience with these specific herbicides. With the exception of picloram, which we propose to apply only to the cut stumps of kudzu in limited quantity and locations, each of the herbicides is the least toxic, least persistent chemical available to meet our purpose and need. We followed published guidance of the Illinois Nature Preserves Commission (INPC 1990) and The Nature Conservancy (TNC 2004) in selecting these commonly used, generally low-impact herbicides that should provide effective treatment. Additionally, we propose to use the most controllable application methods that would have the least residual impact:

1) a hand-held applicator, hack-and-squirt, sprayer, brush or wick applicator
2) backpack sprayer
3) boom-mounted spray rig (on an all-terrain or utility vehicle, pickup truck, or tractor)

We do not propose aerial applications.

Table 2. Herbicides Proposed for Use in Alternative 2.

Chemical Name	Examples of Trade Names	Targeted Use	Examples of invasive plants to be targeted	Risk Assessment
Clopyralid	Curtail™ Reclaim™ Transline™	Foliar spray; broadleaf selective–especially legumes, smartweeds and composites	kudzu, lespedeza, oxeye daisy, crownvetch	SERA 2004a
Glyphosate	Accord® Roundup Pro® Roundup®	Woody and broadleaf plants: stump treatment, 10-20% solution; foliar spray; non-selective;	Amur honeysuckle, autumn olive, Japanese honeysuckle, garlic mustard, multiflora rose	SERA 2003a
Glyphosate (aquatic)	Aquamaster® Rodeo®	Foliar treatment, invasives near open water, non-selective	purple loosestrife, common reed, any species near open water	SERA 2003a
Sethoxydim	Poast® Vantage®	Foliar spray; narrowleaf selective (grasses)	Nepalese browntop, Canada bluegrass, bald brome	SERA 2001
Picloram	Tordon K Tordon 22k; Grazon	Stump and/or basal-bark treatment	kudzu	SERA 2003c
Triclopyr	Crossbow™ Garlon™3A Garlon™4 Habitat®; Pasturegard™ Vine-X®	Stump and/or basal-bark treatment, foliar spot spray; broadleaf selective; woody plants	Chinese yam, kudzu, Amur honeysuckle, autumn olive, lespedeza, clover, Japanese honeysuckle	SERA 2003b
(http://www.fs.fed.us/foresthealth/pesticide/risk.shtml)				

As specified in the Design Criteria in Table 5, we would apply herbicides at or below label-recommended rates, using only those registered by the EPA for the specific type of site and use we propose. We would follow all applicable state and federal laws. We would apply herbicides according to label directions and, within the natural area treatment zones, in accordance with the guidance published by the Illinois Nature Preserves Commission and The Nature Conservancy and monitor our use in compliance with best management practices and direction in the Forest Service Manual (2080, 2150 and 2200). We would prepare a Pesticide Use Proposal (FS-2100-2) and safety plan (FS-6700-7) prior to any herbicide use. We would post signs to alert the public to the location and types of treatments being done and the date when a treated area could be re-entered.

We would apply herbicides during the time of year when application is most effective for a particular species and its life-cycle. (See Table 3 for Illinois Nature Preserves Commission's recommendations.) If a first application of an herbicide should not be as effective as expected, we would re-treat with one of the proposed herbicides to ensure complete removal or control. We would ensure the re-establishment of native vegetation on a treated site through monitoring after removal of the invasive species and reseeding and/or planting native species if necessary to repopulate the site.

Control techniques could vary depending on the size or location of the infestation (see details in Table 3). We developed our proposed methods after review of the guidance published by the Illinois Nature Preserves Commission and The Nature Conservancy, scientific literature, the field experiences of Forest botanists and wildlife biologists, and discussions with invasive species experts.

Prescribed Fire

Prescribed fire is a tool for the execution of a number of invasive plant management options and to mimic historic fire regimes that promote desirable vegetation. As is described on the website of the U.S. Fish and Wildlife Service:

- **Prevention**: The creation of unnatural fire regimes can favor nonnative species (Brooks et al. 2004). Although ecosystems with natural fire regimes are certainly not immune to invasion by undesirable species, restoring or maintaining natural fire regimes may help to prevent invasions by stimulating desirable competitive plants.
- **Containment:** Containing invasive species populations requires prevention of the transport of invasive plant propagules from the infestation to new sites. Burning invasives at the appropriate growth stage can reduce or prevent flower and seed production, thereby reducing the risk of infestation expansion by seed (Pollack and Kan 1998). Existing seedbanks in the soil, litter layer, or inflorescence must also be contained to prevent spread to new sites. Fire temperatures are typically not hot enough to destroy seeds and propagules near the soil surface (Daubenmire 1968). However, seeds remaining in plant inflorescence may be exposed to lethal temperature during fires (Renney and Hughes 1969).
- **Suppression:** Invasive plants may be suppressed by fire if burning is effective in depleting carbohydrate reserves, depleting the seed bank and stimulating desirable plant species that can successfully compete with invasive plant populations (Rice 2005). Multiple burning treatments are often required to sufficiently deplete carbohydrate reserves for perennial species (Burke 1990). Repeated disturbance of fire may weaken desirable plants.
- **Eradication:** To achieve complete control of an invasive species with prescribed burning, all reproductive structures must be destroyed or eliminated by the fire. Though some invasive plants may be eliminated by burning, fires can create conditions that favor invasion and establishment by another invasive species (www.fws.gov/invasives/staffTrainingModule/methods/burning/practice.html).
- Activities associated with the invasive control include prescribed burning and the application of chemicals. These activities have the potential to expose soil. Exposed soil has the potential to erode at a faster rate than normal geologic rates. Soil particles can be loosened and transported in overland flow. Some of the eroded soil is trapped in vegetation and deposited down slope, but some enters adjacent streams and can decrease water quality and the amount of quality aquatic habitat (USDA Forest Service, 2006b).

Direct Effects

Direct effects would be minimized through preventative actions and implementation of the design criteria. Mitigation measures are discussed in EA Chapter 2. Preventative measures are based on Illinois forestry

BMPs guidelines (IDNR, Department of Forestry, Southern Illinois University, Illinois Forest Development Council), Forest Plan Standards and Guidelines and soil suitability and limitation identified by the NRCS. These include careful location of logging facilities, minimizing bare soil exposure, and operating only when the soils are dry enough to support the machinery. The potential erosion hazard on roads and skid trails will be reduced by construction of water control structures, which will reduce slope length and slow surface runoff to minimize erosion (IDNR et al. 2007). Re-vegetating disturbed areas, either naturally or by including seeding under the terms of the sale contract, will protect disturbed areas such as skid trails and log landings within a few weeks to a few months after disturbance (IDNR, 2007). More details about the implementation and effectiveness of the proposed measures can be found in the project file. The prescribed BMPs would be effective in protecting soil and water resources.

Prescribed Burning: The effects of prescribed burning on soil erosion and nutrient loss are related to severity of the burn. These effects are complex and depend on a host of factors but certain generalizations seem relatively consistent. Burning has its most pronounced effect on the forest floor where carbon (C), nitrogen (N), and sulfur (S) are volatilized and calcium (Ca), magnesium (Mg), potassium (K), and phosphorus (P), and other elements are left as ash. The ash is leached by rains into the mineral soil which increases its base saturation and pH (Alban 1977). Increased nutrient availability at higher pHs may result in positive plant responses following fire. Positive plant responses following prescribed burns have been observed (monitoring reports 1993-2007, Van Lear and Kapeluck 1989). This monitoring has shown our prescribed burns are mostly low-intensity fires (monitoring reports 1993-2007). The positive response of plants leads to less soil erosion because plants hold the soil and slow the impact of rainfall. These coincide with results from a variety of other reviews and studies (DeBano 1998, Liechty, Luckow & Guldin 2004; Neary, Ryan & DeBano 2005). Timing of prescribed fire can influence the degree of plant responses. Prescribed fire in late fall to early winter may result in nutrients from ash to leach out of the soil due to the higher precipitation events for that season. Plants may be able to take advantage of ash in the soil after early spring burns after their winter dormancy. Erosion can increase as a result of prescribed fire, but WEPP (Water Erosion Prediction Project, Elliot 2009, Elliot et al. 2009) model runs indicate that the erosion levels are much lower than erosion and sedimentation levels after a high-severity stand-replacement fire. Even if a wildfire occurred in areas treated with thinning and/or prescribed burn, these areas would experience less erosion damage after the fire, wildfires would not burn as hot, and trees may be left with a portion of their foliage. Low-intensity fires result in less soil erosion than high intensity fires and WEPP model runs also bear this out. Low-intensity prescribed fire used alone or in combination with even-aged management would be expected to have a negligible, short term (one to two years) impacts with slight, elevated levels for erosion and sedimentation.

Prescribed fires are ignited via dropping of "Ping Pong balls" containing potassium permanganate (often used to treat drinking water and as a disinfectant) which are then injected with ethylene glycol (common automotive antifreeze). These two substances together in the sphere begin an exothermic reaction and are expelled from the aircraft. It is unknown, even by the manufacturer, how long the plastic will take to decompose; however, on the small chance that the sphere does not ignite, it can be presumed that it will be consumed by the surrounding fire. Potassium permanganate and ethylene glycol are highly reactive and ignite easily. In the unlikely event that the two do not ignite, potassium permanganate is a strong oxidizing agent that will react with organic matter without creating any toxic byproducts. Ethylene glycol, on the other hand, is toxic if ingested. It is, however, readily biodegradable in the environment within 1 to 21 days, with much of the primary degradation occurring within 3 days. Because ethylene glycol is very soluble in water, biodegradation is the most important process that breaks it down. This suggests that bioaccumulation is not likely to occur. It also breaks down very quickly in humans and animals (USEPA 2000). At the levels used in plastic spheres for aerial ignition, ethylene glycol in runoff from airports is a greater environmental concern (Peterson and Gallagher personal communication 2010). As one substance reacts with organic matter without creating toxic byproducts and the other substance is biodegradable and not known to bio-accumulate, no adverse effect on watershed resources is expected from this action.

The total amount of disturbance (erosion, etc.) depends on the timing of the prescribed burning. Prescribed fire which occurs when the soil, litter, and organic matter are moist will typically consume less of these components necessary for substrate for microbial organisms and maintenance of long-term soil productivity. Prescribed fire may include a pre-harvest burn and up to three burns over a ten year period. Implementation of this treatment over three periods of time allows one area to return towards baseline conditions by the time the next burn over a different area would be scheduled. The impact on air quality would be similar allowing one area to return to baseline air conditions by the time the next burn over a different area would be scheduled.

Soil biological properties influence a wide range of organisms which the soil and the properties they regulate**.** These components are made up of both living and dead biomass and both can be affected by the project activities including harvest and prescribed fire. Living organisms are classified in several ways. Soil flora includes algae, some bacteria, mycorrhizae and plant roots. Soil fauna includes protozoa, earthworms, and insects. This is further divided into micro, meso, and macrofauna. These participate in processes such as nitrogen cycling processes (nitrogen fixation and denitrification), decomposition, and mineralization. Management activities, including prescribed burning, will influence these processes (Neary et al. 2005, De Bano et al. 1998, Busse and DeBano 2005).

Fire affects living organisms in direct and indirect ways. Because organic matter and organisms are located at or near the surface, they can be exposed to flaming fuels and smoldering forest floor fuels. In the period after fire, a stable recovery of microbial populations to pre-fire levels can be expected. The moisture content of the litter, organic matter, and soil influences the effect on organisms. Water absorbs a lot of heat and this will reduce the temperatures and amount of substrate consumed. Most soil micro-organisms are heterotrophic and require pre-formed organic material in the litter and soil for their source of energy (Neary et al. 2005, De Bano et al. 1998, Busse and DeBano 2005).

Low severity prescribed fire (such as observed on Forest prescribed burns) has a minimal effect on soil organisms. Temperatures can be non-lethal except in the upper litter layer and the consumption of forest floor substrate is limited. A single-entry burn could be considered to have a minimal effect but repeated entries over time may reduce microbial population size and activity (Neary et al. 2005, Busse and DeBano 2005, De Bano et al. 1998).

Some generalizations can be made from past experience and studies:

- Micro-organisms do re-colonize disturbed forests due to a great physiological and genetic diversity within one or more years (Neary et al. 2005, Busse and DeBano 2005, De Bano et al. 1998).
- Fire effects are greatest in the forest floor and decrease with depth in the mineral soil. Recovery of microbial populations increases with the increasing moisture content of the litter layer and soil profile. Changes in microbial activity often show a positive response to low severity prescribed fire (Neary et al. 2005, Busse and DeBano 2005, De Bano et al. 1998).
- Repeated prescribed fire may reduce organic matter content and increase the loss of soil organisms through erosion. However, monitoring data from Forest prescription fires show an average one to two centimeters of litter consumption with the majority of litter unburned (Forest Service unpublished data 2010). Repeated fires to kill invasive and mesophytic species and allow oak species to establish may be necessary to achieve multiple-use objectives. Forest burns are typically low-intensity–low-consumption burns (Nowacki, Region 9 Ecologist, personal communication 2010).
- Knowledge gaps exist, such as the effect of repeated prescribed burns on organisms (Neary et al. 2005, De Bano et al. 1998, Busse and DeBano 2005).

Based on the above, some recommendations can be made:

- Minimize loss of the forest floor (litter and duff) as micro-organisms are vulnerable to heat damage and substrate changes. Burn when the upper layer of the forest floor is dry enough to carry a fire and the lower layers are moist enough to avoid consumption. These recommendations are achieved on the majority of Forest fires. Monitoring of some recent prescribed burns on the Forest indicates that an average one to two centimeters of duff are consumed during these burns.

- Burning with varying consumption occurring in mosaic patterns can provide substrate and habitat for microbial re-colonization following a fire. Monitoring shows this pattern on Forest burns.

Firelines: Fireline construction is part of this alternative. Erosion levels will vary depending on climatic conditions, slope, soil texture and other factors. Erosion control measures such as water bars would reduce these to minimal levels.

Many firelines may occur on areas with fragipans in the soil profile. Fragipans typically occur at a depth from 18 – 30 inches in the soil profile. Ground disturbing activities, particularly in wet soil conditions would have the potential to degrade soil structure, especially in those locations on soils with fragipans when the disturbance occurs at a depth where the fragipans are present. The hazard to these soils would result from machine based fireline construction. Fireline location employing roads as fire breaks and hand fireline construction in sensitive areas would reduce soil disturbance to these soils to minimal levels.

Pesticide application: Pesticide application is part of the proposed action: six herbicides are proposed for use. In most cases, the herbicides would have a minimal impact on soil and water resources. In most cases, soil micro-organism populations could increase in the presence of herbicides.

Glyphosate is readily metabolized by soil bacteria and many species of soil microorganisms use glyphosate as sole carbon source. Very little information suggests that glyphosate will be harmful to soil microorganisms under field conditions and a substantial body of information indicates that glyphosate is likely to enhance or have no effect on soil microorganisms. Most field studies involving microbial activity in soil after glyphosate exposures note an increase in soil microorganisms or microbial activity and the application of glyphosate may cause transient increases in soil fungi that may be detrimental to some plants. While the mechanism of this apparent enhancement is unclear, it is plausible that glyphosate treatment resulted in an increase in the population of pathogenic fungi in soil because glyphosate was used as a carbon source by the fungi and/or treatment with glyphosate resulted in increased nutrients for fungi in the soil. There is no indication that the transient enhancement in populations of soil fungi or bacteria will result in any substantial or lasting damage to soil ecology (from Durkin 2003-Glyphosate–Human Health and Ecological Risk Assessment Final Report, USDA Forest Service Forest Health Protection).

The most widely used type of surfactants in glyphosate formulations are known as ethylated amines. POEA (polyoxy-ethyleneamine) has been frequently mentioned as a surfactant, but in fact it refers to a group of ethylated amine products used in glyphosate formulations. Monsanto is aware of the irritant and toxic potential of the surfactants in general, the company has now developed new surfactants which have none of the toxic effects. This information is from an article in Pesticides News No.33, September 1996, p28-29 and found on-line at http://www.pan-uk.org/pestnews/Actives/glyphosa.htm. In addition, the relatively small amount of glyphosate and surfactant applied is not expected to have an adverse effect on watershed resources.

Triclopyr is practically non-toxic to fish and aquatic invertebrates. In natural soil and in aquatic environments, the formulations rapidly convert to the acid which in turn is neutralized to a salt. Triclopyr is not strongly adsorbed to soil particles, can be mobile, and is fairly rapidly degraded by soil microorganisms. The half-life in soil is from 30 to 90 days, depending on soil type and environmental conditions, with an average of about 46 days. Breakdown by the action of sunlight is the major means of triclopyr degradation in water. The half-life is 10 hours at 25 degrees C. The major metabolite is trichloropyridinol (EXTONET 1993 online at: http://pmep.cce.cornell.edu/profiles/extoxnet/pyrethrins-ziram/triclopyr-ext.html.

Sethoxydim is moderately to slightly toxic to aquatic species. In soil and groundwater, sethoxydim has low soil persistence. It has a weak tendency to adsorb to soil particles. Indications are sethoxydim could leach in soil. However, in field tests, sethoxydim did not leach below the top 4 inches of soil, and it did not persist. On soil, photodegradation of sethoxydim takes less than 4 hours. Disappearance of sethoxydim is primarily due to action by soil microbes. In water, photodegradation of sethoxydim takes less than 1 hour. Considering the likely amount of the chemical that would be applied over ten years, direct effect would be on target grasses with no measurable effect on soils and water (EXTONET 1993 on-line at: http://pmep.cce.cornell.edu/profiles/extoxnet/pyrethrins-ziram/sethoxydim-ext.html.

Clopyralid, or any other herbicide, may be transported to off-site soil by runoff or percolation. It is degraded primarily by microbes in soils and aquatic sediments (Tu et al. 2001). Rates of microbial metabolism increase with increasing soil moisture and temperature and decrease with increasing amounts of organic matter. No metabolites accumulate during the degradation process; therefore, no additional contamination of the soil environment. Clopyralid is moderately persistent in soils. Because it is degraded entirely by soil microbes, soil conditions that maximize microbial activity (warm and moist) will facilitate clopyralid degradation (Tu et al. 2001). Once clopyralid is applied to soils, it rapidly disassociates, becoming extremely soluble in water, and does not bind strongly with soil particles. Lack of adsorption means that clopyralid has the potential to be mobile and could contaminate underground and surface water via leaching and surface and sub-surface water flows. It is resistant to degradation by sunlight, hydrolysis, or other chemical degradation. It is of very low toxicity to most animals including soil invertebrates and microbes (Tu et al. 2001).

Picloram In heavy clay soil has a half-life of slightly over two months. However, when more organic material is present, the half-life of the compound nearly doubles. Breakdown by soil microorganisms occurs slowly, resulting in the formation of carbon dioxide (CO_2) and the release of a chloride ion. The compound is mobile and relatively persistent in soil and can therefore leach to groundwater. It has been detected in the underground water of some areas. In water, the action of sunlight is an important mechanism leading to the breakdown of the product. Movement of picloram in runoff after heavy rainfall may occur. Due to the relative toxicity of this chemical, it is proposed only as a treatment of cut stumps/limbs (EXTONET 1993 (http://pmep.cce.cornell.edu/profiles/extoxnet/metiram-propoxur/picloram-ext.html).

Indirect Effects

Carbon sequestration: The effect of prescribed burning on the release of carbon dioxide and greenhouse gases into the atmosphere has been mentioned as a concern. An increase of greenhouse gases has been observed during the past few decades and many (including many scientists) recognize this. There is some debate on the role of trees in relation to this increase. Gerould Wilhem of the Conservation Research Institute in Elmhurst, Illinois, in his article, "The Realities of Carbon Dioxide: Seeing Through the Smog of Rhetoric and Politics," states in his summary:

> Planting trees or setting forests aside cannot offset the oxidation of fossil fuels because fossil carbon represents stored carbon from another era. Such organic carbon is converted to CO_2 in surplus amounts. Trees and vegetation of this era already are cycling carbon into the atmosphere at a rate and concentration to which contemporary life forms are adapted. Relatively sudden changes in atmospheric chemistry, such as we are seeing today, impose global system constraints at a rate to which most life forms have difficulty adjusting during their life spans and physiologic development; most cannot adjust at all. These rapid macrohabitat system changes are not in synchrony with other systems such as day length, genetics, physiology, and chemistry (Wilhems 2009).

Johnson's 1992 review and an updated one Johnson and Curtis (2001) are often cited to shed some light on the effects of burning on soil carbon. The 1992 review concluded carbon losses from mineral soil, as a result of low-intensity prescribed were minor to non-existent. Sometimes, soil carbon increased as result of nitrogen-fixing species. Wildfires often resulted in significant carbon losses from the mineral soil but this did not happen in all cases. The effects on carbon were often linked to fire intensity. The review in 2001 looked at additional fire studies, no significant fire response on the surface or whole fire was found. When the studies were separated into classes for analysis (years since the fire), significantly higher carbon levels were noted in the 10+ after fire group. When only the 0 – ten year post-fire categories were analyzed, soil carbon was higher relative to unburned areas following wildfire and lower after a prescribed fire (Johnson 1992, Johnson and Curtis 2001, Hoover 2003)

Hurteau, Koch, and Hungate (2008) made three points relative to carbon protection, fire risk reduction, and accounting of forest carbon offsets:

- In current carbon accounting, forest management impacts on potentially catastrophic disturbances are typically ignored.
- In forests where fire suppression has caused fuel accumulation, forest fuel reduction treatments can diminish the risk of stand-replacement wildfire, thereby promoting carbon storage.
- Carbon accounting should recognize the value of management actions that reduce the risk of carbon loss through stand replacing fire.

Mechanical Methods:

- Pulling and/or digging: Minimal impact to soil and water, as ground disturbances are expected to be minor.
- Cutting and/or Mowing: Minimal impact from compaction from equipment which may result in increasing runoff and erosion.
- Tilling and smothering: Minimal impact from possible minimal compaction from equipment increasing runoff and erosion

Combination Methods:

- Hack and squirt: Minimal impact to watershed resources, as this treatment is not ground-disturbing or -compacting.
- Torching: Minimal impact to watershed resources, as this treatment is not ground-disturbing or -compacting.

Ecosystem Services:

> Healthy forest ecosystems are ecological life-support systems. Forests provide a full suite of goods and services that are vital to human health and livelihood—natural assets we call ecosystem services. Many of these goods and services are traditionally viewed as free benefits to society, or 'public goods'—wildlife habitat and diversity, watershed services, carbon storage, and scenic landscapes, for example. Lacking a formal market, these natural assets are traditionally absent from society's balance sheet; their critical contributions are often overlooked in public, corporate, and individual decision-making (www.fs.fed.us/ecosystemservices).

Conservation denotes wise use and stewardship denotes caring for the land. Prescribed fire does not degrade or eliminate these services and the services continue after a prescribed fire as before. Native Americans used fire for their own ecosystem services: i.e. improved game habitat, facilitated travel, reduced insect pests, remove cover for enemies, enhanced conditions for berries, and drive game. Present-day services such as air cleaning, watershed protection, habitat, scenic beauty, carbon storage, oxygen production and recreation continue as ecosystem services after a burn just as ecosystem services continued after a burn for Native Americans. There is no evidence that ecosystem services are degraded or eliminated after a burn.

Natural and anthropogenic processes occurred in pre-settlement conditions. Further information on this issue can be found on pages 218, 224 – 226 of Appendix I, FEIS for the Forest Plan. A prescribed fire would have the result of speeding up decomposition the volatilization of carbon, nitrogen, and resulting elements returning to the ground as ash. This is also covered sections of the working paper text and appendices. Watershed quality following prescribed burns is covered in the Forest Plan (Chapter 4, pages 23, 24 and Chapter5, pages 41, 47, 48) and in the FEIS (page 72 - 75) for the Plan.

Cumulative Effects

Cumulative watershed effects are the estimated additive changes in watershed disturbance and hazard of damage to soil from fire that might occur from the existing conditions, implementing the proposed project, current activities within the analysis area, plus any foreseeable actions.

Soil erosion is generally low to medium throughout the analysis area although soil erosion is rated high in certain areas (areas with steep slopes) of the 12-digit HUC's making up the analysis area. Soil compaction is generally high throughout the analysis area. Compacted areas such as fire trails could serve as conduits for runoff. Soil productivity is generally low. The hazard of damage to soil from fire is generally medium. Riparian soils occur adjacent to streams throughout the analysis areas and can be subject to occasional to frequent flooding for brief periods. (See soils tables in the working paper appendices.)

Agricultural activity in the project area watersheds is given in the data (in the appendices in the working paper) from the National Agricultural Statistics Service. Though the data is given for crops and animal husbandry on a county basis, it does provide an idea of what kind of activity was going on during the past and present years and the trends it shows can give a clue as to future activity. (NASS 2010)

Federal ownership in the cumulative effects analysis area is 21 percent. The other ownership of 79 percent is likely to influence watershed conditions in the project areas to a greater degree than the project activities of the proposed action.

Alternative 3

Under this alternative, no synthetic herbicides would be used to control invasive species. The methods we propose rely on aggressive manual or mechanical treatments as the first course of control. Natural weed-killers could be applied where manual and mechanical methods are ineffective. This alternative was developed in response to public concerns about the unintended consequences of the use of synthetic herbicides. It is designed to control some invasive species, but would not eradicate many populations because the natural weed-killers only top-kill the plants.

1. Forest-wide treatment of four highly invasive species:

Under this alternative we would concentrate on the same four highly invasive species as under the proposed action—Amur honeysuckle, Chinese yam, garlic mustard and kudzu—but would use manual and mechanical methods as a first line of treatment (Table 4).

Amur honeysuckle is a large woody shrub that can occur as dispersed, individual plants or develop dense, coarse thickets, spreading in the local area. It tolerates high to moderate light-levels. Once treatment is initiated, control can be expected within four years. (See Table 4 for treatment details.)

Chinese yam and garlic mustard, once treated as described in Table 4, would require follow-up treatments for several years, to deplete the seedbank of garlic mustard and to eliminate Chinese yam from natural areas and their treatment zones. Eliminating these plants would increase the light and nutrients available to the affected sites. Higher levels of light—with the associated increase in soil temperature facilitating native seed germination and increased photosynthesis—available water and nutrients will stimulate native plant species and seeds in the treated areas. This will lead to reoccupation of the areas by native species.
Kudzu sites exhibit complete coverage by the plant. Most plants and trees covered by the kudzu will have died from the elimination of light. As kudzu occupies the site, its density is such that the ground surface cannot be seen and the depth of the kudzu and dead plants beneath can be several feet. On the periphery of the occupied site, the kudzu extends runners into adjacent forest, further occupying the area by climbing trees and shrubs and eventually killing the plants. Given the extensive root reserves of kudzu, multiple treatments, as described in Table 4, over several years are anticipated.

Natural herbicides are simple substances that directly top-kill plants upon application. These substances are encountered naturally, but in small quantities. Food-grade vinegar and clove oil are the main active ingredients in one type of natural herbicide. However, the concentrations used in the natural weed-killers are higher than available at a grocery store. Vinegar at the grocery store is usually 5 percent acetic acid, while the natural weed-killer contains a 20-percent solution. These ingredients are relatively well known and normally not harmful to humans or animals. However, when applied in large doses, the results are usually obvious in a very short time. After treatment, their damaging effect is quickly dissipated. Vinegar is acetic acid along with other weak organic acids. Clove oil is an essential oil from the clove plant (*Syzygium* *aromaticum*). This mixture works by disrupting plant membranes and causing the leakage of cells. The damage to plants appears rapidly, in 1-2 days.

A hot-foam machine could be used from roads and some trails to steam-kill invasive species. The Waipuna® hot-foam system, for example, is comprised primarily of a diesel-powered boiler and foam generator that deliver hot water with a foam surfactant to target weeds via a supply hose and a treatment wand. The superheated hot foam (sugar is added to achieve a higher boiling point than water) is applied to the targeted vegetation at a high temperature (200°F) and low pressure; the foam traps the steam, giving it time to "cook," or "blanch," the vegetation. This causes a cellular collapse of the treated aboveground vegetation. This control method is limited in mobility and is best used near developed sites such as campgrounds and trailheads and along roadsides and accessible trails.

2. Management of 23 designated natural areas and their treatment zones:
All invasive species within the specified natural areas (Table 1) would be treated using the methods outlined in Table 4. Management would include the application of prescribed fire in the natural areas and the treatment zones, about 11,220 acres. Existing fire-breaks, such as roads, trails, streams and other natural features, would be used as firelines where possible; but mechanically constructed firelines would be used where necessary. We expect to install about 14 miles of lines by hand and 6 miles mechanically.

The treatment zones would be burned at intervals of 1-3 years, depending on fuel availability and the assessment of effects to determine the need for additional fire. The fire would help restore native vegetation and set back the development of invasive species. Further burns would be done as needed to maintain the areas' ecological integrity once invasive vegetation has been suppressed. Manual and mechanical weed-treatment methods would be applied to manage invasive species either before or after the initial burns, depending on the species present.

Direct effects – Direct effects will be similar to the proposed action except that chemical methods would not be used and the emphasis for treatment would be manual or mechanized methods. This would result in increased soil erosion and compaction from limited use of mechanized equipment and employment of some ground disturbing activities. Prescribed fire would be employed in this alternative equal in acres to the proposed action.

Clove oil (eugenol) is anticipated to be short-lived and rapidly dissipated by volatilization and atmospheric deposition. Eugenol is anticipated to be broken down by rapidly by soil microbes. One study found that Pseudmonas fluorescens bacteria (a common soil bacterium) degraded eugenol. As Eugenol volatilizes rapidly and is anticipated to be broken down rapidly in soils through microbial activity, it is not considered to be a potential underground water contaminant and substantial surface water runoff is not anticipated except through preferential pathways such as cracks and crevices. When dissolved in water, eugenol volatilized slowly in the air and can occur in wet soils as well though microbial degradation may occur in soils first. Air transport of eugenol can occur after application by spray drift and over time by volatilization (Marin Municipal Water District 2008.)

Indirect Effects – Similar to the proposed action. As chemical methods will not be used, minor additional ground disturbance will release some carbon dioxide into the atmosphere and slight increases in erosion and sedimentation will result in some soil carbon moving off-site. As invasive species are controlled, ecosystem services should improve over alternative 1.

Cumulative Effects – The cumulative effects of this alternative would be similar to those of Alternative 1 with regard to the application of prescribed fire, and Alternative 2 with regard to the other proposed actions, the only difference being the use of natural herbicides instead of synthetic herbicides. Even though repeated treatments of natural herbicide might be required, the cumulative effects would be virtually the same as described under Alternative 2: non-measurable and insignificant.

Table 14. Comparison of Herbicide Application by HUC6 Watershed: Proposed Action vs. Agricultural Use.*

Watershed	Herbicide (Pounds of Active Ingredient) C=Clopyralid S=Sethoxydim G=Glyphosate T=Triclopyr				Agricultural Application	
	Acres Treated					
Total Acres/FS Acres and Percent Ownership	Clopyralid	Glyphosate	Sethoxydim	Triclopyr	Acreage	Glyphosate Use
Barren Creek 13,862 / 7656: 55%	0.33	88.1	26.4	0.5	2593	4538
	0.36	36.64	19.63	0.36		
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.0073% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Bay Creek Ditch 11,588 / 4188: 36	0	0	0	22.78	4852	0
				4		
Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Beaver Creek-Saline River 20,780 / 4267: 21	0	0	0	129.66	9306	0
				23.05		
Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Big Creek 12,829 / 4731: 37	0	0	0	0.16	2819	0
				0.28		
Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Big Grand Pierre Creek 15,672 / 7562: 48	0	438	0	0	3549	6210
		182.5				
Total proposed glyphosate application in this watershed is about 7% of total agricultural use.						
Black Branch-Eagle Creek 22,172 / 6487: 29	0	3.6	0	0	7712	13,496
		1.5				
Total proposed glyphosate application in this watershed is about 0.027% of total agricultural use.						
Camp Creek-Ohio River 31,064 / 4261: 14	0.48	22.68	1.63	0.75	3891	6809
	0.16	6.52	3.17	0.16		
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.33% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Cedar Creek 25,422 / 6687: 26	0.69	37.53	1.15	1.16	10,650	18,638
	0.23	15.32	3.03	0.24		
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.2% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Cedar Lake-Cedar Creek 22,129 / 6052: 27	17.33	0	0	29	7237	12,665
	19.15			19.15		
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						

Table 14. Comparison of Herbicide Application by HUC6 Watershed: Proposed Action vs. Agricultural Use.*						
Watershed	Herbicide (Pounds of Active Ingredient) C=Clopyralid S=Sethoxydim G=Glyphosate T=Triclopyr Acres Treated				Agricultural Application	
Total Acres/FS Acres and Percent Ownership	Clopyralid	Glyphosate	Sethoxydim	Triclopyr	Acreage	Glyphosate Use
Cooper Creek-Mill Creek 16,544 / 2623: 16	0.11 0.15	0	0	0.2 0.15	8303	14,530
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Dutch Creek 25,642 / 3849: 15	0	2.08 0.43	0	0	4792	8386
Total proposed glyphosate application in this watershed is about 0.025% of total agricultural use.						
Edmondson Slough-Sexton Ck 21,603 / 6915: 32	0	1.92 0.8	0	0	2921	5112
Total proposed glyphosate application in this watershed is about 0.038% of total agricultural use.						
Fountain Bluff-Mississippi River 27,842 / 3187: 11	0	73.15 25.4	0	0	18,584	32,522
Total proposed glyphosate application in this watershed is about 0.23% of total agricultural use.						
Goose Creek-Big Creek 14,046 / 6369: 45	0.3 0.1	1.77 0.36	0.38 1	0.75 0.15	3516	6153
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.029% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Grassy Creek 18,924 / 1528: 8	0	0	0	13.24 2.35	6197	0
Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Hayes Creek 15,326 / 7297: 48	1.89 0.63	10.6 2.11	5.37 14.3	5.12 0.66	5945	10,404
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.102% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Hutchins Creek 13,080 / 9909: 76	0.33 0.11	2.53 1.47	0	3.14 0.65	2491	7473
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.034% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).						
Kinkaid Lake-Kinkaid Creek 25,699 / 8462: 33	0	441.26	0	0	9364	16,387

Table 14. Comparison of Herbicide Application by HUC6 Watershed: Proposed Action vs. Agricultural Use.*							
Watershed	Herbicide (Pounds of Active Ingredient) C=Clopyralid S=Sethoxydim G=Glyphosate T=Triclopyr					Agricultural Application	
	Acres Treated						
Total Acres/FS Acres and Percent Ownership	Clopyralid	Glyphosate	Sethoxydim	Triclopyr		Acreage	Glyphosate Use
		97.25					
Total proposed glyphosate application in this watershed is about 2.7% of total agricultural use.							
Lake of Egypt 21,766 / 2233: 10	0	2.4	0	0		8645	15,129
		1					
Total proposed glyphosate application in this watershed is about 0.016% of total agricultural use.							
Little Bay Creek-Bay Creek 27,172 / 13,756: 65	1.53	17.7	3.07	4.64		6849	11,986
	0.6	5.94	8.14	0.85			
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.15% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Little Cache Creek 23,699 / 2527: 11	0.98	25.26	16.53	21.05		12,750	22,313
	0.34	8.82	44.04	0.88			
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.113% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Little Eagle Creek 14,481 / 6969: 48	0	3.14	0	0.014		3896	6818
		1.3		0.003			
Total proposed glyphosate application in this watershed is about 0.046% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Little Grand Pierre Creek 13,361 / 5095: 38	0	0.36	0	0.28		3656	6398
		0.15		0.05			
Total proposed glyphosate application in this watershed is about 0.006% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Little Kinkaid Creek-Kinkaid Ck 15,527 / 2577: 17	0	664.5	0	0.28		9036	15,813
		108.27		0.05			
Total proposed glyphosate application in this watershed is about 4.2% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Little Lusk Creek-Lusk Creek 31,812 / 18,044: 58	2.25	3.12	0	248		5957	10,425
	0.8	1.3		44.8			
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.03% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Little Saline River	4.5	3.63	0.0019	6.2		5851	10,240

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Watershed	Herbicide (Pounds of Active Ingredient) C=Clopyralid S=Sethoxydim G=Glyphosate T=Triclopyr					Agricultural Application	
	Acres Treated						
Total Acres/FS Acres and Percent Ownership	Clopyralid	Glyphosate	Sethoxydim	Triclopyr		Acreage	Glyphosate Use
20,928 / 8019: 38	7.25	1.18	0.05	8			
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.035% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Lusk Creek 24,610 / 5553: 23	0	1.8	0	45.6		8151	14,264
		0.76		8.11			
Total proposed glyphosate application in this watershed is about 0.013% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Mill Creek 17,573 / 2129: 12	0	2.45	0	0		10,180	17,815
		1.02					
Total proposed glyphosate application in this watershed is about 0.014% of total agricultural use.							
Peters Creek-Ohio River 31,158 / 2401: 0.08	0	22.9	0.29	0.2		9329	16,326
		6.87	0.74	0.14			
Total proposed glyphosate application in this watershed is about 0.14% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Pinhook Ck-Big Grand Pierre Ck 23,292 / 7314: 31	0	6	0	0.47		6715	11,751
		2.5		0.05			
Total proposed glyphosate application in this watershed is about 0.051% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Rock Creek 17,093 / 4267: 25	0	0	0	25.85		4868	8519
				2.75			
Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Running Lake Ditch 23,003 / 4172: 18	0	26.98	12.5	21.34		16,153	28,268
		7	33.23	1.13			
Total proposed glyphosate application in this watershed is about 0.095% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Sandy Creek 19,027 / 8508: 45	0	1.92	0	0		6843	11,975
		0.8					
Total proposed glyphosate application in this watershed is about 0.016% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Seminary Fork-Clear Creek 20,094 / 5004: 25	0.16	4.14	0	0.26		6279	10,988
	0.07	0.8		0.07			
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004).							

Table 14. Comparison of Herbicide Application by HUC6 Watershed: Proposed Action vs. Agricultural Use.*							
Watershed	Herbicide (Pounds of Active Ingredient) C=Clopyralid S=Sethoxydim G=Glyphosate T=Triclopyr					Agricultural Application	
	Acres Treated						
Total Acres/FS Acres and Percent Ownership	Clopyralid	Glyphosate	Sethoxydim	Triclopyr		Acreage	Glyphosate Use
Total proposed glyphosate application in this watershed is about 0.038% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Sister Islands-Ohio River 34,000 / 3680: 11	15.6	24.38	13.24	20.7		5537	9690
	11.25	5.6	35.3	11.31			
Total proposed clopyralid application in this watershed is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in this watershed is about 0.25% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Spring Valley Ck-S Fork Saline R 21,085 / 4520: 21	0	0.12	0	0		9417	16,480
		0.05					
Total proposed glyphosate application in this watershed is about 0.00073% of total agricultural use.							
Sugar Creek 13,464 / 6862: 51	0	6.72	0	0		5144	9002
		2.8					
Total proposed glyphosate application in this watershed is about 0.075% of total agricultural use.							
Town Creek-Big Muddy River 36,231 / 18,560: 51	0	58.75	0	0.007		14,835	25,961
		24.38		0.001			
Total proposed glyphosate application in this watershed is about 0.226% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							
Worthen Bayou 10,321 / 1356: 13	0	24.6	0	0		8087	14,152
		10.25					
Total proposed glyphosate application in this watershed is about 0.174% of total agricultural use.							
TOTAL HERBICIDE APPLICATION	46.5	2024	80.6	601.4		282,900 (glyphosate)	
TOTAL ACREAGE TREATED	41.2	560.37	162.63	129.4		495,075	
Total proposed clopyralid application in all watersheds is about 2.2% of total agricultural use (Durkin and Follansbee 2004). Total proposed glyphosate application in all watersheds is about 0.72% of total agricultural use. Total proposed triclopyr application in this watershed is about 1% of total agricultural use (Durkin 2011).							

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Appendix

Personal Communications Memos

John: Over the years, I've had many opportunities to go out in the field with numerous colleagues from across the eastern United States to evaluate prescribed burns. In southern Illinois, many of those field outings were with Dr. Charles Ruffner (SIU) and Scott Crist, whom I'm CCing here. Being the Regional Ecologist, I'm in the unique position to interact with field personnel from across the Region, allowing me to compare and contrast the effectiveness of prescribed burning for oak regeneration and/or oak ecosystem restoration. The recent "3rd Fire in Eastern Oak Forests Conference" (May 2008) served as a great catalyst bringing people together from across the East to discuss oak-fire relations, especially during the component field trip. It is from all these experiences that I make the following observations.

The southern Illinois story:
The current situation in southern Illinois is typical of much of the East, with fire-tolerant oaks relegated to forest overstory positions and fire-sensitive mesophytes (maple, beech, etc.) dominating forest midstories and understories. This switch in species composition is largely due to fire suppression, which dates back to the 1950s in southern Illinois. In essence, upon fire suppression, overstories closed and shade-intolerant oaks were no longer able to effectively regenerate and compete against shade-tolerant mesophytic species. This is a well documented phenomenon throughout the East. Returning fire back to these systems has been recognized by many local professionals and limited burning has occurred in southern Illinois now for a couple of decades. Dave Allen (IL DNR), Charles Ruffner, and Scott Crist (USFS) have all been instrumental in reintroducing fire back onto southern Illinois landscapes and should be lauded for their foresight and dedication.

One of the problems I have seen when visiting burn sites is that fires tended to be "too cool." The conditions associated with these altered ecosystems in their present state (cool shaded conditions; wet, flat-lying mesophytic litter; lack of fine "grassy" fuels) makes it difficult to initially burn these systems at the intensity needed to immediately knock back the small-diameter mesophytic competitors. As such, multiple burns are needed to repetitively injure competing mesophytes to the point of death, which ends up spanning many years. This is not a novel observation, as the lack of fire intensity was pointed out to me by many participants at the 3rd Fire in Eastern Oak Forests Conference field trip. There seems ample opportunity to speed up oak regeneration/restoration by incorporating other silvicultural treatments, such as thinning from above (increasing understory light/heating/drying and fuel levels), thinning from below (decreases understory competitors while increasing light/heating/drying and fuel levels) and/or herbiciding (directly kills competing understory vegetation). I know Charles Ruffner is experimenting with different treatment combinations as we speak, which is good and where the USFS should be headed, perhaps in collaboration with Dr. Ruffner. This is what our joint R09-NRS Oak Ecosystem Restoration effort is all about -- to systematically evaluate a number of treatments that best (and most quickly) restores oak ecosystems to their former glory. Getting "hotter" surface burns back onto the oak landscape (within a safe window of operation) is a treatment definitely worth pursuing.

Respectfully submitted, Greg (Nowacki)

John:

As we discussed yesterday by phone, Massac County has not been designated by USEPA as a nonattainment area for the 24-hour fine particle (PM2.5) air quality standard. Attached if the federal register notice published by USEPA promulgating such designations for all areas in the country. Massac County was designated as "unclassifiable/attainment" for the standard based on measured air quality data collected in Paducah from 2007 thru 2009. Previous measurements, from 2006 thru 2008, showed violations of the standard, but the more recent data, which were the basis for the final designations, indicated that the area was meeting the standard. Hope this helps.

Rob Kaleel
Manager, Air Quality Planning Section
Illinois EPA

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