Final Environmental Impact Statement
2016-2020 Fernow Experimental Forest
Tucker County, West Virginia
United States Department of Agriculture Forest Service
Northern Research Station

Lead Agency:	USDA Forest Service Northern Research Station
Responsible Official:	Thomas M. Schuler Project Leader Timber and Watershed Laboratory P.O. Box 404 Parsons, WV 26287
For Further Information Contact:	Melissa Thomas-Van Gundy NEPA Coordinator Timber and Watershed Laboratory P.O. Box 404 Parsons, WV 26287

Summary:

The USDA Forest Service, Northern Research Station (NRS) proposes to continue on-going long-term research activities on the Fernow Experimental Forest, Tucker County, WV, over the next several years. The proposed action and alternatives analyzed in this Final Environmental Impact Statement (FEIS) were designed to implement directions contained in the 2011 Revised Forest Plan for the Monongahela National Forest, the NRS-01 Research Work Unit Description, and the individual research study plans. The purpose of this project is to continue important long-term research studies, and to manage the Fernow Experimental Forest for long-term research. Three alternatives were assessed: the no action, proposed action, and modified proposed action. Alternative C, the modified proposed action is the preferred alternative for implementation. The modified proposed action, involves using the following silvicultural treatments in existing research studies: diameter-limiting cutting treatment on 160 acres, single-tree selection on 113 acres, 31 acres of patch cutting, prescribed fire treatment of 398 acres, herbicide treatment of understory/midstory on 12 acres, and underplanting of hardwood seedlings on 6 acres. Other treatments include fertilization of 89 acres with ammonium sulfate fertilizer, (and additions of dolomitic lime to 4 of those acres), herbicide treatment of invasive exotic plants, and maintenance of roads, decks, and other infrastructure.

The direct, indirect, and cumulative effects of the no action, proposed action, and the modified proposed action alternatives are disclosed in this FEIS. We have reviewed, evaluated, and responded to substantive comments provided during project scoping. In addition, we have evaluated the effects of the alternatives upon hydrology, air, soil, geologic, aquatic, wildlife, vegetation, recreation, and heritage resources, and have evaluated the economic impacts and the effects on consumers, civil rights, minority groups, and women.

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Chapter 1 – Purpose of and Need for Action

Introduction

In compliance with the National Environmental Policy Act (NEPA) and other relevant State and Federal laws and regulations, the USDA Forest Service has prepared this Final Environmental Impact Statement (FEIS) on the potential effects of silvicultural and ecological treatments in the Fernow Experimental Forest (FEF). This document provides information on research projects proposed for implementation in the FEF over the next several years.

This FEIS discloses the direct, indirect, and cumulative environmental impacts and any irreversible or irretrievable commitment of resources that would result from the proposed action and alternatives. It is prepared according to the format established by the Council on Environmental Quality (CEQ) regulations for implementing the NEPA (40 CFR 1500-1508). Chapter 1, in addition to explaining the purpose of and need for the proposed actions, discusses the relationship of the proposed actions to various planning documents, and identifies significant issues driving the analysis. Chapter 2 describes the proposed actions, alternatives to the proposed actions, and includes a comparison of the alternatives. Chapter 3 describes the physical, biological, and social environments that could be potentially affected by the proposed actions and alternatives. The environmental effects of each of the alternative being considered are disclosed in Chapter 3. Chapter 4 contains tables and figures, the list of preparers, the FEIS distribution list, literature cited, a glossary, a list of scientific and common names of plants and animals found on the FEF, and an index. Appendix A contains a summary of comments received during public review of the proposed action and our responses. All documents incorporated by reference are available at the Timber and Watershed Laboratory in Parsons, WV.

The interdisciplinary team used a systematic approach to analyze the proposed action and alternatives, estimate the environmental effects, and prepare this FEIS. The planning process complies with NEPA and CEQ regulations. Planning was coordinated with the appropriate Federal, state and local agencies.

Project Area

The ~4,600-ac FEF is located south of Parsons, WV and is administered by the staff of RWU-NRS01, Ecological and Economic Sustainability of the Appalachian Forest in an Era of Globalization (Fig. 1-1). The mission of the work unit is to develop timely, relevant knowledge and provide management guidelines to sustain and enhance the ecological and economic function and values of Appalachian forests.

The FEF is located in the Central Appalachian Broadleaf Forest (Province M221), which includes parts of Georgia, North and South Carolina, Virginia, Maryland, Pennsylvania, and West Virginia (Cleland et al. 2007). The FEF is within the Allegheny Mountains Section (M221B), with most of the area (4,430 ac) within the Western Allegheny Mountains subsection (M221Bb) and only 116 ac within the Northern High Allegheny Mountains subsection (M221Ba) (Cleland et al. 2007). The FEF is part of the Allegheny Front Sideslopes land type association (LTA). LTAs are differentiated by landforms, natural overstory communities, and soil associations and often are thousands of acres in size. The potential natural vegetation of the ecological section is strongly influenced by elevation and aspect and includes northern

hardwoods, red spruce, mixed mesophytic hardwoods, and oak communities. Braun (1950) classified vegetation as "mixed mesophytic type". Characteristic tree species include, but are not limited to northern red oak, yellow-poplar, black cherry, sugar maple, bitternut hickory, black birch, red maple, and American beech. The topography is mountainous with elevations ranging from 1,750 to 3,650 feet above sea level. Mean annual precipitation is about 56 inches and is distributed evenly throughout the year. The growing season is approximately from May through October with an average frost-free period of 145 days.

Slopes range from 20 to 50 percent over most of the FEF. The most common soils mapped in the FEF are the Calvin and Dekalb soil series. The Calvin series consists of moderately deep, well-drained acidic soils formed in material weathered from interbedded shale, siltstone and sandstone. Dekalb soils also are acidic, deriving from acidic sandstones. All of the other soil series mapped in the FEF also are acidic; however, Belmont soils, which extend along a band on the east side of the FEF are formed from weathered limestone and are much less acidic than the other soils.

The Elklick watershed, which comprises the majority of the FEF, was initially logged between 1903 and 1911 during the railroad-logging era (Fansler 1962, Trimble 1977). However, many trees were not removed due to insufficient size, undesirable species, or poor form. At that time, sugar maple, American beech, black birch, and the hickories were some of the least desirable species. Additionally, merchantability standards were a function of the distance to the standard gauge railroad. Portions of the FEF were cut more heavily than others. Forest fires may have been an important disturbance agent prior to initial logging and perhaps after logging, although actual documentation of past fires does not exist for the Elklick watershed. Only a small portion of Elklick watershed was farmed, and the forest was able to regenerate following the cessation of logging activities.

The Federal government purchased the land in 1915 and dedicated it to forest and watershed research in 1934. The FEF was selected because in topography, history of cutting and fires, and variety of forest types and conditions, the area was representative of more than 13 million acres of mountainous forestland in West Virginia and adjacent states. Since establishment as an experimental forest, fire and grazing have been excluded except where prescribed fire has been used in research. Chestnut blight was the next major disturbance to the FEF. First noted in West Virginia as early as 1909 (Brooks 1911), the blight resulted in a 25 percent reduction in standing volume on the experimental forest in the 1930s (Weitzman 1949). The FEF closed during World War II; however, silviculture and watershed research was reinitiated in 1948 and has continued to date without interruption.

Through time, additional acreage was added to the FEF so that it now incorporates part of the Stonelick Run watershed and the headwaters of the Sugarcamp Run and Canoe Run watersheds. Elklick Run drains into the Black Fork River, and Stonelick, Canoe Run and Sugarcamp Run all drain into the Shavers Fork River. The Black Fork and Shavers Fork Rivers join to form the Cheat River just north of Parsons, WV.

Purpose of and Need for Action

The purpose of the proposed actions is to continue ongoing research studies on the FEF and to maintain the integrity of the FEF for long-term research. The need for these specific proposed actions is found in the various study plans that establish the experimental designs, timing of treatments, and study durations. Some studies include experiments that were designed to last 80 years or more. These data represent some of the most complete, continuous long-term records on ecosystem processes in the world. We want to continue these experiments as designed and continue to gather information about the effects of various silvicultural practices and other disturbances on forest ecosystems in the central Appalachians. We will use these data to provide information on basic ecosystem processes in unmanaged and managed forests, on species diversity of plants and animals, and on other ecological parameters. Research results from the FEF are used to guide management on private and public lands in the central Appalachian region. Results from FEF studies also contribute to data compilations that have been used in establishing state and federal policies.

The FEF has many partners and collaborators who rely on the existing studies as framework for basic research and for innovative studies. Therefore, it is important to manage the FEF to ensure availability for collaborative research and to ensure safety for all visitors to the FEF. Maintenance activities include: applying gravel to road surfaces as needed, replacing culverts on skid roads and haul roads as needed, maintaining water bars on skid roads, maintaining ditches and culverts, seeding decks and landings, using herbicides and other practices to control the spread of invasive plant species, such as Japanese stiltgrass, tree-of-heaven and other species, removing hazard trees from along the roads, and maintaining openings used for weather stations. The proposed activities not related to maintaining the FEF as an outdoor laboratory are based on established study plans or study plans under development with anticipated implementation within the time-frame of this environmental effects analysis. These studies are summarized below.

Large area comparisons of forest management practices

This study was initiated in 1950. One objective of this study is to determine the effects of three uneven-aged silvicultural practices (single-tree selection, diameter-limit, and patch cutting) on wood yield and stand growth. The treatments are duplicated on three oak site index classes. Another objective is to determine the effects of the different silvicultural practices on species composition and log quality across site quality classes. This research is critical to understanding the effects of current harvesting practices, particularly those used on private land, on long-term sustainability and diversity of central Appalachian hardwood forests, and for developing management guidelines and recommendations for these forests.

This study plan is being modified to address issues of forest management and forest resiliency under a changing climate. Principles of adaptive silviculture for climate change will be added to the study, including treatment of understory and midstory vegetation in some plots to control species composition and underplanting of tree species in other plots to test facilitated migration. Other plots would receive no treatment other than the planned silvicultural practice of single-tree selection, diameter-limit, or patch cutting harvest.

Cutting practice level demonstration sites

This study is similar to the large area comparison study. Smaller areas (5 acres each) along an easily accessible trail demonstrate the long term changes from two levels of singe-tree selection, diameter-limit, and clearcut harvests. This research is critical to understanding the effects of current harvesting practices, particularly those used on private land, on long-term sustainability and diversity of central Appalachian hardwood forests, and for developing management guidelines and recommendations for these forests.

Watershed acidification

The watershed acidification study involves artificial acidification on the FEF to determine the effects of artificial watershed acidification on vegetation growth and nutrient status. The principal objective of this research is to determine changes in soil chemistry, soil leachate chemistry, and streamflow chemistry resulting from increased levels of nitrogen and sulfur deposition, and to evaluate the effects of these changes on vegetation growth and ecosystem nutrient status. Ammonium sulfate fertilizer would be applied to one 85-acre watershed and the effects on ecosystem parameters would be determined. The study results would quantify the susceptibility of watersheds in the central Appalachians to acidification by acid deposition. Also, the data would be useful for testing watershed acidification models. This whole-system manipulation approach would quantify the integrated response of a watershed to sulfate and nitrogen loadings.

Prescribed burning and variable intensity overstory mortality for enhanced wildlife habitat structure and long-term oak restoration

The use of prescribed fire and overstory mortality to enhance wildlife habitat structure and long-term oak regeneration is the main objective of this study, which began in 2005. The objectives of this research are to address the short-term habitat needs for tree-roosting bats and to test the use of prescribed fire and overstory removal for the long-term oak regeneration is enhanced and restoration of a fire-adapted structure and species composition is achieved. Through a series of prescribed fires and periodic overstory mortality treatments (herbicides and/or girdling), we would assess improvements in bat roosting and forage habitat. Over the longer period, overstory mortality treatments would focus on removing non-oak species, and prescribed fires would be used to increase the numbers and size of oak seedlings/saplings (or other fire tolerant species) for future accession into the overstory. Unlike previous oak-fire-light studies, this study does not have timber management as an immediate management goal. Study results would be useful for those managers that wish to manage specifically for bats and other important wildlife species, and restore fire adapted structure and species composition over longer time periods.

Exploring the causes of major changes in tree species composition in eastern deciduous forests: tests of three prominent hypotheses

This study was established in 1997 to evaluate forest responses to three ecological disturbances in terms of species composition and structure. Current forests are considered to exist under very different conditions than pre-European contact forests, with higher deer densities in many places and altered fire regimes. Current successional theories may not apply under these new circumstances. Three key processes, canopy gaps, understory fire, and deer browse, and their

interactions are known to affect the development of forest composition, and changes in these processes during the last century may explain the current observed species shifts. Understanding the response of individual tree species to individual disturbances or combinations of disturbances is needed for predicting success of a silvicultural practice.

Long term soil productivity study

The effects of air pollution and harvesting on soil resources continue to be an important issue for eastern hardwood forests. This study utilizes plot-based treatments of a one-time harvest removal (in 1996) and annual fertilization with ammonium sulfate fertilizer to accelerate removal of base cations (calcium, magnesium) from the forest, potentially ameliorative liming with dolomitic limestone on a subset of plots, and evaluates the long-term effects of base cation removal on a forest community hypothesized to be sensitive to acidification. By understanding the response of these important forest communities, we can then predict the response of hardwood forests to changing nutrient levels.

General Description of Actions

For the studies that involve timber harvest, the treatments involve cutting individual trees, according to the silvicultural prescription and removal of the boles from the stand. Ground-based skidding would be used to move the trees to log decks. Only existing skid trails and roads would be utilized. After completion of treatments, roads and decks would be closed. All management actions would comply with Monongahela National Forest Plan Standards and Guidelines (USDA 2011) or West Virginia's Best Management Practices (BMPs).

For studies involving prescribed fire, burn plans and the prescribed fires themselves would be conducted according to state regulations administered by the West Virginia Division of Forestry. Typically on the FEF, our prescribed fires are slow moving head fires that produce, on average, 2-4 feet flame lengths. However, for the prescribed fire study described above, we anticipate some patches of moderate intensity fire capable of creating infrequent individual tree mortality. Our fires are conducted in the spring prior to green-up of the herbaceous understory. All personnel supervising and working on the fire would have received training in use of prescribed fire and in fire suppression and would be fire-line qualified.

Relationship to Other Planning Documents

The actions proposed for implementation on the FEF are consistent with the 2011 Revised Forest Plan, Monongahela National Forest, Management Prescription 8.5 (Chapter III, p. 58-60). Projects proposed here also are consistent with Research Work Unit Description for NRS-01 and individual study plans. The Research Work Unit Description (RWUD), the guiding document for Research Work Unit (RWU) activities, was last updated and approved in 2009 and will be updated again within the next five years. Study plans have been reviewed for experimental and statistical rigor by scientists within and outside of the RWU, and for appropriateness and compliance with Northern Research Station direction by Station personnel.

Local administration of the FEF is by NRS-01, *Ecological and Economic Sustainability of the Appalachian Forest in an Era of Globalization*. The mission of this work unit is to develop timely, relevant knowledge and provide management guidelines to sustain and enhance the ecological and economic function and value of Appalachian forests, in the context of changing environments and human values. NRS-01 is engaged in a series of important interdisciplinary studies, with the overall goal of these studies being to:

1. Understand forest ecosystem processes and properties and their responses to natural disturbances and management actions, at multiple scales in order to provide useful management information critical for sustaining and enhancing Appalachian forests and communities, in light of changing disturbance regimes.

2. Discover and disseminate knowledge of forest management, silviculture, forest product economies and markets, and efficient resource utilization. Further, we would deliver tools and recommendations to help our partners and customers better sustain forests for a variety of outcomes, products and uses.

This RWU also has responsibility to manage the FEF for long-term silvicultural, hydrologic and ecological research and demonstrate results for stakeholders. It is necessary for us to conduct experimental manipulations to continue the long-term research as designed, and to meet the mission of the work unit. We also must manage the resources of the FEF in such a way as to ensure that long-term research is not impaired, which requires maintenance of roads and structures, control of non-native invasive species, and other management activities.

What Do We Want to Achieve

We want to continue ongoing research studies on the FEF and maintain the integrity of the FEF for long-term research. Researchers, staff, and collaborators working on the FEF have a long history of producing high-quality research and providing exceptional experiences to graduate and undergraduate students.

Public Involvement

The CEQ defines scoping as "… an early and open process for determining the scope of issues to be addressed and for identifying the significant issues related to a proposed action" (40 CFR 1501.7). The scoping process was used to invite public participation and collect initial comments. The public was invited to participate in the project in the following ways:

Notice of Intent: A Notice of Intent was published in the *Federal Register* on Friday, December 12, 2014, when it was decided that an EIS was to be completed for the project.

Public Mailing: In December 2014 a letter providing information and seeking public comment (scoping document) was mailed to approximately 200 individuals and groups that had previously shown interest in Forest Service projects in West Virginia. The mailing included Federal agencies, State agencies, county offices and various non-governmental organizations and individuals. An e-mail account was established in December 2014 and linked to the National Forest Schedule of Proposed Actions where the proposed action was also described.

Local News Media: A legal announcement about the project was printed in the December 16, 2014 and December 17, 2014 editions of the *Grant County Press* and *Parsons Advocate,* respectively.

Comments from the public were reviewed, analyzed and evaluated and responses to those comments are contained in the appendix of this FEIS. The Notice of Availability of the FEIS will be published in the *Federal Register*, the *Grant County Press*, the newspaper of record, and in the *Parsons Advocate*.

Issues

Significant issues for the FEF proposed research activities were identified through public and internal scoping and were used to formulate alternatives. Similar issues were combined into one statement where appropriate. The following issues were determined to be significant and within the scope of the project decision. These issues are also addressed through the proposed action and alternatives.

Issue 1 – Threatened, Endangered, and Sensitive Species (TES)

Proposed activities could impact TES species found on the FEF. Site disturbing activities, particularly tree felling, could directly or indirectly affect species or their habitat. Threatened and endangered species known to occur or that may occur on the FEF include Virginia big-eared bat, Indiana bat, northern long-eared bat, and running buffalo clover. Bats are particularly of concern given the presence of white-nose syndrome which has been documented in Virginia and West Virginia. White-nose syndrome (WNS; so called due to the presence of white fungal growth on the muzzles, ears, and/or wing membranes of affected bats) is associated with a cold-loving fungus named *Pseudogymnoascus destructans*.

Numerous sensitive species are also known to occur or may occur on the FEF. Refer to the Threatened, Endangered, and Sensitive Species discussion (3.6 Wildlife Resources) of this FEIS and the Biological Assessment for Threatened, Endangered and Sensitive Species on the Fernow Experimental Forest, Tucker County, West Virginia (hereafter referred to as the Biological Assessment or BA) for a complete listing of TES species found in the FEF. The Fernow has formally consulted with the U.S. Fish and Wildlife Service regarding impacts on running buffalo clover and the Indiana bat for the past 15+ years.

Issue 2 – Hydrologic and Sediment Impacts to Streams

Proposed activities could affect stream sedimentation, channel morphology, and sediment flow regimes. This could have direct, indirect, and cumulative effects not only to water resources but to other resources in the area as well.

Other concerns raised during scoping were used to help frame the effects discussion or were deemed beyond the scope of this FEIS. All comments can be found in Appendix A of this FEIS.

Decisions to be made

Site-specific effects and issues related to the proposed action and alternatives are assessed and disclosed in this FEIS. The Responsible Official, NRS-01 Project Leader, will make a decision

based on a review of the FEIS. In keeping with the mission of the FEF, the Project Leader must decide whether to proceed with the proposed action or an alternative. The decision will be documented in a Record of Decision (FSH 1909.15, 27.2), and a Notice of Decision is expected to be issued in early 2016, in the *Federal Register*, the *Grant County Press*, and *Parsons Advocate*. The Notice of Decision will also detail requirements and timelines to object to the decision (36 CFR 218).

Chapter 2 – Alternatives

Introduction

This chapter describes and compares the alternatives considered by the Forest Service for the FEF. It includes a discussion of how alternatives were developed, an overview of mitigation measures, monitoring, and other features common to all alternatives, a description of each alternative considered in detail, and a comparison of these alternatives focusing on the significant issues. It also identifies Alternative C (the modified proposed action) as the preferred alternative. Chapter 2 is intended to represent the alternatives in comparative form, defining the issues and providing a clear basis for choice among options by the decision maker and the public (40 CFR 1502.14).

Some of the information in Chapter 2 is summarized from Chapter 3 - Affected Environment and Environmental Consequences. Chapter 3 discusses the basis for establishing baselines and measuring the potential environmental consequences of each of the alternatives. For a full understanding of the effects of the alternatives, readers will need to consult Chapter 3.

Development of Alternatives

Each alternative represents a site-specific proposal developed through interdisciplinary team evaluation. The team used information from the analysis of scoping comments to formulate different alternative approaches. Preliminary analysis and management direction were used to further refine the alternatives described here.

Items Common to All Alternatives

The Forest Service uses many mitigation and preventive measures in the planning and implementation of research activities. The application of these measures begins early in the research design phase of a project. The following items are listed to highlight some of the measures or processes that are common to all alternatives; this is not a complete list.

Wildlife Habitat

> Tree felling would be conducted only between September 1 and March 31.
>
> Prescribed fires would be conducted only between October 1 and May 31.
>
> Healthy butternut trees would be identified and retained in study area. Shagbark hickory trees would be left where possible except where retention would compromise the integrity of the research studies or present a safety hazard.
>
> Timber harvests will be scheduled to minimize direct impacts to federally listed Myotid bats (Indiana bat and northern long-eared bat). We will harvest research units based on their distance from the hibernacula, slope aspect, and research needs. Specifically, we will harvest those units that are less likely to support swarming and roosting Myotid bats (e.g. cooler, moister units with more north, northeast, and east facing slopes located farther from Big Springs Cave) first each year. Timber removal in other scheduled units with more roost tree habitat shall occur later in the season while the bats are in the hibernacula. While there may be some changes to the proposed harvesting schedule over

the five-year period due to weather or other logistical issues, we shall not change the schedule of which units will be harvested first each year.

All roost trees known to be used by federally-listed Myotid bats on the FEF will be retained until such time as they no longer serve as roost trees (e.g. loss of exfoliating bark or cavities, blown down or decay).

Soils and Water Quality

Gravel would be applied to road surfaces as needed.

Culverts would be replaced on haul roads and skid roads as needed.

Culverts and ditches on all roads would be maintained as needed.

Logs would be skidded using a rubber tired skidder or crawler tractor with a logging arch.

Logging and skidding would not be done when conditions are excessively wet, so as to protect against unnecessary erosion and damage.

After logging is complete, skid roads would be resurfaced, and water control devices such as water bars and dips constructed to control the movement of water.

All logging decks would be reclaimed, with lime applied and seeded with a mixture of clover, rye, timothy, and various grasses to prevent erosion.

All applicable BMPs in the version of the "West Virginia Silvicultural Best Management Practices for Controlling Soil Erosion and Sediment from Logging Operations" manual that is valid for the time period in question will be employed. Currently, at the time of writing this FEIS, the 2015 revision of the BMPs is in effect. BMP use in forest operations is required by the 1977 Clean Water Act, as amended and the West Virginia Logging Sediment Control Act of 1992.

Riparian Habitat

<u>Partial harvest areas</u>

Perennial streams would be protected with a 100-foot-wide vegetative strip. A minimum of 75 percent crown closure would generally be maintained. There would be no vehicular traffic or herbicide use in the vegetative strip.

Non-perennial streams (i.e., intermittent and ephemeral) would be protected with a 50-foot-wide vegetative strip. Within this strip, crown closure generally would be 60 percent. There would be no vehicular traffic or herbicide use in the vegetative strip.

<u>Patch cutting harvest areas</u>

To limit disturbance to intermittent and/or perennial streams in the patch cutting areas over time, we will use the length of the stream channel in the harvest unit and the rotation age and cutting cycle of the silvicultural prescription to determine maximum length of stream channel disturbed during the current cutting cycle. For example, the rotation

length is 80 years with a 10 year cutting cycle so we would limit disturbance to 1/8th of the stream length during any given cutting period. For example if there are 600 feet of intermittent stream within the compartment, the maximum extent of the stream we would disturb would be 1/8th of the 600 feet each cutting cycle or about 75 feet. These calculations will be made for the estimation of effects to riparian areas.

Patch cuts will be laid out such that they would not straddle intermittent or perennial streams.

All harvest areas

Trees would not be cut from within the stream channel or off the stream banks. Logging equipment would be restricted from this area except at designated stream crossing points.

Heritage Resources

Keeping with standard Forest Service practice, all sites that have not been evaluated for eligibility on the National Register (unevaluated sites) will be avoided during project planning or implementation.

Alternatives Considered In Detail

The proposed action, a no action alternative, and a modified proposed action alternative were considered in detail. The alternatives are defined as: Alternative A – No Action, Alternative B -- Proposed Action, and Alternative C – Modified Proposed Action. The No Action Alternative is defined as no experimental logging, burning or fertilizer treatments, and no use of herbicides to control invasive exotic plants at this time; the experimental areas would remain subject to natural changes only. Ungated Forest Service roads would continue to remain open to public vehicle use and use would continue to be restricted on gated or closed Forest Service roads. Road Maintenance of roads and ditches would continue and we would continue to collect data from studies in the absence of new treatments. Alternatives B and C satisfy the purpose of and need for action, while still responding to the issues discussed in Chapter 1. Alternative C is the Preferred Alternative. Definitions of technical terms and abbreviations are provided in the Glossary.

Alternative A: No Action Alternative

CEQ Regulations (40 CFR 1502.14d) require that a No Action alternative be analyzed in every EIS. This alternative represents the existing condition against which all other alternatives are compared. The emphasis of this alternative is to continue existing research studies and maintenance of roads and other infrastructure on the FEF, however without experimental manipulations. Ungated Forest Service roads would continue to remain open to public vehicle use, and use would continue to be restricted on gated or closed Forest Service roads. This alternative does not include timber harvest, prescribed fire, application of fertilizer, or other management called for in existing research studies. Invasive non-native plant species will not be controlled by herbicides under this alternative. Thus, only data collection and monitoring would continue.

Alternative B: Proposed Action

The proposed action includes projects that are repeat treatments in ongoing long-term research studies (Table 2-1, Fig. 2-1). The proposed action involves using the following silvicultural treatments in existing research studies: diameter-limiting cutting treatment on 160 acres, single-tree selection on 113 acres, 31 acres of patch cutting, and prescribed fire treatment of 398 acres. Other treatments include fertilization of 89 acres with ammonium sulfate fertilizer, (and additions of dolomitic lime to 4 of those acres), herbicide treatment of invasive non-native plants, and maintenance of roads, log decks, and other infrastructure.

Conventionally, timber harvest on the FEF has occurred during the dormant season, September 1 to March 31, to protect Indiana bat populations when they are outside of their hibernaculum. However, in this FEIS the harvests are scheduled and referred to by the calendar year coinciding with the end date, e.g., harvest year 2016 refers to the period from September 1, 2015 to March 31, 2016.

Commercial Timber Harvest

The commercial timber harvests planned for harvest year 2016 to 2020 are proposed to continue a long-term study involving a comparison of the effects of diameter-limit harvesting, single-tree selection, and patch cuts, along with unmanaged reference areas. Diameter-limit harvesting will occur in compartments 9A and 9B and watersheds 2A and 2B. With this partial harvesting technique, trees above a specified diameter are removed for forest products. This harvest technique, while not strictly an example of uneven-aged silviculture, does create an uneven-aged stand structure especially if applied over decades and is the most common form of timber harvest on private lands in the eastern US. Diameter-limit harvesting began in compartments 9A and 9B in 1954 and 1953, respectively and in 1958 for watershed 2A and 2B.

In compartments 9A and 9B, all trees over 17 inches in dbh will be removed with ground-based skidding on 40 acres in harvest year 2016 (9A) and 81 acres in harvest year 2017 (9B). The years specified are target dates to conform to the needs of the long-term silvicultural study requirements but may be adjusted slightly in order to accommodate unforeseen logistical issues. In watershed 2A and 2B, all trees over 17 inches in dbh will be removed with ground-based skidding on 12 acres in harvest year 2016 (2B) and 27 acres in harvest year 2019 (2A). For this treatment, harvests are scheduled 15 years apart for site index categories 70 and 80 (compartment 9A, 9B, and watershed 2A) and 20 years between harvests for site index 60 compartments (watershed 2B). In all areas, cull trees 5 inches in dbh or greater will be cut and left on the ground and all grapevines will be severed.

Trees will be harvested by single-tree selection in compartment 20A, 8C, and 8D, and watershed 5A over the next 5 years. This single-tree selection is a true uneven-aged silviculture system where a target stems/acre distribution, largest tree diameter to retain, and target residual basal area are all pre-determined. This type of harvest creates multiple age classes when applied over time. Single-tree selection harvest started in compartment 20A in 1952, in 1950 in compartment 8C, 1949 in compartment 8D, and 1958 in watershed 5A.

Under single-tree selection, trees over 11 inches in dbh are managed to fit a pre-determined distribution of stems/acre based on the ratio among 2-inch dbh classes (often referred to as a “Q”

ratio), a largest diameter to manage for, and a target residual basal area (square feet/acre) in sawlog-sized trees. Parameters for the residual stand are adjusted by site index based on study design. Regeneration harvests scheduled for the next five years are all on site index 80; hence, the largest diameter tree to retain is 32 inches at dbh (all stems over 32 inches in dbh are harvested), the target residual basal area in sawlogs is 65 square feet/acre for trees 11 inches in dbh and greater, and the "Q" is 1.3, which is the ratio of trees in subsequently smaller size classes. In harvest year 2018, compartment 20A (25 acres) and watershed 5A (78 acres) are planned for harvest. In harvest year 2019, compartment 8C (5 acres) and 8D (5 acres) are planned for harvest. Compartments 8C and 8D are part of the Cutting Practice Level demonstration plots and 8D is managed down to 5 inches in dbh and has a targeted residual basal area of 85 square feet/acre for trees in the managed size classes. In all areas, cull trees 5 inches dbh or greater will be cut and left on the ground and all grapevines are severed. By study design based on site index harvest for all of these areas are on a 10-year cutting cycle

Patch cuts of about 0.4-acre each will be made in compartments 7A, 7B, 17A, 17B, 18C, and 19A. With this technique, a young age class is created in a specific area and all stems regenerate simultaneously. By contrast to a larger area-wide clearcut, distinct patches of differing ages are created across the compartment, creating a stand of multiple age classes. These patch cuts began in 1956 in compartment 7A, in 1955 for compartment 7B, in 1957 for compartments 17 A and 17B, in 1952 in compartment 18C, and in 1957 in compartment 19A.

In harvest year 2019, 2 acres of patch cuts (within 31 acres), 2 acres of patch cuts (within 11 acres), and 3 acres of patch cuts (within 22 acres) are planned in compartments 17A, 17B, and 19A, respectively. In harvest year 2020, 6 acres of patch cuts (within 37 acres), 10 acres of patch cuts (within 60 acres) and 8 acres of patch cuts (within 45 acres) are planned in compartments 7A, 7B, and 18C, respectively. In each 0.4-acre patch, all stems down to 1 inch in dbh will be cut and merchantable material removed. In older patches, grapevines will be severed when observed.

Application of Fertilizer

Ammonium sulfate fertilizer will be applied to watershed 3 (85 acres) and to the long-term soil productivity (LTSP; 4 acres) plots every year. Dolomitic limestone will be applied to 2 acres of the LTSP plots every other year. In watershed 3, fertilizer is applied aerially; on the LTSP, fertilizer and lime are applied by hand. Fertilization of watershed 3 began in 1989 and in 1997 on the LTSP plots.

Prescribed Fire

In the next 5 years, prescribed fire may be used on about 363 acres in compartments 13, 21, and 45 and on approximately 35 acres of compartment 48. Control lines are in place and include existing roads and short sections of dozer lines that will need to be reopened and cleared of litter and woody debris before a prescribed fire. All areas have burned at least once; compartments 13 and 21 were burned in 2007 and 2009, compartment 45 in 2007 and 2008, and compartment 48 in 2001.

Maintenance of Fernow Experimental Forest

Maintenance activities include applying gravel to road surfaces as needed, replacing culverts on skid roads as needed, maintaining water bars on skid roads, maintaining ditches and culverts, using herbicides to control the spread of invasive plants, and felling trees to maintain required opening sizes for weather stations. Invasive or noxious plants that may be controlled by herbicides include Japanese stiltgrass, tree-of-heaven, and poison hemlock.

Alternative C: Modified Proposed Action

The modified proposed action includes all of the same treatments and actions as listed in the proposed action with the addition of herbicide treatment of understory/midstory on 12 acres and underplanting of hardwood seedlings on 6 of these acres.

Commercial Timber Harvest

Commercial timber harvests planned for Alternative C are the same as identified in Alternative B. In addition, Alternative C includes other herbicide treatments and understory plantings. As part of the long-term study involving comparison of the three management techniques described in Alternative B, we plan to initiate a new phase of this study designed to enhance resiliency of these forest to climate change by increasing the diversity of the regeneration and facilitating the migration of more southern varieties of species already occurring on the FEF. To do this, we will use herbicide on 1 acre in each of the following - compartments 7A, 7B, 9A, 9B, 17A, 17B, 18C, 19A, 20A, and watersheds 2A, 2B, and 5A for a total of 12 acres to control interfering vegetation in the understory and midstory. Glyphosate will be applied to stems 5 inches in dbh or smaller of selected species to enhance the diversity of the natural regeneration.by preventing one or two species from dominating the understory. The intent is to use herbicide to influence the species composition of the naturally occurring regeneration. On 6 acres total in the same compartments and watersheds, we will plant tree seedlings (northern red oak, yellow-poplar, and possibly one other species to be determined later) to test the facilitated migration of selected genotypes in anticipation of predicted changes in climate. These treatments are designed to test the hypothesis that enhancing diversity can increase forest resilience given the projected effects of climate change over the coming decades.

Application of Fertilizer

Alternative C is the same as Alternative B.

Prescribed Fire

Alternative C is the same as Alternative B.

Maintenance of Fernow Experimental Forest

Alternative C is the same as Alternative B

Table 2-1. Locations and planned harvest year of Alternatives B and C.

Harvest year	*Location*	*Type of activity*	*Acres*	*Alternative*
2016	Compartment 9A	Diameter limit harvest	40	B and C
		Herbicide and plant	1	C
	Watershed 2B	Diameter limit harvest	12	B and C
		Herbicide and plant	1	C
	Watershed 3	Apply fertilizer	85	B and C
	LTSP	Apply fertilizer	4	B and C
2017	Compartment 9B	Diameter limit harvest	81	B and C
		Herbicide and plant	1	C
	Watershed 3	Apply fertilizer	85	B and C
	LTSP	Apply fertilizer	4	B and C
2018	Compartment 20A	Single tree selection harvest	25	B and C
		Herbicide and plant	1	C
	Watershed 5A	Single tree selection harvest	78	B and C
		Herbicide and plant	1	C
	Watershed 3	Apply fertilizer	85	B and C
	LTSP	Apply fertilizer	4	B and C
2019	Compartment 17A	Patch cut	2	B and C
		Herbicide and plant	1	C
	Compartment 17B	Patch cut	2	B and C
		Herbicide and plant	1	C
	Watershed 2A	Diameter limit harvest	27	B and C
		Herbicide and plant	1	C
	Compartment 19A	Patch cut	3	B and C
		Herbicide and plant	1	C
	Compartment 8C	Single tree selection harvest	5	B and C
	Compartment 8D	Single tree selection harvest	5	B and C
	Watershed 3	Apply fertilizer	85	B and C
	LTSP	Apply fertilizer	4	B and C
2020	Compartment 7A	Patch cut	6	B and C
		Herbicide and plant	1	C
	Compartment 7B	Patch cut	10	B and C
		Herbicide and plant	1	C
	Compartment 18C	Patch cut	8	B and C
		Herbicide and plant	1	C
	Watershed 3	Apply fertilizer	85	B and C
	LTSP	Apply fertilizer	4	B and C
Not determined	Compartment 48	Prescribed fire	35	B and C
	Compartment 45	Prescribed fire	301	B and C
	Compartment 21	Prescribed fire	31	B and C
	Compartment 13	Prescribed fire	31	B and C

Mitigation Measures

In addition to the mitigation actions listed under **Items Common to All Alternatives** (page 2-1), the following mitigation measures were identified as needed through the analysis of environmental effects and will be implemented.

Table 2-2. Mitigation measures identified from analysis of effects.

Resource and Concern	Forest Plan Direction	Implementation Practice or Feature
Treatment of vegetation in stream channel buffers with herbicides may adversely impact riparian habitats, aquatic biota, and water quality.	Standards: SW37, VE32 Goals: VE19, SW20, SW21 & SW31	No spraying or application of any herbicide by any method will be done within riparian vegetative strips: 100' for perennial channels, 50' for intermittent and ephemeral channels; except for treatment of non-native invasive species, herbicide application may be made within these buffers, but then only with a formulation registered for aquatic use.
Timber harvest within riparian areas poses a threat to aquatic biota through increases in sediment, channel instability, and stream temperatures and decreased large woody material recruitment	Standards: SW34, SW37, SW40 Goals: SW29, SW31, Water and Soil 8525	Monitor vegetative strips post-harvest for percent crown closure
Timber harvest activities on steep slopes (>40%) and very steep slopes (>50%) represent an increased risk to soil degradation and sediment delivery to streams which would adversely affect aquatic biota	Standard: SW07 Goal: Water and Soil 8525	Harvest on slopes greater than 50 percent should be avoided Harvest on slopes greater than 40 percent, to the most practicable extent possible, should occur during the driest soil conditions of the harvest season

Prescribed burning may produce particulate emissions significant enough to impact public health in a town or impact visibility in a Class I wilderness area	Standards: AQ04, FM14 Goal: FM08	If there is potential for the burn to produce significant emissions, smoke modeling can be conducted the morning of the burn to ensure that meteorological conditions are sufficient to minimize impacts to towns and Class I wilderness areas.
Fire line construction or fire control may reduce large woody material in riparian areas		Large woody material will not be cut or removed within stream channels or buffers.
Historic Properties	Standard: HR05	Projects shall be designed to avoid, minimize, or mitigate adverse effects to NRHP-eligible or unevaluated heritage resources. In-place protection of all identified eligible or unevaluated heritage resources is the minimum requirement. Heritage resources evaluated and determined not eligible for inclusion in the NRHP are afforded no such protection.
Historic Properties – known historic culverts and bridges	Standard: HR05	Protection measures require written approval from Monongahela National Forest Heritage Program Manager prior to implementation.
Historic Properties – known sites	Standard: HR05	Avoid know sites within the timber harvest units (alternatives B and C). Activities within the boundaries of each property are prohibited with the exception of using the developed transportation system.
Protection of known roost trees used by threatened or endangered bats		Trees identified as roost trees for threated or endangered bats from past monitoring and research that are within harvest units will be retained during harvest.

Comparison of Alternatives

This section is a comparison of the two alternatives and forms the basis for discussion of the effects in the next chapter.

Table 2-3. Comparison of alternatives

Criteria	Alternative A	Alternative B	Alternative C
Total silvicultural treatment area (acres)	0	304	304
Est. volume (board feet removed)	0	2,213,000	2,213,000
Miles of skid road re-opened[1]	0	14.33	14.33
Area in logging decks (acres)	0	1.24	1.24
Area treated with prescribed fire (acres)	0	398	398
Miles of reconstructed fire lines	0	5.14	5.14
Area treated with fertilizers (acres)	0	89	89
Area herbicide and plant (acres)	0	0	12
Total area to be treated (acres)[2]	0	789.24	789.24
Benefit/Cost ratio	NA	12.2	11.6

[1] No new skid roads would be constructed.

[2] Total area treated is not a sum of areas by treatment because some areas may receive more than one treatment.

Adverse effects to water quality from sediment movement and delivery are a concern with continued use of the FEF for research. The FEF was divided into 13 subdrainages for analysis of effects on water and riparian resources; projects are proposed in 10 of those subdrainages. Table 2-4 displays the total acres of proposed treatments by alternative and by subdrainage to compare potential impacts to aquatic and riparian resources.

Table 2-4. Subdrainages and acres of treatment by alternative

Subdrainage	Total area (ac)	Total acres of treatment	
		Alternative A	Alternative B&C
Side Hill	83	0	77
John B. Hollow	395.5	0	224
Camp Hollow	489	0	201
Hickman Slide	294.5	0	16.
Bear Run	167	0	121
Big Spring Run	200	0	10
Upper Elklick Run	736	0	98
Stonelick Run	618	0	6
Canoe Run	691.5	0	9
Sugarcamp Run	221	0	16
Total	3,896	0	777

The planting and herbicide actions proposed in Alternative C occur in the same area proposed for timber harvest in Alternative B; therefore, the total acres of treatment are the same for both alternatives.

Monitoring Activities

Because many of the proposed actions are continuing treatments on ongoing research studies, their measurement and monitoring would continue as part of the research study. Forest species composition, stand development, and productivity would continue to be monitored on a regular basis on the nearly 200 permanent growth plots located on the FEF.

The following monitoring activities are proposed to address issues raised in this FEIS related to threatened and endangered species and water quality. Details of monitoring and experimental design can be found in individual study plans, where applicable. This information would be put into annual monitoring reports and may be published in scientific journals as appropriate.

1. Winter hibernacula surveys of Big Springs cave will take place annually or biannually to monitor bat populations on the FEF. Biologists from the West Virginia Division of Natural Resources and/or the U.S. Fish and Wildlife Service will perform these winter surveys, and surveys will be scheduled and follow protocols to minimize the potential spread of white-nosed syndrome by humans and to limit stress to hibernating bats.

2. All known running buffalo clover populations on the FEF have been physically monumented, located using GPS devices, and added to the geographical information system. Because it has become impractical to monitor all of the 5,000 to 6,000 individual RBC plants on the FEF annually, we will monitor each population at least once every two years during the next 5 years. During this monitoring, individual plants are counted or sampled, rebar and flagging noting the location of the occurrence would be added as needed and general conditions of the occurrence and location noted.

3. Conduct monitoring of federally listed *Myotid* bat activity on the FEF annually. We will establish two long-term monitoring sites for bats using US FWS approved protocols. Monitoring of these sites shall be initiated the first year after finalization of the EIS. We will continue monitoring the two long-term monitoring sites in subsequent years as described unless changes are coordinated with and approved by the US FWS prior to the initiation of that monitoring. Changes or additions to the monitoring protocol may occur in any year due to unforeseen complications resulting from WNS, or if additional wildlife research personnel (and/or graduate student(s)) commence studies on federally listed *Myotid* bats utilizing the FEF.

4. Any dead or injured bats located in the action area during implementation of the proposed action regardless of species, shall be immediately reported to the US FWS West Virginia Field Office (WVFO). We shall record information regarding the date, time, and location of any bat found, and the possible cause of injury or death, and provide this information to the WVFO. No one, with the exception of trained staff or researchers authorized to conduct bat monitoring activities, will handle any live bat, regardless of its condition. Any dead bats believed to be federally listed shall be transported on ice to the WVFO or WVDNR. Care will be taken in handling dead specimens to preserve biological material

in the best possible state. If needed, staff from the WVFO and/or WVDNR will assist in species determination for any dead or moribund bats. If a listed species is identified, the US FWS staff will contact the appropriate Service law enforcement office.

5. Air quality monitoring would continue as currently conducted.

6. Stream water quality and soil water quality monitoring in watershed 3 would continue as currently conducted.

7. Stream water quality monitoring in Camp Hollow Run below watershed 3 would continue as currently conducted.

8. Monitor fine particulate emissions from prescribed burn at the location of a sensitive receptor (town center, Class I area) if impacts are anticipated.

Chapter 3 – Affected Environment and Environmental Effects

The existing conditions and affected environment for resources of the FEF are described below followed by a summary of the direct, indirect, and cumulative effects resulting from implementation of the proposed activities. These analyses were taken from larger reports written by resource managers and research scientists familiar with the FEF. Those reports are part of the Record of Decision. The analyses of effects from the proposed action and alternatives were used by the responsible official in selecting the preferred alternative.

3.1 Hydrologic Resources

Affected Environment

Effects to water and riparian resources are discussed in terms of the 10 subdrainages in which the compartments or watersheds occur (Table 3-1, Table 3-2, Table 3-3, and Fig. 3-1). Side Hill subdrainage contains 76.6 acres of compartment 45. John B Hollow subdrainage contains 224.4 acres of compartment 45. Camp Hollow subdrainage contains all of watershed 3 and watershed 2 (2A and 2B) and 78.2 acres of watershed 5. Hickman Slide Run subdrainage contains all of compartments 7A and 7B. Bear Run subdrainage contains all of subcompartments 9A and 9B. Big Spring Run subdrainage contains compartments 8C and 8D. Upper Elklick subdrainage includes all of compartments 13, 17A, 17B, 19A, and 21, 44.5 acres of compartment 18C, and 18.8 acres of compartment 20A. These subdrainages are all located within the Elklick Run drainage basin.

The remaining three subdrainages in the FEF are outside the Elklick Run drainage but they contain only small areas proposed for treatment. Stonelick subdrainage contains 1.6 acres of compartment 48, and 16 acres of the long-term soil productivity (LTSP) research area. Canoe Run subdrainage contains 0.9 acres of compartment 18C, 6.4 acres of compartment 20A, and 9.7 acres of compartment 48. Sugarcamp Run subdrainage contains 17.8 acres of compartment 48. The Sugarcamp Run, Canoe Run, and Stonelick Run subdrainages are located in the Shavers Fork watershed.

The soil series for the FEF within the compartments and watersheds in the action alternatives are Belmont, Calvin, Cateache, Cookport, Dekalb, Ernest, Gilpin, and Meckesville (Fig. 3-2). In general, Belmont, Cateache, Ernest, and Meckesville have high erodibility, Dekalb has low erodibility, and Gilpin and Calvin soils have moderate erodibility. Fluvaquents, which is a great group rather than a soil series, also are present in thin strips in riparian areas. These are relatively young sediment deposits that are considered highly erodible. Land management practices in areas containing soils of high erodibility must be performed with care and planning to avoid extensive erosion, gully formation, or small scale hillslope failures. On the FEF, the most highly erodible soils occur primarily on the eastern half of Elklick Run watershed. Low and moderately erodible soils exist primarily on the western half of Elklick Run watershed and in the Stonelick Run, Canoe Run, and Sugarcamp Run subdrainages.

Based on on-the-ground geologic mapping of the FEF, these 10 subdrainages contain 7 bedrock geologic formations: Alluvium, Chemung, Pocono, Mauch Chunk, Hampshire, Greenbrier, and Pottsville (Fig. 3-3).

Perennial streams are defined as those whose streambed lies below the water table during the entire year. Nonperennial channels are those which have the streambed below the groundwater table only part of the year (i.e., intermittent channels) or where the streambed is always above the groundwater level (i.e., ephemeral channels). True distinction between these types of channels is not simple or necessarily constant from year to year depending upon local water table conditions within a given year. Consequently, for purposes here, channel type definition was based on visual channel condition combined with field experience. From this, perennial channel length for subdrainages of the Elklick Run watershed included in this analysis is estimated to be 6.17 miles, and nonperennial channel length is approximately 16.45 miles. Perennial channel length in the subdrainages of the Shavers Fork watershed included in these analyses is approximately 4.43 miles. Nonperennial channel length in the subdrainages of the Shavers Fork watershed is approximately 9.33 miles. The length of each type of channel by subdrainage is displayed in Table 3-3.

The majority of the known hydrologic information for the FEF comes from gauged watersheds located on Hampshire geology and primarily Calvin soils. This information is strongly applicable to the western half of the FEF, where soil and geology characteristics are similar to those gauged catchments. Some hydrologic conditions on the eastern half of the FEF, where limestone geology is common, likely are much different.

Baseflow alone occurs about 70 to 75 percent of the time throughout the perennial and intermittent streams in Elklick Run watershed. Baseflow comes from deep soil water and groundwater contributions (DeWalle et al. 1997). In the Hampshire geology, groundwater residence times average about 1.5 years. Stormflow is present during the remaining 25 to 30 percent of the time. Stormflow contributions to flow in Calvin soils originate from shallow soil water contributions (Edwards et al. 2002a) although even during stormflow hydrographs baseflow contributions continue to be the dominant flow component. The true stormflow contribution to streamflow, determined using oxygen-18 separation analyses indicates that shallow soil water contributions generally comprise only a small percentage of total stormflow (DeWalle et al. 1997). Because of the general interconnectedness often associated with limestone formations, the baseflow component of stormflow in limestone-influenced streams may be even greater than for other local streams.

Approximately 70 percent of the largest storms and 60 percent of the largest stormflow volumes occur during the dormant season for this area (Bates 2000). Flood flows are driven by climate- and precipitation-controlled characteristics, such as length, amount, and intensity of the storm, antecedent soil moisture, and presence of snowpacks. High flows, including floods, are most often associated with large regional events of extended duration, including those initiated from hurricanes or nor'easters (e.g., rain-on-snow events).

Stream water in and around the FEF, including streams influenced by limestone geology, is generally clear during baseflow periods, with turbidity values typically less than 5 NTU (e.g., Edwards 2008, Edwards et al. 2009). Turbidity increases during stormflow but the degree of turbidity change varies greatly among sites and across storms. Maximum measured stormflow turbidity level from a control watershed located on moderately erodible Calvin soil on the FEF was 15 ppm (Reinhart and Eschner 1962) compared to maximums of 25 and 210 ppm for watersheds on Calvin soil that were harvested and employed BMPs. All of these figures probably are biased low because intensive stormflow sampling was not performed, and

stormflow sampling is required to ensure an adequate interpretation of turbidity responses (Edwards et al. 2004b). For comparison purposes, the maximum turbidity measured from intensive stormflow sampling on an unharvested watershed on moderately erodible soils located near the FEF over 7.5 years was 106 NTU and the mean of all storm peak turbidities was 17.5 NTU (unpublished data). From a paired watershed study off the FEF, the mean of all peak turbidities during 15 months of harvesting and road construction, including 3 stream crossings, was 276 NTU and the greatest turbidity was 2,352 NTU (Edwards et al. 2009). Turbidities in the FEF measured from a spring and in a stream associated with limestone geology and highly erodible Belmont and Meckesville soils from August 2007 to October 2009 ranged from 0.1 to 292 NTU, and had means of 3.0 and 3.2 NTU, respectively (unpublished data).

Based on previous local monitoring experience, most if not all streams within the 10 subdrainages probably experience peak turbidity before peakflow. These streams tend to be sediment-source limited rather than energy limited. As such, sources of available sediment both from the hillside and within channel are mobilized and peak during the rising limb of the storm hydrograph; thus, even under conditions of maximum storm energy (i.e., peakflow) sediment concentrations already are declining.

Elklick Run is the stream that drains the Elklick Run watershed. Wolman pebble counts and riffle stability index calculations have been completed annually from 2000 to 2010 (unpublished data). These measurements have shown that Elklick Run is an aggrading stream in the segments where bedrock is not the dominant substrate. As a result it is retaining more sediment in these sections than it is transporting. Elklick Run has substantial lengths of bedrock streambed which may aggravate problems associated with sediment accumulation, because sediment deposition is limited to and concentrated primarily in reaches that do not have exposed bedrock on the stream bottom. Consequently, the length of channel available to store excess sediment is substantially shorter than the entire channel length. As the channel aggrades in these stream segments, aquatic habitat diversity decreases, and pools and riffles become less distinct, thereby creating plane-bed conditions.

Sediment contributions to Elklick Run (i.e., the source of sediment for aggradation) are believed to be attributable primarily to the presence of Forest Service Road (FR) 701. FR 701 runs directly along Elklick Run for almost the entire length of the stream. The road has been in place since 1936 and receives substantial vehicular use throughout the year from both research personnel and the general public. FR 701 has undersized stream crossing culverts associated with some smaller tributaries and undersized cross drain culverts that lead to road washout problems during high flows. Many of the cross drain culverts also are directly connected to Elklick Run by constructed ditches in the streamside area, as a consequence of having the road drainage system and stream at the same elevation. At other places where the road is at a higher elevation than the stream, hanging culverts exist which have eroded the fill down slope of the culvert outlets. Whether due to large storms, direct connections to the stream, or hanging culverts, much of the eroded sediment is delivered directly to Elklick Run. FR 701 also is susceptible to erosion in many places along its length because the gravel has been largely worn from the surface. Some sections of FR 701 are re-graveled annually, but the road bed is very compacted and the road has a relatively high traffic load, so much of this gravel gets ‘kicked off’ the driving surface within the year it is applied. Road re-grading is not sufficiently frequent to restore gravel in a timely manner.

Other roads in the FEF also provide sediment sources for transport into Elklick Run directly or into tributaries that feed into Elklick Run. FR 704 (Hickman Slide Road) probably has been the second most substantial chronic source of sediment for Elklick Run and some Elklick Run tributaries since the road was constructed. Causes contributing to the sediment inputs are: its intersection with Elklick Run coincides with a low water bridge; steep road grade (particularly in its first several hundred yards as it leaves FR 701); highly erodible soils along much of the length of the road; poor road location; inadequate cross drain spacing given its steepness; substantial traffic levels; and relatively frequent use or disturbance by heavy equipment. In 2009, FR 704 was re-graveled and broad-based dips were installed and re-established, but sediment delivery from it into Elklick Run continues to be visible during storm events.

Forest Road 707 (Bear Run Road) appears to have less of an effect on sediment delivery to Elklick Run. Even though parts of it are relatively steep, it is still reasonably well graveled with coarse limestone making it less susceptible to erosion. However, some of the culverts are undersized and some of the broad-based dips do not function properly, so they hold water rather than disperse it. Additionally, there recently have been several failures of the fillslope on Bear Run Road, and these may eventually result in an even greater increase in sediment delivery to Elklick Run and Elklick Run tributaries (e.g., Bear Run).

Forest Road 709 (Fork Mountain Road) appears to have little impact on water resources because of its ridge top location. The intersection of FR 709 and 701 is one of the few places where there is any possibility of sediment delivery to Elklick Run by Fork Mountain Road. However, even at that location, drainage from Fork Mountain Road does not show evidence of chronic sediment inputs or road drainage problems. Other Forest Service system roads on the FEF are gated, so while they likely provide some erosion to receiving streams, their impact is probably less particularly due to lower traffic volumes.

Because Elklick Run is aggrading, from the context of channel stability it is considered to be an unstable stream. Annual channel cross section measurements measured between 2000 and 2010 at nine permanent locations in Elklick Run (where bedrock was not present in the bed in 2000) showed that the channel overall did not appear to be widening or deepening. Two of the cross sections in middle Elklick showed some change, but these were from local morphological changes at those specific transects involving normal cycles of accumulation and washout of woody debris.

The instability of Elklick Run appears to be expressed in the short-term by streambed fining. However, visual observations during pebble counts and other monitoring efforts suggest that there was a substantial loss of and complete filling of large pools from 2007 to 2009 in middle sections of Elklick Run. This includes some pools that previously had bedrock substrate for the 8 previous years of monitoring. The cause of this drastic pool filling is believed to be several large runoff events that occurred in 2007-2009; during these events there was substantial transport of large substrate, and much of the material present in these areas is large cobbles to small boulder-sized material. This more abrupt loss of pools further exacerbated the chronic habitat loss from sediment accumulation in the channel.

However, in 2012 superstorm Sandy resulted in substantial inputs of wood (i.e., broken tree tops, uprooted tree falls, etc.) to Elklick Run. These woody additions are probably the single largest inputs during the past 50+ years. Initially much of the woody material fell over the channel

rather than in the channel, but through time it has begun to collapse into the channel and capture other organic debris and sediment. As a result, there has been a substantial increase in pool and riffle sequence development in Elklick Run; however, these tend to be sporadic and concentrated where the largest wood fell into the channel, and most of Elklick Run continues to have a bedrock streambed. Without continued wood recruitment, the existing log jams will eventually fail due to organic matter breakdown, and there is a strong probability that most of the aquatic habitat that developed as the result of superstorm Sandy will wash out and be lost over time.

Cross section measurements in Camp Hollow from 2000-2010 also indicate no obvious trends or changes in channel width or depth. While there was little direct forest management during the 10 years of monitoring along Camp Hollow, this stream receives flow from two watersheds that have undergone harvesting during that time period, watersheds 2 and 5. Local cross section measurements in watershed 2 showed no substantial changes during those 10 years. Wolman pebble counts in watershed 2 have been similar through time, though the percentages of substrate fragments in smaller sizes (especially 16 mm and smaller) were elevated in 2002. This difference is not believed to be linked directly to management practices that occurred, because harvesting in watershed 2 was performed in 1997 and 2004.

Channel cross section measurements from 2005-2009 in four transects of John B Hollow show little change through time, including after the watershed underwent controlled burning in 2007 and 2008. However, cumulative percent finer plots from Wolman pebble counts for one of the cross sections have shown a fairly wide distribution through those years, with 2009 showing very large increases in particles 32 mm and smaller. While the watershed in this area was burned, the fire did not combust a particularly large amount of the organic layer, at least in the near-stream area, so it is unlikely that the burn was responsible for either the temporal variability or high percentage of fines found in 2009. This reach appears to have been unstable since measurements began. It is very incised and U-shaped, particularly for its small width and high position in the watershed. It is located just upstream from an undersized stream crossing culvert that is not installed at the proper angle. The presence and problems associated with this culvert are believed to be the reasons for the substantial channel incision and degree of destabilization (including channel substrate problems).

Three cross section transects were measured in Bear Run from 2001-2004. This overlapped with harvesting in that subdrainage from 2001-2002. Throughout that period of monitoring, there was little change in those cross sections. One of the cross sections was in a very incised transect at the start of monitoring (i.e., prior to harvesting during this period). The exact cause of this incision is not immediately apparent, but some may be attributable to a downstream stream crossing culvert (on Bear Run Road) and some may be due to past harvesting and skidding activities in the watershed.

Direct/Indirect Environmental Effects

Alternative A – No Action

In this alternative, no trees would be harvested, no skid roads would be re-opened, and no fire lines would be constructed. However, current open system roads would remain open, and their use would remain near current levels. Forest Service and other researchers would continue to use the system roads to access sites that would continue to be monitored in the absence of

additional treatments. Public use for access to the FEF and to Otter Creek Wilderness for recreation would continue. Normal system road maintenance activities also would continue. Continued disruption of sediment regimes from weir pond cleaning, the presence of FR 701 and FR 704, and from the old reservoir would be expected.

Stream channels within drainages that have experienced morphological changes due to skid road effects (increased runoff and direct sediment inputs) could experience slow recovery to their original channel geometries or substrate conditions in the absence of repeated skid road use. The presence or absence of recovery would be partially dependent upon the rate and success of vegetation (especially trees) re-establishment on skid roads, and the degree of culvert washout on the skid roads at stream crossings. Due to the generally smaller area in roads and decks in Stonelick Run, Canoe Run, and Sugarcamp Run subdrainages, recovery in streams within these subdrainages would be expected to be quicker and less problematic than in subdrainages of the Elklick Run watershed.

However, in the absence of skid road use, evaluation of skid road (i.e., non-system roads) and culvert condition and maintenance of the culverts likely would be much less frequent than what currently occurs. Consequently, the opportunity for culvert clogging and washout exists in the No Action Alternative, and the probability of these occurrences increases over time. As a result, culverts could plug and skid roads could experience washouts and become much more substantial contributors of sediment to tributaries and perennial streams as well as larger downstream connected streams and rivers. This may increase the negative effects associated with sediment delivery and sediment routing for a longer period in the subdrainages where skid road problems develop or where they already exist.

Environmental Effects Common to Alternatives B and C

Restricting logging only to the dormant season would increase stream sedimentation over levels that would occur with logging during drier seasons or periods. Soils are wettest during the dormant season because evapotranspiration demands are lowest. The mid-October through late November period of the dormant season is the driest portion of the dormant season because soil recharge still is occurring and average total monthly precipitation levels are lowest for these months. Completing the most problematic land disturbance activities (i.e., in terms of hydrology and erosion and sedimentation) during this drier period would help reduce sedimentation problems. As management activities proceed into the wetter winter season, restricting logging and skidding to times when soils and roads are frozen or are not excessively wet would help control the amount of sediment that both erodes and is delivered to streams. However, in this climate, soils do not typically freeze deeper than a few inches at most, so churning up soil with skidder tires and dragging logs can negate advantages associated with winter skidding.

Controlling water and soil movement on skid roads after they are closed with smoothing, water barring, and outsloping, and on log decks with liming, fertilizing, and grass seeding similarly would help reduce in-stream sedimentation. Restricting the level of tree removal and logging equipment use in near-stream areas would help avoid erosion in these near-stream areas and subsequent in-stream sediment deposition. These mitigations (page 2-8), along with providing buffer strips and not allowing trees on the stream bank and in channels to be harvested, would contribute to stream bank stability and reduce the probability of changing channel morphology. Riparian vegetation also would maintain stream temperatures at acceptable levels and provide

future sources of large wood for stream channels. Use of current West Virginia's BMPs (WV Division of Forestry 2015) would help control erosion and sedimentation overall and work toward keeping turbidity changes to levels allowed by West Virginia's laws (e.g., West Virginia's 1992 Logging Sediment Control Act) and Federal laws (e.g., Clean Water Act and amendments).

Overall, implementation of these mitigation measures would reduce both the direct and indirect effects of all Action Alternatives on water and riparian resources over what would be experienced otherwise. These mitigations also work toward reducing cumulative effects.

Alternative B – Proposed Action

Side Hill Subdrainage

Side Hill subdrainage is 83.0 acres. There are no haul roads in the subdrainage, but the lower boundary of Side Hill subdrainage is FR 701. There are 3.14 miles of skid roads in the subdrainage, which occupy 5.91 percent of the subdrainage area. There are no perennial or nonperennial streams in the subdrainage, but ditch lines of FR 701 contribute directly into perennial Elklick Run.

Compartment 45 occupies 76.6 acres, or 92.3 percent of Side Hill subdrainage. All of compartment 45 is upslope of FR 701 and it is composed of Hampshire geology overlain almost entirely by Calvin soil, which is moderately erodible. A very small strip along FR 710 on the east side of the subdrainage is a Fluvaquent, which is highly erodible. In Alternative B, all of compartment 45 in the Side Hill subdrainage would be subjected to prescribed fire.

A moderate intensity fire would be the desired level for the treatment in compartment 45, but it is expected to burn fairly rapidly due to the steepness of the hillside. This would result in combustion of the litter layer and small fuels, but the humus layer would remain intact. Tree tops and large wood would be removed with a bulldozer from the surface of about 2.34 miles of existing skid roads that will be used as fire lines which would help reduce hot spots and humus layer combustion. An existing fire line would be reopened by bulldozing to mineral soil around the ridges of Side Hill subdrainage to control the fire. The fire lines would be reopened within a day or two of the burn. Because litter would become re-established on the fire lines relatively quickly from redistribution of leaves from outside the burned area by wind, no water control features would be used to rehabilitate the fire lines after the burn. FR 701 would serve as the fire line along the lower edge of the compartment and subdrainage.

The prescribed fire would have little effect on soil moisture and there are no streams, and hence no streamflow effects in the Side Hill subdrainage. The lack of channels within the subdrainage coupled with little mineral soil exposure is expected to result in little erosion and no sediment transport to channels or ditch lines connected to streams. Consequently, the treatments proposed for Side Hill subdrainage would not directly or indirectly affect hydrology or sedimentation.

John B Hollow Subdrainage

John B Hollow subdrainage is 395.5 acres. It has 1.33 miles of perennial stream channel length and 2.27 miles of nonperennial channels. Within John B Hollow subdrainage, there are 2.55 miles of haul roads, and 6.41 miles of skid road. These comprise just over 16 acres, or 4.09

percent of the subdrainage area. There are no decks in the subdrainage. The haul road in John B Hollow has been in place for several decades. A substantial length of this haul road runs along the contour and parallels the perennial stream. It crosses the perennial stream one time and also crosses two nonperennial tributaries. Fifty-eight percent of the stream length in John B Hollow subdrainage is in compartment 45; this includes 1.29 miles of perennial channel length and 0.8 miles of nonperennial streams.

Compartment 45 comprises approximately 57 percent (224.4 acres) of John B Hollow subdrainage. The treatment proposed for the part of compartment 45 within John B Hollow subdrainage is a moderate intensity prescribed fire. Due to the steepness of the hillside, the fire is expected to burn fairly rapidly, which would result in combustion of the litter layer and small fuels, but the humus layer would remain intact. A fire line to mineral soil would be reopened around the compartment boundary to control the fire. Additional fire lines to mineral soil would be reopened by hand and would be approximately 2 ft wide. No fire lines would be constructed near stream channels. The fire lines would be reopened within a day or two of the burn.

The bulldozed fire lines that are reopened would disturb more area than hand-dug fire lines because of the greater width of the former. However, the bulldozed fire lines would be relatively far from streams and litter would become re-established relatively quickly on the fire lines from wind redistributing leaves from outside the burned area, and hand-dug fire lines would be away from streams, which would essentially eliminate sedimentation. The prescribed fire would have little effect on soil moisture or streamflow. Consequently, the treatment proposed for John B Hollow subdrainage would not directly or indirectly affect sedimentation or hydrology.

Camp Hollow Subdrainage

Camp Hollow subdrainage is 489.2 acres in size. It includes 1.98 miles of haul roads, about half of which is Fork Mountain Road which runs along the ridge top in the head of Camp Hollow subdrainage. The other half is Camp Hollow Road which runs adjacent to perennial Camp Hollow Run and includes about 6 stream crossings on this stream and an additional stream crossing of an intermittent channel near the end of Camp Hollow Road. Another 6.63 miles of skid roads in Camp Hollow subdrainage occur within watersheds 2, 3, and 5. There are 3 decks along Camp Hollow Road that are very near the perennial stream channel. There are another 2 decks in Camp Hollow subdrainage on the ridge top of watershed 5 on Fork Mountain Road. The total area in haul roads, skid roads, and decks in Camp Hollow subdrainage is 15.88 acres, or 3.25 percent of the subdrainage area.

The soils in Camp Hollow subdrainage are predominantly Calvin and Dekalb. The Dekalb soils occur primarily along the Fork Mountain ridge top and along the southern ridge top boundary along the border with Upper Elklick subdrainage. There also are 2 small areas of Ernest soil. Ernest and Calvin soils are moderately erodible and Dekalb has low erodibility.

There are three watersheds that are proposed for treatment in Camp Hollow subdrainage under Alternative B. All of watershed 3 would continue to be treated aerially 3 times a year with ammonium sulfate fertilizer to study the effects of acidification on watershed processes. Compartment 5A in watershed 5 (i.e., watershed 5A) would be harvested by single-tree selection. And watershed 2 (both sections 2A and 2B) would undergo diameter-limit harvesting.

Watershed 3 is 84.7 acres in area, which is 17.3 percent of Camp Hollow subdrainage. Watershed 3 contains 0.13 miles of haul road on the ridge along Fork Mountain. This haul road does not have any stream crossings in watershed 3 and water drained from the road is cast off onto bowl-shaped rolling topography rather than steep hillsides, so sediment delivery to streams in watershed 3 from the haul road is not a problem and that situation is not expected to change since haul road use is not expected to change due to the proposed treatment.

There are 2.22 miles of skid roads in watershed 3. These were constructed before 1973, and have mostly been unused by vehicles since 1972, so they have developed a protective vegetation and litter layer on them, and trees now grow within some of the skid roads. However, a 0.4-mile length of skid road is used very infrequently by light all-terrain vehicles to retrieve soil water samples. This segment of the skid road runs from the ridge top on the north side of watershed 3 to the southern side of watershed 3. It crosses the headwaters of the nonperennial channel 3 times. This section of the skid road shows evidence of light ATV use -- wheel tracks can be seen and some exposed soil is present. However, the surface was not rebladed before ATV use was initiated, so some litter still exists on the road thereby helping to reduce erosion.

The proposed acidification treatment in watershed 3 would not increase erosion or in-stream sedimentation to the catchment's stream system since the application of fertilizer is aerial and would not increase soil disturbance. Changes in hydrology would not be expected from the limited use of the skid road. Therefore, channel morphology, in-channel sediment storage and routing, and sediment budgets would not change in response to ammonium sulfate applications.

Watershed 5 is 90 acres. It includes two compartments, 5A and 5B, but treatment is proposed only for compartment 5A. Henceforth it will be referred to as watershed 5A. Watershed 5A comprises most of watershed 5's acreage, 78.2 acres, and it is 16 percent of the area in Camp Hollow subdrainage. In Alternative B, watershed 5A would receive a single-tree selection harvest spread over the entire area that would reduce basal area by approximately 20 percent.

Watershed 5A has 0.25 mile of haul road that is confined to the ridge top. Two decks also are located along the haul road, and these encompass 0.38 acres. There are 2.27 miles of skid roads, constituting 3.54 acres.

There is 0.13 mile of perennial stream channel near the mouth of watershed 5A. An additional 0.97 mile of nonperennial channel is located throughout watershed 5A. The principal skid road in watershed 5A runs parallel to the main stream channel from the mouth of the watershed almost the entire way to the ridge top. In the lower portion of the watershed, that skid road is less than 125 feet from the 0.13 mile of perennial channel. In the upper two-thirds of the watershed, that skid road, on average, is about 150 feet from the nonperennial segment of the channel. Other shorter segments of skid road also are within tens of feet of the channel or immediately adjacent to it, and there are about eight locations where the skid road crosses the nonperennial stream. Most of the soils in watershed 5A are moderately erodible, but there are a few locations that contain soils with low erodibility.

Streamflow increases within watershed 5 from harvesting in watershed 5A would not be expected given that the basal area removal will be 20 percent of the watershed 5A area, and even less than that for the total watershed 5 area (i.e., including watershed 5B which will have no harvesting). Further, the harvesting would be as single-tree selection spread across the area

which also would temper runoff alterations. Thus, hydrologic changes from harvesting would not be expected to change in-channel sediment routing and erosion processes. The acreage in roads and deck in watershed 5A also is not large enough to approach the level needed to observe changes in streamflow by roads (Verry 2000). Therefore, increases in stream runoff or channel morphology changes also would not result from the roads in watershed 5A.

By contrast, skid road contributions of sediment to the stream channel in watershed 5 likely would increase from renewed skid road use, as long lengths of the skid roads in watershed 5A are less than 100 feet from the stream, including the perennial reach. The relatively large number of stream crossings by the skid road also would be expected to provide a chronic source of sediment to the stream when the road was in use. These sediment inputs would alter local sediment deposition in the stream and potentially influence erosion processes by increasing sediment budgets. Following harvesting, the skid roads would be water barred on spacings required in West Virginia's Forestry BMPs to help control erosion and sedimentation until the roads restabilize and litter layer and other vegetative cover become established.

Watershed 2 occupies 38.3 ac, or 7.9 percent, of the Camp Hollow subdrainage. It includes two sections, 2A and 2B, both of which would receive a diameter-limit harvest in Alternative B. Approximately 38 percent of the basal area in the 26.8 acres of watershed 2A would be harvested and about 26 percent of the basal area in the 11.5 acres of watershed 2B would be harvested. This represents about 34 percent basal area (based on area-weighting) for all of watershed 2.

Watershed 2 has no haul roads, and no log decks within its boundaries. There are 1.03 miles of skid roads, constituting 1.61 acres. Much of the skid road length follows along and within 100 ft of both sides of the stream channel in WS2. Overall, 4.2 percent of the acreage in watershed 2 is composed of skid roads.

No perennial stream channel exists in watershed 2, but there is a single nonperennial channel that is 0.33 mile long. Soils within the watershed are almost entirely Calvin soils which are moderately erodible, overlaying Hampshire geology.

Streamflow increases (compared to a control watershed) from watershed 2 have been documented for most water years since treatment began in 1958. Most of these increases occurred during the dormant season. However, the presence of streamflow increases probably is not predominantly due to any of the past harvests on the watershed (either in watershed 2A or 2B). Instead the increases probably are artifacts of the relatively low flows (and low precipitation) on both the control watershed (watershed 4) and watershed 2 during the 6 years of calibration (1952-1957). Nearly all of the years since then with significant flow increases had streamflows on both the control and watershed 2 that were above those observed during calibration (unpublished data). Thus, these values lie outside the range in which flow deviations can be predicted accurately. However, some increase in streamflow within watershed 2 is expected for one to two years following the proposed harvesting since 34 percent of the watershed basal area will be removed. The increases from the treatment should be expressed predominantly during the growing season when flows are normally low. Consequently, while streamflow may be elevated slightly, the increases will not be sufficient to change stream power so within-stream erosion rates would not be elevated.

Only a small percentage of watershed 2 is composed of skid roads, so significant runoff to the stream system is not expected and significant morphology changes would not be expected. Sediment contributions to the stream channel would be a more likely occurrence, particularly since existing skid roads are parallel to and close to the channel. These sediment inputs could alter local sediment deposition and erosion in the nonperennial channel in the watershed, but the effects should be short term since logging and skid road use within the watershed would be completed quickly, and the skid roads are put to bed after harvesting is completed.

Any potential effects to Camp Hollow subdrainage would be from activities in watershed 5A and watershed 2, not from watershed 3, since watershed 3 would not experience changes to stream runoff or in-stream sedimentation by the proposed activities in Alternative B. However, the changes to Camp Hollow subdrainage are not expected to be significant. Cross section measurements made in upper, middle, and lower reaches of Camp Hollow Run from 2002 to 2009, including 2004 when watershed 2 was harvested previously, showed no meaningful changes in channel morphology. Although these measurements are only short-term results, they suggest that changes to the larger, downstream perennial channel from smaller contributing watersheds would not be significant unless much larger areas were treated or the amount of basal area removed and roaded acreage were substantially greater. The percentage of disturbed soils and harvested basal area in Camp Hollow subdrainage would be less than the levels that would be needed to change the hydrology, channel morphology, or sediment budgets on a subdrainage scale.

Hickman Slide Subdrainage

Hickman Slide subdrainage covers 294.5 acres of which 5.13 acres (2.12 miles) is a cut-and-fill haul road that is open to low-density traffic year-round and generally is completely graveled. Both broad-based dips and culverts are employed as cross-drainage features. Another 12.44 acres (7.97 miles) of Hickman Slide subdrainage is occupied by skid roads that are closed and waterbarred when not in use. Log decks occupy 0.44 acres in the subdrainage.

Hickman Slide subdrainage has a total of approximately 2.24 miles of stream channel within its boundaries. Approximately 0.85 mile is perennial stream and 1.39 miles is nonperennial stream. The perennial stream is crossed by the haul road in Hickman Slide subdrainage in 6 locations and nonperennial tributaries are crossed at about 10 locations by the haul road and skid roads.

The soils in Hickman Slide subdrainage are predominantly Calvin (moderate erodibility), Dekalb (low erodibility), Belmont, and Cateache (the latter two are high erodibility). A very small strip along FR 710 on the west edge of the subdrainage is a Fluvaquent, which is highly erodible, and a small portion of the upper ridge (east side of the subdrainage) is Cookport (low erodibility). The underlying geology in the subdrainage is dominated by the Pottsville and Mauch Chunk formations, with Pocono, Hampshire, and Greenbrier formations also present but occupying about only one-third to one-half the area of the Pottsville and Mauch Chunk.

Treatment, via patch cut harvesting is proposed for only two compartments in the subdrainage, compartments 7A and 7B. Respectively, approximately 6 and 10 acres of compartments 7A and 7B would be harvested, which would be about 5.4 percent of the subdrainage area. Compartment 7A is located in the lower slope area of Hickman Slide subdrainage, and has Belmont soil in its upper one-third, Dekalb soil in its middle 10 to 15 percent, and Calvin soil in

the lower half of the subcompartment. Dekalb soil overlying Pottsville geology has a low erodibility potential and Calvin soil has a moderate erodibility potential. Compartment 7B is covered by Belmont and Cateache soils, which have higher erosion potential but patch cutting would involve only a small portion of subcompartment 7B and only 3.4 percent of the entire subdrainage area.

Approximately 0.70 and 1.94 miles of skid roads would be reopened in compartments 7A and 7B, respectively, along with a combined total of 0.18 acre of reopened decks for the two subcompartments. The total area of re-disturbed skid roads and decks in Hickman Slide subdrainage would be less than 2.3 percent of the total subdrainage acreage. Some haul road and skid road use and deck use in compartment 7A would be close to perennial stream reaches. Decks and skid roads in compartment 7B are not close to any stream reaches.

Given the low amount of basal area reduction planned for the two compartments and the small total area to which the harvesting would be applied, no substantial increases in soil moisture in the subdrainage are expected. However, there could be short-term (first growing season following harvesting) local changes in soil moisture because whole patches of trees are being harvested. The soils in both compartments are sufficiently thick to provide a reservoir for storing excess moisture so it would be released as streamflow slowly over time. This is especially true for compartment 7B, which has more treated acres since it has thick Belmont and Cateache soils. Consequently, neither direct hydrologic changes nor indirect in-stream erosion or other morphological channel changes attributable to hydrologic responses would be expected.

Direct entry of sediment into stream channels in Hickman Slide subdrainage would be possible from skid road use, particularly in compartment 7A, where Belmont soil occurs. While generally built along the contour, the skid roads cross stream channels several times in compartment 7A. Given the high erodibility of this soil, sediment likely would enter the channel at these crossings, particularly since harvesting would occur during the wetter months of the year when soil is most easily detached and transported. Decks in subcompartment 7A also are close to perennial streams, making them much more susceptible to sediment inputs to the stream and sediment transport once in the stream. Turbidity increases in stream water likely would be visible at some times during operations near stream crossings and on decks, particularly during storm events, even if harvesting and skidding operations were suspended during those periods. Sediment additions to the channel should end or decrease substantially when skid road use is terminated because the skid roads would be waterbarred; however, some sediment resulting from skid road use could be stored in the stream channel for a long period of time, and would be flushed slowly from the subdrainage during high flow events.

Sediment from the haul road also could reach the stream channel through ditches and culverts, dips, and other water control features. However, increases in sediment delivered to stream channels from haul roads would not be expected to increase much over what currently occurs because the system roads are open year round and are fairly well graveled. The primary source of sediment to streams from these haul roads is believed to be from the ditch lines and from erosion and scour below cross drain features where water is side cast onto the hill slope. This type of erosion can effectively lengthen and extend the active stream channel up to the cross drain outfalls. Erosion from ditch lines and channel extension is particularly chronic and problematic from haul roads constructed in soils that are highly susceptible to eroding.

Actions proposed in Alternative B would be expected to result in additions of sediment to the stream channel from the road system and change the sediment balance of the stream in Hickman Slide subdrainage, at least in the short term.

Bear Run Subdrainage

Bear Run subdrainage is 167 acres in size. All but about 46 acres of Bear Run subdrainage is comprised of compartments 9A and 9B. In 2015, the steep riparian zone (about 13.6 acres) along Bear Run was excluded from current and future treatment in compartment 9A to help reduce soil disturbance in the riparian area and to protect water quality.

There are approximately 1 mile of haul road and 5.11 miles of skid roads in Bear Run subdrainage. These occupy 10.38 acres. Most of the haul road length occurs in compartment 9A while most of the skid road length is in compartment 9B. Most of the skid roads are on the contour, though some are perpendicular to the contour in the more gently sloping portions of the subdrainage. Another 0.32 acre of area exists as decks in the subdrainage, with almost all of that in compartment 9B. The largest deck is 0.19 acre, but it is located in a relatively flat area on a high point far from any stream channels.

Bear Run subdrainage has about 0.4 mile of perennial channel, but it is fully contained within the riparian zone excluded from treatment. There is another 0.97 mile of nonperennial channel length in the subdrainage. About one-third of that is also in the riparian exclusion, and 0.28 mile and 0.33 mile are in compartments 9A and 9B, respectively.

Bear Run subdrainage contains a mixture of soil series, similar to Hickman Slide subdrainage, as it is adjacent to it and occupies the same slope positions. Soils in the lower (down slope) compartment 9A in Bear Run subdrainge are almost entirely Calvin, with some Dekalb further from the channel. There is a very small amount of Belmont soil in the upper portion of 9A along the boundary with compartment 9B. Compartment 9B is composed almost entirely of Belmont soil and some Cateache along the upper boundary of the compartment. Consequently, soils in the lower portion of the subdrainage have a lower erosion potential than those further upslope (i.e., in compartment 9B).

Diameter-limit harvesting is proposed for 39.8 acres in compartment 9A and 80.9 acres in compartment 9B. The ridge top area of Bear Run subdrainage would not be treated. Thus 72 percent of the subdrainage area would receive treatment. Only about 23 percent and 38 percent of the basal area of compartment 9A and 9B, respectively, would be removed. While the proposed harvested portions of the watershed include only 72 percent of the Bear Run subdrainage, about 37 percent of the basal area in that part of the subdrainage would be harvested. This portion of the subdrainage also contains most of the stream length. Therefore, measurable streamflow increases likely would occur and predominantly during the growing season. Summer baseflows rather than stormflows would be augmented because the thick Belmont and Cateache soils present in compartment 9B where most of the harvested trees would occur would be able to store any additional soil moisture resulting from the reductions in evapotranspiration, and release that moisture to streams slowly. Consequently, while annual or growing season flow increases may be measurable, they would not be sufficient to increase within-channel erosion or channel morphology changes.

Based on visual observations, channel changes probably already have occurred within the Bear Run subdrainage due to the presence of the haul and skid roads in the highly erodible soils in the upper two-thirds of the subdrainage. Channel widening may have occurred, though head cutting is believed to have occurred due to the stream channel crossings without culverts on skid roads in the upper portion of the subdrainage. The potential for additional head cutting is high in these highly erodible soils with reentry and reuse of these skid roads.

Sediment from the haul road also reaches the stream channel. Several undersized culverts exist on the haul road, and dips no longer work as effectively as they did at the time they were installed. Erosion from dips is evident and minor washing and erosion on the haul road at the locations of the undersized culverts exists. Due to these undersized culverts, channel extension probably has and is occurring, which increases sediment delivery during hillside cutting. The potential for channel extension is very high in highly erodible soils. A fillslope slide also occurred in 2015 on Bear Run Road near where it crosses Bear Run. While it was repaired, it is likely that this may continue to be a source of problems in this steep topography and a potential sediment source if instability continues.

Chronic additions of sediment to the stream channel (channel extension and head cutting) from the road system are expected to continue to alter the sediment balance of the stream channel in the Bear Run subdrainage. In turn, changes in within-channel erosion, deposition, and morphology could occur. The degree of potential problems would depend upon the amount of sediment actually reaching the channel. Visible turbidity changes particularly during storm events would be likely in at least some of the streams in the subdrainage.

Big Spring Run Subdrainage

Big Spring Run subdrainage is 200 acres. The subdrainage holds 1.49 miles of haul road and 2.13 miles of skid roads. A single 0.07-acre deck is located along FR 701. FR 701 makes up most of the haul road length in Big Spring subdrainage, with Turkey Run Road making up the rest of the haul road length. About half of the length of FR 701 and all of Turkey Run Road is in the southern half of the subdrainage. The remaining half of FR 701 is in the middle portion of the subdrainage and follows along the entire length of the main channel of Big Spring Run. FR 701 crosses five nonperennial tributaries of Big Spring Run, three in the very headwaters, and two near their confluence with Big Spring Run.

Most of the main channel of Big Spring Run is perennial, as is one short tributary, totaling 0.58 mile. The remaining 1.30 miles of channel length is nonperennial. The valley segment along Big Spring Run is very wet and soils are mucky most of the year, particularly along the upper half of the stream.

Soils in Big Spring Run subdrainage range from highly erodible, with Belmont and Cateache series located primarily in the upper half of the subdrainage, to Dekalb and Calvin soils with low and moderate erodibilities in the lower half of the subdrainage. Meckesville soil occurs along the entire valley segment of the main channel of Big Spring Run, which is highly erodible.

Compartments 8C and 8D are located adjacent to each other in the northern portion of the subdrainage. Each is 5 acres in size and each comprises 2.5 percent of the Big Spring Run subdrainage area. In Alternative B, compartment 8C would receive a single-tree selection

harvest that would remove 19 percent of its basal area. Compartment 8D would have an intensive single-tree selection harvest that also would remove 19 percent of the basal area.

Stream length in the compartments is quite limited. There are no perennial streams in either compartments and there is only 0.03 mile of nonperennial channel length in compartment 8D. Less than 0.01 mile of nonperennial channel cuts across one corner of compartment 8C.

A skid road runs north to south through the two compartments near their western borders. This same skid road passes just upslope from the head of another nonperennial tributary in compartment 8D. Another skid road runs through compartment 8D east to west, and two go through compartment 8C east to west off that skid road. Total skid road lengths in compartments 8C and 8D, respectively, are 0.29 mile and 0.18 mile.

Even though highly erodible Belmont soils occur across compartments 8C and 8D, the small size of each of the compartments (5 acres) would temper increased erosion from skid road use. Relatively few trips would be made on the skid roads because the proposed basal area removal in each is small. The limited stream length that exists within and close to the two compartments and the relatively gentle topography would help to control sediment delivery to stream channels in Big Spring Run subdrainage. Therefore, activities proposed in Alternative B would not contribute significantly to increased sediment loads to the stream channels or result in changes to in-channel sediment budgets or sediment routing.

Measurable changes to local hydrology and streamflow also would not occur from the proposed harvesting treatments. The percentage of basal area would be only a very small portion of the total basal area in the subdrainage. Significant increases in soil moisture are also not expected because the harvesting practices involve single-tree selection. Any small increases in soil moisture that might occur from intensive single-tree selection in compartment 8D would occur during the growing season when soil moisture deficits are greatest and would be retained easily by the thick Belmont soils present.

Compartments 8C and 8D comprise only 5 percent of the total area of Big Spring Run subdrainage and they are located in the uppermost headwater areas of two nonperennial tributaries of Big Spring Run. Since local changes to in-stream sediment and hydrology would not be measurable, there would be no significant direct or indirect effects to water resources in Big Spring Run subdrainage.

Upper Elklick Subdrainage

Upper Elklick Run subdrainage is 736.1 acres. It includes all of the headwaters of Elklick Run, which is the principal perennial stream in the Fernow Experimental Forest.

Total haul road length is 4.0 miles, which is almost entirely FR 701. There are also 17.7 miles of skid road. Just over 37 acres of roads exist in Upper Elklick Run subdrainage. Fourteen log decks and one gas well pad cover an additional 1.27 acres. Roads, decks, and the well pad comprise 5.22 percent of the area of Upper Elklick Run subdrainage.

Upper Elklick Run subdrainage has 1.87 miles of perennial stream channel, which is almost the entire portion of the main stem of Elklick Run that lies within the subdrainage and a portion of a tributary to the main channel. There also are 6.04 miles of nonperennial channel that includes all

the other tributaries and a very short headwater reach of the main stem of the Elklick Run.

FR 701 parallels Elklick Run's main channel and is within 50 ft (and often less) of the channel for most of the entire stream length in Upper Elklick Run subdrainage. All the nonperennial tributaries on the right side of Elklick Run also are crossed by FR 701 as it loops back toward the reservoir that once served as the Parsons water supply. As a result, there are many stream crossings on Elklick Run and its tributaries within Upper Elklick Run subdrainage.

Soils on the west side of FR 701 in the subdrainage are predominantly Calvin and Dekalb. Soils on the east side of the road in the lower one-third to one-half of the subdrainage also are dominated by Calvin and Dekalb. This area contains most of the compartments proposed for treatment in the subdrainage. Further upslope the soils include Meckesville (which is high erosion hazard), Belmont, Cateache, and Dekalb along the ridge top.

Upper Elklick Run subdrainage includes seven compartments proposed for treatment in Alternative B. Compartments 13 and 21 would be subjected to prescribed fire; compartments 17A, 17B, 18C, and 19A would have patch cuts; compartment 20A would have single-tree selection harvesting.

Compartment 13 is 31.3 acres and is located near the mouth of Upper Elklick Run subdrainage. The compartment contains no haul roads and 0.81 mile of skid roads. Approximately 0.44 mile of nonperennial tributary to Elklick Run longitudinally bisects compartment 13.

The soils in compartment 13 are predominantly Calvin in the lower third, Dekalb in the middle third, and Meckesville and Gilpin sharing the upper third of the area. Therefore, most of the soils in the compartment have moderate or low erodibilities.

A fire line will be reopened (bulldozed) to mineral soil around the boundary of compartment 13. No other fire lines, including hand-dug lines would be constructed within the compartment. The fire lines would be reopened within a day or two of the burn. The proposed prescribed fire would be moderate intensity and primarily would consume only the litter layer and small fuels. It would not have a significant effect on reducing evapotranspirational rates within the compartment. Thus, the fire itself would not increase soil moisture, alter streamflow, or affect channel morphology or sediment relationships caused by hydrologic changes. Streamflow increases and changes to channel morphology or sediment budgets also would not be expected.

The fire line would approach Elklick Run at the lower end of compartment 13, which increases the susceptibility for erosion and sedimentation. However, litter cover on the entire fire line is expected to be restored quickly by adjacent land that was unburned. The fire line at the base of compartment 13 may recover faster because it lies at a lower elevation; low elevations are points of litter accumulation from gravity and wind. Consequently, the potential for soil erosion and sedimentation would be small.

Compartment 21 (30.9 acres) is located in the headwaters of Upper Elklick Run subdrainage and would be treated essentially the same way as compartment 13. Compartment 21 contains 0.64 miles of perennial stream channel, and 0.1 mile of nonperennial stream channel. The soil in the compartment is almost entirely Calvin, which is moderately erodible.

Elklick Run and FR 701 bound the northwest boundary of compartment 21. FR 701 also

comprises its southern and southeastern borders. There are 0.53 mile of skid roads within the compartment and one skid road runs within 50 ft of most of the length of the perennial stream channel. However, none of the skid road soils would be disturbed during the treatment. The only soil disturbance in the unit would be the reopening of a bulldozed fire line to mineral soil around sections of the compartment's boundaries that are not bounded by FR 701. The fire lines would be reopened within a day or two of the burn.

The reopened fire line will generally be away from stream channels. Litter cover is expected to be restored quickly by adjacent land that was unburned. Consequently, the potential for elevated soil erosion and sedimentation from the fire lines would be small. Continued chronic inputs of sediment from FR 701 into Elklick Run would continue, but the fire would not increase those inputs.

Compartment 17A occupies 31.4 acres, or 4.3 percent, of the Upper Elklick Run subdrainage. In Alternative B, 2.4 acres of the compartment would have six 0.4-acre patch cuttings, which would remove 25 percent of the basal area in compartment 17A. There are no haul roads in compartment 17A, but FR 701 runs along both the upper and lower boundaries of the compartment. There are two skid roads in compartment 17A that total 0.81 miles or 1.26 acres. There are decks along the haul roads and these comprise 0.17 acre of area.

Compartment 17A has 0.06 mile of perennial Elklick Run, which also runs along the lower slope boundary of the compartment. There is 0.77 mile of nonperennial channels. Soils within compartment 17A are primarily Calvin and Dekalb, with only a small area in Meckesville soil in the upslope area of the compartment.

Harvesting would be in concentrated units as patch cuts, but the basal area removed within the subdrainage would be insufficient to affect transpiration and soil moisture sufficiently to alter streamflow in Elklick Run in a significant or measurable way. Therefore, direct and indirect changes in water resources would not result from changes in flow or energy.

One of the two skid roads in compartment 17A is in a mid-slope position and is located in a position that would be unlikely to contribute sediment to the nonperennial channel in compartment 17A. However, the second skid road parallels the nonperennial channel fairly closely for several tenths of a mile and crosses it once. The greatest potential for contributions would occur along the upper half of this road. Skidding logs on this road would have a high potential for increasing sediment contributions to the stream, given its close proximity and the presence of a crossing; the soil in that part of the compartment is Calvin which is moderately erodible. These contributions might change the sediment relationships in the nonperennial channel and possibly result in small, localized changes to channel morphology resulting from increasing sediment inputs. However, changes in sediment relationships to Elklick Run would probably not be measurable because this stream is predominantly influenced by much larger sediment inputs from FR 701.

Compartment 17B occupies 11.3 acres, or 1.5 percent, of the Upper Elklick Run subdrainage. In Alternative B, 2 acres of the compartment would have five 0.4-acre patch cuttings. There are no haul roads in compartment 17B, but there is 0.31 mile of skid roads, constituting about one-half acre of subdrainage area. There are no log decks in the unit. Compartment 17B also has no stream channels within its boundaries. Soils within compartment 17B are primarily Calvin in the

lower two-thirds and Dekalb in the upper one-third, with a small strip of Meckesville bisecting the area of Dekalb soil.

Harvesting would remove approximately 25 percent of the basal area in compartment 17B, but that translates to a much smaller percentage basal area removal across the subdrainage. Consequently, insufficient basal area would be removed within the compartment to affect transpiration and soil moisture sufficiently to alter streamflow in the headwaters of Elklick Run in a significant or measurable way. Therefore, treatments in compartment 17B would not result in direct or indirect changes to water resources or stream channels from changes in flow or energy.

Increased sedimentation to the streams is not expected from skid road use, due to the distance between the road and the channels. Since direct inputs of sediment would not change from activities in compartment 17B, indirect effects, such as channel morphology changes, also should not occur.

Compartment 19A occupies 22.4 acres, or 3.0 percent, of the Upper Elklick Run subdrainage. In Alternative B, 2.8 acres of the compartment would have seven 0.4-acre patch cuttings, which would remove approximately 23 percent of the basal area in compartment 19A.

There are no haul roads in compartment 19A but FR 701 runs along both the upper and lower boundaries of the compartment. There are two skid roads in compartment 19A that total 0.99 mile or 1.54 acres. There are decks along the haul roads and these comprise 0.09 acre of area.

Compartment 19A has 0.03 mile of perennial Elklick Run along the lower slope boundary of the compartment. There is 0.55 mile of nonperennial channels. Soils in compartment 19A are primarily Calvin and Dekalb with a very small area in Meckesville soil in the most upper headwaters of the compartment.

Harvesting would be in concentrated units as patch cuts, but the basal area removed from the compartment would be less than the amount needed to increase streamflow in the subdrainage. Therefore, direct and indirect changes in water resources would not result from changes in flow or stream energy.

The two skid roads in compartment 19A run parallel along both the right and left sides of the nonperennial channel. Neither of the skid roads crosses the stream. The skid roads remain at least 50 feet from the channel, but there are several extended sections where the distance between the stream and a road is only 50 feet. Because the side slopes on which the skid roads exist are relatively steep in compartment 19A, skidding logs on these roads would create a high potential for increasing sediment contributions to the stream where the roads are close to the stream. These contributions could change the sediment relationships in the nonperennial channel and possibly result in small, localized changes to channel morphology resulting from increasing sediment inputs. However, changes in sediment routing in Elklick Run would probably not be measurable because this stream is predominantly influenced by much larger sediment inputs from FR 701.

Compartment 20A has 18.8 acres in Upper Elklick Run subdrainage and would receive a single-tree selection harvest spread across the entire compartment. Approximately 25 percent of the basal area in the compartment would be harvested.

There are no perennial or nonperennial streams in compartment 20A. The soils in compartment 20A are Cateache, Belmont, and Meckesville, which are all highly erodible.

A haul road outside subcompartment 20A runs along much of its length on its western boundary. There is one deck (0.15 acre) at the bottom of subcompartment 20A along that haul road. There is 0.77 mile of skid road length in compartment 20A.

Streamflow changes in the treated compartment would not occur as there are no streams within or near it. Any small increases in soil moisture that might occur locally within the compartment from losses to evapotranspirational demands would occur during the growing season, and would be easily retained and released slowly by the relatively thick soils. Consequently, hydrologic changes in Upper Elklick Run subdrainage would not occur, nor would hydrologically-driven changes, such as channel morphology and sediment budgets. Although erosion could occur in compartment 20A from skid road use, sediment delivery to streams in Upper Elklick Run subdrainage also would not be expected to occur because there are no streams in the compartment, no channels are close to the compartment, and concentrated surface flow would be unlikely due to the high permeability of the soils and underlying limestone geology.

Approximately 13.3 percent of the Upper Elklick Run Subdrainage would be treated in Alternative B. The combined influences of all the proposed activities in the affected compartments would not significantly affect either streamflow, energy, or sediment budgets in Elklick Run because the area affected is small, few of the treatments would affect sediment locally, and none would affect streamflow. The effects to sediment in local tributaries would not result in measurable changes to sedimentation in Upper Elklick Run because the stream is primarily influenced by large, chronic inputs of sediment from FR 701 which would continue to be present and used, regardless of whether Alternative B was implemented or not.

Stonelick Run Subdrainage

Stonelick Run subdrainage is 617.8 acres. It has 2.75 miles of haul roads that comprise 6.68 acres, all of which run along the ridge tops in the subdrainage. Nine decks totaling 0.62 acre are present along the haul roads. There are 5.89 miles of skid road in Stonelick Run subdrainage, which are confined primarily to the northeast upland areas. A total of 2.67 percent of the subdrainage is occupied by haul roads, skid roads, and decks. Perennial stream length in Stonelick Run subdrainage is 1.53 miles, which occurs only on the main channel. All of the 4.75 miles of side channel tributaries are nonperennial.

Compartment 48 and the long-term soil productivity research area (LTSP) are located within Stonelick Run subdrainage. A low intensity prescribed fire is proposed for compartment 48 that will result in no basal area reduction. Fertilizer and lime additions are proposed for the long-term soil productivity research area.

Compartment 48 occupies 1.6 acres of the ridge top, or 0.3 percent of the subdrainage area. No stream channels occur in compartment 48 in Stonelick Run subdrainage, and no tributaries in the subdrainage come close to the compartment. Moderately-erodible Calvin soil is present.

The low intensity burn is expected to combust only the litter layer, so the humus layer would be retained to protect the soil from erosion. A bulldozed fire line would be reconstructed around the lower boundary of compartment 48 which would remove litter, slash, and the humus layer, but it

would not increase sedimentation because there are no nearby streams and the fire line would become re-covered by litter relatively quickly. The area involved also is very small and a very small proportion of the subdrainage, so there would be no significant increases in erosion, soil moisture, or runoff from the prescribed fire in compartment 48.

The LTSP research area lies along a relatively flat ridge top area in the subdrainage. It is 16 acres, or 2.6 percent of the subdrainage area. There are no haul roads or decks in the area, but there are two skid roads with a total length of 0.42 mile that comprise 0.66 acre. Only one of the skid roads in the area continues to be used and it has no stream crossings. The unused skid road has a single stream crossing; within the research area, the stream is ephemeral and is 0.23 mile long.

Research in the area was begun in 1995. At that time, control plots with no treatments and treatment plots with whole tree harvesting were established. Post-harvesting, 8 0.5-acre treatment plots receive applications of fertilizer (4 plots) or fertilizer and lime (4 plots) on a pre-defined schedule. Fertilizer is applied every March, July, and November, and lime is applied in March every other year. All applications are made by hand. In Alternative B, the chemical treatments would continue on this schedule but no ground disturbing or tree harvesting activity would accompany these treatments.

The skid road to the research plots is accessed by truck. The road has several areas that are poorly drained, and consequently, have ruts and wet spots throughout much of the year. However, there is no evidence of eroded soil reaching the stream channel at those or other locations on the road. Given the relatively flat ridge top area, road failure that would increase sediment delivery to the ephemeral channel is not expected. In addition, changes in streamflow would not occur.

Because of the small percentage of the subdrainage area that would be affected by the treatments and the lack of hydrologic or sedimentation effects expected, there would be no direct or indirect effects in the Stonelick Run subdrainage.

Canoe Run Subdrainage

Canoe Run subdrainage is 691.5 acres. There are 2.01 miles of haul road and 3.07 miles of skid road in the subdrainage. All roads constitute 9.66 acres or 1.40 percent of the subdrainage area. There are no decks located in Canoe Run subdrainage. Canoe Run subdrainage includes 2.25 miles of perennial stream, which reaches almost to the top of the watershed. There also are 2.46 miles of nonperennial stream channel. The haul road crosses nonperennial stream reaches four times in the subdrainage, but it does not cross the perennial channel. Skid roads do not cross any of the streams, though two join together very near a nonperennial stream. All the miles of skid roads are located in the head of the subdrainage, primarily near the ridge.

Canoe Run subdrainage includes portions of compartments that cross into Canoe Run subdrainage from other subdrainages: compartments 18C, 20A, and 48. Canoe Run subdrainage holds the lesser portion of each of the three compartments. All are along the northern ridge top of the catchment. The proposed treatments are a single-tree selection harvest (compartment 20A), patch cutting (compartment 18C), and a prescribed fire with no basal area removal (compartment 48). Compartment 18C in Canoe Run subdrainage is only 0.9 acre, compartment

20A is 6.4 acres, and compartment 48 is 9.7 acres. Compartment 18C would contain a 0.4-acre patch cut and compartment 20A would hold a single-tree selection. Only 1 percent of the Canoe Run subdrainage area would be affected by the harvesting in compartments 18C and 20A. The controlled burn in compartment 48 would be restricted to only 1.5 acres and comprise only 0.2 percent of the subdrainage area.

There are no perennial streams in these three compartments in Canoe Run subdrainage. The only stream channel that exists in the three compartments is 0.14 mile of nonperennial channel length in compartment 48.

There also are no haul roads or decks in any of the compartments. There is a haul road just outside of compartment 48, which would serve as part of the boundary fire line for the compartment. There are no skid roads in compartment 48, but a fire line would be reconstructed around the compartment by bulldozing down to mineral soil along the remaining boundary where no haul road exists. The soils in compartment 18C are Dekalb and in compartment 48 are Calvin, both of which are moderately erodible. The portion of compartment 20C in Canoe Run subdrainage has Cateache soils which are highly erodible.

The proposed harvesting in compartments 18C and 20A would remove less basal area in the subdrainage than is needed to influence streamflow or stream energy. Consequently, any local increases in soil moisture could be easily stored in soil and would likely be exploited quickly by remaining overstory and understory vegetation. Similarly, the intensity of the fire in compartment 48 would be too low to increase runoff or alter transpiration, so it would not affect streamflow. Sediment delivery to streams in Canoe Run subdrainage from harvesting or skid road use in compartments 18C and 20A would not be expected because there are no streams in those compartments.

The prescribed fire in compartment 48 would be applied to only 0.2 percent of the subdrainage area. The prescribed fire would be relatively light and confined to the ridge top, leaving the humus layer intact to protect mineral soil from erosion. Increased erosion from the fire line would not be expected even where the nonperennial stream is crossed by the bulldozer, because the channel is ephemeral in that reach and litter cover would be restored quickly by adjacent unburned/untreated areas. Consequently, increased erosion and sedimentation from burning and fire line construction would be insignificant.

Due to the lack of effects from treatment in each compartment, there is no expectation of direct or indirect effects to the hydrology, sediment budgets, or stream channel condition in the Canoe Run subdrainage.

Sugarcamp Run Subdrainage

Sugarcamp Run Subdrainage is 221.3 acres. It contains 1.37 miles of haul roads, 1.52 miles of skid roads, and 0.1 acre of decks. The total area in roads and decks is 5.78 acres, or 2.61 percent of the subdrainage area.

There are 0.65 mile of perennial stream channel and 2.12 miles of nonperennial channel in the subdrainage. The nonperennial tributaries extend into the mid-slope portions of the subdrainage, but rarely extend upslope near the ridge tops.

There is one proposed treatment in Sugarcamp Run subdrainage in Alternative B. Compartment 48 would receive prescribed fire treatment with no accompanying basal area removal. The compartment itself is split into two ridge top positions within the subdrainage, and 16.1 of the 17.8 acres of the compartment would be treated with the prescribed fire. Thus, the prescribed fire would affect 7.3 percent of the subdrainage area.

There are no roads or decks in either portion of compartment 48 in Sugarcamp Run subdrainage, nor are there any stream channels present. The soils in compartment 48 are mapped as Calvin and Dekalb, which are moderately erodible.

Past bulldozer-created fire lines would be reopened in compartment 48. All bulldozer fire lines would involve removing the downed wood, litter layer, and humus, thereby exposing mineral soil. The burn is expected to be low intensity so the humus layer would not be combusted. Overstory vegetation would remain intact so transpiration rates would not be altered. Consequently, neither streamflow nor soil erosion would increase from burning because of the low intensity. Elevated erosion from the reopening of bulldozed fire lines would not occur because they would be installed only a day or two prior to the burn and they would be re-covered with leaves and litter soon after the burn from surrounding, unburned areas. The lack of streams in compartment 48 would further ensure that even if some erosion occurred, there would be very little chance of sediment reaching any stream channels.

Consequently, there are no anticipated direct or indirect effects in Sugarcamp Run subdrainage from the prescribed fire.

Alternative C – Modified Proposed Action

The modified proposed action involves only minor additional herbicide and seedling planting treatments in 12 compartments/watershed areas already being treated with some type of harvesting activity. The herbicide application will involve 1 acre in each of the following compartments/watershed areas: 7A, 7B, 9A, 9B, 17A, 17B, 18C, 19A, and 20A, as well as watershed 2 (2A and 2B) and watershed 5A. Six of these 12 acres also will be planted with tree seedlings.

This level of herbicide treatment will not reduce transpiration sufficiently to increase soil moisture or streamflow. The litter layer will not be affected by herbicide application, so erosion will not increase. Tree planting will have no immediate effects on transpiration, and the density of trees and associated basal area within the planted areas will not increase (due to competition) above natural levels. Since the seedlings will be hardwoods, no change in streamflow beyond what typically occurs during natural regrowth following harvesting is expected.

Consequently, no additional direct or indirect effects (above those described for Alternative B) from the herbicide treatments and seedling planting are expected for Alternative C.

Cumulative Effects

Alternative A – No Action

The condition of Elklick Run is currently affected by the presence of the road system and the old Parsons city reservoir dam. Sediment inputs are elevated because much of the Forest Service road system in Elklick Run drainage basin drains directly into Elklick Run or one of its perennial

tributaries. The maintenance and condition of these system roads would not change under the no action alternative. However, since skid road maintenance might decline if they are no longer used (see direct effects of Alternative A), increased sediment contributions to nonperennial and perennial channels from culvert plugging and skid road washout might result. If this occurs, minor skid road sediment contributions may become sufficiently great to result in measurable cumulative effects in the subdrainages as well as in Elklick Run watershed. If this occurs, stream recovery may be set back or require even longer recovery times.

No noticeable change in cumulative effects related to sediment routing or channel conditions in Stonelick Run, Canoe Run, and Sugarcamp Run subdrainages or in Shavers Fork River would be expected from the no action alternative due to the relatively limited lengths of skid roads and their locations being primarily near ridge tops and away from waterbodies with few waterbody crossings.

Climate change is a less predictable influence on water resources, but it would ubiquitously affect all streams and rivers within the watershed, regardless of whether they were in managed or unmanaged subdrainages. While the specific influences of climate change in this region are not currently well understood, there is a general consensus that climate change will result in more frequent weather extremes. Increasing frequency of large or high intensity precipitation events and high streamflow events will likely have a more substantial effect on physical water resources and erosion processes than drought events. The former could result in elevated erosion and sediment transport, both on the hillside and within the channel. With more frequent large streamflow events, bankfull (i.e., flow with ~1.5-year recurrence interval) could become associated with higher discharges, which in turn could result in changes to channel morphology, such as channel widening and/or deepening. Where streambeds are already comprised of bedrock, increased width would result. Increased rainfall intensity could result in increased soil compaction where mineral soil is exposed, such as on skid roads. Compaction could result in short-term (until the litter layer is restored) increases in soil erosion and sediment delivery. Re-vegetation (and further soil stabilization to help reduce erosion) of skid roads might be delayed due to the combination of soil compaction and loss of stable growing media.

Alternative B – Proposed Action

Cumulative effects of past, present, and reasonably foreseeable actions on both federal and private lands are discussed. Land disturbances having the greatest potential for cumulative flow and sediment-related effects to streams include road construction, re-commissioning (e.g., skid road re-blading), and use, as well as any activities that result in substantial soil disturbance and exposure.

Cumulative effects are described by subdrainage and also in terms of the larger Elklick Run watershed and Shavers Fork watershed. Because the subdrainages contain compartments and watersheds that have received treatments in the past, cumulative effects from these other areas are considered within the analysis.

Side Hill Subdrainage

Compartment 45 is the only area in Side Hill subdrainage that received treatments in the past. It received a low to moderate intensity prescribed fire in 2007 and 2008. In 2007, individual trees

in six 0.3-acre plots were herbicided. If the herbicided trees were not killed, they were re-herbicided in 2008. Litter was restored quickly by leaf fall from the residual live trees, and there would have been no measurable increased runoff resulting from either the burning or tree mortality given the low intensity of both within the subdrainage. Consequently, there are no cumulative effects in Side Hill subdrainage.

John B Hollow Subdrainage

Compartment 45 is the only compartment that has received treatments in the past in this subdrainage. It received a low to moderate intensity prescribed fire in 2007 and 2008. In 2007, individual trees in 34 0.3-acre plots were herbicided. If the herbicided trees were not killed, they were re-herbicided in 2008. Litter was restored quickly by leaf fall from the residual live trees, and there would have been no measurable increased runoff resulting from either the burning or tree mortality given the low intensity of both within the subdrainage.

The haul road in John B Hollow subdrainage (FR 702) is the primary chronic cause and source of altered hydrologic regimes and channel morphology and increased sediment delivery to the perennial and nonperennial stream reaches. There has been no increased road use in compartment 45 from the treatments in 2007 and 2008, and because the road is gated, traffic levels still remain relatively low compared to open roads on the FEF. Runoff from the road probably has not changed due to road use. Undersized and improperly sloped stream crossing culverts along the entire road remain the largest problems and provide the causes for channel incision and head cutting. Therefore, there are chronic effects to the sediment regime and channel condition due to the long-term presence of the haul road in this subdrainage that exceed the negligible effects from proposed treatments.

Camp Hollow Subdrainage

Treated areas in Camp Hollow subdrainage are restricted to watershed 3, watershed 2, and watershed 5.

Past harvesting also occurred in watershed 3. In 1958-1959, a single-tree selection treatment was applied. Selected trees ≥5 inches in diameter were harvested. Increased streamflow was observed in 1960. In 1970, the watershed was clearcut, except for a bufferstrip around the stream channel. In 1972, the bufferstrip also was clearcut and all the woody debris in the channel was removed. Significant streamflow increases were observed through about 1986, but after that time streamflow returned to pretreatment levels.

Watershed 2 has received diameter-limit harvests in one or both of its two sub-areas (watersheds 2A and 2B) in 1958, 1972, 1978, 1988, 1997, and 2004. Streamflow increases (compared to what is predicted from a nearby control watershed) from watershed 2 have been documented for most water years since treatment began in 1958, largely due to the repeated harvesting. Until the post-2004 period, most of these increases occurred during the dormant season, which is contrary to what would be expected from harvesting-induced effects that are typically expressed during the growing season. Some of these dormant season streamflow changes could have been due to changes in canopy architecture of the re-growing trees compared to the original stand; that is, more snowfall or winter rainfall reached the forest floor and became streamflow because of changes in canopy structure. However, much of the increase reported during the dormant season

may not be related to harvesting at all. Instead the increases may be artifacts of the relatively low flows (and low precipitation) on both the control and watershed 2 during the 6 years of calibration (1952-1957). Nearly all the years with significant flow increases since the calibration period had streamflow discharges on both the control watershed and watershed 2 that were above those observed during calibration (unpublished data). These values lie outside the range in which flow deviations can be predicted accurately. The unreliability of the predictions coupled with the small increases in flows that occurred in any year support that increased streamflow on watershed 2 is not attributable to harvesting or associated activities. Increases in both growing and dormant season streamflow since the 2004 harvesting have been consistent each year. It is likely that some of this increase was due to harvesting since 22 percent of the watershed's basal area was removed.

Additional past harvesting in Camp Hollow subdrainage included single-tree harvesting in watershed 5. The two sub-areas (watersheds 5A and 5B) were harvested every 10 years from 1958 to 1998, and also in 1983 and 2007. Discontinuous streamflow measurements since the first single-tree selection harvests generally indicate that harvesting has not been sufficient to cause an increase in streamflow within watershed 5; however, 78 of the 90 acres in the watershed were harvested in 2007, which resulted in a significant increase in streamflow for about two years, which is a typical duration for harvesting-induced discharge increases in this region.

The proposed harvesting in watersheds 2 and 5 are not expected to result in hydrologic alterations, and residual effects from the past harvesting in any of the watersheds in the subdrainage no longer exist; consequently, no cumulative effects are expected beyond the direct and indirect hydrology effects described previously for this subdrainage.

Overall, skid roads, haul roads, and log decks constitute only 3.25 percent of the Camp Hollow subdrainage area. This figure is well below the 15 percent given for ditched roads (Verry 2000) that can result in hydrologic and channel morphology alterations. FR 712 runs along the entire perennial length of Camp Hollow Run. This road is gated, but still receives regular use by research vehicles. Some sediment from the road and ditch line does reach the channel. There are no undersized culverts on FR 712, so washouts and large sediment inputs into the channel during large flows are uncommon problems.

Approximately 4 percent of the area of watershed 2 is in skid roads. Hillslope and road contributions of sediment to the stream channel from past skid road usage would have been likely since existing skid roads run parallel to and within 100 ft of the channel on both sides of the channel, and in some locations it is much closer than 100 ft. To-stream sediment delivery was observed from the skid road for a short period after the 2003 harvesting before the skid road was water barred. Concentrated flow also has been observed in lower watershed elevations from the water bars to the stream during monitoring visits. These sediment inputs within individual storm events are probably small, but represent long-term chronic problems that are likely to persist because of the proximity of the road to the stream channel. Sediment inputs to Camp Hollow Run also may have occurred due to use of the deck adjacent to the stream during logging in watershed 2. Therefore, past activities in watershed 2 probably changed sediment budgets within the local nonperennial stream.

Sediment contributions to the stream in watershed 5 also may have been significant due to the close proximity of the skid roads to the stream and the number of stream crossings present. The

skid roads in watershed 5 are steep and in close proximity to the stream channel, so chronic sedimentation from them is likely. The valley segment in the lower portion of the watershed is also extremely wet and vulnerable to soil erosion and disturbance. Ruts and log drags along the stream were evident during the 2007 harvest, and erosion from those disturbed areas was observed during a monitoring visit. Several large, dominant trees also were harvested or knocked over in the riparian area near the mouth of the watershed which opened the channel up to solar radiation over an approximate 200-ft length. Therefore, it is likely that stream temperatures increased in this portion of the channel, particularly since summer baseflows in this watershed are very low and slow velocity.

The skid roads in watershed 3 are well healed over and do not appear to provide a significant sediment source to the channel. There was visible evidence of active head cutting in the main stem of watershed 3 about 15 years ago, which had elevated sediment inputs to the stream. This is believed to be a residual effect of the woody debris removal from the stream channel in 1972. Now that larger wood is again being restored to the channel by the naturally thinning and re-growing stand, head cutting appears to have terminated and overall the channel seems to be recovering through sediment aggradation. The channel is noticeably narrower and less U-shaped than it had been more than a decade ago.

Because of the probable increases to in-stream sedimentation that occurred from treatments and road presence in watersheds 2, 3, and 5, these watersheds have contributed to the cumulative sediment effects in Camp Hollow subdrainage.

In addition, the gauged watersheds (watersheds 2, 3, 4, and 5) in Camp Hollow subdrainage also contribute to cumulative sediment effects from the presence of weirs. Watershed 4 is a control watershed that remains unharvested and unroaded. Much of the sediment in these watersheds, whether naturally- or anthropogenically-created, settles out into the weir ponds prior to reaching Camp Hollow Run. However, when the weir ponds are cleaned (approximately annually), most of the deposited soil is placed in the stream immediately below the weir outlet. This technique returns sediment to the downstream reach but it is delivered to Camp Hollow Run in large pulses that do not resemble natural sediment regimes. These sediment pulses may have a larger negative influence on Camp Hollow Run than more natural irregularly-spaced pulses because with readily available sediment sources high inputs can be transported during relatively low flows. Because these inputs are controlled by their source rather than by energy inputs, sediment dynamics of Camp Hollow Run would be expected to be different than if the weir ponds were not in place.

Consequently, while the proposed actions in watersheds 2, 3, and 5 will have limited direct and indirect effects, past treatments and actions, and existing roads and disturbed areas in Camp Hollow subdrainage have resulted in the creation of some chronic hydrologic and sediment conditions that could increase effects associated with the proposed treatments. Consequently, cumulative effects within the Camp Hollow subdrainage exist, but they are primarily attributable to the roads, skid roads, and weirs/weir ponds.

Hickman Slide Subdrainage

Hickman Slide subdrainage includes several areas that are not proposed for treatment in the next 5 years but that have had treatments in the past. Compartments 5 (A, B, and C) and 7 (A, B, and

C) have had 2 percent financial maturity, patch cut, or single-tree selection treatments every 10 or 15 years, depending upon the compartment involved, since 1956. Together the two compartments occupy all of the acreage within Hickman Slide subdrainage. In general, the application of treatments in Hickman Slide subdrainage have removed less than 20 percent of the basal area within the subdrainage at any one time, so hydrologic effects would have been unlikely. Consequently, the proposed harvests would not be expected to contribute to cumulative hydrologic effects.

Within Hickman Slide subdrainage, there are 18.02 acres of roads, skid roads, and decks, which constitutes 6.12 percent of the subdrainage area. This figure includes the portion of FR 701 that lies within the subdrainage. This figure is well below the 15 percent given for ditched roads to avoid changes to channel morphology (Verry 2000). However, FR 704 (Hickman Slide Road) is a chronic source of sediment to Hickman Slide Run. Even with the surfacing and drainage improvements made to the road during the past 10 years, sediment delivery to the stream remains elevated. Sediment from this road results in visible turbidity levels in the stream and contributes to cumulative sediment effects within the subdrainage. These road effects would be expected even without any of the proposed treatments in the subdrainage as there are no plans on closing the road or implementing closure techniques that would substantially decrease sediment inputs.

Bear Run Subdrainage

Compartment 9 (A, B, and C) comprises almost the entire area within Bear Run subdrainage. There has been harvesting in some portion of compartment 9 every 15 years since 1955. The most recent harvests in Bear Run subdrainage were in 2001, 2002 and 2011. The 2001 and 2002 harvests were diameter-limit harvests that were applied to approximately 81 percent of the subdrainage area and removed approximately 32 percent of the basal area in that area. Increases in streamflow probably occurred as a result of those harvests. Since hydrologic effects of clearcutting generally disappear within 5 to 7 years, the effects of these much less intensive harvests would have been of much shorter duration. The harvesting in 2011 removed a much smaller basal area, and an insufficient amount to influence streamflow. Consequently, these past harvests would not contribute to cumulative hydrologic effects in Alternative B.

Residual sedimentation effects from skid road use also would be expected to be negligible as litter has had time to accumulate on those roads. Understory vegetation also would have had some opportunity to become established to help stabilize surface soils. A slip on Bear Run Road fillslope occurred in 2014 and was repaired. However, the repair is showing signs that it may fail soon, so it may become a more chronic problem and potentially a source of sediment. Consequently, there may be some cumulative effects in Bear Run subdrainage if this slip reoccurs or worsens.

Upper Elklick Run Subdrainage

Upper Elklick Run subdrainage includes a large number of compartments that have had treatment during the past, including several that have no proposed treatments in this FEIS.

Compartment 14 (27.02 acres) was commercially clearcut in 1954. Compartment 25 (52.7 ac) was diameter-limit harvested in 1951. Since those initial harvests, neither compartment has had other treatments. The transpirational rates on these compartments would have returned to pre-

harvest conditions in the ~50 years of re-growth, and soil disturbance also would have recovered during that time. Therefore, no residual effects in Upper Elklick Run subdrainage from past activities in compartments 14 or 25 would contribute to cumulative effects.

Compartments 34 and 35 had seed tree harvests in the early 1960s and then were thinned in 1991. These compartments are 8.8 and 11.1 acres, respectively, and all the basal area was removed from each compartment during the second seed tree cut in 1963 and 1964. During the thinning approximately two-thirds of the basal area was removed from the compartments. Since approximately 20 years have passed since the harvest and accompanying ground disturbance, no hydrologic or sediment effects would be expected to contribute to cumulative effects in Upper Elklick Run subdrainage.

Compartment 31 (18.8 acres) received an intensive selection harvest in 1960 and 3 percent financial maturity harvests in 1972, 1982, 1993, 2005 and 2014. In the first harvest, 31 percent of the basal area was removed, and in the subsequent financial maturity harvests no more than 24 percent of the basal area in the compartment was harvested in each year. The most recent harvest in 2014 removed only 8 percent of the basal area. Roads in this compartment are not close to streams, and they were not expected to provide sedimentation problems at the time of previous treatments, including the most recent treatment. Consequently, the combination of the time since harvest and the low percentage of basal area removed in each harvest, and the lack of sediment inputs would not contribute to cumulative effects in Upper Elklick Run subdrainage.

Compartment 16 is divided into 3 sections. Compartment 16A received two harvests more than 35 years ago from which streamflow effects would no longer be present due to the amount of time for re-growth. In 1990, approximately 63 percent of the basal area across 24.1 acres was harvested. Any harvest-related effects would have disappeared during the past 20 years and would not contribute to cumulative sediment or hydrologic effects. Compartments 16B and 16C received single-tree selection harvests in 1951, 1961, 1971, 1982 (16B only), 1991, 2003, and 2011. Harvesting prior to 2011 would not have been sufficient to create streamflow changes at the time of the treatment given the low amount of basal area removed in the compartments. The 2011 harvests removed less than one-third of the basal area from compartments 16B and 16C and the area involved was less than 7 percent of the subdrainage area. Therefore, there should be no residual hydrologic effects from these treatments, even if soil moisture increased locally from the harvesting.

However, sediment accumulations were noted in the stream channels in compartment 16 just before the 2003 harvests, which were attributed to erodible soils, skid road use, and skid road crossings. Use of these skid roads during 2011 also was predicted to increase sediment delivery to the stream channels, especially in compartment 16B (FEF 2010 EIS). Channel widening and incision also were noted in 2009. These past sediment inputs could exacerbate sedimentation problems beyond those predicted as direct and indirect effects in this subdrainage, and stored sediments and lingering sediment sources could contribute to cumulative effects in the Upper Elklick Run subdrainage.

Compartment 27A received diameter-limit harvests in 1951, 1969, 1984, 1999, and 2012, and compartment 27B received single-tree selection harvests in 1951, 1970, 1991, 2003/2004, and 2013. The areas, respectively, comprise approximately 4.7 and 3.4 percent of Upper Elklick Run subdrainage. The basal area removed from the compartments was not sufficient to increase

streamflow, so no residual cumulative effects to hydrology would be expected in Upper Elklick Run subdrainage.

No sediment effects would be expected from compartment 27B because of the distance between roads in the compartment and streams. However, some of the skid roads in compartment 27A are close to streams, and sedimentation effects from past skid road use in compartment 27 were predicted in the FEF 2010 EIS. Assuming stream sedimentation did occur, the associated effects could continue to be expressed in the stream channels for years or decades. Consequently, compartment 27B could contribute to cumulative sediment effects in Upper Elklick Run subdrainage.

Compartment 30 has been treated with 0.4-acre patch cuts approximately every 10 years since 1964. In each treatment year, 13 to 20 percent of the compartment's basal area has been harvested. None of these harvests removed enough trees over a large enough area to increase soil moisture or streamflow locally or on a subdrainage basis. Therefore, past activities in compartment 30 would not contribute to cumulative hydrologic effects in the Upper Elklick Run subdrainage. By contrast, there is an 800-ft length of skid road that is relatively close to a stream channel in this compartment, and it was predicted to be a potential, short-term source of sediment in the FEF 2010 EIS. It is possible that some sediment did reach the stream during the 2014 treatment and remains stored in the channel, so that it could provide a source of elevated sediment during certain storms. Therefore, a small potential for cumulative effects from past skid road use remains in this subdrainage.

Compartment 17A has received small patch cuts (0.4 acre) approximately every 10 years since 1957, and compartment 17B has received the same type of harvest in 1957, 1971, 1987, and 2003. Reductions in transpiration would have been insufficient to increase streamflow, so no residual effects would be expected. Sedimentation effects from past skid road use also are not expected because of the proximity of streams and roads. Consequently, past activities in compartment 17 would not contribute to cumulative effects in the subdrainage.

Compartment 18 has three sections (18A, 18B, and 18C) that each have had patch cuts applied on approximately 10- or 15-year intervals since 1952. The most recent patch cuts were in compartment 18B in 2013. The other compartments had harvests more than 7 years ago. Due to the limited amount of basal area removed, streamflow increases from these harvests would not have occurred in the subdrainage, and therefore, would not be contributing to cumulative effects.

In the FEF 2000 EIS, stream crossing washouts and sedimentation from poor placement of skid roads and undersized culverts were noted in compartment 18. Between 2000 and 2005, these problems were addressed and skid road effects in the compartment are no longer a problem. However, streambed fining and channel morphology changes were observed prior to 2000, and it is likely that sediment previously contributed to the stream and channel morphology changes that occurred prior to 2000 will continue to contribute to cumulative effects in the subdrainage until excess sediment is flushed and the tributaries stabilize. This may require several decades.

Compartment 26 (26A and 26B) had 6 percent financial maturity harvests in 1951, 1971, 1982, 1992, and 2005. Approximately one-third of the basal area in the compartment was removed in each of these harvests. Since the compartment comprises only about 6 percent of Upper Elklick Run subdrainage and the most recent harvest was about 10 years ago, no cumulative hydrologic

effects in Upper Elklick Run subdrainage from this compartment would be expected.

Compartment 26A may have elevated sediment delivery in the watershed from stream crossings and the relatively close proximity of skid roads running parallel to much of the stream channel length in the compartment. Increased sedimentation and channel morphological changes, especially near the stream crossings are possible residual effects from the long-term presence of these skid roads, so additional cumulative effects to Upper Elklick Run subdrainage stemming from in-channel stored sediments, chronic delivery, and channel instability are expected from this compartment.

Compartment 19 is divided into two sections (19A and 19B) that have received different harvesting treatments on different cycles. Compartment 19A received a selection harvest in 1958 and has received patch cuts every 10 years since then. Compartment 19B has received single tree selection harvests in 1957/1958, 1967, 1982, 1997, and 2011. Streamflow effects from past harvesting in either compartment would not measurably affect streamflow in this subdrainage due to the small amount of basal area removed. There was a slight potential noted in the FEF 2005 EIS for sediment delivery increases from skid road use during the 2008 harvest in compartment 19A, and similarly from skid road use in 2011 in compartment 19B. But these were predicted to be minor and short-term so the influence on cumulative effects for Upper Elklick Run subdrainage are probably not much greater than the direct and indirect effects described for compartment 19A.

Compartments 13 and 21 had repeated small farm woodlot harvests since 1950. The last harvest in section 13A was in 1999 and in 13B it was in 2003. In 21A, the last harvest was in 2002 and in 21B it was in 1998. All of these harvests were small and involved only a minor amount of disturbance, so the effects were negligible. In 2007, prescribed fires were applied to these compartments in combination with manually applied herbicide treatments (on 9 0.3-acre plots) to kill overstory trees in order to create habitat for endangered bat species. The herbicide treatments were reapplied in 2008 to individual trees that survived the previous year's treatment. There was no skid road re-commissioning for these burns or herbicide treatments. Fire lines were bulldozed around the compartments to mineral soil to contain the burning; however, there was no cut-and-fill type of disturbance associated with fire line construction. Because fire lines were at the level of the adjacent soil, no water control features were needed after burning was completed. Only the leaf litter was combusted, so erosion would not have been elevated following burning. Consequently, there are no cumulative effects to Upper Elklick Run subdrainage from past treatments in compartments 13 or 21.

Compartment 20 includes three sections, 20A, 20B, and 20C. There were single-tree selection harvests in 20A in 1952, 1968, 1973, 1977, 1988, 1998 and 2006. There was a selection harvest in 20B in 1952 and 1968, and then 4 percent financial maturity harvests in 1977, 1987, 1998, and 2006. Four diameter-limit harvests were applied to 20C, in 1952, 1970, 1990, and 2010. There was not enough basal area removed in the harvests during the last 10 to 15 years to have changed streamflow measurably, so cumulative hydrologic effects would not exist. The lack of stream channels and the distance between streams and roads also makes sedimentation and channel morphology changes from these treatments unlikely. Consequently, there would be no additional cumulative sediment effects from these past treatments in Upper Elklick Run subdrainage.

In 2007-2008, a natural gas well was drilled on the FEF in compartment 16A. Approximately

3.5 acres was cleared for the access road, well pad, and reserve pit. A large cut bank was created during well pad construction due to the steepness of the hillside. This cut bank exposed a spring that had a relatively large volume of flow, at least during wet periods. Water from this spring created a number of problems, particularly those involving erosion and sediment transport (Edwards 2008). During the first several days that the spring was emergent, most of the spring water and transported sediment was delivered directly into a sinkhole. It is not known whether this water became part of the groundwater system or soon emerged as streamflow. There was no evidence from monitoring in nearby more-sensitive spring and streamflow locations that the water or sediment reached those points (Edwards 2008). A drainage system eventually was constructed to take the water down slope where infiltration was promoted, and when drainage exceeded infiltration rates, the overflow would be spread over the surface as sheet flow. Visual evidence and observation suggest that the drainage system has worked as designed and overland flow has not entered a roadside ditch or a nearby stream. The emergent spring flow also resulted in increased erosion and sediment transport in one portion of compartment 16A. Silt fences were erected to capture sediment in that area, and approximately 1.5 tons were collected prior to installation of the drainage structure (Edwards 2008). Since then, sediment capture decreased dramatically and essentially stopped once the drainage-control structure was installed.

The emergence of subsurface flows in the drill pad cut slope altered the hydrology of the subdrainage for a few years. However, since the water is now recharged to the soil, the effects have lessened. Past erosion losses delivered to the sink hole are unknown because the delivery point is unknown.

The well pad access road crossed several small streams, and some of these have evidence of erosion above and below the crossings. Head cutting is evident on several of the crossings, probably due to the design used for crossing culvert installation. These changes probably will continue for some time, and will result in elevated sediment routing in those channels. The ditchline along the access road also is connected to the ditchline of FR 701. Sediment deposition in that latter ditch increased during and immediately after construction, but appears to have stabilized because most of the disturbed area has been re-vegetated and the road surface and some of the ditchline has been surfaced with large good-quality gravel. The outlet for the sediment is onto the forest floor on the downhill side of FR 701, so the risk of it reaching a stream channel is not great.

A 1.1-mile-long gas pipeline also was constructed in Upper Elklick Run subdrainage in 2009. It originates at the well pad and continues northwest across the subdrainage, occupying approximately 5 acres. The pipeline depends on water barring for runoff control on steep sections, and crowning and outsloping on flatter sections. It also was seeded soon after construction of water control features with a native seed mix. Erosion from the pipeline was monitored for approximately 2 years, and erosion levels decreased dramatically once vegetation became re-established on it (unpublished data). About 3 growing seasons after the completion of the pipeline, the surface was largely covered by densely-growing *Rubus* spp., which appears to have greatly contributed to soil stabilization. Most of the pipeline is located far from streams, so it is unlikely that it contributed to stream sedimentation, even before full vegetation establishment, anywhere other than where it crosses under Elklick Run.

When the pipeline crossing under Elklick Run was constructed, the stream channel was excavated with heavy equipment. Flow was low and was largely controlled by pumping around

the construction. Straw bales also were installed in the channel to filter out suspended sediment. Turbidity samples collected during the time of construction show relatively small increases 180 ft downstream, so sediment routing during construction was fairly limited (Edgerton 2008). Following construction, the pipeline approaches on the northwest side of the Elklick Run crossing were heavily seeded, and silt fence was erected along the top of the stream bank. Because the approach on the southeastern side of the crossing was adjacent to FR 701 and a tributary intersects Elklick Run near the pipeline crossing, seeding on that side was done only in areas of soil exposure that would not receive additional gravel or riprap. Riprap was placed on the stream banks of both sides of the channel to protect the exposed soil from erosion and undercutting. Native stream substrate was replaced in the stream bed during pipeline backfilling. Currently, erosion from this crossing appears to be very minor. There may be some limited cumulative sediment effects from the construction disturbance, but there is no substantial evidence of channel instability, erosion, or aggradation in this section or immediately upstream or downstream from the crossing.

Overall in Upper Elklick Run subdrainage, there are 38.40 acres of roads, skid roads, and decks, which constitute 5.22 percent of the subdrainage area. This figure includes the portion of FR 701 that lies within the subdrainage and is well below the 15 percent given for ditched roads to avoid changes to channel morphology (Verry 2000). However, the sediment budget in Elklick Run has been and continues to be affected significantly by FR 701, because this road runs along the channel for almost the entire channel length. There are 2.82 miles of FR 701 within Upper Elklick Run subdrainage. This road provides a continuous source of sediment and small mineral materials (e.g., limestone dust and particles) to Elklick Run, both from heavy traffic use and from undersized culverts that were installed in the road during its initial construction in 1936. The road would continue to provide a source of sediment to Elklick Run in the foreseeable future with or without the activities proposed for Upper Elklick Run subdrainage, because it is open to the public year round. There are no plans to close or restrict use on this road because it also provides access to Otter Creek Wilderness.

Combined, the harvesting treatments proposed for the next 5 years in Upper Elklick Run subdrainage involve about 5 percent of the subdrainage area. Therefore, streamflow would not be cumulatively affected by these harvests.

Stonelick Run Subdrainage

There are six research areas in Stonelick Run subdrainage: compartments 39, 48, 49, 61, 90, and the LTSP research area.

Compartment 39 was harvested in 1962, 1965, and 1988. No residual streamflow effects would be expected given the small amount of harvesting involved and the recovery time that has passed since the last treatment. Residual sedimentation effects also are not expected because of the ridge top location of this compartment and general lack of streams in the area.

Compartment 48 was treated with prescribed fire in spring 2001. Compartment 49 was prescribed burned in 2002, 2003, 2005, and 2014. The prescribed fires were relatively light and the humus layer remained mostly intact, protecting mineral soil. The limited length of bulldozed fire lines also would not have increased sedimentation because of their ridge top locations and rapid re-covering by litter. Consequently, the past burning would not contribute to cumulative

effects.

Compartment 61 was harvested using a 3 percent financial maturity harvest in 1974, 1984, 1994, 2006, and 2014. Residual road effects in this compartment still may be resulting in elevated sedimentation in the streams in this compartment due to the road density and proximity to streams. So while basal area removal does not contribute to cumulative effects, sedimentation and residual in-channel sediment storage could contribute to cumulative effects in Stonelick Run subdrainage.

The LTSP research area was previously referred to as compartment 71. It received vertical strip clearcuts in 1977 (4 acres) and 1987 (4 acres). Because of the small acreage and basal area removal and the ridge top location, there would be no cumulative effects from these past activities. The LTSP study was installed in 1995 and 75 percent of a 16-acre area was clearcut in 1-acre blocks in 1996. This harvest also would not add to cumulative effects because of the limited area involved and ridge top location. Also, there have been 15 years of recovery following the harvesting.

A 3-acre group selection cut was applied to compartment 90 in 1991. Insufficient basal area was harvested to have affected streamflow significantly then or to have had a continued effect at the subdrainage level. Also, sedimentation effects would not have occurred because of the ridge top location and lack of streams in the compartment. Consequently, there are no cumulative sedimentation effects in Stonelick Run subdrainage attributable to roads in compartment 90.

A 2-acre site was cleared on the ridge top of Stonelick Run subdrainage in 2005 for use as a gas well pad. However, the site was abandoned and left undisturbed except for the clearing. This area does not contribute to cumulative effects within the subdrainage because of the lack of disturbance and its recovery via re-growth, as well as its small area and ridge top location.

Overall, there are 16.49 acres of roads and decks in Stonelick Run subdrainage. This constitutes 2.67 percent of the subdrainage. This figure is well below the 15 percent given for ditched roads (Verry 2000) that should not be exceeded to avoid streamflow changes that in turn can change channel morphology. Consequently, there would be no cumulative effects due to roads in Stonelick Run subdrainage.

Canoe Run Subdrainage

Canoe Run subdrainage contains compartments 20, 43, 48, and 90 and other non-research areas of the Monongahela National Forest.

One or more portions of compartment 20 received harvests in 1952, 1968, 1970, 1973, 1977, 1987, 1988, 1990, 1997, 1998, 2006, and 2010. Even the most recent harvesting did not remove enough basal area to have affected streamflow. There is no residual sedimentation effect expected because there are no streams in these compartments and the area of highly erodible soils is small. Consequently, no hydrologic or sediment cumulative effects in Canoe Run subdrainage are expected from past treatments in compartment 20.

Compartment 43 had seed tree and thinning treatments in 1960, 1963, and 1980. The treated area was 9.9 acres or 1.4 percent of the subdrainage. It is on the ridge top away from streams so no hydrologic or sediment cumulative effects would be expected from treatments that are more

than 30 years old.

Compartment 48 received a low intensity controlled burned in 2001 that only consumed the litter layer. The limited length of bulldozed fire lines also would not have increased sedimentation because of their ridge top locations and rapid re-covering by litter. Consequently, the past burning would not contribute to cumulative hydrologic or sediment effects.

Compartment 90 had a single 5.5-acre group selection cut in 1991 which removed 34 percent of the compartment's basal area. There are no streams in compartment 90 and it is on a ridge top. No hydrologic or sediment cumulative effects would be expected from this past treatment.

The Monongahela National Forest logged areas near Big Springs Gap, Turkey Run, and Condon Run in 1972. None of these activities removed sufficient basal area in the subdrainage to have affected streamflow significantly then, and since almost 40 years have passed, any potential residual hydrologic effects should not be present. Consequently, there are no cumulative hydrologic or sediment effects related to these harvests in the Canoe Run subdrainage.

There are 9.66 acres of Canoe Run subdrainage in roads and decks. This comprises 1.40 percent of the acreage in Canoe Run subdrainage. This figure is well below the 15 percent given for ditched roads (Verry 2000) that should not be exceeded to avoid streamflow changes that in turn can change channel morphology. Consequently, there would be no cumulative effects due to roads in Canoe Run subdrainage.

Sugarcamp Run Subdrainage

There are three research compartments in Sugarcamp Run subdrainage that have had previous treatments: 48, 49, and 90.

Compartment 48 was treated with low intensity prescribed fire in spring 2001. Compartment 49 was treated with low intensity prescribed fires in 2002, 2003, 2005, and 2014. The humus layer in these compartments remained intact, thereby protecting mineral soil. The bulldozed fire lines would not have increased sedimentation due to rapid re-covering by litter. Burning and fire line construction was excluded from the riparian and near stream areas in compartment 49. Consequently, the past burning in these compartments would not contribute to cumulative hydrologic or sediment effects in Sugarcamp Run subdrainage.

Compartment 90 had a single 5.5-acre group selection cut in 1991 which removed 34 percent of the compartment's basal area. There are no streams in compartment 90 and it is on a ridge top. No cumulative hydrologic or sediment effects in this subdrainage would be expected from this past treatment.

There are 5.78 acres in roads and decks in Sugarcamp Run subdrainage. These comprise 2.61 percent of the acreage in Sugarcamp Run subdrainage. This figure is well below the 15 percent given for ditched roads (Verry 2000) that should not be exceeded to avoid streamflow changes that in turn can change channel morphology. Consequently, there would be no cumulative hydrologic or sediment effects due to roads in Sugarcamp Run subdrainage.

Cumulative Effects on Elklick Run Watershed of Alternative B: Proposed Action

Elklick Run watershed at the confluence with the Black Fork River contains 3,602 acres of the FEF and 111 acres of private land. All of this private land occurs in the northeastern end of Elklick Run watershed. Private land along the top of Fork Mountain is on the ridge top and does not influence stream channels within Elklick Run watershed. Lower hillslope and riparian sections of privately owned land downstream from the entrance to the FEF were roaded and harvested twice during the last 15 years after receiving no harvesting for at least 30 years. Sediment inputs into the Elklick Run watershed from this privately-held forested land may be measurable due to the high erodibility and steepness of the soils in which the skid roads were constructed on the hillside directly above Elklick Run. Because the harvest on the private land was fairly heavy, no additional harvests or skid road use by the land owners is expected in the foreseeable future.

There are additional research compartments and watersheds within the Elklick Run watershed that are not proposed for treatment in this FEIS but have been treated in the past, and therefore, could contribute to cumulative effects in Elklick Run.

Watershed 1 was clearcut intentionally without BMPs in 1958, and increases in streamflow became nonsignificant within 6 years after harvesting. Increases in turbidity/suspended sediment disappeared within only a few years after harvesting (Hornbeck et al. 1993). However, there is evidence of channel instability in watershed 1, probably due to poor skid road location and skidder use within the channel. The weir pond in watershed 1 is also cleaned using the same approach as the other watersheds described earlier.

Channel instability in watershed 1, and more importantly the unnatural pulses of sediment inputs from weir cleaning throughout the FEF might be cumulatively large enough to contribute to measurable effects in different reaches of Elklick Run watershed. The fact that the weirs are spread across the Fernow would help reduce the effects that otherwise might occur if these weir cleaning effects were restricted to a single subdrainage. While sediment inputs from cleaning watersheds 1, 6, and 7, which are all downstream of the reservoir, may help reduce “hungry water” effects (i.e., sediment transport in the water column is less than transport capacity of the water column), the introduction of sediment in pulses that do not necessarily simulate natural processes could contribute to cumulative sediment effects in Elklick Run watershed, particularly in terms of aquatic organism responses. Sediment inputs from cleaning other weir ponds upstream of the dam would primarily contribute to cumulative effects in the upstream reaches of Elklick Run prior to becoming stored behind the dam wall.

Compartment 70 had vertical (perpendicular to the contour) strip clearcuts in 1974, 1984, and 1994, each covering approximately 7 acres. Contour strip clearcuts in approximately 7-acre strips in 1977, 1987, and 1997 were applied to compartment 72, and contour strip clearcuts also were applied in 5.2-acre strips in compartment 73 in 1978, 1988, and 1998. None of these clearcuts removed enough basal area within the 40-60 acre compartments to increase soil moisture or streamflow locally, or within the Elklick Run subdrainage. Stream sedimentation may have been increased for a short time in streams down slope of the vertical clearcuts due to dragging logs up very steep hillsides. These scars have healed and the effects are probably small enough that even if residual in-channel sediment exists, it probably would not contribute measurably to cumulative effects in the Elklick Run watershed.

Compartment 80 (13.1 acres) underwent a deferment harvest in 1981, at which time 81 percent of the compartment's basal area was harvested. There was little skid road disturbance from this harvest. Consequently, past activities in compartment 80 would not contribute to cumulative effects in the Elklick Run watershed today.

Compartments 36 and 37 had seed tree harvests in 1962 and 1964 followed later by thinnings in 1987. Streamflow effects would not have been measurable and there are no streams in the compartments, so residual sedimentation effects would not exist. Consequently, the past activities in compartments 36 and 37 would not contribute to cumulative effects in the Elklick Run watershed.

Compartment 60 received 4 percent financial maturity harvests in 1981, 1992, and 2005. None of those harvests removed sufficient amounts of basal area within the watershed to affect streamflow, and soil moisture increases would have been localized and very short-lived. Because of the reasonably long distances between skid roads in the compartment and streams in the subdrainage, sedimentation effects from past treatments in compartment 60 were probably negligible and are unlikely to cumulatively contribute to proposed treatment effects.

Compartment 38 was harvested using a seed tree cut in 1961. The 30 remaining seed trees were harvested in 1964. Approximately 59 percent of the basal area was removed in a thinning of 10.8 acres in 1991. It has received no treatments since that time. Effects from past harvesting would no longer be evident, so these treatments would not contribute to cumulative hydrologic effects in Elklick Run watershed.

Watersheds 6 and 7 are 55 acres and 60 acres, respectively. The lower half of watershed 6 was clearcut in 1964 and the upper half was clearcut in 1968. The upper half of watershed 7 was clearcut in 1963 and the lower half was clearcut in 1967. Immediately after clearcutting each half, herbicides were applied to retain the areas barren of vegetation through 1969. This study was implemented to examine if streamflow could be augmented for a longer duration than harvesting alone by prolonging the return of transpirational demands. After herbiciding was terminated, watershed 7 was allowed to re-grow naturally to hardwoods. Watershed 6 was planted to Norway spruce to examine the effects on species conversion.

Statistically significant streamflow augmentation occurred on watershed 6 until 1986. From 1987-1993, no significant streamflow increases were observed relative to a control watershed. From 1994 to the present, streamflow levels are significantly lower than predicted (compared to a control) because the Norway spruce attained full occupancy and canopy closure. Conifers generally have greater interception losses and evapotranspirational demands than hardwoods because of their greater leaf surface area and needle retention throughout the year. Channel condition changed substantially in watershed 6 as the result of decreased flows. The channel itself is much narrower and less deep due to aggradation and the channel banks becoming dominated by mosses (Edwards and Watson 2002); however, in the past 3-4 years, the canopy has opened up (especially in response to superstorm Sandy) and the channel appears to be widening and returning toward (but not yet near) its original pre-stand conversion condition. The watershed soils are well covered with a thick needle layer, which appears to have reduced terrestrial erosion processes and sediment delivery. This treatment probably has resulted in long-term reductions in streamflow to Wilson Hollow Run, a tributary to Elklick Run.

In watershed 7, streamflow augmentation from clearcutting and herbicide treatments occurred until about 1989. About 15-20 years was needed for the watershed to become fully reoccupied by hardwoods due to the herbicide treatments, and to have interception and evaporative losses return to levels that were similar to other hardwood stands that fully occupy their catchments. However, dormant season discharges remain significantly elevated, and were about 1 inch greater than predicted in water year 2010. In water years 2011 and 2012, dormant season streamflow increased even more above predicted values, about 4 and 4.5 inches, respectively, in those years. The reason for the jump in dormant season yields during those two years (2013 and 2014 values are not available) is unknown. Some of the 2012 increase may have been due to tree damage during superstorm Sandy that allowed more snowfall to reach the ground, as broken tops intercepted much less snow than normal. However, some increase also may be due to reduction in interception losses (by different canopy architecture) associated with different species in the re-growing stand compared to the original stand.

Erosion was not measured during past treatments on watershed 7. However, the prolonged lack of vegetation and litter cover during and for several years following herbiciding may have resulted in increased erosion from the watershed. The channel is dominated by very large substrate that appears to be quite different than other watersheds of the same geology in that subdrainage or other drainages in Elklick Run watershed. There are also high percentages of large coarse fragments on the soil surface in the stream side area. These both suggest that there was a substantial amount of erosion and loss of finer particles in the reasonably near past. However, there is no strong evidence of substantial soil erosion on the hillside now. It is possible that there are residual erosion-related effects in the watershed, but if the stream is in a recovery process it probably is moving toward sediment accumulation rather than elevated channel erosion. Consequently, there is a possibility that the treatment in watershed 7 could still be affecting the sediment budget in Wilson Hollow Run, but the effects could be a reduction (i.e., moving toward recovery) rather than an increase in sediment transport.

A more obvious sediment effect from watersheds 6 and 7 is the same effect described for other watersheds that experience weir pond cleaning. The soil removed from these two weir ponds annually is returned to Wilson Hollow Run after cleaning and the large pulses of sediment that are delivered do not mimic natural inputs. The total sediment delivery to Wilson Hollow Run may not be changed, but the timing of delivery is substantial enough to significantly alter the sediment regime of the stream and possibly translate to measurable changes downstream in Elklick Run, particularly if considered cumulatively with other inputs in the watershed.

Within the Elklick Run watershed, there is infrastructure that could influence hydrology and/or sediment. Haul roads, skid roads, and decks comprise 3 percent of the watershed area, and this is well below the 15 percent required to affect runoff. Consequently, increased contributions of discharge attributable only from the density of roads would not be expected to be sufficient to alter channel morphology. However, one of the greatest sources of cumulative effects in Elklick Run watershed is FR 701. As described in the 'Affected Environment' section, FR 701 as well as other system roads provides a chronic source of fine sediment and coarse fragments from road wash to Elklick Run. Many of the cross drain culverts on FSR 701 in upper and middle reaches of Elklick Run are at approximately the same elevation as the stream, and typically they are connected directly to Elklick Run by excavated ditches. In the lower half to one-third of Elklick Run, many of the cross drains are hanging culverts. These deliver concentrated flow to Elklick

Run along with sediment derived from the road and ditch line and soil eroded from fills below the culvert outlets. The road has been a sediment source to Elklick Run for decades and there are no plans to close this road or implement practices that would substantially reduce sediment inputs. Consequently, it contributes to cumulative effects within the Elklick Run watershed, and would continue to do so even if no treatments were applied within the watershed.

The reservoir on Elklick Run that once served as the Parsons water supply is another substantial factor contributing to cumulative sediment effects in Elklick Run watershed. The reservoir alters the sediment regime in Elklick Run by storing coarse fragments and fines behind the dam, which in turn creates "hungry water" (i.e., sediment transport in the water column is less than transport capacity of the water column) capable of accelerated erosion downstream of the dam. This is believed to be the reason that much of the streambed substrate below the dam is bedrock. In some respects, some portion of sediment inputs that occur downstream of the reservoir, whether from roads or treatments may help reduce downstream in-channel erosion by contributing to sediment transport. Elimination of hungry water and return to a more normal sediment routing regime throughout the channel will occur only when the reservoir fills entirely with sediment so sediment inputs and outputs equilibrate, or when the dam fails.

There is a possibility that the dam on the old Parsons city reservoir may be fully or partially removed during the next 5 years to restore hydrologic and sediment routing to a more normal condition and improve aquatic health. If this is done, it is also likely that some types of structures will be installed in Elklick Run to help retain sediment throughout the mainstem channel and create better habitat. In 2012, there was substantial blowdown and broken tops that were deposited in Elklick Run by superstorm Sandy. Many of these originally were lying across the streambank, but through time these are beginning to fall into the bankfull channel and accumulate other woody debris and sediment behind them. If the dam is removed while some of this wood is still in place, these natural "structures" should help to restore sediment throughout the channel; however, the degree to which this wood will provide stability will depend upon its strength and integrity at the time the dam is removed.

Additional gas wells could be drilled in the next 5 years within the FEF; however, the current depressed price of natural gas is expected to limit gas exploration for a number of years, so the potential for gas exploration in the Elklick Run watershed during the next 5 years is low. If drilling does occur, it is likely that no more than a single additional well would be added within the next 5-year cycle given the time required for planning, excavation, and drilling. The effects of future pad construction and drilling depend upon the location of the pad relative to water resources. If they drill near water bodies or within karst topography, there could be cumulative hydrologic and sediment effects. If drilling is contained on or near ridge tops, the potential for additional effects becomes much less.

Pipeline construction would be required for any successful gas well plays within Elklick Run subdrainage. New pipeline segments presumably would connect to the existing pipeline, which would decrease the total length of required soil excavation. If future pipelines can be routed to avoid water bodies, the chance of stream sedimentation decreases. If water bodies cannot be avoided, the potential for stream sedimentation and additional cumulative effects would increase.

Overall, the treatments proposed for Alternative B could result in cumulative effects that would be measurable at some of the subdrainage levels, but not at the scale of the 3,713-acre Elklick

Run watershed. About 750 acres of compartment and watershed area, or 20 percent, of the Elklick Run drainage area would be treated in the proposed activities in Alternative B. Cumulative effects at the Elklick Run watershed level would be primarily from the presence of Forest Service roads, particularly FR 701, and to a lesser extent FR 704, and to the presence of the old Parsons city reservoir.

Climate change provides another, less predictable influence on water resources. While the specific influences of climate change in this region are not currently well understood, there is a general consensus that climate change will result in more frequent weather extremes. Increasing frequency of large or high intensity precipitation events and high streamflow events will likely have a more substantial effect on physical water resources and erosion processes than drought events. The former could result in elevated erosion and sediment transport, both on the hillside and within the channel. With more frequent large streamflow events, changes to channel morphology, such as channel widening and/or deepening could result. Where streambeds are already bedrock, such as much of Elklick Run, and down cutting is not possible, increased widening might result. Increased rainfall intensity could result in increased soil compaction where mineral soil is exposed, such as on skid roads. Compaction could result in short-term (until the litter layer is restored) increases in soil erosion and sediment delivery. Re-vegetation (and further soil stabilization to help reduce erosion) of skid roads might be delayed due to the combination of soil compaction and loss of stable growing media.

Cumulative Effects on Elklick Run Watershed of Alternative C - Modified Proposed Action

The cumulative effects on Elklick Run watershed from Alternative C would be the same as for Alternative B.

Cumulative Effects on Shavers Fork Watershed of Alternative B - Proposed Action

The Shavers Fork watershed drains approximately 119,700 acres at the confluence with Stonelick Run and neighboring Fernow subdrainages. The watershed contains both Forest Service (73 percent) and privately-owned land (27 percent). There is a mix of land uses and management activities within the watershed including roads and road maintenance, agriculture and grazing, forests (with timber harvesting on private lands), minerals extraction, rural residential, and a small percentage of area in municipal developments. Because the proposed treatments in Stonelick Run, Sugarcamp Run, and Canoe Run subdrainage involve a very small amount of land that generally have no or limited direct and indirect effects, they would not contribute to cumulative effects in the Shavers Fork watershed.

The Monongahela National Forest implemented a large-scale watershed restoration project (2,667 acres) in the Lambert Run subdrainage of the Upper Shavers Fork watershed within the past 5 years. The project goals are to restore hydrologic function and native red-spruce-northern hardwood ecosystems. Deep soil ripping was applied to 80 acres of heavily compacted soil on abandoned strip mine lands in summer 2013. The result of this activity has been increased water infiltration and increased soil water holding capacity. It also has allowed newly planted native trees and shrubs to revegetate the landscape thereby ecologically connecting the forest habitats to undisturbed areas surrounding the project area. Roads associated with historic timbering and mining have also been decommissioned and vernal wetlands created. Overall, these soil disturbing activities have acted to improve soil quality and thereby improve watershed health.

Also in the last 5 years a new quarry has been approved in the Shavers Fork watershed approximately 14 miles upriver from the FEF. At full operation the quarry will include 190 acres of surface excavation, additional underground excavation, valley fills, and a containment pond on a tributary of the Shavers Fork.

There is highway construction (Corridor H extension) planned within part of the Shavers Fork watershed, including through National Forest lands. To accommodate that core drilling and monitoring requirements prior to the initiation of construction, new temporary access roads have been developed and more likely will be constructed within the next 5 years. Actual highway right-of-way clearing and construction activities will not begin well into the future (not within the next 5 year period) as the National Forest specialists reports for the NEPA decision for sections within the Shavers Fork watershed have only recently been started.

Climate change provides another, less predictable influence on water resources. While the specific influences of climate change in this region are not currently well understood, there is a general consensus that climate change will result in more frequent weather extremes. Increasing frequency of large or high intensity precipitation events and high streamflow events will likely have a more substantial effect on physical water resources and erosion processes than drought events. The former could result in elevated erosion and sediment transport, both on the hillside and within the channel. With more frequent large streamflow events, bankfull could become associated with higher discharges, which in turn might result in changes to channel morphology, such as channel widening and/or deepening. Where streambeds are already comprised of bedrock, increased widening might result. Increased rainfall intensity could result in increased soil compaction where mineral soil is exposed, such as on skid roads, private lands containing gardens, agricultural fields, and other disturbances. Compaction could result in short-term (until the litter layer is restored) increases in soil erosion and sediment delivery. Revegetation (and further soil stabilization to help reduce erosion) of skid roads might be delayed due to the combination of soil compaction and loss of stable growing media. Climate change effects would be expected to influence all streams and rivers within the watershed, regardless of whether they were in managed or unmanaged subdrainages.

Alternative C – Modified Proposed Action

The cumulative effects for Shavers Fork watershed for Alternative C are the same as those described for Alternative B.

3.2 Air Resources

Affected Environment

The FEF is affected primarily by air masses from the west and southwest, although fronts do occasionally come from the southeast. Most air masses derive from the Ohio River Valley and are transported to central West Virginia. Upon meeting the Allegheny Mountains, the air mass rises, and as it does so, it cools and precipitation falls. Annual rainfall on the FEF is 56 inches per year, and average rainfall pH is 4.2 (Adams et al. 1994). Although the area is generally

characterized by unstable air masses that move quickly, early morning fog is common, particularly during the summer. These inversions are usually short-lived, however.

Local emission sources include a charcoal manufacturing plant, vehicular traffic, residential wood burning, burning of slash and land-clearing on private land, and other relatively small emission sources (Table 3-4). The Clean Air Act requires that an activity not cause or contribute to violations of the National Ambient Air Quality Standards (NAAQS) for six pollutants: particulate matter (PM_{10} and $PM_{2.5}$), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), and lead (Pb). The primary purpose of these standards is to protect human health, with the secondary purpose to protect human welfare and the environment. An area in violation of a NAAQS is called a nonattainment area. Pollution sources contributing to nonattainment areas are subject to tighter restrictions. There are no nonattainment areas in Tucker County or any of the immediately surrounding counties (U.S. EPA Air Quality web page: http://www.epa.gov/air/oaqps/greenbk/). The Clean Air Act also has provisions for the "Prevention of Significant Deterioration" and the prevention of visibility impairment in federally mandated Class I areas. Otter Creek Wilderness (adjacent to the FEF) is a Class I area, as is Dolly Sods Wilderness (located approximately 25 mi east of FEF).

Acidic Deposition

Acidic deposition has been the most intensively studied of the major air pollutants on the FEF. Formed by the burning of fossil fuels – coal, oil and natural gas – sulfur dioxide and nitrogen oxides can transform into strong acids of low ionic strength in the atmosphere and return to earth as acidic deposition in the form of rain, snow, gasses, dry particles, clouds, and fog. There are relatively few industrial sources locally, although emissions from automobiles and trucks can contribute significant amounts of nitrogen. Most of the pollutants that are deposited in Tucker County come from the west, typically from industry along the Ohio River Valley.

The NRS-01 Timber and Watershed Laboratory participates in the National Atmospheric Deposition Program (NADP), a nationwide precipitation chemistry monitoring program. The results of this program demonstrate that although atmospheric deposition has been decreasing, some of the highest levels of nitrogen and sulfur found in the eastern U.S. are deposited on the FEF via wet deposition. Total wet deposition is approximately 8-14 kg nitrate ha^{-1} yr^{-1} and 10-20 kg sulfate ha^{-1} yr^{-1} (NADP 2015; Fig. 3-4). Dry deposition loads are estimated to be approximately the same as wet deposition loads. The greatest deposition occurs during the growing season (Gilliam and Adams 1996).

Stream water pH of most streams draining the FEF range from 6.24 to 8.04, with frequent episodic acidification events where pH ranges from 5.5 to 6.2 (Williard et al. 1999, Wooten et al. 1999, Adams et al. 2007, Casto 2015). Research has documented the symptoms of nitrogen saturation on watershed 4, an untreated control watershed with a mature stand (~100 years old) of mixed hardwoods (Peterjohn et al. 1996, Gilliam et al. 1996). These symptoms include: high relative rates of net nitrification, elevated export of nitrate and of base cations such as calcium (Ca) and magnesium (Mg), little seasonal variability in stream-water nitrate concentrations and low retention of organic nitrogen relative to other forested sites. These conclusions appear to be in contrast to earlier research suggesting productivity of these forests is limited by nitrogen (Auchmoody and Smith 1977). This could imply that nitrate deposition since the 1970s has saturated the watershed or simply that the two studies came to different conclusions. No adverse

effects of nitrogen saturation have been detected in the forest vegetation, however, and fertilization with ammonium sulfate was found to increase diameter growth of a young stand of trees (DeWalle et al. 2006).

Results of a lichen survey in Otter Creek recorded a large number of lichen species in the Otter Creek Wilderness, including many pollution-sensitive species, suggesting that the lichen flora had not been adversely affected by air pollution (Lawrey and Hale 1988). Results of a resurvey done in 1993 found similar species-rich lichen flora communities, again indicating little (if any) adverse effect of pollution at that time. However, comparison of mean sulfur concentrations in *Flavoparmelia caperata* specimens collected in Otter Creek showed a statistically significant increase between 1988 and 1993 (Lawrey 1993).

Recently, deposition has been changing in Tucker County. Sulfate and nitrate deposition at the Nursery Bottom has declined (NADP 2015; Fig. 3-4), and this change is attributed to the 1990 Clean Air Act Amendments. Similar trends in sulfate and nitrate deposition are observed in the bulk deposition data collected at Bearden Knob (Fig. 3-5). Deposition of basic elements (Ca, Mg) has decreased since the late 1970s as fly ash and particulate emissions have decreased (NADP/NTN data; http://nadp.sws.uiuc.edu).

Ozone

Ozone concentrations have been monitored at the Nursery Bottom site (1673 ft elevation; location of the NRS-01 office), and at the nearby high elevation Bearden Knob site (3855 ft elevation). Ozone exposures at the two sites exhibit important differences: concentrations at the Bearden Knob site show relatively little diurnal variation and remain around 0.045 parts per million (ppm) (seasonal hourly average, April to October), while those on the Nursery Bottom show a large variability throughout the day from a low of around 0.02 ppm to a high of around 0.045 ppm (Lefohn et al. 1994). Thus, the peak concentrations of the two sites are the same but the exposure of the vegetation differs, with lower exposures at the lower elevations of the FEF. Ozone levels sufficient to cause foliar injury of sensitive plant species have been recorded (Edwards et al. 1991, Lefohn et al. 1994), and some ozone symptoms have been recorded in Otter Creek (Jackson and Arbucci 1989) but widespread injury has not been observed.

Response of vegetation to ozone in these areas from 1988 through 1999 was determined using the combination of W126 values (sigmoidally weighted exposure index), the number of hours that average concentrations were greater than or equal to 0.10 ppm (N100), and the presence of moderate or more extreme droughts (Edwards et al. 2004b). These values generally suggested minimal ozone effects, or effects to only highly sensitive tree species, with the exception of values in 1988. Values at Parsons in 1988 indicate that moderately sensitive and/or resistant tree species could have experienced growth reductions due to ozone; however, average Palmer index conditions for 1988 indicated severe drought for most of West Virginia. As a result, high stomatal resistance (leaves closed their pores) would have been common, so moderate and severe ozone damage would have been unlikely because the ozone would have been less able to get into the leaves to do damage. Otter Creek and Dolly Sods Wildernesses were evaluated for ozone injury during this drought period and ozone damage symptoms were less than those observed in 1989-1990 under near normal conditions (Edwards et al. 2004a).

The US EPA currently has a proposal to update the 8-hour ozone standard, both primary and secondary values. They are proposing setting the primary 8-hour standard at a level between 0.065 and 0.070 ppm. Garrett County Maryland has ozone levels that meet the current standard (0.075 ppm) but are above 0.070 ppm so they would be in nonattainment under the current proposal. Data through 2014 indicate that the Nursery Bottom site (near the FEF but not on the FEF) would meet the proposed new primary ozone standard; Bearden Knob would meet a primary ozone standard set at 0.070 ppm, but not a standard set at 0.065 ppm (Fig. 3-6). The secondary standard is a measure of ozone exposure to plants during daylight hours of the growing season (summer months) – the W126 mentioned above. Higher ozone levels are weighted more since they have a greater impact on plant health and growth. The US EPA is proposing to set the secondary standard between 13 and 17 ppm-hours. Data through 2014 indicate that both Bearden Knob and Nursery Bottom would meet the proposed new secondary ozone standard based on W126 index calculations (Fig. 3-7). There is no obvious trend in ozone exposure. The US EPA indicates that nearby Garret County Maryland would not meet the secondary ozone standard if it is set at the lower level of 13 ppm hours.

Fine Particulates

Even though particulate matter itself has no serious effects on ecosystems it does affect human health and visibility. Because of its smaller size, $PM_{2.5}$ (particles less than 2.5 microns in diameter) poses greater respiratory system health risks than PM_{10} (particles less than 10 microns in diameter). Approximately seventy percent of the particulates in smoke from prescribed burning are less than 2.5 microns in size.

The US EPA $PM_{2.5}$ primary standard requires concentrations of $PM_{2.5}$ not to exceed a 24-hr average of 35 $\mu g\ m^{-3}$ (micrograms per cubic meter). Average annual $PM_{2.5}$ concentrations are not to exceed 12 $\mu g\ m^{-3}$ for the primary standard (health) and 15 $\mu g\ m^{-3}$ for the secondary standard (welfare). In West Virginia, there are no counties designated as nonattainment for the $PM_{2.5}$ standards (Fig. 3-8).

Visibility

Visibility is strongly affected by light scattering and absorption by fine particulate matter (less than 2.5 microns in diameter). Among the constituents of the fine particulate matter, fine sulfate particles (which result from conversion of gaseous sulfur dioxide emissions) are currently responsible for most of the visibility impairment throughout the eastern U.S. Ammonium sulfate is a key component of light extinction and reduced visibility. Ammonium sulfate concentrations at Bearden Knob were high compared to other sites in the eastern U.S., but sulfate deposition and ammonium sulfate concentrations are decreasing (NAPAP 2011, NADP 2015). The FEF participates in the IMPROVE network (Interagency Monitoring of Protected Visual Environments), designed to monitor visibility using aerosols and particulate concentrations. Trend plots from the IMPROVE monitoring site at Bearden Knob show that light extinction values are decreasing and visibility is improving for the 20 percent worst visibility days, exceeding the uniform rate of progress glide path outlined in the Regional Haze Rule for achieving natural background visibility by 2064 (Fig. 3-9). The 20 percent best visibility days are also showing improvements recently (http://vista.cira.colostate.edu/views/; Fig. 3-9). Median visibility throughout the eastern U.S. from 2009-2013 was estimated to be 52 miles (84 km; http://vista.cira.colostate.edu/views/).

Direct/Indirect Environmental Effects

Alternative A – No Action

Under Alternative A, air resources would likely maintain their current condition. There will be no additional emissions from logging or burning if these activities are not occurring within the project area, and therefore no direct or indirect effects on air quality as a result of this alternative.

Environmental Effects Common to Alternatives B and C

Vehicular and equipment use associated with timber harvest and transporting logs produce some air pollutants, predominantly nitrogen oxides, hydrocarbons, and particulate matter. Particulate matter associated with harvest, also known as fugitive dust (PM_{10}), is produced primarily during periods when unpaved roads are dry; approximately 90 percent of this fugitive dust attenuates within 50 meters of an unpaved road (Davis 2000).

Smoke from prescribed burning has the potential to cause significant effects on air quality within and surrounding the FEF. Prescribed fires can produce enough fine particulate matter to be a public health and/or welfare concern. Fine particulates ($PM_{2.5}$) in smoke can travel downwind and impact air quality in local communities, causing health problems, impairing visibility, and/or being a general nuisance to the public. Prescribed fire also produces potentially significant amounts of carbon monoxide, and may also produce emissions of hydrocarbons, but these pollutants rapidly dilute in the atmosphere and are only a concern to personnel in close proximity to the fire (typically only the firefighters working on the fire).

Alternative B – Proposed Action

Under Alternative B, a total of just over 2.2 million board feet of timber would be removed over a five year period using traditional logging methods. Based on this approximate volume of timber, rough annual emissions estimates of associated logging activities were developed using conservative Environmental Protection Agency Tier 1 emission factors (US EPA 1997, 1999, and 2002) and basic operations assumptions for a "typical" logging operation in mountainous areas. Nitrogen oxides (NOx), hydrocarbons (VOCs), and particulate matter (PM) were determined to be the most harmful emissions emitted from harvesting equipment (including haul trucks, pickup trucks, chainsaws, dozers, skidder/forwarder, and log loaders), and are of the greatest concern in regard to ecosystems and human health. These timber harvest emissions estimates were compared to total regional emissions (in tons per year) of the same pollutants from all source sectors. Regional emissions estimates come from the 2011 National Emissions Inventory (http://www.epa.gov/ttnchie1/net/2011inventory.html), and include total emissions from Tucker County and all adjacent counties. Emissions from timber harvest activities were viewed as a percent of the total regional pollution load on an annual basis (Table 3-5). The results of this analysis show that the effects of felling, skidding, and yarding on air quality would be very small in comparison with total regional emissions, and short term in nature. Proposed mitigations to protect other resources such as soil, hydrology, and fisheries would have minimal effect on air resources.

A total of approximately 398 acres would be treated with prescribed burning over a five year period. With weather and administrative delays there is a possibility that all units could be burned in the same year; this scenario will be used in this analysis to consider a "worst case" for smoke emissions and effects. Although burning could be completed over a period of several days on each of the units, screening was conducted assuming burning would be completed in one day, again as a "worst case" scenario.

During burning it is estimated that a total of 66 tons of particulate matter (PM_{10}), 56 tons of fine particulate matter ($PM_{2.5}$) and 10 tons of nitrogen oxides (NOx) would be released to the atmosphere (Fire Emission Production Simulator model run results, Anderson et al. 2015). The PM and NOx emissions estimates were compared to regional emissions (in tons per year) from all source sectors. Regional emissions estimates come from the 2011 National Emissions Inventory (http://www.epa.gov/ttnchie1/net/2011inventory.html), and include total emissions from Tucker County and all adjacent counties. Total emissions from prescribed fires were viewed as a percent of the annual regional pollution load (Table 3-6). These prescribed fire emissions would represent less than 1.8 percent of the emissions for the region on an annual basis. It is important to note that the prescribed fire emissions presented here represent the total that will be emitted on up to a five-year period. Thus, prescribed fire emissions from the FEF in any given year should be less than what is reported here, and it is expected that these percentages will be much lower. Therefore air quality effects from prescribed fire would be very small in comparison with total regional emissions.

Suitable burning conditions will be determined based on fuel characteristics and local weather conditions, but all units will be burned at a low to moderate intensity. The burn plan will be written, and prescribed fires will be conducted, according to state regulations administered by the West Virginia Division of Forestry, and the most recent basic smoke management practices will be followed (Godwin et al. 2014). Caution will be taken to ensure that emissions from prescribed fires do not significantly contribute to an exceedance of NAAQS or visibility impairment in a Class I wilderness area. Smoke modeling can be performed as a mitigation to estimate the concentration and trajectory of anticipated emissions for planning and decision-making purposes. Without this mitigation smoke could enter a populated community, affecting public health, or a Class I wilderness area, affecting visibility; these impacts would be short term in nature.

Alternative C – Modified Proposed Action

Harvesting and burning treatments in Alternative C are the same as Alternative B, therefore the effects on air resources are the same.

Cumulative Effects

Alternative A – No Action

Without direct or indirect effects, there are no cumulative effects to air resources from the no action alternative. Deposition of sulfate is expected to continue to decrease, and deposition of N is expected to stay level or decrease over the long run with implementation of recent regulations. However, local emissions of nitrogen dioxide may increase in the foreseeable future due to continued construction of an interstate highway

through Tucker County, and the resulting predicted increase in vehicular traffic associated with its completion.

Alternative B – Proposed Action

The FEF is located within an area of the Monongahela National Forest in which no other prescribed burning or timber harvests are planned within the foreseeable future. Local emissions, particularly of nitrogen dioxides, may increase in the foreseeable future due to construction of an interstate highway through Tucker County, and the resulting predicted increase in vehicular traffic associated with its completion. Because of the rapid movement of air masses through the region, and because local emissions are small compared to those of the Ohio River Valley, emissions from the proposed prescribed burns would not contribute significantly to local pollution levels, nor contribute to a NAAQS violation in Tucker County or the surrounding areas. There is currently one natural gas well located on the FEF and several others in the surrounding area. Natural gas wells emit relatively small amounts of fugitive methane, associated with the natural gas itself, and nitrogen oxides, carbon monoxide, volatile organic compounds (VOCs), and some particulate matter from drilling and pumping. These emissions are small on their own but can add up if there is a high concentration of active wells in one area. Regionally, deposition of sulfate is expected to continue to decrease, and deposition of N is expected to stay level in the foreseeable future. Because of the small acreage involved in the harvesting and burning, and the short duration of the prescribed burning, the incremental impact on the air resource would be short term and insignificant.

Alternative C – Modified Proposed Action

Harvesting and burning treatments in Alternative C are the same as Alternative B, therefore the effects on air resources are the same.

3.3 Soil Resources

Affected Environment

Effects to the physical and chemical properties on soils within the FEF from logging, prescribed fire, fertilization, herbicide use, and planting are described below. Specific concerns related to physical properties include: compaction of soil, loss of soil structure, rutting, infiltration capacity, and erosion. Concerns related to chemical properties are changes in organic matter or organic carbon content, changes in nutrient levels which could lead to changes in aboveground vegetative productivity, acidification, and contamination from toxics. Effects on soil biota will not be addressed, due to a paucity of research data which evaluates the effects on soil fauna. In particular, research on soil microbial communities is very new, and there are little data available; also due to the relative recency of advanced techniques for studying and monitoring the effects, monitoring is not yet feasible. Carbon cycling at the ecosystem scale will not be included in this analyses, although where soil organic matter or carbon may be impacted, such possible effects will be noted.

Soils within the FEF belong to the following soil series: Belmont, Calvin, Cateache, Cookport, Dekalb, Ernest, Gilpin, and Meckesville, based on NRCS's web Custom Soil Survey report

(created January 26, 2010; www.websoilsurvey.nrcs.usda.gov/app). The majority of the soils within the Proposed Actions areas are Calvin channery silt loam (61.2 percent of the Proposed Actions area). Slope classes range from 3 to 8 percent slopes to 35 to 70 percent slopes. The Dekalb, Belmont, and Cateache also make up a large portion of the area included in the Proposed Actions. Meckesville silt loam (2.2 percent), Fluvaquents-Uduflents complex (1.0 percent), and Ernest silt loam (0.5 percent) make up the remainder of the soil types within the proposed action area. Brief soil series descriptions follow.

The Calvin series is the most common on the FEF (30.4 percent) and consists of moderately deep, well drained soils formed in material weathered from interbedded shale, siltstone, and sandstone. The depth to bedrock ranges from 20 to 40 inches. The available water capacity is low or moderate. Permeability in the subsoil is moderately rapid, and runoff is very rapid. Natural fertility is low. These soils are very strongly acid or strongly acid. The root zone of some plants is restricted at a depth of 20 to 40 inches.

The Dekalb series (23 percent of the FEF) consists of deep, well drained soils formed in acid material weathered from sandstone, and some interbedded siltstone and shale. They are on uplands and the depth to bedrock ranges from 20 to 40 inches. The available water capacity is very low to moderate. Permeability in the subsoil is rapid, and runoff is very rapid to rapid. Natural fertility is low, and soils are extremely acid through strongly acid. The root zone of some plants is restricted at a depth of 20 to 40 inches.

The Belmont series consists of deep, well drained soils formed in material weathered from limestone with some interbedding of shale, siltstone, and sandstone. These soils, which make up about 5 percent of the soils on the FEF formed on uplands. Depth to bedrock ranges from 40 to 60 inches, and the available water capacity is high. Permeability in the subsoil is moderate, and runoff is very rapid. Natural fertility is moderate to high. The reaction is strongly acid through slightly acid in the surface layer and upper subsoil. It is moderately acid through mildly alkaline in the substratum.

The Cateache series consists of moderately deep, well-drained soils with moderate permeability, and can be found on about 15 percent of the FEF. These soils are formed in residuum weathered mainly from red interbedded siltstone and shale. They are on mountains and ridges. Slopes range from 3 to 80 percent. Soils are well-drained with medium to very rapid runoff.

The Meckesville series (Canoe Run, Upper Elklick Run) consists of deep, well drained soils formed mainly in acid and lime-influenced colluvial material that moved down slope from soils on uplands. These soils are found on foot slopes, benches, along drainages, and in coves. Depth to bedrock is generally greater than 60 inches. The available water capacity is moderate. Permeability is moderate above the brittle part of the subsoil and moderately slow in the part below. Runoff is medium to rapid and natural fertility is moderate to high. This soil series occupies only a small percentage of the FEF.

The Ernest series consists of very deep, moderately well drained soils formed in colluvial materials that moved down slope from soils on uplands. These soils have a water-restricting layer between 27 and 47 inches below the surface, which interferes with the downward movement of water. This slow downward movement of water results in soil wetness. Depth to bedrock is generally greater than 60 inches. The available water capacity is moderate. Runoff is

rapid, and natural fertility is moderate. Ernest soils are strongly acid or very strongly acid throughout. These soils occur in only limited areas on the FEF, in or near riparian areas.

The Fluvaquents-Udifluvents complex is largely made up of recent stream deposits that vary widely in drainage and in texture within short distances. A large part of this land type is gravelly throughout. Small areas are very stony. The areas of gravelly materials are well drained or somewhat excessively drained. The areas of fine-textured material and those in depressions are very poorly drained. Depth to bedrock is variable. These soils are the major component soils of riparian zones.

Direct/Indirect Environmental Effects

Alternative A – No Action

Under the No Action alternative, no acres would be disturbed through logging, road development, herbicide treatment, fertilization, or fire. Therefore, existing processes of soil weathering, erosion, nutrient cycling, etc. would continue, and soil conditions would remain relatively unchanged (see Affected Environment above).

Environmental Effects Common to Alternatives B and C

Potential effects on soils from these research activities and connected actions within the Proposed Actions consist of: 1) disturbance and exposure of soil; 2) soil compaction; 3) increased soil movement; 4) changes in soil moisture; 5) increased soil temperature; 6) altered nutrient cycling, 7) changes in soil fertility, and (8) soil toxicity.

Because both action alternatives include harvesting, prescribed fire, and fertilization, the environmental effects of these activities are common to both, and are described under Alternative B below. Also, maintenance activities are common to both so are included in this description.

Alternative B – Proposed Action

Soil disturbance

Soil disturbance disrupts litter accumulation and decomposition, and makes the soil susceptible to erosion, and to compaction. However, natural disturbances (windthrow and fire) to the forest floor (litter layer) are common in forested areas. Although high infiltration capacities of most undisturbed forest soils prevent overland flow (Hewlett and Hibbert 1967), removal of the litter layer and forest floor can increase the potential for erosion, and affect soil temperature and nutrient cycling. Harvesting activities may temporarily disturb the forest floor by mixing the organic layers with mineral soil. Removal of a portion of the forest stand can result in increased sunlight reaching the forest floor, higher soil temperature and moisture, as well as increased decomposition and mineralization of the organic layers. The forest floor may also be disturbed through burning, with the extent of forest floor disturbed generally proportional to the fire intensity (Groeschl et al. 1990). Generally, prescribed fires remove a small amount of the forest floor (Pritchett and Fisher 1987). A spring prescribed burn conducted on the FEF (Stonelick subdrainage) in spring of 2002 resulted in a decrease in average depth of forest floor from 2.2 to

1 inch, although the pattern of burn was very patchy, and most of what was lost was in the most recently fallen litter (L layer) of the forest floor (Adams 2002).

Kochenderfer et al. (1997) reported that the amount of exposed soil as a result of skid roads decreases rapidly after logging. This is due to reestablishment of grasses and woody vegetation in the disturbed areas. The study measured skid and truck roads in 1987 and again five years later in 1992. In 1992 woody vegetation was dominant on half the original truck road area cleared in 1987, and on skid roads in the more heavily cut portions of the untreated area. Exposed bare soil on both road types had decreased to 23.5 percent by 1992.

Soil disturbance may result from the Proposed Action activities, and erosion can occur as a result of soil disturbance. Approximately half of the area within the proposed actions area is rated as severe erosion hazard when subjected to activities that disturb and expose the soil surface (non-road related). About 30 percent of the Proposed Action area is rated as moderate erosion hazard, and 16 percent as slight. Note, however, that these ratings are based on slope and the soil erosion factor K, and the assumption that soil loss is caused by sheet or rill erosion in off-road or off-trail areas where 50 to 75 percent of the surface has been exposed. In most cases, the proposed actions are not likely to disturb soil very extensively, and much less than 50 percent of the soil would ever be exposed.

Soil disturbance from prescribed, low to moderate-intensity fires is possible, but was found to be proportional to fire temperature in a prescribed burn conducted on private forest land in a similar setting approximately 40 miles from the FEF in 1999 (R. Collins, Univ. Pittsburgh, unpublished data). Controlled low to moderate intensity burns are not expected to result in significant soil disturbance, or large areas of bare soil (Dissmeyer and Stump 1978, Wendel and Smith 1986). Soils within the proposed prescribed fire areas (398 acres) are of the Calvin and DeKalb series, both of which are rated as “Low” for potential for damage from fire by the NRCS. Generally, the forest floor would not be disturbed over much of the area, and leaf fall the following autumn would restore cover to those areas where the forest floor is burned. Therefore, even if the prescribed fires remove 50 percent of the forest floor, with a small and patchy spatial extent, soil disturbance will be limited and probably not detectable.

The majority of the soil disturbance that would occur under the Proposed Action would be associated with the use and reconstruction of skid trails in the treatment areas. Reconstruction of skid roads would expose soil on the cut and fill slopes. Soil disturbance from the proposed activities would be limited to skid trails, logging decks, and fire lines on 31.2 acres, or about 3.2 percent of the treatment area. Effects would be short-term, of a few months at most while logging activities are on-going, or immediately after the burn until leaf fall or leaf-out. Also, the effects would be short-lived because skid trails would be reshaped, and water barred after use is completed.

Direct and indirect effects on soil disturbance should be minimal.

Soil Compaction

Soil compaction is the result of heavy equipment and logs passing over an area. The degree of compaction depends mainly on the moisture content of the soil at the time. Bulk density and amount of pore space did not change significantly after the initial passes of the skidding

equipment (Koger et al. 1985, Shetron et al. 1988). Therefore log landings and primary skid trails are the areas where compaction is most likely to be significant, due to repeated passes of logs and equipment. Compaction makes it difficult for plants to develop deep root systems, which can result in reduced plant growth. Compaction also decreases the ability of the soil to absorb water, reduces soil macro-pore space, and may result in increased runoff and erosion.

Compaction from logging equipment can increase soil bulk density, which results in a decrease in soil pore space, soil air, and water holding capacity and an increase in surface runoff. These effects from compaction can decrease plant growth and increase erosion and off-site soil movement. The degree of compaction depends on the number of passes over the soil and moisture content of the soil at the time of the passes. Reduction in the number of pore spaces does not normally occur on well-drained soils until three or more passes of skidding equipment. Therefore, log decks and primary skid trails are areas of concern for compaction. Reopened bulldozed fire lines are probably less of a concern. Therefore only about 3 percent of the areas to be treated would likely be affected by compaction, or less than 1 percent of the entire FEF.

Skid roads and log decks would be closed after logging is complete. Log decks would be seeded with grasses and legumes and limed and fertilized. Revegetation helps to ameliorate compaction, through the effects of plant roots. Thus, impacts on soil density would be negligible. These roads and decks have been used repeatedly over the last 50 years of research; therefore the Proposed Action is unlikely to result in additional measurable impacts.

There are minimal direct and indirect effects of soil compaction from the proposed actions.

Soil Movement

Increased soil movement, through mass wasting or erosion, can result in nutrient loss from a site, sediment inputs into drainage waters, and decreased productivity. Research on the FEF and elsewhere has demonstrated that roads are the major source of eroded sediment, not removal of timber (Patric 1976, Kochenderfer et al. 1987). Proper use of water bars and grass seeding minimizes erosion and compaction effects in the short and long term. Water bars divert water off of skid roads in small amounts before it can develop enough energy to erode away soil. Establishment of grasses reduces soil movement and the amount of exposed soil, and also increases percolation of water into the ground. The net result is decreased overland water flow and reduced risk for soil erosion.

Soil movement could occur on long unimpeded slopes with moderate to steep grades where mineral soil is exposed to rain drop impact. Soils of the Calvin series, which have moderate erodibility, make up the majority of the Proposed Actions area, and Dekalb soils, the second most common soil series, are characterized by low erodibility. Soils in the Belmont, Cateache, Ernest, and Meckesville series have high erodibility, but occupy less than 20 percent of the Proposed Actions area. Thus, the majority of the soils represent low to moderate erosion hazard. Most of the Proposed Action area would experience minimal disturbance (see above), so movement of soil is expected to be minimal. Soil movement is most likely to occur on skid trails and log decks. A small portion of the Proposed Action will be in skid roads and decks (around 3 percent). Because skid roads and decks are closed and rehabilitated after use, and BMPs followed during logging, erosion would be minimized.

Approximately 398 acres would be burned during the period covered in this analysis, using low to moderate intensity prescribed ground fires. Significant erosion from such fires has seldom been reported (Pritchett and Fisher 1987, Swift et al. 1993). Soil erosion from prescribed burning varies with fire severity, and the percent of the area where the forest floor is burned and mineral soil is exposed. As described above, soil disturbance from loss of the forest floor is predicted to be minor and patchily distributed. Following prescribed burns in Stonelick subdrainage of the FEF in 2000, there were no areas of bare soil reported (M.B. Adams, unpublished data). Controlled burns may increase hydrophobic conditions in forest soils but insights from foresters and soil scientists working in burned areas suggest that hydrophobicity probably does not play an important role in post-fire erosion in eastern forests (Callaham et al. 2012).

There is little risk of mass wasting on the FEF because there would be no new construction of roads on particularly sensitive soils (Cateache) with this alternative. Indeed, there would be no new road construction on steep slopes, thus, there would be an insignificant risk of mass wasting.

Standard mitigation measures include use of water bars and reseeding decks and landings after logging is complete. These BMPs would reduce the potential loss of soil from these areas.

Direct and indirect effects on soil resources through soil movement would be negligible.

Soil Moisture

Soil moisture and soil temperature are relatively unaffected by harvesting activities unless the forest canopy is disturbed considerably, as in a clearcut. The remaining tree canopy and forest floor moderate extremes in soil temperature. There is little evidence to suggest changes in soil moisture and temperature in areas of partial removal of the overtsory. Streamflow is not affected by timber harvest until approximately 25 percent of the basal area is removed from a stand (Hornbeck et al. 1993).

Burning may increase soil temperature during the burn with effects on soil biota and nutrient cycling/leaching. Heating can kill soil biota, alter soil structure, consume organic matter and remove site nutrients during the burn. The extent and severity of soil heating is related to the intensity of the fire. Light to moderate intensity fires have no effect on soil structure and little or short-term effects on soil biota (Giai and Boerner 2007). However, severe fires can reduce soil porosity, infiltration and moisture holding capacity and can sterilize the upper layer of soil. Soil temperatures following a burn are influenced by changes in the insulating capacity of the litter layer and changes in heat absorption as a result of the ash deposit, and changes in vegetation structure and cover. The darker soil of a burned surface effectively absorbs solar radiation, therefore the surface layers of soils in burned stands are warmer than in unburned stands, especially prior to the leaf out and canopy development. However, unless the canopy shade is also removed, the effects on soil temperature are likely to be of minor consequence in well-stocked or dense stands (Pritchett and Fisher 1987).

If the majority of the forest floor is removed in burning, water absorption and retention may be reduced, and evaporation increased. Available soil moisture may decrease as a result. However, because the majority of the forest floor remains intact in most prescribed fires, evapotranspiration will decrease, due to removal of competing vegetation, but soil moisture

increases. Sykes (1971) showed that water infiltration increased in burned sites promoting even more rapid growth of grass and shrub soil cover. Swift et al. (1993) found no increase in erosion following a burn, when 70 percent of the humus was charred. Soil moisture was found to increase immediately following a site preparation burn in the southern Appalachians (Swift et al. 1993). Other researchers have also reported increases in soil moisture of 6 to 10 percent following fires (Klock and Helvey 1976).

The available water capacity of the majority of the soils within the project area ranges from very low to high. Increased soil moisture could occur in the patch cuts, due to complete canopy removal and resulting decreases in transpiration. However, these are relatively small areas, about 0.4 acres in size and totaling only 31 acres, or less than 0.1 percent of the total FEF area. Also, in these small openings, the effects are likely to be minimized due to edge effects and rapid revegetation of the harvest patches. Downslope movement of water through uncut areas prior to reaching streams also minimizes changes over large areas. Also, because of rapid revegetation in the growing season, effects are likely to be short-lived. Therefore, harvesting effects on soil moisture would be insignificant.

Repeated burning resulting in the removal of a significant portion of the forest floor could result in changes in soil moisture by increasing evapotranspiration from the forest floor and soil. However, because the majority of the forest floor remains intact in previous prescribed fires on the FEF, evapotranspiration is found to decrease, due to removal of competing vegetation, but soil moisture increases. The NRCS rates soils within the proposed action as being “low” in potential for damage to physical characteristics by fire. Thus, while changes in soil moisture may occur as a result of the prescribed fire treatments, the extent and severity of those effects are likely to be small, and probably undetectable.

Direct and indirect effects of the Proposed Action on soil moisture would be negligible.

Soil Temperature

An increase in surface soil temperature is expected to occur for a period of time following patch cutting. Such increases are expected only in the upper horizons, however. This would continue until revegetation provides sufficient canopy cover. In these same units, surface soil temperatures might be expected to be lower than normal during the winter months, with a slightly greater chance of soil freezing, although snow cover is a more important predictor of soil freezing. This effect is likely to be temporary, until revegetation creates sufficient canopy cover.

Although surface soil temperatures would probably increase during burning, soil temperature changes are not expected to occur below a depth of six inches even in the burn treatment area. Higher surface temperatures would result in increased soil biota activity, increased organic matter decomposition, increased humus production, and an increase in nutrients for plants. Changes in soil temperature are not expected to be large or long lasting due to rapid revegetation by shrubs, herbs and sprouts, and since canopy closure is expected to occur within the first ten years after harvest.

Repeated burning resulting in the removal of a significant portion of the forest floor could result in changes in soil temperature, by increasing exposure of the soil to solar radiation. Unless the canopy is significantly altered, however, the effects will only be observable during the dormant

season. Although we may predict small changes in surface soil temperature as a result of prescribed fires, the extent of those effects are likely limited to a few centimeters depth (Gonçalves et al. 2012). It is difficult to measure such small changes in soil temperature (Certini 2005). Thus, direct and indirect effects on soil temperature are likely to be unmeasurable and negligible.

Thus, direct and indirect effects on soil temperature are likely to be unmeasurable and negligible.

Nutrient Cycling

Changes in nutrient cycling, particularly in leaching of nutrients from a site, may result from forest harvesting, and from other management activities, such as prescribed burning and fertilization. Bormann and Likens (1979), in an experiment at Hubbard Brook, New Hampshire, reported that dissolved nutrient run-off levels in a clearcut watershed were 13 times higher than in an uncut area when regrowth of vegetation was prevented for 3 years by use of herbicides. However, in other research, when clearcut watersheds were allowed to naturally regenerate, the export of nutrients was only slightly increased because of rapid uptake by new vegetation, and effects were temporary (Aubertin and Patric 1972, Kochenderfer and Aubertin 1975, Galone 1989, Kochenderfer and Edwards 1991).

Timber harvesting removes nutrients from a site in the forest product. Numerous studies have evaluated the effects of harvesting on nutrient pools. Generally the amount of nutrient removed is proportional to the biomass removed (Adams 1999). The more intensive a harvest, the more biomass, and therefore nutrients, are removed from the site. A pulpwood harvest, where all stems 4 inches in dbh and greater are removed, removes more biomass than a stem-only harvest, where stems smaller than 8 inches dbh are left on the site. The greatest removals of biomass and nutrients occur with whole-tree harvesting, where all aboveground wood material is removed from the site, including tops and branches. Whole-tree harvesting can remove as much as 180 lbs nitrogen (N) per ac compared to 97 lbs N per ac in a sawtimber harvest (Adams 1999). However, repeated light cuts can remove as much biomass and nutrients over the course of a rotation as one commercial clearcut (Patric and Smith 1975, Adams et al. 2000).

Controlled burning potentially affects nutrient cycling, soil temperature, and changes in soil fertility. Large amounts of N, the nutrient most commonly limiting to forests, may be released via volatilization in fires as well (Vose et al. 1993). Leaching of nutrients from soil after fire is influenced by the increased quantity of ions available, changes in uptake and retention by plants, absorptive properties of the forest floor and soil, and patterns of precipitation and evapotranspiration. Even in the most extreme cases, nutrient losses by leaching are small relative to other loss pathways and total nutrient capital, and soil fertility increases after fire have been widely reported (Fisher and Binkley 2000). Also, fire has been shown to significantly increase mineral soil pH (Groeschl et al. 1990). Soil heating from medium temperature fires was shown by Stark (1977) to have little influence on the leaching of calcium (Ca), magnesium (Mg), and iron (Fe) from soils beneath Douglas-fir forests. Fire has been shown to increase nitrification making N readily available for plant growth (Tiedemann et al. l978). Increased available soil N has been documented as an effect of burning (Groeschl et al. 1990).

Fertilization with ammonium sulfate may affect the nutrient status of the soil on watershed 3, or the long term soil productivity (LTSP) study site. Adding N and sulfur (S) could increase the

amount of each of these nutrients available to plants in the soil, which in turn could result in increased plant nutrient uptake and content. Results from this ongoing study show some changes in soil N and in N cycling in the soil (Gilliam et al. 2001, Adams et al. 2006). Unlike nitrate, sulfate (SO4) is absorbed reasonably strongly by clay and organic matter within the soil (Edwards et al. 2002a). The fertilizer treatment may also affect base cation nutrient cycling in the soil by increasing the leaching of base cation nutrients, particularly Ca and Mg. Such a treatment effect has been observed in soil solution and stream water chemistry (Edwards et al. 2002a, 2002b), but no significant change in the base cation status of the soils on watershed 3 has been detected by repeated sampling (Adams et al. 2006). Also, the hypothesis of base cation depletion is one of the hypotheses being tested by the proposed research.

Lime additions to one fourth of the plots on the LTSP study could feasibly increase the productivity of the soil, by improving acidity and pH, and increasing soil concentrations of Ca and Mg, although the amounts added are relatively low. No obvious effects on soil chemistry have been detected after 10 years of treatment (M.B. Adams unpublished data).

Use of herbicides may have direct effects on soil processes if applied directly to the soil, as in broadcast spraying. Some herbicides may also create indirect effects on soil processes and properties through effects on vegetation over a sufficiently large area. Relatively little research literature is available on the effects of common pesticides on soil physical and chemical properties, however.

For most macronutrients, the aboveground nutrient content of the forest stand is relatively small compared to the total nutrient pool of the soil (Patric and Smith 1975, Adams 1999). Probable direct and indirect effects of the proposed harvesting activities on nutrient cycling include: increased mineralization of organic material, resulting in increased available nutrients, particularly N; increased nitrification of soil N to nitrate (NO_3), which is a more mobile form; increased leaching of soil nutrients (N, potassium (K), Ca, Mg) as uptake by plants decreases temporarily due to removal of the overstory; and increases in rates of cycling of some nutrients in the upper soil horizons. Increased production of carbon dioxide from the soil may also occur. Increased soil moisture, higher surface soil temperatures, and increased organic matter that have been observed after clear cutting produce ideal conditions for rapid decomposition of surface organic matter. Mineralization of organic compounds and nitrification has been shown to increase after clear cutting. Such effects would be short-lived in the patch cuts because of rapid revegetation of the site by nutrient-demanding young vegetation. However, effects on nutrient cycling in partial harvest areas (diameter-limit and single-tree selection) are not likely to be detectable in the short-run because of the dispersed nature of the removals. Removal of scattered trees is likely to have relatively little, if any, detectable effect on microclimate at the soil level, and similarly on nutrient cycling processes. Also, because the rates of nutrient cycling processes vary considerably spatially within a stand, detecting a significant effect is unlikely. Sprouts from the existing root systems on harvested areas along with new germination would benefit from any increase in available nutrients.

Harvesting can remove significant amounts of nutrients from a stand. However, because of the relatively dispersed nature of the cuts, the nutrient removals are not expected to be significant in the Proposed Action areas, particularly for N (Adams 1999). Whole-tree harvesting could result in a decrease of 30 to 50 percent of the total Ca pool, assuming no weathering inputs (Adams et al. 2004). There is no whole-tree harvesting proposed on the FEF, and only a few small harvests

in any given year, so the effects of the proposed research harvest removals on nutrient cycling should be minimal.

The proposed burning treatment may temporarily increase available soil nutrients, particularly N, phosphorus (P), K, Ca, and Mg, while causing a short-term increase in volatile losses of N. Other processes potentially affected include leaching of nutrients, and mineralization and nitrification. However, only about 398 acres would be burned during the five-year period of the analyses (about 8 percent of the FEF), so changes are not likely to be detectable. Rapid revegetation after a spring burn would take advantage of increases in available nutrients, so that leaching would be minimized.

Two studies ("The Effect of artificial acidification on vegetative growth and nutrient status" and the LTSP study) were designed to evaluate the effects of nutrient amendments on soil and vegetation processes, including nutrient cycling. Since January 1989, ammonium sulfate fertilizer has been applied three times per year to watershed 3, for an annual rate of 32 lbs N ac^{-1} and 40 lbs S ac^{-1}. Numerous papers have been published by FEF scientists and show that nutrient cycling on watershed 3 has been affected by the fertilization treatment (Adams et al. 1993, Adams et al. 1995, Edwards et al. 2002a, Edwards et al. 2002b, Adams et al. 2006). Specifically stream water concentrations of NO_3, SO_4, Ca and Mg have increased over time, foliar nutrient concentrations have increased in some tree species, and soil solution concentrations have also been affected. It is hypothesized that Ca and Mg are being removed from exchange sites in soil by the acid anions, predominately NO_3. Repeated sampling of the soil on watershed 3 has not shown a significant decrease in mineral soil exchangeable Ca and Mg (Adams et al. 2006). After 10 years of ammonium sulfate fertilization (at the same levels as watershed 3) and dolomitic lime additions to the LTSP study, no changes in bulk soil chemistry were detected (M.B. Adams, unpublished data). Continuing the fertilizer applications may cause continued removal of Ca and Mg from the soil exchange sites, and increased leaching, particularly of NO_3 and SO_4. The experimental design calls for continued monitoring to evaluate the extent of this process, and documentation of other changes in soil chemistry.

With the exception of the 2 studies which involve fertilization, direct and indirect effects of the Proposed Actions on nutrient cycling are likely to be negligible, particularly with respect to nutrient leaching from the soil. These 2 studies are designed specifically to create direct and indirect effects on nutrient cycling, and to study those effects over time.

Soil Fertility

Soil fertility may be expected to increase from pre-harvest levels indirectly from harvesting and controlled burns as increases in soil moisture and soil temperature contribute to an increase in organic matter decomposition. This effect would produce an increase in nutrients available to plants and soil organisms on the sites. This flush in nutrients, along with additions of N from the atmosphere and precipitation, is expected to promote rapid growth on the sites. On log decks, where soils have been disturbed, additions of limestone and fertilizer prior to revegetation would directly contribute to soil fertility. Possible losses of nutrients to groundwater and volatilization are expected to be offset by additions of nutrient rich tops and woody debris left on-site after harvest and in controlled burns. Although frequently hypothesized, nutrient deficiencies as a result of overstory removal have generally not been reported in eastern hardwood forests (Adams 1999). Therefore, no adverse impacts to soil fertility are expected from the proposed harvesting

treatments.

The loss of forest and the potential to grow trees from the creation of bladed roads is considered to be a long-term impact and is considered significant when roads cover 15 percent or more of a watershed (Kochenderfer et a. 1987). Skid roads and decks cover little more than 1 percent of the Proposed Action area. Prior research on the FEF has shown that skid roads do not significantly impact long-term soil fertility, from direct loss of soil itself, if properly managed (Kochenderfer et al. l987).

Two studies, ("The Effect of artificial acidification on vegetative growth and nutrient status" and the LTSP study) were specifically designed to evaluate the effects of nutrient amendments on soil and vegetation processes, and aboveground productivity, which is one measure of soil fertility. Although numerous papers have been published by FEF scientists which show that nutrient cycling has been affected by the fertilization treatment (Adams et al. 1993, Adams et al. 1995, Edwards et al. 2002a, Edwards et al. 2002b, Adams et al. 2006), repeated sampling of the soil on watershed 3 has not documented a significant decrease in mineral soil exchangeable Ca and Mg (Adams et al. 2006). Changes in litter chemistry were documented mid-way through the treatments (Adams et al. 1995, Adams and Angradi 1995), but were not detected in later samplings. After 10 years of ammonium sulfate fertilization (at the same levels as watershed 3) and dolomitic lime additions to the LTSP study, no changes in bulk soil chemistry have been detected (M.B. Adams, unpublished data). Direct effects on the mineral soil are equivocal, partly due to the inherent spatial and temporal variability in soil nutrient content, and the difficulties in sampling to account for this natural variability. Continuing the fertilizer applications may cause continued removal of Ca and Mg from the soil exchange sites, and ultimately changes in the soil base cation status, thus affecting soil fertility. The experimental design calls for continued monitoring to evaluate the extent of this process and documentation of other changes in soil fertility.

With the exception of the two studies mentioned above, direct and indirect effects of the Proposed Action on soil fertility would not be significant. As the objectives of these two studies include evaluating the effects of nutrient amendments on ecosystem processes, the study design will allow us to evaluate the significance of the hypothesized effects.

Alternative C – Modified Proposed Action

Most of the Proposed Actions within Alternative C are those already considered under Alternative B, and the effects are also described under Alternative B. However, Alternative C includes selective use of herbicide to control understory vegetation (tree seedlings and saplings) on 12 acres and underplanting of hardwood seedlings on 6 acres.

Potential direct and indirect effects on soils from these additional activities and connected actions include: 1) disturbance and exposure of soil; 2) changes in soil moisture; 3) increased soil temperature; 4) altered nutrient cycling 4) changes in soil fertility, and 5) soil toxicity.

Use of herbicides generally has little direct effect on soil physical properties, although indirect effects through impacts on soil biota and vegetation are possible. However, relatively little data exist on such effects on, nor is the biotic component of FEF soils sufficiently described to evaluate effects. Because herbicides will be used to treat individual stems (not broadcast

sprayed), these treatments are unlikely to cause soil disturbance, soil compaction, or increased soil erosion.

Mortality of aboveground vegetation from herbicides can indirectly alter soil moisture and temperature regimes and processes of nutrient cycling and soil fertility if enough vegetation is affected. However, the treatments will remove selected individual trees on a single plot of 1 acre (total 12 acres over 5 years), and all of the vegetation to be removed is understory or mid-story vegetation, leaving an intact forest canopy. Therefore changes in soil moisture and temperature are unlikely to occur, or to be detectable should they occur.

Because there are no direct and indirect effects on soil physical properties likely from the herbicide treatments, it is unlikely that altered nutrient cycling or changes in soil fertility will result. Indirect effects on these properties would be mediated by the amount of vegetation killed within an area and the relative abundance of that particular species of vegetation. Because of the high spatial variability in soil chemistry, nutrient cycling, and the distribution of targeted vegetation, it is unlikely that any effects on nutrient cycling or soil fertility would be detectable, should they exist.

Some herbicides can accumulate in the soil, or leach through soil to water, and prove toxic to soil organisms, and other organisms. Glyphosate is labelled to be soil-inactive – that is, the active ingredient binds to soil clay particles and organic matter and is rendered inactive to plants and other organisms. Because the herbicide will be injected into single stems or sprayed directly on foliage and not applied directly to the soil, direct and indirect effects on soil toxicity are considered unlikely.

This alternative also proposes underplanting of 6 acres with hardwood tree seedlings, to study facilitated migration of tree species and genotypes as a tool in mitigating climate change effects on forests. Some minor soil disturbance will be necessary during the planting of the seedlings, but generally would be distributed across 1 acre per year, and should not contribute to changes in any of the soil resources analyzed.

Cumulative Effects

Alternative A– No Action

There were no direct or indirect effects on soil resources under the No Action Alternative, therefore there will be no cumulative effects. Natural processe will continue at current rates.

Alternative B – Proposed Action

Early in the 20th century, much of the area that is currently the FEF was logged and this activity, in all probability, had an effect on the soil resource. The railroad used to log the FEF area was located along Elklick Run, and in the streambed in some cases. Much of the harvesting involved removal of all timber within an area, although there were residual trees along ridge tops that were not cut because they were of little commercial value or were inaccessible. It is believed that erosion was significant from this logging, and there may have been post-logging fires, which also contributed to erosion. With the possible exception of constructing haul roads and skid roads, past research activities have had relatively minor and short-term effects on the soil resource because of the dispersed nature of most of the activities, and the relative lack of soil

disturbance. Additional effects on the soil resources from the proposed alternative are likely to be negligible because of the relatively small amounts of land being disturbed, and because of the mitigation activities.

Past federal activities have consisted mainly of system road construction/reconstruction and timber harvesting. Recent controlled low intensity burns have affected relatively few acres of the FEF and recovery from such burning is generally rapid with little or no long-term adverse environmental effects. Also all of the soil types within the FEF are considered to have low potential for damage by fire (NRCS). The proposed prescribed fire research would affect a very small proportion of the FEF, most of which has been lightly used for research in the past. The cumulative effects of this proposed study on soil resources are believed to be non-detectable. Also, proposed harvesting activities would affect less than 6 percent of the FEF land area with no significant adverse impacts to forest soils.

There should be no cumulative effects of the nutrient amendment treatments outside of watershed 3, except possibly in the stream, nor outside of the LTSP study site. Repeated monitoring has shown no significant effects on stream chemistry approximately 975 feet downstream of the mouth of watershed 3 suggesting that dilution continues to render any effects undetectable. We expect that the volume of water (from experimental watersheds 4, 5, and 2) will continue reasonably unchanged, and so we will be unlikely to detect any cumulative effects from the treatments to watershed 3. It is hypothesized that eventually changes in soil chemistry of watershed 3 and the fertilized LTSP plots will be detected, but we do not know when that might happen. Therefore cumulative effects of continued fertilization on soil resources are predicted, but the timeframe remains uncertain.

In 2008 and 2009, a natural gas well site and accompanying pipeline were developed on the FEF, requiring an area slightly less than 7.5 acres. All vegetation was removed from these areas, and considerable soil disturbance occurred during initial clearing and reshaping of the well pad site. The sites have been reasonably stabilized, and erosion minimized from these sites. The Proposed Actions will not like contribute directly or indirectly, therefore, cumulative effects for soil resources are believed to be minimal within the context of the entire FEF.

At present, reliable well-accepted predictions for climate change in the area of the FEF do not exist. Based on long-term monitoring data from the FEF, mean annual air temperature has increased; trends in precipitation amount and timing are not clear. While such changes in climate could affect soils over the longer term, we cannot predict any cumulative effects to soil resources due to climate change.

Cumulative effects of the proposed action would not be significant for soil resources.

Alternative C – Modified Proposed Action

Cumulative effects of Alternative C would not be significant for soil resources.

3.4 Geology and Minerals

Affected Environment

Seven bedrock geologic formations underlie the FEF. They are the Chemung Formation, Hampshire Formation, Pocono Formation, Greenbrier Group, Mauch Chunk Group, Pottsville Group, and Allegheny Formation (Taylor and Kite 1998). The Chemung and Hampshire formations occur west of Elklick Run and the Hampshire, Pocono, Greenbrier, Mauch Chunk, Pottsville, and Allegheny formations occur east of Elklick Run (Fig. 3-3).

The Chemung is made up of interbedded sandstone and shale of marine origin, and occurs at the ridge of Fork Mountain and within the lower areas of Stonelick Run, Sugarcamp Run, Fire Run, and Canoe Run. The Hampshire is comprised of nonmarine sandstone and shale and overlies the Chemung. The Pocono is described as erosion-resistant marine sandstone that overlies the Hampshire. Bedrock benches east of Elklick Run and several knobs west of Elklick have been identified as the Pocono (Taylor and Kite 1998). The Greenbrier is made up of marine limestones and calcareous shales and overlies the Pocono. Outcrops are visible at mid-elevations along McGowan Mountain. The Mauch Chunk contains nonmarine, red sandstone and shale and overlies the Greenbrier. The Pottsville sandstone also resists erosion and is nonmarine in origin; it overlies the Mauch Chunk. The Allegheny is comprised of interbedded sandstone, shale, and coal and occurs over the Pottsville on the highest knobs of McGowan Mountain (Taylor and Kite 1998).

Within the Monongahela National Forest, karst (landscape formed primarily by the dissolution of limestone, and characterized by sinks, caves, and subsurface drainage) occurs where major limestone rock formations intersect, and thus, are exposed on, the land surface. These areas are where the Greenbrier Group (Mississippian age), Helderberg Group (Devonian Age) and several Silurian and Ordovician age limestone strata make up the surficial bedrock. Big Spring Cave, located within the Greenbrier Group at the head of Big Springs Run, is the only sizeable cave on the FEF, and is within the 102-acre Biological Control Area. The cave is a winter hibernaculum for the federally-endangered Indiana bat and the federally threatened northern long-eared bat. Two small inaccessible caves exist below the Hickman Slide Road: Fish Trough Cave and Hickman Slide Pit Cave. Neither is located in an area proposed for treatment, and entrances to each are approximately mid-slope. Two additional openings into the subsurface limestone have been noted southwest of Big Spring Cave.

Sinkholes and other karst landforms also have been identified within the lower ~66 feet of the Greenbrier Group (Taylor and Kite 1998). Two sinkholes were found within the Biological Control Area. They were described as small, with the largest approximately 18 feet in diameter and 3-7 feet deep (Taylor and Kite 1998). A sinkhole, about 2 -3 feet in diameter, appeared in late 2004 in compartment 17. Several small sinkholes were discovered in compartment 16 during development of a natural gas well site in 2008, with one larger, deep sinkhole located above FR 701 which is about 7-8 feet deep. It is believed to have expanded, particularly in depth, due to road runoff that is directed to it from a cross drain culvert on FR 701.

Precipitation is the main source of groundwater recharge within the FEF. A large percentage of the precipitation that recharges groundwater systems in this region discharges into nearby streams, with very little groundwater moving into deeper aquifers. Groundwater flows in karst

generally occur in enlarged solution fractures and solution conduits. This can make karst aquifers susceptible to contamination from pollutants, including sediment.

The Greenbrier-derived soils along the west-facing slopes of McGowan Mountain support running buffalo clover, another federally endangered species (Section 3.6 and 3.7). Colonies of the southern rock vole, a USDA Forest Service Eastern Region sensitive mammal, have been found on the FEF in rocky areas underlain by the Mauch Chunk and Pottsville Groups along the mid-slopes of McGowan Mountain (See Section 3.6).

The minerals within and underlying the FEF are privately owned. In 1915, when the federal government acquired the land that is now the FEF, the mineral rights were reserved by the seller. The two most important mineral resources that occur in the area are coal and natural gas. Although coal-bearing geologic formations occur at the higher elevations in the eastern portion of the FEF, mineable coal does not appear to be present.

Natural gas resources in the area have been identified, and exploration and development of these resources has occurred. In 2004, an energy company leased the privately owned minerals that underlie the FEF, and in 2008, a natural gas well was drilled and a pipeline and supporting infrastructure constructed. The well was drilled into the Oriskany sandstone and reached a total depth of 7,832 ft. Gas was proved in the Huntersville Chert portion of the Oriskany and associated strata after hydrofracturing. However, the well was problematic and the well bore was refractured to release gas within the Sycamore Grit stratum. This layer proved more profitable, and gas began moving through the pipeline in January 2010 and is still producing gas as of June 2015.

Direct and Indirect Environmental Effects

Alternative A – No Action

There would be no changes in geologic or mineral resources if this alternative were implemented.

Alternative B - Proposed Action and Alternative C – Modified Propose Action

The proposed actions within watersheds 2, 3, and 5A, the LTSP area, and compartments 19, 21, 48, and 45 would not affect caves or cave ecosystems because subsurface hydrologic connections between these project areas and caves and cave ecosystems are virtually impossible. Limestone rock units and karst do not occur within or have subsurface hydrologic connections to these compartments. The surficial bedrock geology within these compartments includes sandstone, siltstone, shale and conglomerate of the lower Mississippian age Pocono Group and the Devonian age Hampshire Formation and Chemung Group. The caves that provide habitat for the endangered Indiana bat and threatened northern long-eared bat are in limestones of the Greenbrier Group and occur within a contiguous exposure of the Greenbrier Group rock unit. The Greenbrier Group is stratigraphically above the units overlain by Pocono, Hampshire and Chemung rock, and has eroded away in this portion of the FEF, making a groundwater connection between them and any Greenbrier Group karst areas virtually impossible.

Fertilizer treatments would not affect caves or cave ecosystems because subsurface hydrologic connections between watershed 3 and the LTSP research site and caves and cave ecosystems are

virtually impossible. Limestone rock units and karst do not occur within nor have subsurface hydrologic connections to the area proposed for fertilizer additions.

The proposed actions within compartments 7, 8, 9, 13, 17, 18, 19, and 20 are not likely to substantially affect caves or cave ecosystems. While these areas are at least partly on or above the karst-forming Greenbrier Group, there are no known caves within these compartments. All compartments have been logged in the past. The Greenbrier Group rock unit, which contains limestone, occurs in the FEF in a narrow outcrop between approximately 2,300 and 2,800 feet in elevation, with the outcrop generally spanning 80 to 120 vertical feet. There are no known caves within these compartments. Proposed activities affecting the land surface on and upslope (and in this case, up-strata) of the Greenbrier Group involve single-tree selection, diameter-limit cuts, patch cuts, and prescribed burning. The proposed activities involve logging utilizing ground-based skidding and existing skid trails and roads with no new road construction in the units underlain by the Greenbrier Group.

Best management practices provide for control of runoff such that water would be dispersed. This dispersal avoids substantial changes to water flow direction, and minimizes water's ability to cause erosion and carry sediment which could eventually reach an unknown entry into the karst groundwater system. Proposed tree removal is limited in extent and dispersed, through partial cuts or small clearcut patches. Prescribed burning would not substantially decrease the soil-holding capacity of the root mat. Therefore, the proposed activities in compartments underlain by or upslope of limestone are not likely to substantially change water yield, nor substantially increase risk over background for soil movement off the planned cutting units (See Sections 3.1 and 3.3).

No harvesting activities are allowed within the Biological Control Area, directly surrounding the Big Spring Cave. The amount of timber proposed for harvesting in other compartments is not sufficient to significantly change the flow of groundwater or to affect streamflow; therefore, activities would have no indirect effects on the geologic resources.

Devonian, Silurian and Ordovician limestones (in which several important caves have formed) occur at depths of thousands of feet beneath the project areas. This is well below depths at which freshwater would be expected to occur.

Changes to groundwater quality in karst systems from herbicide use would be unlikely because herbicides would be used according to published guidelines. Mitigation measures require karst features, such as sinkhole or cave openings, be protected as if they were live streams. This mitigation would further reduce the risk that herbicides would enter the groundwater system.

Because there are no proposed activities that involve extraction of geologic material, there are no other direct effects of the proposed activities on the geologic resources.

There would be no direct, indirect, or cumulative effects of the proposed alternative on mineral resources because the private mineral owner would be able to exercise their rights to the mineral estate regardless of actions within the FEF.

Cumulative Effects

There would be no cumulative effects on the geologic resources from any of the alternatives.

3.5 Fisheries and Aquatic Resources

Affected Environment

The FEF is comprised of two 6th level HUC watersheds: Dry Fork-Black Fork (050200040407) and Haddix Run-Shavers Fork (050200040304), which are part of the Cheat River Watershed. About 79 percent of the FEF is in the Dry Fork-Black Fork Watershed and 21 percent is in the Haddix Run-Shavers Fork Watershed. See section 3.1 – Hydrologic Resources for further details on the subwatersheds of the FEF.

The largest perennial stream on the FEF is Elklick Run in the Dry Fork-Black Fork Watershed. This subwatershed contains numerous smaller perennial and nonperennial streams namely: Slip Hollow, John B. Hollow, Wilson Hollow, Camp Hollow, Big Spring Run, Bear Run, Hickman Slide, and Fishing Trough Hollow. A small reservoir (1.3 acres in size) is located on Elklick Run about two miles upstream from its confluence with the Black Fork River. Elklick Run empties into the Black Fork River about two miles southeast of Parsons, West Virginia. There are 6.09 miles of perennial streams in this subwatershed.

The Haddix Run-Shavers Fork Watershed contains several small perennial and nonperennial streams including: Stonelick Run, Sugarcamp Run, and Canoe Run. These streams empty into the Shavers Fork about five miles south of Parsons. There are 4.43 miles of perennial streams in this subwatershed.

The history of these watersheds parallels that of watersheds across the Monongahela National Forest. Widespread, although variable, timber harvest and associated railroad, timber road, skidding, and stream fluming operations in the early 20th century resulted in substantial impacts to FEF watersheds (Trimble 1977, Schuler and Fajvan, 1999). Additive impacts from chestnut blight and potential post-harvest fire continued watershed impacts (Weitzman 1949). After the establishment of the area as an experimental forest, silviculture and watershed research has continued to affect FEF watersheds. Contemporary activities include: timber harvest (single-tree selection, diameter limit, patch cuts, clearcuts), artificial watershed acidification, prescribed fire, terrestrial lime and fertilizer application, and road construction and maintenance.

Legacy effects from turn of the 20th century logging, fire, road construction, and reservoir construction continue to impact stream habitat and limit the full functionality of aquatic biota on the FEF (Adams et al. 2012). The primary impacts from these activities which affect perennial streams and fish populations are changes to sediment transport, water chemistry and temperature, and in-stream habitat. Particularly downstream of the Elklick Run Reservoir habitat changes include increased scour, bed degradation, and the resultant reduction in slow water habitat, large woody material (LWM), and suitable spawning gravels. Despite these residual impacts, fish populations on the FEF appear to be stable. A long-term brook trout study conducted in cooperation between the Forest Service and West Virginia University (WVU) indicates that per capita population growth rate for brook trout in Elklick Run averaged approximately zero between 2003 and 2011, indicating a stable population (Hartman and Andrew 2013). Residual condition factor, a measure of individual weight relative to expected weight based on length, was slightly below average of the 25 WV streams in the study (= -0.02) for brook trout in Elklick

Run. An additional consideration for existing conditions of stream habitat affecting aquatic biota and stream processes is the increase in LWM from super storm Sandy in 2012. Additions of LWM in Elklick Run exceed 800 pieces per kilometer, representing an almost 300 percent increase in the amount of LWM in this stream compared to pre-Sandy conditions (Hartman and Andrew 2013). Impacts to stream habitat and brook trout populations will continue to be evaluated by the long-term brook trout study.

Documented diversity of fish species on the FEF is relatively low. However, the Forest's only aquatic Management Indicator Species, wild brook trout, occurs on the FEF. Elklick Run is one of 25 sites monitored annually for the long-term brook trout study. Additionally, a more widespread fishery assessment on the FEF was conducted in several streams (Hartman and Cox 2001). These efforts have documented six species of fish on the FEF: brook trout, rainbow trout, brown trout, western blacknose dace, mottled sculpin, and white sucker. At the 6th HUC watershed level, total fish species richness values for the affected watersheds are: Haddix Run-Shavers Fork = 30 and Dry Fork-Black Fork = 21. No Regional Forester Sensitive Species (RFSS) of fish are found in either watershed (Welsh and Cincotta 2007). One aquatic amphibian RFSS, hellbender, occurs in the Cheat River Watershed; however, hellbenders prefer larger, permanent streams and suitable habitat is not likely on the FEF.

Fish are highly sensitive to extremes of pH, as well as rapid fluctuations in pH. Results from several studies over the past two decades have shown stream water pH on FEF streams typically ranges from 6.2 to 8.0; however periodic episodes of increased acidity from approximately 5.5 to 6.2 frequently occur (Williard et al. 1999, Wooten et al. 1999, Adams et al. 2007, Casto 2015). In ephemeral and intermittent stream sections, pH values below 5.0 have been recorded (Edwards and Wood 2011). General remediation of pH to > 6.5 occurs in perennial segments and over the past twenty years pH in Elklick Run has ranged from 6.8 to 7.9 with a mean of 7.3 (Adams et al. 2007, Edwards and Wood 2011). Susceptibility to pH extremes, particularly acidity, is dependent on life stage and age-class with eggs and larvae generally being more sensitive than older age-classes (Wesner et al. 2011). Sublethal effects include decreased egg and larval survival and decreased growth and condition of juveniles and adults. Optimal pH range for brook trout is 6.5-8.0 (Menendez 1976, Raleigh 1982). Stream water pH ranges observed in perennial streams on the FEF are typically within the optimal range and it is expected that effects from acid deposition on the fish community are minimal in the existing environment.

Research and monitoring of other aquatic biota, including macroinvertebrates and stream salamanders, provides added opportunities to evaluate watershed impacts particularly as a result of limited mobility and decreased recolonization ability of these taxa in comparison to fish. Macroinvertebrates are highly sensitive to changes in stream water quality and substrate material, as well as changes in stream flow such as velocity and shear stress (Extence et al. 1999; Kobayashi et al. 2010). Studies on the FEF macroinvertebrate community indicate a response to past land use. Macroinvertebrate studies on the FEF in low-order streams indicate relatively diverse and robust assemblages (Angradi 1997). However, given the bedrock/alluvium nature of Elklick Run and the relatively high percentage of fine sediment, habitat conditions and subsequent assemblages of macroinvertebrates may have a shifted baseline composed of sediment-tolerant and sediment-adapted species (Angradi 1999, Taylor and Kite, 2006). Impacts at this trophic level would likely influence higher-level population dynamics, such as those of

fish and amphibians. In addition to prey base modifications, observed impacts to stream salamanders include sedimentation and the resultant habitat degradation and changes to soil moisture and temperature resulting from long-term timber harvest (Crawford and Semlitsch 2008, Moseley et al. 2008).

Direct/Indirect Environmental Effects

Alternative A – No Action

This alternative represents the existing condition against which all other alternatives are compared. The emphasis of this alternative is to continue existing research studies, however, without experimental manipulations. This alternative does not include manipulation (treatment) of existing research studies or allow the use of herbicides to control invasive exotic plant species. Thus, only data collection and monitoring would continue.

Under Alternative A, existing conditions and effects to aquatic resources from past silvicultural and watershed treatments would continue until natural processes either remediated or exacerbated these conditions.

Under Alternative A, fisheries and aquatic resources would likely maintain their current condition. Implementation of FEF research activities in conjunction with BMPs has resulted in relatively stable dynamics for fisheries and aquatic resources, although historical impacts have shifted many habitat and community baseline characteristics. The cessation of timber harvest, fertilizer application, prescribed fire, and herbicide would likely have minor beneficial effects to aquatic resources. Potential beneficial effects include: decreased sediment supply to streams, increased stream shading and riparian LWM, decreased risk from herbicide toxicity, and decreased risk of riparian soil temperature increases.

Alternative B – Proposed Action and Alternative C – Modified Proposed Action

<u>Timber harvest</u>

Primary effects from timber harvest on aquatic resources are related to ground-disturbing activities which can change sediment movement and erosional rates, percentage of canopy cover, stream and riparian temperature, stream flow regime, and large woody material recruitment. Furthermore, skid trail, landing, and system road construction, reconstruction and maintenance lead to increased risk of sediment transport, increased drainage network size, and hydrologic modification (Grayson et al. 1993, Jones et al. 2000). Areas proposed for timber harvest are generally at a higher relative elevation in the watershed and are typically associated with ephemeral channels; however, sediment delivery from timber activities to intermittent and perennial streams from ephemeral channels can be substantial without proper design features and mitigations (Wipfli et al. 2007). With all design features, BMPs, and mitigations equal, clear cut harvests represent the greatest risk to aquatic resources through adverse effects from sedimentation and changes to hydrology. The patch cuts proposed for implementation in Alternatives B and C are small patch cuts of about 0.4 acre in size and dispersed throughout the study compartments, so adverse effects are likely reduced. However, negative correlations between selection cut effects and brook trout have been observed in headwater streams (Van Dusen and Huckins 2005).

Sediment

The introduction of sediment from ephemeral channels and timber road networks may negatively affect brook trout, as well as other fish species and aquatic biota. Sediment decreases the reproductive success of fish as a result of decreased egg to emergence survival through entombment and asphyxiation (Franssen et al. 2012). Studies specific to Monongahela National Forest streams have demonstrated the negative correlation between brook trout biomass and fine sediment (Hakala 2000, Edwards et al. 2007). Positive correlations between stream substrate embeddedness with the extent of road presence and timber harvest are well documented (Binkley and Brown 1993, Eaglin and Hubert 1993, Sutherland et al. 2002).

The transportation system for the proposed timber harvest consists of existing haul roads, skid trails, and landings. Increases in sediment would primarily result from activities associated with the reuse of these existing features, such as blading road surfaces, and the subsequent exposure of fine sediment. Adherence to Forest Plan Standards, design features, and BMPs, would significantly reduce sediment to streams and it is expected that no substantial adverse effects to fisheries and aquatic resources will result from the action alternatives.

Water temperature

Increased stream temperature from riparian clearcutting is common with increases in daily maximum water temperature greater than 8°C reported (Quinn and Wright-Stow 2008, Studinski 2010). Temperature increases to this extent in the project areas would completely remove the viability of brook trout population, negatively impact the entire fish assemblage, and cause aquatic ecosystem modifications at the primary productivity and macroinvertebrate level. Riparian buffers are extremely effective in reducing negative impacts to stream temperature associated with timber harvest (Wilkerson et al. 2006, Clinton 2011). Adherence to riparian buffer protection, as specified in Table 2-2, would significantly reduce the risk of stream temperature increases and it is expected that no substantial adverse effects to fisheries and aquatic resources will result from the action alternatives.

Hydrology

Timber harvest can affect stream flow regime which may impact aquatic biota through changes in habitat or effects to life cycles through acute stream conditions such as increased flood peak or decreased base flows at critical periods (e.g., reproduction, incubation). Approximately 20-30 percent of the watershed basal area needs to be removed before an increase in flows due to harvesting can be detected (Hornbeck et. al. 1997, Hornbeck and Kochenderfer 2000). Total proposed patch cuts (0.4 acre patch cuts) are less than 1 percent of watershed basal area over the course of the study period. Single-tree selection and diameter-limit harvest methods also fall well below levels indicated to result in detectable changes to stream flow. It is expected that no substantial adverse effects to fisheries and aquatic resources will result from the action alternatives. See section 3.1 Hydrologic Resources for more details.

Stream habitat, large woody material, and channel conditions

In the short-term, channel conditions and large woody material are not likely to be impacted by

the proposed timber harvest as a result of riparian buffers; however, the proposed reduction in crown closure within the buffers represents a risk in the reduction of future large woody material recruitment into the stream and riparian zones. There is a low to moderate risk of adverse effects to stream habitat conditions as a result of sediment inputs which may modify stream habitat conditions by pool filling, substrate embeddedness, and changes to pool/riffle dynamics. If harvest within riparian buffers to conduct aquatic or riparian-related research is necessary, adherence to Forest Plan Standards, design features, and BMPs are paramount to ensure no substantial adverse effects to fisheries and aquatic resources result from the action alternatives.

Prescribed fire treatment

In the next 5 years, prescribed fire may be used on approximately 363 acres in compartments 13, 21, and 45 and on approximately 35 acres of compartment 48. Control lines are in place and include existing roads and short sections of dozer lines that will need to be cleared of debris before a prescribed fire. All areas have burned at least once before; compartments 13 and 21 were burned in 2007 and 2009, compartment 45 in 2007 and 2008, and compartment 48 was burned in 2001.

Effects from prescribed fire to stream habitat and biota are largely the result of impacts to riparian functions including decreased sediment filtration, increased sediment movement, changes in water yield and quality, and reduction in large woody material. These effects are directly related to the size and severity of the fire and the proximity to the stream (Gresswell 1999). Fire control activities may also affect stream and riparian conditions primarily as a result of soil disturbance associated with fire line creation and maintenance.

Sediment

Effects to aquatic resources from sediment associated with fire can be a direct result of ash deposition into the stream or by indirect mechanisms such as increased erosion as a result of exposed soil or mechanical manipulations associated with fire control activities. Prescribed fire on the FEF proposes to make use of existing roads, trails, control lines and geographic features, such as ridgelines and stream corridors, to serve as fire breaks along the perimeter of proposed burn units. Existing control lines would require debris clearing in preparation for use as fire lines.

Fire preparation, control, and suppression tactics have the greatest potential to disturb soil and contribute to increased stream sedimentation. Therefore, potential effects to aquatic resources from sediment produced by fire are the same as those as those described in the “Timber harvest” section (in Fisheries and Aquatic Resources). Literature on low to moderate intensity prescribed burns in the eastern U.S. generally indicate no significant impacts to streams from sediment produced from prescribed fires that burn within prescription (Kolka 2012). However, wildfires and higher intensity prescribed burns with characteristics that mimic wildfires are strongly correlated with significant sediment production and subsequent adverse effects to aquatic biota (Gresswell 1999).

Although higher intensity fires have greater potential for significant effects on aquatic and riparian environments, prescribed fires can be implemented with provisions that reduce the risk of adverse effects. Fire would be permitted to burn into stream channel buffers in accordance

with burn plan specifications which would be developed in coordination with aquatic specialists.

Water yield and quality

Changes to water yield can result from fire as a consequence of increased soil hydrophobicity. The decrease in permeability increases runoff and creates greater extremes in streamflow; however, the magnitude and scale of effects to water yield are directly proportional to the severity of the burn and the area burned (Gresswell 1999). Water quality may also be affected by fire through water chemistry changes such as alterations to levels of nitrogen, phosphorus, cations, sulfates, mercury, and carbon (Kolka 2012). Changes to water yield and quality have the potential to affect aquatic biota through physical changes to habitat, chemical changes to water, and alterations in habitat accessibility especially in low flow conditions.

Prescribed burns that are maintained at low to moderate intensity generally produce little to no increase in streamflow (Kolka 2012). Excluding changes to water chemistry resulting from sediment produced from fire control efforts, studies indicate that low to moderate intensity prescribed burns in the eastern U.S. are not likely to cause significant impacts to streams from water chemistry changes from fires that burn within prescription (Kolka 2012). Additionally, ash deposition increases soil pH thereby reducing and possibly retarding soil acidification which may have beneficial effects to aquatic biota (Boerner et al. 2005). With the adherence of burn plan specifications developed in coordination with aquatic specialists, it is expected that no substantial adverse effects to fisheries and aquatic resources will result from the action alternatives.

Large woody material

The recent influx of down trees and large woody material into FEF streams from super storm Sandy represents a positive trend towards the historic volume of wood in these streams. Large woody material functions as a primary grade control, sediment trap, organic input, cover and refuge for fish and macroinvertebrates, and as a feeding substrate (Wipfli et al. 2007, Studinski 2010). Prescribed fire has the potential to adversely affect LWM in two primary ways: burning of wood typically in fires that burn hotter than the prescription, and direct removal of wood from stream channels and buffer zones used as fire lines. Prescribed fires allowed to burn into riparian areas, particularly in wetter climates, tend to pose a low risk for LWM (Beche et al. 2005, Kolka 2012). However, removal or sectioning of wood in the stream or riparian zone reduces LWM functions and may destabilize stream channels. Large woody material will not be cut within stream channels or buffer zones. Following this BMP, no adverse effects to aquatic resources are expected from the action alternatives.

Fertilization/liming

Ammonium sulfate fertilizer will be applied to watershed 3 (85 acres) and to the long-term soil productivity (LTSP; 4 acres) plots every year. Dolomitic limestone will be applied to 2 acres of the LTSP plots every year. In watershed 3, fertilizer is applied aerially; on the LTSP, fertilizer and lime are applied by hand. Fertilization of watershed 3 began in 1989 and in 1997 on the LTSP plots.

Fertilization may affect nutrient cycling and results from an ongoing study on the FEF indicate changes to nitrogen concentrations, base cation status, and pH have occurred (Adams et al.

2007). The primary concern for aquatic biota is the acidification of watershed 3 as a consequence of fertilizer application. The lowered pH observed in Camp Hollow is remediated shortly after leaving the watershed 3 boundary (Casto 2015). Effects to aquatic biota are not expected to extend downstream beyond the stream section previously impacted by the long-term application of fertilizer.

Lime treatment has the potential to increase concentrations of Ca and Mg as well as soil pH; however, the proposed amount of lime treatment is relatively low and effects to aquatic biota are not likely. Under the action alternatives, continuing impacts to aquatic biota in watershed 3 and Camp Hollow are expected to occur as a result of increased acidity. No adverse effects beyond those identified are anticipated to affect aquatic biota as a result of fertilization and liming.

Maintenance of roads, decks, and other infrastructure

Management activities include: applying gravel to road surfaces as needed, replacing culverts on skid roads as needed, maintaining water bars on skid roads, maintaining ditches and culverts, seeding decks and landings, using herbicides to control the spread of invasive plants, and felling trees to maintain openings around weather stations.

Maintenance activities generally protect the road surface from rutting and reduce the amount of sediment generated from the road (Kennedy 1997). Improving road surfaces and drainage can help reduce sediment inputs into streams (Swift 1984, Trieu 1999). Replacement or maintenance of culverts, ditches, and water bars is expected to reduce sediment delivery to streams. Seeding decks and landings is expected to reduce sediment exposure and potential delivery to streams. Effects from the use of herbicide are more thoroughly covered in the "Herbicide treatment/planting" section under Alternative C. The use of herbicide to control the spread of invasive plants poses a low threat to adversely affect aquatic biota.

Direct and Indirect Environmental Effects of Alternative C – Modified Proposed Action

Herbicide treatment/planting

The effects of herbicides to aquatic resources vary depending on environmental conditions at the time of application as well as post application. Glyphosate is highly soluble, but adsorbs rapidly and has low leaching potential because it binds so tightly to soil (SERA 2011). The recommended formulation for this chemical is sold as Rodeo® because it does not contain surfactants, which have the potential to be mobile and pollute surface or groundwater sources and also kill aquatic organisms such as amphibians. Studies indicate little to no adverse effects to fish, amphibians, and macroinvertebrates from glyphosate over time under various application methods and exposure rates (SERA 2011). The greatest risk to these organisms is accidental spills which may introduce lethal concentrations into localized environments. When used according to label specifications and design features, the risk of adverse effects to aquatic biota is low. No herbicide will be applied in the riparian buffer zones (Table 2-2).

Cumulative Effects

While effects may extend beyond the project boundary to private land, analysis of cumulative effects is largely limited to the FEF since the affected watersheds are almost exclusively within the boundaries of the FEF. It is assumed that activities beyond the FEF would not have a

significant influence on cumulative effects caused by the proposed actions. Primary impacts considered for cumulative effects include past, present, and reasonably foreseeable impacts.

Alternative B – Proposed Action

The level of timber harvest in the action alternatives is not great enough to influence stream flow or water quality on the watershed scale and is not anticipated to add to the cumulative effects from activities off-Forest. The influence of sediment produced from timber activities and associated road use is the primary concern for aquatic resources. Sediment produced in association with timber harvest in addition to potential sediment produced by fire activities has the potential to cumulatively adversely affect aquatic biota through degradation of stream habitat. The proposed actions are continuations of previous research, and as a result, current conditions in the FEF indicate that the continuation of fire and timber harvest do not pose a significant risk for adverse effects from these activities. As a result of small patch sizes, temporal distribution of activities, and no new construction of linear landscape features, it is unlikely that cumulative effects associated with sediment production will be observed. Furthermore, adherence to West Virginia BMPs for road maintenance, fire management and timber harvesting will minimize effects to aquatic resources.

While past timber harvest on the FEF is not likely contributing a significant amount of sediment to project area streams, the impacts of past harvest in riparian areas is likely still impacting stream channel conditions, the ability of these channels to retain woody material, and the aquatic biota dependent on these habitat characteristics. Therefore, any harvest within the riparian buffer zone is likely to continue these adverse effects. Additionally, the presence of the Elklick Reservoir will likely continue to contribute to degraded habitat conditions for brook trout downstream of the reservoir. Discussion of the removal of Elklick Reservoir has been initiated. The process of planning and implementing the dam removal will take several years. While short-term negative effects to aquatic resources (e.g., sediment introduction) may be present during dam removal, the long-term effects of removing the dam are highly likely to benefit aquatic resources in the FEF. Restoration of more natural hydrological processes and sediment transport would improve stream habitat in Elklick Run and highly likely contribute to healthier fish populations.

The continuation of fertilizer application to watershed 3 has likely affected aquatic biota in the upper reaches of Camp Hollow and will likely continue in the foreseeable future as the acidification study continues. Additional effects from fertilizer and liming are not likely to contribute to cumulative effects to aquatic resources due to the limited spatial scale of application. Effects from past road construction and road presence likely have a significant impact on aquatic biota through changes in hydrology, sediment supply, and water quality. Road maintenance should provide some mitigation for these effects, but long-term adverse effects to brook trout are likely to continue.

Climate change is expected to introduce new threats to aquatic biota and exacerbate current threats (Brooks 2009). Changes to stream channels and habitat may be altered by changing hydrology. Increased average stream temperature will increase the risk to cold-water fish communities. Altitudinal and latitudinal shifts in cold- and cool-water fish species ranges are already occurring (Field et al. 2007). The position of cold-water fish communities in the central Appalachians is typically the upper reaches of the watershed, and consequently, fish populations

are more limited in altitudinal adjustment potential in response to increased stream temperature. This scenario is further worsened by barriers to movement such as road and stream intersections. The combination of thermal sensitivity and restricted mobility makes brook trout one of the most susceptible species to climate change (Wenger et al. 2011). Expected brook trout declines are correlated to increased temperature as well as impacts related to fall spawning behavior including lower flow conditions in fall and adverse effects to eggs and fry associated with changes to hydrology (Wenger et al. 2011). The fragmentation and hydrologic influence of the Elklick Reservoir also contributes to the long-term adverse effects to brook trout and other aquatic biota.

Maintaining and protecting flow, riparian health, large woody material, and stream channel conditions are critical to reducing cumulative adverse effects on aquatic biota from project activities and climate change. Effects from past and future projects on the FEF are not expected to produce negative cumulative effects as long as Forest Plan standards, BMPs, and design features are followed, particularly in regard to protecting aquatic resources from sediment impacts and climate change.

Alternative C – Modified Proposed Action

The cumulative effects of Alternative C are identical to Alternative B with the exception of the effects of herbicide use. Cumulative effects from herbicide treatments are not expected under this alternative. Under Alternative C, herbicide applications are proposed on less than 1 percent of the project area and treatments will not occur within the riparian areas. Treatments are expected to result in changes to the future forest composition; however, this is not expected to result in changes to hydrology, sediment transport, large woody material recruitment, or other biophysical dynamics that would affect aquatic biota.

3.6 Wildlife Resources

Affected Environment

The variety in geological formations, soils and climate in combination with historic and current land use practices on the FEF have produced a range of forest types and habitat niches for wildlife species. In general, forest types on the FEF are mixed hardwood (white oak, black oak, red oak, sugar maple and yellow-poplar; see section 3.6 Forest Vegetation for details). Drier conditions are associated where white and black oak forest types dominate. Moister conditions are found in sugar maple and yellow poplar areas. About 1,350 acres of the FEF are under (or have been under) some form of uneven-aged silviculture and even-aged silvicultural practices are used on about 500 acres. About 41 percent of the FEF is unmanaged, no timber harvest or prescribed fire occurs in the areas, and uneven-aged forest structure is developing since the last timber harvests in the early 1900s. To the FEF's southeast lies Otter Creek Wilderness Area, providing over 6,000 acres of forested land. A mosaic of private and Forest Service border the remaining FEF boundary with a mix of forested and open land types.

Big Spring Cave, located at the head of Big Springs Run, is the only sizeable cave on the FEF and is located within a 77-acre Biological Control Area. The cave is a winter hibernaculum for

several bat species including the federally-endangered Indiana bat and northern long-eared bat. Additional sinkhole openings associated with this cave formation have been found within the biological control area. This formation is considered active and new sinkholes may be discovered on the surface or breakdown or other structural changes within Big Springs Cave may occur at any time. Two small inaccessible caves exist below the Hickman Slide Road however no active bat use has been documented.

Wildlife species utilizing the FEF can be broadly defined as generalists or specialists based on habitat preferences and niche function. Species in the generalist category are those that use the widest array of habitat types (forested or non-forested) and communities within those types. Specialists require both general habitat but also are dependent upon physical variables such as karst formations, emergent rock, springs, seeps, standing water, and elevation, as well as biological variables including: deciduous and coniferous vegetation, stand density, cavity trees, standing snags, and downed coarse woody debris; leafy browse, woody undergrowth, and herbaceous cover; and soft and hard mast. Both generalists and specialists species of wildlife occur on the FEF.

Effects to terrestrial wildlife species and their habitats will be based on two major habitat types – forest lands and non-forested lands. The effects the proposed actions may have on Threatened, Endangered or sensitive (TES) wildlife species and their habitats are documented in the Biological Assessment (BA) and summarized in section 3.6a below. Effects to aquatic wildlife species and habitat from the proposed actions and alternatives are addressed in section 3.5 Fisheries and Aquatic Resources.

Forested Lands

The FEF is dominated by closed canopy mixed mesophytic forests (Braun 1950, Schuler and Fajvan 1999). Present forest stands originated in the early 1900s following the railroad logging of the area. In addition to logging, fire, and grazing, natural disturbances such as windthrow have shaped the habitats present today. Chestnut blight in the 1930s removed an important hard mast-producing overstory tree species. Silvicultural research that began in 1949 has continued to the present, providing areas of early successional and mid-successional habitat.

On private lands in north-central West Virginia, past and ongoing timber management has consisted of partial overstory removal that has favored the establishment, maintenance, and growth of shade-tolerant overstory vegetation such as red and sugar maple, at the expense of shade-intolerant, mast producing oaks and black cherry that are highly valuable for regional wildlife species. Research-related harvesting activities on the FEF have consisted mostly of un-even-aged management and some even-aged regeneration cuts.

Some wildlife species occur primarily in large, relatively undisturbed blocks of forest, whereas other species prefer disturbed areas with scattered openings. Harvesting activities on the FEF provide such openings on a temporary basis without fragmenting or converting forest to permanent openings, providing habitat for both suites of species. However, because the time period for establishment and development of undisturbed forest environments can be long term, it is important to assess the impact of proposed silvicultural treatments on wildlife habitat. Large, contiguous blocks of forest need not be wholly comprised of mature trees as many forest wildlife species exhibit a seral stage plasticity allowing use of a wide variety of stand types and

ages throughout their life history. Such species include pileated woodpeckers, southern flying squirrels, and bobcats.

Conversely, the time period when forests are considered in an early successional stage, which is most valuable to early successional species, is short (Atkeson and Johnson 1979). Early successional habitat is important for several wildlife species including many neotropical migrant songbirds, ruffed grouse, turkey, rabbits, and small mammals (Confer and Pascoe 2003, Yahner 2003). Many neotropical migrant songbirds that depend upon early successional forest types have been declining in numbers throughout recent years. Therefore, it is important to understand that forests can be manipulated to meet disturbance-dependent wildlife species needs.

Studies on wildlife response to silvicultural activities have been conducted or are ongoing in the Allegheny Highlands of West Virginia on the FEF, the surrounding Monongahela National Forest, and the nearby MeadWestvaco Ecosystem Research Forest (no longer in operation). Taxa studied include:

- Reptiles and amphibians: Marcum 1994, Pauley 1995a, Pauley 1995b, Pauley and Rodgers 1998, Knapp 1999, Waldron 2000, Johnson 2002, Knapp et al. 2003, Ford et al. 2010a, Mosley et al. 2010, Riedel et al. 2012
- Neotropical migratory songbirds: Miller et al. 1995, Gehring 1997, DeMeo 1999, Duguay et al. 2000, Weakland 2000, Williams and Wood 2000, Weakland et al. 2002, Dellinger et al. 2003
- Ruffed grouse: Michael et al. 1982, Plaugher 1998, Dobony 2000, Whitaker 2003
- Wild turkey: Gehring 1997
- Raptors: Ford et al. 1999b, Smith 2003, Katzner et al. 2012
- Shrews: Ford and Rodrigue 2001, Ford et al. 2002, Ford et al. 2006
- Bats: Stihler 1994, Stihler 1995, Stihler 1996, Owen 2000, Menzel et al. 2002, Owen et al. 2002, Owen et al. 2004b, Ford et al. 2005, Johnson et al. 2009a, Johnson et al. 2010, Ford, et al 2011, Johnson et al 2011, Johnson et al. 2012a, Johnson et al. 2012b, Kime et al. 2012, Karp et al. 2013, Johnson et al. 2013.
- Rodents: Healy and Brooks 1988
- Allegheny woodrats: Castleberry 2000a, Castleberry 2000b, Castleberry et al. 2002
- Squirrels: Gehring 1997
- Northern flying squirrels: Urban 1988, Stihler et al. 1995, Odom et al. 2000, Menzel 2003, Menzel et al. 2004, Ford et al. 2004, Ford et al. 2010b
- Fisher: Gehring 1997
- Raccoons: Ford et al. 1999a, Owen 2003, Owen et al. 2004a
- Black bear: Rieffenberger et al. 2000
- White-tailed deer: Miller et al. 1999, Campbell 2003, Campbell et al. 2004, Laseter et al. 2004

Results of these studies indicate a lack of response or completely beneficial impacts to these species and/or their habitats from forest management practices. One reason for this may be that so much of the surrounding landscape remains in mature forest.

Non-forested Lands

Approximately 91 acres of nonforested openings (about 2 percent of the FEF) exist as logging decks, weir sites, skid roads, parking areas, fields, and a natural gas well site and pipeline. Although none of these areas are substantial in size, some wildlife species prefer these disturbed open or edge areas surrounded by contiguous forest. These species include the indigo bunting, song sparrow, chipping sparrow, and rufous-sided towhee (Buckelew and Hall 1994). Some bat species may also utilize these small gaps as foraging areas (Ford et al. 2005, Yates and Muzika 2006). Game species such as ruffed grouse, wild turkey, and white-tailed deer readily utilize these open and edge areas as well (Wentworth et al. 1990, Wunz and Pack 1992, Plaugher 1998).

Roads fragment habitat at the stand scale and can provide barriers to some small mammal, amphibian and reptile movements (Cromer et al. 2002), although in eastern forested landscapes unimproved roads provide important travel corridors to non-volant small mammals (Ford et al. 1997, Yates et al. 1997, Hadley and Wilson 2004a, 2004b) and bats (Menzel et al. 2005). Roads can increase disturbance to some wildlife species, although roads provide access to hunters that are important in controlling white-tailed deer populations on the FEF.

There are 29.9 miles of graveled haul road on the 4,615 acre FEF. Road densities on the adjacent MNF are 1.3 miles per square mile of land areas. Some roads on the FEF, (FR 701, FR 704, FR 705, and FR 324) are open to year-round public use whereas others (FR 702, FR 703, FR 712) are closed to general public use. Roads are closed for wildlife and habitat protection, to protect research installations, and to reduce maintenance costs.

Direct/Indirect Environmental Effects

Alternative A – No Action

Forested Lands

There would be few direct effects on wildlife from not proceeding with planned research studies or management plans on the FEF. No additional “edge” would be created through management activities. Natural events such as blowdown would still create canopy gaps providing some level of early and mid-successional habitat. However, there would be an overall decline in the amount of early successional habitat which could impact species that prefer these disturbed areas. As existing early and mid-successional stands mature, conditions would favor forest interior species. Maintenance of mast-producing overstory tree species could become problematic as shade intolerant tree species are slowly replaced by shade tolerant overstory species with little mast/wildlife value such as red and sugar maple. In the short-term, some wildlife habitat attributes such as standing dead snags, available cavity trees, and amounts of downed coarse woody debris may increase. Internal forest fragmentation would decline as past harvest areas continue to mature.

Non-forested Lands

There would be no change to the existing conditions from this alternative. No forested land would be converted to non-forest. Maintenance of existing openings and roads would continue.

Alternative B - Proposed Action and Alternative C – Modified Proposed Action

Since the action alternatives, Alternatives B and C differ only in the addition of 12 acres of under-planting and 6 acres of herbicide application to control understory species composition, the effects from the actions of both alternatives are described below.

Forested Lands

Under alternatives B and C, over the next five years, even-aged regeneration harvests (patch cutting) are proposed on 31 acres (~1 percent of the FEF), single-tree selection and diameter-limit harvests are proposed for 273 acres (6 percent of the FEF), and prescribed burning is proposed on 398 acres (9 percent of the FEF). With patch cuts, about 0.4 acre openings are created within the compartments where other patch cuts have occurred leading to a mix of patch ages over time. Within each patch, however, all stems down to 1" dbh are removed. Under single-tree selection and diameter-limit harvesting, individual trees are selected for removal. Large canopy openings are rare in the single-tree selection harvest areas, however under diameter-limit harvesting, where trees are removed strictly based on their diameter, some multi-tree canopy gaps may be created.

It is possible that wildlife species occupying cut trees at the time of harvest could be temporarily impacted. Seasonal harvesting (September 1 to March 31) would eliminate the direct impacts to nesting birds as logging would occur in the months outside of the nesting season. Roosting bats may be temporarily displaced if they are roosting in trees when harvested, however this should be rare as bats should be able to detect and escape. The open understory available immediately after harvesting in the patch cuts and some diameter-limit compartments would provide suitable hunting and feeding areas in the short-term for raptors (Smith 2003). Indirect and direct effects of all harvest types include temporary disruption of winter denning activity for some herpetofaunal and mammalian species, and the potential disorientation and/or death of some individuals displaced from their winter den sites. Skidding felled timber adds additional noise and may disturb nearby wildlife for a short time.

Timber harvesting would result in a minor, short-term reduction in hard mast production for wildlife. However, in several study compartments residual overstory oak and hickory trees would be retained to provide a seed source for regeneration, and these trees will provide a hard mast food source for wildlife; all shagbark hickories are retained for bat habitat. Canopy openings, such as those possible with diameter-limit harvests, have been shown to boost residual oak mast production, particularly in years of poor acorn production (Healy 1997). Minor short-term reductions of hard mast could indirectly impact species such as bears, squirrels, white-tailed deer and Allegheny woodrats (Castleberry 2000b) however, the area affected is small relative to available mast production on the FEF and the reduction would be insignificant on the landscape scale.

Even-aged regeneration harvesting, such as patch cutting, greatly increases the amount of soft mast (blackberry, blueberry, and greenbrier) available to wildlife in the area (Johnson et al.

1995). Soft mast is an important food source for many wildlife species. Increased light to the forest floor following all harvest types would stimulate woody browse production and other forage used by wildlife. Small forest gaps created by patch cutting would provide a habitat mosaic in an otherwise closed canopy forest, and interior forest species, such as the red-shouldered hawk, would not be affected by these forest gaps on the landscape (Henneman and Andersen 2008). Because conditions created from partial harvests is similar to un-harvested areas in terms of successional stage or stand structure, the utility of single-tree selection and diameter-limit harvest to early successional wildlife species would be less than those from even-aged regeneration harvests. However, diameter-limit harvests produce complex multi-layered stand structures thought to benefit many interior and interior-edge songbird species (Weakland 2000). Also, shrews are as abundant or more abundant in stands subjected to diameter-limit harvests than in uncut stands in the Allegheny Highlands of West Virginia (Ford and Rodrigue 2001).

Minor negative impacts to some wildlife species may occur as a result of timber harvesting. Salamander populations tend to decline following regeneration harvests in the Appalachians (Pauley and Rodgers 1998, Knapp 1999, Knapp et al. 2003, Crawford and Semlitsch 2008), although impacts following shelterwood harvests with residual overstory trees that provide site shading may not be distinguishable from uncut stands (Bartman 1998, Crawford and Semlitsch 2008, Semlitsch et al. 2009). Biological viability of salamander species richness or abundance is not threatened on the FEF, local extirpation does not occur (Ford et al. 2000a) and full recovery takes place in a few years depending on elevation and site quality (Ash 1988, Ford et al. 1999a, Harper and Guynn 1999). In some regions of the United States, forest openings created by timber harvesting contribute to cowbird parasitism on other songbird species (Robinson et al. 1995). However, research on the surrounding MNF across a wide variety of landscapes from areas with no fragmentation to fragmented areas with approximately 40 percent core area, and research on the wholly forested but intensively managed MeadWestvaco Ecosystem Research Forest found few cowbirds on the landscape. Cowbird parasitism did not appear to be a biological concern in this heavily forested portion of the central Appalachians (DeMeo 1999, Weakland 2000).

After the first growing season, even-aged regeneration harvest areas would provide important thick ground and shrub cover for rabbits and hares, ruffed grouse, bear, early successional songbird species, such as the golden-winged warbler, and other generalist and specialist wildlife species (Atkeson and Johnson 1979, Kubel and Yahner 2008). Forage and thick woody cover areas are essential in order to maintain viable populations of ruffed grouse (Plaugher 1998) as well as Appalachian cottontails and snowshoe hares in the central Appalachian region. Generally, these brushy areas are used by a variety of small mammals (Healy and Brooks 1988), and Allegheny woodrats utilize these areas for foraging habitat (Castleberry 2000b). The greatest number of bird species in the central Appalachians occurs in regenerating stands (Weakland 2000). The open overstory stimulates vigorous herbaceous and shrub layer development in the first few years following harvests (Della-Bianca and Johnson 1965, Ford et al. 1993). However, only 31 acres of even-aged regeneration harvesting is proposed in Alternatives B and C, therefore the effect will be minimal.

Impacts to wildlife from the 398 acres of prescribed fire proposed in Alternatives B and C likely would be transitory or unnoticeable to most small mammal, salamander, and reptile species

(Ford et al. 1999a, Rowan 2004). Tree-roosting bats and birds most likely will flush from roost trees during a prescribed burn that generates too much heat (Rodrigue et al. 2001, Dickinson et al. 2009, Johnson et al. 2009a). Any overstory mortality as a result of prescribed fire would create standing snags, which would be beneficial to many wildlife species including bats, birds, and squirrels. Additionally, prescribed burning would encourage the regeneration of mast-producing tree species such as oaks and hickories over the long term. Coarse woody debris important to small mammals and salamanders would be reduced (Kirkland et al. 1996); however, most coarse woody debris consumed in prescribed fires falls within the smallest size classes. Salamanders could be negatively impacted if leaf litter combustion is substantial (Ash 1995). Woodland salamanders on the FEF responded to the reduction of leaf litter from two prescribed fires by utilizing artificial cover placed in the areas to sample salamanders; however there was no change in the species composition of salamanders before and after the fires which suggests that woodland salamanders were somewhat tolerant of prescribed fire (Ford et al. 2010a). Rodents benefit from the increase in exposed seeds resulting from light burns (Ahlgren 1966). Exposed insects and insects attracted to charred wood and exposed soil also may benefit small mammals (Sullivan and Boateng 1996, Ford et al. 1999a).

Ammonium sulfate fertilizer would not be applied in high enough load that the concentrations would be toxic to fauna. No change in soil chemical properties, salamander capture rates and body condition, and shrew capture rates were found during monitoring of the fertilizer study (Adams et al. 2007, Moseley 2008). Therefore, there would be no direct or indirect effects to wildlife as a result of ammonium sulfate fertilization treatment.

Herbicide application would target specific plants; however wildlife may be affected by herbicide directly by contact or indirectly by ingestion of treated vegetation or insects on treated vegetation. Most commonly used herbicides degrade quickly once they enter the environment, and therefore, are neither cumulative nor bioaccumulative (Tatum 2003). Degradation of glyphosate is primarily by soil microbes, it has an average half-life in soils of 47 days, and glyphosate has an extremely high ability to bind to soil particles, keeping it from being mobile in the environment (Tu et al. 2001). Additionally, modern herbicides have been designed to target biochemical processes unique to plants, thus, having a low direct toxicity to animals. An analysis of herbicide use on non-native invasive plants on the MNF concluded that for many species of concern, including TES, herbicide application could result in negative impacts to individuals but these impacts would not be likely to cause a trend toward delisting or loss of viability (USDA FS 2010). Since the areas to be treated on the FEF are small is size (12 non-contiguous acres in harvest areas and small patches of invasive species when found), direct and indirect negative effects to wildlife species from herbicide use on the FEF will be minimal.

Non-forested Lands

No additional nonforested land would be created under alternatives B or C; therefore, effects would not be significant.

Roads can represent barriers to dispersal and survival to some wildlife species as well as dispersal corridors, feeding areas, and breeding areas for other species. Woodland salamanders and some small mammals are reluctant to cross some road types (Trombulak and Frissell 2000, Marsh 2007), although narrow, gated roads with little traffic do not seem to pose a barrier to terrestrial salamanders (Marsh 2007). Conversely, many frogs and toads use flooded road ruts as

breeding pools in the Allegheny Highlands of West Virginia (Pauley and Rodgers 1998). Bats in eastern landscapes use roads as foraging areas and travel corridors (Menzel et al. 2005). Daylighted roads with grassy banks serve to connect metapopulations of early successional small mammal species, such as least shrews (Ford et al. 1997) and old-field mice (Yates et al. 1997) in the Southeast. Because no new permanent roads would be constructed for the proposed action, road impacts to wildlife from the proposed action would be insignificant.

Cumulative Effects

All Alternatives

Global climate change could potentially alter wildlife habitat in the Appalachian Mountains, although the extent of habitat alteration remains unknown; see section 3.7 Forested Vegetation for a review of current modeled impacts to forest vegetation. If temperatures warm, many species will thrive and extend their range, while for other species suitable habitat will decline and extirpations (and perhaps extinctions) may occur. Moist, cooler forests such as spruce and cove hardwoods may be replaced by drier, oak-hickory forests. Wildlife species that utilize these cooler forest types, such as northern flying squirrels, Cheat mountain salamanders and northern goshawks, will potentially face population declines. However, forest types in the FEF are not the predominate types required by these species, so the proposed actions will not contribute to the cumulative effects of global climate change on this habitat type.

The spread of drier, oak-hickory forest will benefit species dependent upon hard mast, such as squirrels, Allegheny woodrats, white-tailed deer, black bear and some bird species. Bats will benefit from the abundance of live roost trees, as these provide long-term roost sources. The amphibian guild would become slightly less diverse as the species that currently inhabit the cooler northern hardwood forest would decline in the forest and be replaced by those that prefer warmer, drier climates. Depending upon the scope of global climate change, the change most likely to occur on the FEF would be a gradual change from a predominately northern hardwood forest to a predominately oak-hickory forest. Global climate change is independent of and would occur regardless of any of the proposed actions on the FEF. The scope of the proposed actions is insignificant on the landscape scale and in the timeframe of global climate change; therefore, there would be no additional cumulative effects to global climate change as a result of Alternative B.

Alternative A – No Action

Forested Lands

Timber management on private lands in the surrounding area would remove the most financially valuable trees in the short term, such as the oaks and black cherry, and would tend to favor retention of shade-tolerant species, such as red and sugar maple, and the slow-growing and poor-mast producing American beech. Federal lands, such as the FEF provide significant amounts of hard mast for wildlife on a regional basis. Therefore, in the short term this alternative would not affect disturbance species because of the current relative abundance of mast. Additionally, habitat diversity would decrease as stands become older and no new disturbed, early successional habitat resulting from timber harvest would be produced. Disturbance wildlife species abundance would decline over time. Annual inputs of large coarse woody debris would increase with the no action alternative.

No significant changes are expected on area private lands or the adjacent Otter Creek Wilderness Area on the MNF. Private lands would continue to provide some open and early successional habitat. Similarly, habitat distinctions between the FEF and the Otter Creek Wilderness Area, where no human-caused disturbance occurs, would continue to lessen with the no action alternative.

Non-forested Lands

There would be little change as maintenance of existing openings and roads would continue.

Alternative B – Proposed Action and Alternative C – Modified Proposed Action

Forested Lands

Overall impacts to wildlife from the proposed action would be small. Habitat changes from the proposed action would provide habitat for a wide range of generalist and specialist species. The proposed action should have no negative impact that would threaten the biological viability of any wildlife species that currently occurs on the FEF. Rather, the proposed action would increase overall wildlife biodiversity and species richness as a reflection of the variety of successional stages and forest structure that would be created over the duration of each study.

The FEF is located within a 26,506 acre area of the MNF where no prescribed fire or timber harvest is planned the foreseeable future. No significant changes are expected on area private lands or the adjacent Otter Creek Wilderness Area on the MNF. Private lands would continue to provide some open and early successional habitat. Similarly, habitat distinctions between the FEF and the Otter Creek Wilderness Area would remain essentially unchanged.

Because the area to be treated in the proposed action is small relative to the entire FEF and miniscule in the context of a landscape surrounding the FEF, there would be no or insignificant cumulative effects on wildlife populations as a result of Alternative B.

Non-forested Lands

There would be little change as maintenance of existing openings and roads would continue and no new non-forested areas are to be created.

3.6a Threatened, Endangered, and Sensitive Wildlife

Affected Environment

The affected environment for TES wildlife species on the FEF is the same for general wildlife species and is given in section 3.6 Wildlife Resources above.

The BA and the Likelihood of Occurrence Table for this project are the basis for the analysis of effects to TES species on the FEF. The Likelihood of Occurrence Table lists the habitat and current status of all threatened, endangered and sensitive species currently on the Eastern Region

Sensitive Species list that may be found on the FEF. This table was developed to compare required habitats for the TES species with available habitat on the FEF. Federally listed wildlife species that occur or could potentially occur on the FEF include: running buffalo clover, Virginia big-eared bat, Indiana bat, and northern long-eared bat. Effects to running buffalo clover from the proposed action and alternatives are covered under section 3.7 Forest Vegetation.

Direct/Indirect Environmental Effects

Alternative A – No Action

This alternative would not affect threatened and endangered species directly, as no trees would be felled. As described in the BA, analysis of the No Action alternative resulted in a finding of "no effect" was made for Virginia big-eared bat, Indiana bat, and northern long-eared bat.

Alternative B – Proposed Action and Alternative C – Modified Proposed Action

Since Alternatives B and C differ only in the addition of 12 acres of under-planting and 6 acres of herbicide application to control understory species composition, the effects from the actions of both alternatives are described below.

Direct and indirect impacts of patch cutting, single-tree selection harvests, diameter-limit harvests, prescribed burning, fertilizer application, and herbicide use on threatened and endangered species that occur or may occur on the FEF are possible but unlikely. The BA for this project documents the analysis and findings of effects to threatened, endangered, and sensitive species from the proposed action and alternatives. Those findings are summarized here; for more details please see the BA.

Virginia big-eared bat -endangered

Since only two Virginia big-eared bats (VBEB) have been found foraging on the FEF since 1995 and caves, cliff faces, and old buildings make up their day roost habitat, the proposed harvest treatments will have no effect on VBEB or their habitat. All proposed prescribed fires are beyond 0.25 miles of Big Springs Cave and will be conducted during weather conditions that promote lifting of smoke from the area, for firefighter safety and to limit possibility of smoke entering the cave. There would be no direct, indirect, or cumulative effects to VBEB from the proposed applications of herbicide or fertilizer. For these reasons, the finding for VBEB is "no effect" for Alternatives B and C.

Indiana bat – endangered

Big Springs Cave on the FEF is a Priority Three winter hibernacula for the Indiana Bat. Pre-WNS, male Indiana bats that utilized Big Springs Cave as hibernacula appeared to remain on or near the FEF during the non-hibernation season. Females emerging from the cave in the spring appeared to move to maternity roost sites off the FEF and not return until the fall swarm. There has been no evidence of maternity colony activities on the FEF; however their presence cannot be discounted. No harvest activity on the FEF from April 1 – August 31, will eliminate direct disturbance during a critical time period when females would form maternity roost networks and care for young. It is possible that bats may emerge from Big Springs Cave before timber harvest stops on April 1st. In WNS-affected bat populations, surviving bats often emerge from caves earlier in the spring and in a weakened state due a lack of fat reserves and dehydration.

Therefore, the potential for harming a roosting bat that has just emerged from hibernation or by taking a potential roost tree cannot be discounted.

Past studies on the FEF have shown male Indiana bats utilize a wide range of tree species for roosting, although shagbark hickory was the most preferred. Generally, roost trees were classified as being canopy dominant, possessing some exfoliating bark, and usually on a south, southwestern, or western aspect (Johnson et al. 2009a, Stihler 1996, Ford et al. 2002b). Despite the current relatively low Indiana bat density on the FEF, the abundance of roost tree habitat and roost trees available on the FEF, the small acreage to be cleared on the landscape, and the timing of harvesting, the possibility of direct effects cannot be discounted for Indiana bats that may be utilizing roost trees in the treatment areas. Although some potential Indiana bat roost trees may be removed during harvest, additional roost trees may be created due to partial overstory removal. Retaining shagbark hickories and snags during harvesting coupled with management that favors oaks species will improve existing Indiana bat habitat. Of the roost trees identified on the FEF, one roost is located in Compartment 9B designated for diameter limit harvest in 2017; and one roost is located in Compartment 7B designated for a patch cut in 2020. These known roost trees will be retained.

Female Indiana bats establish loose maternity colony roost networks on the landscape and show annual site fidelity to roost trees, although these roost networks are more broadly distributed on the landscape when compared with northern long-eared bats. Despite the widespread nature of Indiana bat maternity roost networks, the fact that roost trees are not a limiting factor for Indiana bats on the FEF, and the potential for creation of additional roost trees as result of single-tree selection, indirect effects to Indiana bats as a result of roost tree habitat alteration due to tree harvesting cannot be discounted.

Research units scheduled to be treated in a given year will be harvested based on their distance from the hibernacula, slope, aspect, and research needs. Those cooler, moister units with more north, northeast, and east facing slopes located farther from Big Springs Cave will be harvested first each year, while other scheduled units with more roost tree habitat will be harvested later in the season while the bats are in the hibernacula. While there may be some changes to the proposed harvesting schedule over the five-year period due to weather or other logistical issues, there will be no change to the schedule of what units will be harvested first each year in order to protect areas that Indiana bats may be utilizing during the fall swarm.

Herbicide application would be species-specific, targeting exotic plant species on the FEF or used on one-acre plots to control understory species composition (for a total of 12 acres over 5 years). There would be no direct or indirect effects to Indiana bats due to herbicide application because application would be directly on targeted plants and no Indiana bats would be present on targeted species.

Prescribed burning on the FEF may occur while Indiana bats are out of Big Springs Cave, although prescribed burns may occur approximately 1 mile from the nearest opening to the Big Springs Cave system. Proper burning conditions to achieve burning objectives and provide safe working conditions for firefighters would include weather patterns that would lift and remove the smoke from the prescribed burn area. Therefore, there would be no direct or indirect effects to the Big Springs Cave hibernaculum as a result of prescribed burning.

Indiana bats might be capable of escaping burning roost trees when necessary if volant. Female Indiana bats utilizing roost trees in the early spring may be in a state of torpor while day-roosting; however torpor would occur during cool and/or wet weather which would not be conducive to successful prescribed burning conditions (Dickinson et al. 2009). Although healthy bats roosting in trees should be able to avoid direct effects of prescribed fire, post-WNS affected populations may emerge in a weakened state and be unable to escape burning trees. Therefore, due to the possibility of harming WNS affected bats during spring prescribed fire, there could be direct negative effects of prescribed burning on Indiana bats. Prescribed burning would encourage the regeneration of mast-producing tree species such as oaks and hickories. These species also provide high quality live roosts for many bats (Dickinson et al. 2009).

Fertilization of watershed 3 or in the LTSP study site would have no direct effect on Indiana bats as the fertilizer would not be applied in high enough density and are not toxic to fauna at this concentration.

Considering the potential for negative effects, a finding of "may affect, likely to adversely affect" was determined for Indiana bats.

Northern long-eared bat - threatened

Roost tree studies on the FEF and industrial managed forests in WV show male and female northern long-eared bat (NLEB) utilize several tree species for roosting, although they show a strong preference for black locust. Other tree species included: black cherry, sassafras, and maples (Owen et al. 2002, Menzel et al. 2002, Ford et al. 2006b). Northern long-eared bats use both live trees and snags as roosts on the FEF, and roost trees have substantial amounts of cavities, broken limbs, and exfoliating bark. Unlike Indiana bats, this species appears to be less disturbance-dependent and prefers areas with higher basal area. Live roost trees used by males are usually medium to large canopy-dominant trees, whereas snags used as roost trees were generally smaller than surrounding tress and suppressed (Ford et al. 2006b). Snags used as maternity roosts are generally taller yet smaller in diameter then surrounding snags and live trees, and are surrounded by higher basal area than random snags (Owen et al. 2002, Johnson et al. 2012a). Often maternity roosts are located at or below the forest canopy in areas with higher basal area, suggesting that solar exposure may not be a critical factor for NLEB maternity colonies (Menzel et al. 2002, Owen, et al 2002). Maternity roost networks are associated with ridgetops on the FEF (Johnson et al. 2012a). Over 130 known NLEB roost trees have been identified on the FEF.

Winter bat surveys of Big Springs Cave have been conducted periodically since the early 1950s; however specific NLEB counts have only been included in surveys since 1984; NLEB numbers were typically between 1-9 bats per site each survey year. WNS was first documented on the FEF in Big Springs Cave during the winter of 2010-2011, and overall populations of NLEB have declined on the FEF in subsequent years. There have been no documented NLEBs counted since the 2011 winter survey. However, since NLEB do not hibernate in large groups, the importance of Big Springs Cave as a hibernacula for NLEB is unclear.

Northern long-eared bat roost tree monitoring has occurred on the FEF and surrounding areas since 2000. The FEF provides habitat for swarming, hibernating, migrating, and summering NLEB, even with WNS present. Prior to the confirmation of WNS on the FEF, the NLEB was

the most common bat species documented on the FEF. Male NLEB roosts and maternity colonies were common on the FEF landscape. Even though it is uncertain if NLEBs hibernate in Big Springs Cave, they do go in and out of the cave to mate during the fall, exposing them to the white nose fungus. Populations of NLEB have shown dramatic declines on the FEF post WNS confirmation.

Seasonal restrictions on timber harvest ensures that when NLEB maternity colonies form and flightless (non-volant) bat pups are present, there would be no timber harvest activity occurring. NLEBs will be on the landscape foraging and moving toward fall swarming around Big Springs Cave during September and October or until hibernation occurs. It is during this time (post September 1) that bats may be affected by timber harvest activities. Regardless of harvest treatment type, activities associated with direct tree removal could affect NLEB and their foraging and roosting habitat. Tree removal during the non-hibernation period (March – November) may result in mortality or injury (take) of a roosting NLEB, if a tree that contains a roosting bat is harvested or felled accidentally.

Due to the possibility of roost network fragmentation and roost tree loss, there is a possibility of indirect effects to NLEB as a result of single-tree selection. Of the 131 known roost trees, 4 occur in Watershed 5A. This unit is scheduled for single tree selection harvest in 2018. All 4 known roost trees will be retained.

The use of no harvest or limited harvest in streamside management zones will insure continued protection in NLEB foraging and travel corridors. Therefore, there would be no indirect effects to NLEB foraging and travel corridor habitat alteration resulting from the silvicultural treatments.

Despite the current relatively low NLEB density on the FEF, the abundance of roost tree habitat and roost trees available on the FEF, the small acreage to be cleared on the landscape, and the timing of harvesting, the possibility of direct negative effects cannot be discounted for NLEB that may be utilizing roost trees in the treatment areas.

There would be no direct or indirect effects to NLEB due to herbicide application because application would be directly on targeted plants. Because herbicides would be applied directly to target species and not to the surrounding environment, there would be no direct or indirect effects to NLEB habitat, as overall habitat would remain the same.

Prescribed burning on the FEF could occur from October 1 – May 31 if fire conditions would adequately support a burn. During October/November, it is probable that NLEBs will be fall swarming around Big Springs Cave entrance. Although all prescribed burns would occur approximately 1 mile from the nearest opening. Proper burning conditions to achieve burning objectives and provide safe working conditions for firefighters would include weather patterns that would lift and remove the smoke from the prescribed burn area. Therefore, there would be no direct or indirect effects to the Big Springs Cave hibernaculum as a result of prescribed burning.

Burning could occur on the FEF when NLEBs are out of the hibernaculum (March – May and October - November) and roosting. Healthy NLEBs might be capable of escaping burning roost trees when necessary; however, post-WNS affected populations may emerge in a weakened state

and be unable to escape burning trees. Therefore, due to the possibility of harming WNS affected bats during spring prescribed fire, there is a possibility of direct negative effects of prescribed burning on NLEBs.

Past use of prescribed fire on the FEF appears to show that NLEB roost networks have some tolerance for disturbance resulting from prescribed fire. While additional potential roost trees can be created in forested stands by utilizing prescribed fire, the ephemeral nature of roost trees in burned areas should be considered when determining the effects of fire intensity on roost tree habitat as some roost trees may be lost as a result of high fire intensity. Maternity colonies in burn areas on the FEF were located in cavity trees that were in a relatively higher crown class yet smaller in diameter then random trees and snags. Additionally roost trees were located in larger canopy gaps than roost trees in non-burned areas (Johnson et al. 2009a).

While NLEB roost tree networks on the landscape provide some resiliency to roost tree loss, a loss of >20 percent of roost trees in a network may lead to network fragmentation (Silvis et al. 2014), which could potentially cause reproductive failure from displaced females. Prescribed fire can affect the availability and distribution of roosts within roost tree networks (Johnson et al. 2012b). In smaller roost tree networks, the possibility of network fragmentation cannot be discounted. The habitat within the prescribed burn compartments does provide some habitat with a higher probability of providing suitable habitat for NLEB roost trees than other areas of the FEF. The presence of suitable roost tree habitat in the burn areas coupled with the possibility of roost network fragmentation make it possible for indirect negative effects to NLEB to occur as a result of prescribed fire.

Fertilization of watershed 3 or in the LTSP study site would have no direct effect on NLEB as the fertilizer is applied during the daytime hours when any NLEBs are roosting. Fertilizer applications would not be applied in high enough density and are not toxic to fauna at this concentration.

Considering the potential for negative direct and indirect effects, a finding of “may affect, likely to adversely affect” was delivered for NLEB.

Regionally sensitive species and other species of concern

For sensitive animal species known to occur on the FEF, including the southern water shrew, southern rock vole, Virginia northern flying squirrel, little brown bat, tri-colored bats, and timber rattlesnake, findings of “may impact individuals but not likely to cause a trend to Federal listing or loss of viability” were made for the proposed action. Under the proposed action, southern rock vole and timber rattlesnake den site suitability at unbuffered rock outcrops may decrease. However, foraging habitat diversity would increase for both of these species. Other sensitive species including the Greenbrier cave amphipod and the eastern small-footed myotis had a finding of “no impacts” for the proposed action and Alternative C.

A review of the 2008 list of Birds of Conservation Concern shows that about two-thirds of the species would not find suitable habitat on the FEF. Conducting timber harvest during the winter months protects birds from direct impacts during nesting season. Moreover, beginning in 2012, we moved to stop tree felling activities in the month of May to avoid impacting tree roosting bats

in poor condition after the winter hibernation period. This move also helps us avoid impacting migratory birds because all tree felling is completed by the end of March at the latest.

Cumulative Effects

All Alternatives

White-nose syndrome, a fungus that affects bats in their winter hibernacula, is an ongoing threat to bat species on the FEF. White-nose syndrome is so called due to the presence of white fungal growth on the muzzles, ears, and/or wing membranes of affected bats. This fungus has recently been identified as the psychrophilic fungus *Geomyces destructans* (U.S. Fish and Wildlife Service 2009). Besides the presence of the white fungus on hairless portions of the face, wing, and tail, affected bats have little to no fat reserves and can be found moving near cave entrances and/or leaving the caves and flying in the middle of the day during hibernation season. Numerous dead bats are often found near cave entrances during winter cave surveys of affected caves. Scientists estimate over 500,000 bats deaths may now be associated with WNS since it was first noted in 2006. The New York State Department of Environmental Conservation reports up to 95 percent decrease in the populations of some bat species affected by WNS since it was discovered. Little is known about the etiology and mechanics of the spread of WNS, although recent findings support the hypothesis that causative agents responsible for WNS appear to remain in the cave during the spring and summer months, thus, providing a source of infection for uninfected bats entering the hibernacula in the fall (E.R. Britzke, US Army Corps of Engineers, personal communication).

Big Springs Cave is located in the Biological Control Area of the FEF where no silvicultural or fertilization treatments will occur. None of the proposed actions have been shown to contribute to the spread of WNS as this fungus is closely tied to conditions in the cave, not to conditions outside of the hibernacula. The probability of harming a bat on the FEF as a result of the proposed actions is small due to the cave protection measures and seasonal timber harvesting and the proposed actions are not likely to contribute to the cumulative effects of WNS on bats. However, bat-to-bat spread of WNS will be difficult to control due to the social nature of bats, their tendency to visit numerous caves during the fall swarm, and that many species aggregate in dense clusters during hibernation.

Alternative A – No Action

If no timber harvesting or prescribed fire take place over the next five years on the FEF, there would be no additional loss of roost trees over the background-level occurring as snags decay and fall.

Alternative B – Proposed Action and

Alternative C – Modified Proposed Action

Bat populations will continue to be impacted by WNS regardless of timber harvest or prescribed fire. Continued timber harvest and prescribed fire will remove roost trees, however, seasonal restrictions on timber harvest will protect individual bats. The small area impacted by timber harvest and prescribed fire results in minimal negative impacts to TES species over time. However, as documented in the BA, potential negative effects may occur.

3.7 Forest Vegetation

Affected Environment

Species Composition

The vegetation on the FEF developed after near total removal of all trees from about 1903 to 1911 (Adams et al. 2006) and the loss of American chestnut due to blight by 1948 (Schuler and Gillespie 2000). The 4,615 ac FEF is located in the Central Appalachian Broadleaf Forest (Province M221), which includes parts of Georgia, North and South Carolina, Virginia, Maryland, Pennsylvania, and West Virginia (Cleland et al. 2007). The FEF is within the Allegheny Mountains Section (M221B), with most of the area (4,430 ac) within the Western Allegheny Mountains subsection (M221Bb) and only 116 ac within the Northern High Allegheny Mountains subsection (M221Ba) (Cleland et al. 2007). The FEF is part of the Allegheny Front Sideslopes land type association (LTA). LTAs are differentiated by landforms, natural overstory communities, and soil associations and often are thousands of acres in size. The potential natural vegetation of the ecological section is strongly influenced by elevation and aspect and includes northern hardwoods, red spruce, mixed mesophytic hardwoods, and oak communities.

The ecological land type (ELT) is the next lower level of ecological unit and integrates landform, soils, and natural vegetative communities and often ranges from tens to hundreds of acres. There are 6 ELTs mapped for the FEF and portions of all 6 are affected by the proposed action and alternatives. The ELTs found on the FEF are: Allegheny Front sugar maple/red oak, Allegheny Front sugar maple/basswood, Allegheny Front beech, Allegheny Front chestnut oak/red oak, and Allegheny Front sugar maple/hemlock (DeMeo et al. 1995). The ELTs also represent several major plant associations and include the white oak-black oak group, the red oak-sugar maple group, and the yellow-poplar-mixed hardwoods group (Barrett 1995).

While various classification systems are used to categorize vegetative communities, rarely to these communities achieve stasis. The groups described here do not represent stable or climax communities, particularly over longer time-spans. The vegetative composition present on the FEF today is due to a large number of factors – both biotic and abiotic. Species composition has been strongly influenced by climatic changes that have occurred since the end of the Wisconsin glaciation (c. 18,000 year B.P.) and past disturbances, both natural and anthropogenic. Pollen analysis of sediment cores from Big Run Bog in Tucker County, West Virginia (about 6 mile NE of the FEF) reveals dramatic changes in species composition from tundra-associated sedges and grasses (17,000 year B.P. to 13,860 year B.P.), to red spruce and balsam fir domination (13,860 year B.P. to 10,500 year B.P.), to a mixed conifer - northern hardwood forest (10,500 year B.P.). For the last 8,000 years, oak, birch, and American chestnut dominated the upland forests surrounding Big Run Bog (Larabee 1986).

Dendroecological analysis of old-growth remnant stands suggests past disturbances such as windthrow and fire have played an important role in maintaining oak species on mesic sites (Abrams and Nowacki 1992, Abrams et al. 1995, Schuler and McClain 2003, McEwan et al. 2007). In the Ridge and Valley physiographic province of central Pennsylvania, disturbance from fire and other events occurred on average every 20 years on ridges and about every 30 to 60

years in bottomlands (Nowacki 1995). In several studies of past fire regimes, the results are notable in their similarities with fire recurrence intervals ranging from one to two decades in mixed-oak forests (Shumway et al. 2001, Schuler and McClain 2003, McEwan et al. 2007, Hutchinson et al. 2008).

Species composition is still being influenced by biotic and abiotic factors. Biotic factors such as white-tailed deer herbivory and the accidental introduction of exotic pathogens (e.g., gypsy moth, Dutch elm disease, beech bark disease, chestnut blight, and hemlock woolly adelgid) have already dramatically influenced virtually all of today's forests in the central Appalachian region. In most cases, these factors reduce species richness and may lead to the unintended establishment of invasive exotic species. Timber harvesting also can influence species composition in different ways. Single-tree selection, which results in uneven-aged stands, caused a significant decline in woody species diversity over the past 50 years (Schuler 2004). However, that same study also showed that unmanaged stands (i.e., no cultural treatments or harvests) experienced similar declines in diversity. In both instances, a dramatic increase in shade tolerant sugar and/or red maple resulted in the decline of virtually all other species. Intermediate cuttings, such as thinnings, often accelerate the trend to more shade-tolerant species (Schuler and Gillespie 2000). Some regeneration harvest techniques can reverse this trend and significantly increase the percentage of shade-intolerant species such as yellow-poplar (Brashears et al. 2004). Natural regeneration following large disturbances such as tornado damage or larger clearcuts (e.g., 25 acres) often result in the predominance of species that are capable of a rapid recovery and fast growth. These are often species that are shade-intolerant and have the potential for abundant regeneration, either from seeds or sprouts.

Throughout the region, species composition of the Central Appalachian Broadleaf Forest is becoming less dominated by oaks, and increasingly dominated by more shade-tolerant species (Nowacki and Abrams 2008). Attempts at solving the oak regeneration problem have included under-planting (Johnson 1984, Johnson 1992), shelterwood treatments (Loftis 1990, Schlesinger et al. 1993, Schuler and Miller 1995), prescribed fires (Wendel and Smith 1986, Van Lear and Waldrop 1989, Brose and Van Lear 1998), herbicide treatment of understories (Loftis 1990, Schlesinger et al. 1993, Schuler and Miller 1995), and clearcutting or shelterwoods combined with plastic tree shelters to protect planted or natural oak seedlings (Tuley 1983, Lantagne et al. 1990, Smith 1993, Lantagne 1995, Gillespie et al. 1996, Schuler and Miller 1996). While progress is being made (Brose et al. 2008), robust silvicultural prescriptions are still being developed. Recent work has shown the need for canopy reduction in conjunction with prescribed fire for successful oak regeneration (Iverson et al. 2008, Hutchinson et al. 2012a, 2012b, Brose et al. 2013) and need for a fire-free period to allow for oak sapling development and recruitment (Brose 2004, Johnson et al. 2009b, Dey et al. 2010, Brose et al. 2014).

Even given constant change, certain forest types are still widely recognized and used to define stands or compartments for forest management. The FEF is divided into management units of either compartments (based on forest type and productivity classes) or watersheds. These designations are for the generally larger-scale and longer-term research on the FEF where some degree of manipulation of the environment is occurring; other undesignated areas have been used for research, but ground-disturbing activities are not occurring or not planned for the foreseeable future. About 59 percent (2,680 ac) of the FEF is currently in areas with active or inactive research studies. Most of the FEF is considered to be composed of the following forest types.

White Oak-Black Oak Type Group

The white oak-black oak type on the FEF represents fair growing sites and has an oak site index$_{50}$ of approximately 60. It represents stands with fair to medium productivity relative to other sites in the central Appalachians but is the lowest productivity class on the FEF. These stands are similar to those described by Braun (1950) as oak-chestnut forests, although due to chestnut blight, chestnut is no longer an overstory constituent. Site locations are often characterized as ridge tops or south and western exposures. Species composition in this group on the FEF is often characterized by chestnut oak, pignut hickory, red maple, and American beech. Common shrubs include blueberry, mountain laurel, greenbrier, and serviceberry.

Average annual growth rates of 50 cubic feet or about 200 board feet per acre are expected. However, over the past 50 years on the FEF, sites of this productivity class have exceeded 300 board feet per acre per year when managed by periodically reducing stocking levels (Schuler 2004).

Red Oak-Sugar Maple Type Group

This group on the FEF represents good to excellent growing sites and has an oak site index$_{50}$ of about 70 to 80. Productivity ranges from good to excellent. Site locations are often on north- and east-facing aspects and on middle to lower slopes. Species composition is described as mixed mesophytic and includes northern red oak, yellow-poplar, sugar maple, black cherry, white ash, basswood, cucumbertree, white oak, and American beech. Understories can be quite diverse and include spicebush, eastern hophornbeam, serviceberry, striped maple, and rhododendron. Throughout the region, species composition of this group is becoming less dominated by oaks and is increasingly dominated by more shade-tolerant species, often sugar maple. Intermediate cuttings, such as thinnings, seem to accelerate this change (Schuler and Gillespie 2000).

Average annual growth rates are expected to range from 300 to 400 board feet acre per year. However, over the past 50 years on the FEF, managed sites of these productivity classes have ranged from about 300 to 500 board feet per acre per year, respectively, for oak site index$_{50}$ 70 and 80 (Schuler 2004, Schuler and McGill 2007).

Yellow-poplar-Mixed Hardwoods

This group is a highly productive combination of hardwood species and is usually dominated by yellow-poplar. It is found on land with an oak site index$_{50}$ of 86 and above (Barrett 1995). On the FEF, this group is closely integrated with the red oak-sugar maple type and occupies smaller coves within broader spatial units designated as oak site index$_{50}$ of 80. The primary difference is that the percentage of the stand occupied by yellow-poplar increases as site quality increases. None of the compartments or watersheds where timber harvest is proposed is composed entirely of this forest type; however, it does exist within some areas on smaller scales. Even-aged regeneration methods in this forest type usually results in the continued dominance of yellow-poplar because of its capability for rapid height growth (Brashears et al. 2004).

Age Classes

About 41 percent of the FEF is not managed for long-term research nor is in designated unmanaged control areas. In these areas, growth of the forest after the commercial logging of the early 1900s has occurred with little to no management. Older short-term studies and demonstration areas may have impacted some of these areas of the FEF. In these portions of the

FEF the forests are approximately 100 years old and likely developing characteristics typical of forests undergoing understory re-initiation where shade-tolerant shrubs and herbs are developing in the understory, suppressed or overtopped overstory stems are declining, and canopy gaps are begin to form (Oliver and Larson 1996).

For areas under management, approximately 1,353 acres have been or are managed using some version of uneven-aged management (or similar partial overstory removal harvest) since 1949-50. These areas make up about 50 percent of the FEF that is under management, or about 30 percent of the total FEF. Approximately 506 acres of the FEF are now or have in the past been managed under some even-aged management system since 1949-50; about 19 percent of the area under management or 11 percent of the total FEF. About 253 acres of the FEF have been designated as control areas where no management takes place but research study plots have been established. Other than about 55 acres in a sub-watershed where a hardwood overstory was converted to conifer forest (watershed 6), hardwoods have been the focus of management and research.

Of the 506 acres under even-aged management, the last stand-initiating harvest (an initial cut for a shelterwood) took place in 2009 and 2010 in compartments 49-1 (47 acres) and 49-2 (30 acres). Other than these most recent harvests, compartments under even-aged management range in age from 66 to 17 years old and from 5 to 85 acres in size.

In 2008 and 2009, a natural gas well site and accompanying pipeline were developed on the FEF converting about 7.5 acres from forest to grass cover or access road corridor. These canopy removals are considered permanent openings and conversion from forest cover. The rights to mineral resources under the FEF are privately owned. There are no known additional gas wells or pipelines planned for the FEF; however, gas development has fluctuated in response to gas prices and gas supplies. Consequently, there is a possibility that additional openings and loss of forest cover will occur in the future if the gas-bearing formation under the FEF proves economical, particularly if gas prices increase.

Threatened, Endangered, and Sensitive Species

There are two plant species listed as regionally sensitive (for the USDA FS Eastern Region) which occur or may occur on the FEF: butternut and white monkshood. One federally endangered plant species, running buffalo clover (RBC) is known to occur on the FEF. See the Biological Assessment for details.

Running buffalo clover has a high affinity for calcium-rich soils, which are abundant in the eastern portion of FEF. It is most often found in locations underlain by limestone or other calcareous bedrock and is not known to fix nitrogen (Morris et al. 2002). This species persists in mesic woodlands with partial sunlight and periodic disturbance (Madarish and Schuler 2002). Running buffalo clover has been documented in compartments 5, 7, 9, 8, 13, 16, 17, 18, 20, 72 and watershed 5. Monitoring of RBC has occurred annually on the FEF since 1994 and the number of known plants (i.e., rooted crowns – the commonly accepted unit of measure) was 7,442 during the 2014 and 2015 monitoring seasons (June – August). RBC is most commonly found on skid roads on the FEF. It has clearly been shown that the use of these skid roads for logging diminishes the number of plants temporarily, but that population densities recover in about 3 to 5 years (Madarish and Schuler 2002). In fact, RBC may need periodic disturbances to persist in forested understory environments (Burkhart et al. 2013). In 2009, anecdotal evidence in compartment 13 suggested that a spring prescribed fire may have stimulated flowering of

RBC. Disturbances to the canopy increase sunlight and ground disturbance reduces competition from other herbaceous species. Ground disturbance may also increase germination via mechanical scarification of RBC seed. White-tailed deer may be a factor in the movement of RBC seed locally, but digestion of RBC seed by deer did not change RBC seed germination rates (Ford et al. 2003).

Herbaceous Layer

The herbaceous layers of four watersheds on the FEF with different management histories but similar parent materials have been intensively evaluated (Gilliam and Turrill 1993, Gilliam et al. 1995, Gilliam et al. 2006) and provide the basis for most of this description. Cover, biomass, richness at two spatial scales, and diversity were evaluated; stand age ranged from about 20 years of age to greater than 80. Common herbaceous species included stinging nettle and wood nettle, species of violet, greenbrier, blackberry, Christmas fern and shield fern. Species composition could not be correlated with stand age or management history. The investigators found little difference among watersheds. Species diversity appeared to be predominantly related to physiographic properties of the individual watersheds. In contrast, in plots with experimental manipulations in browse (fencing), creation of canopy gaps, and prescribed fire, herbaceous layer richness, cover, and diversity increased with the combination of canopy gaps and a single ground fire (Royo et al. 2010). The study also showed that deer populations at moderate levels can promote herbaceous species richness and abundance through preferential browsing (Royo et. al 2010).

The herbaceous layer was also described in areas of the FEF derived from limestone parent material (Madarish and Schuler 2002, Morris et al. 2002). These sites often support running buffalo clover and some common associates such as panicgrass, white snakeroot and hog peanut. In contrast to the findings of Gilliam et al. (1995), RBC does seem to be correlated with management history (Burkhart et al. 2013). A list of plant species found on the FEF was completed by Madarish et al. (2002).

Non-native invasive plant species are known to occur on the FEF. We have found Japanese stiltgrass, tree-of-heaven, garlic mustard, multiflora rose, and various agriculture-related weeds, such as burdock, in study areas and in non-study areas. Japanese stiltgrass is present on much of the FEF, primarily along truck and skid roads, but it is beginning to expand into other disturbed areas as well. Control of this species is more problematic because broadcast sprays are likely to affect other species. Also, because this species is known to produce seed that can remain viable for several years, application of foliar herbicide must be repeated until Japanese stiltgrass is largely controlled. Tree-of-heaven stems are uncommon on the FEF. Garlic mustard has been found along roads with limited movement off road banks. In the past, garlic mustard has been removed by hand in select areas and Japanese stiltgrass has been treated with herbicide in one compartment.

Direct/Indirect Environmental Effects

Alternative A – No Action

Species Composition

Since no timber harvest, fertilizer application, herbicide application, planting, or prescribed fire would occur if the No Action alternative were implemented, species composition changes occurring without management would continue to occur. Under this alternative, succession would continue to favor development of shade tolerant species of red maple, sugar maple, and beech. Advanced regeneration of oaks and cherry would be expected to decline as competition for light and moisture increases. Older trees would be more common, and as they die they would become dead standing trees and large woody material on the forest floor. Nutrients would cycle and once again become available to forest vegetation, both herbaceous and woody. Larger blowdowns would occur as stands became more susceptible to high winds and snow and ice damage. This would create opportunities for some shade-intolerant species to persist. The percentage of oak would continue to decline.

Age Classes

Stands would continue to age and develop without management, becoming uneven in age class and structure over time.

Threatened, Endangered, and Sensitive Species

Running buffalo clover populations in compartments 8D, 8C, 9A, 9B, 17, 20A, and watershed 5A would persist for the time period considered within this EIS, but would likely decline in some compartments without the ground and canopy disturbance from timber harvest in those areas. RBC needs periodic (e.g., 10 to 15 years), moderately level ground, and canopy disturbances to thrive, and this alternative does not include any scheduled disturbances.

Herbaceous Layer

There will be no direct or indirect effects to the herbaceous layer if the No Action alternative is implemented. The expected changes to the overstory listed above for species composition will create differing light-levels on the forest floor. The herbaceous layer is expected to change in species composition as the forest ages without management.

Invasive species, especially Japanese stiltgrass and tree-of-heaven, would not be controlled, but the lack of ground-based disturbance from experimental silvicultural manipulations may limit the spread. Japanese stiltgrass would likely continue to spread, but primarily along the edges of roads used by the public for recreational access to the FEF.

Alternative B – Proposed Action and Alternative C – Modified Proposed Action

Species composition

Species composition in the areas proposed for single-tree selection and diameter-limit harvesting (273 acres or 6 percent of the FEF) is expected to change with dominance of shade-tolerant tree species increasing gradually over time. The 0.4-ac openings in the patch cutting areas were designed to be large enough for shade-intolerant tree species to regenerate; however, oak regeneration has been limited in past openings. A gradual increase in shade-tolerant tree species

is expected in these 31 acres (~1 percent of the FEF) as well. By contrast, the prescribed fire treatments on 398 acres (~9 percent of the FEF) are designed to encourage oak reproduction over fire-sensitive species such as red maple. In these areas, prescribed fires should maintain the species composition over time.

Although uneven-age regeneration methods (the single-tree selection and diameter-limit cuttings proposed) usually hasten the decline of oak, natural regeneration is robust in the black oak-white oak and red oak-sugar-maple types and would assure abundant regeneration in harvest units. Regeneration is derived from existing understory stems, stump and root sprouts from cut trees, and seedlings derived from the seed bank; planting is not required. The composition and growth rates of the newly established regeneration are of principal interest in our research studies. Deviations from expected trends may represent the effect of changes in the biotic and abiotic factors influencing the forest environment.

Damage to residual trees will occur during logging, impacting residual trees directly. However, one of the goals of the research is to evaluate such effects over time with respect to different forest management practices. We expect some differences in residual stand quality within different silvicultural treatments.

Overstory removal that creates canopy gaps about 0.4 acres in size or larger would change the microclimate and species composition of the understory. Gaps created from tree removal would increase light penetration to the forest floor. Any advance regeneration would immediately take advantage of the increased light. Shade-intolerant tree species such as yellow-poplar and black cherry would be favored, but shade-tolerant species such as sugar maple and American beech would not be excluded. Woody species diversity at the patch scale (i.e., 0.5 to 2.5 acres) often increases following the creation of canopy gaps (Schuler and Gillespie 2000).

We acknowledge that the silvicultural treatments called for in alternatives B and C are not necessarily optimal for continuing the current species composition of the overstory. The purpose of the proposed actions is to conduct research that compares a range of silvicultural systems that are currently utilized throughout the central Appalachian region.

Age Classes

The distribution of age classes across the FEF will not change appreciably with the implementation of the action alternatives. No large-scale patches of young forest are created in any alternative; the 31 acres of patch cuts are not contiguous. Managed and unmanaged areas of the FEF will continue to develop uneven-aged stand structure within the stands, compartments, and watersheds. Little age-class diversity between stands, compartments, and watersheds exists on the FEF currently as few areas are in larger (greater than 5 acres) patches of even-aged forest.

Threated, Endangered, and Sensitive Species

Individual RBC plants would be crushed as a result of harvesting. However, the overall effect of the action alternatives would benefit RBC in the longer-term because of its apparent requirement for periodic disturbance (Burkhart et al. 2013). Although individual RBC plants would be destroyed if either action alternative is implemented, population viability analysis using the diffusion approximation approach (Dennis et al. 1991) resulted in a very low probability of extinction (POE) (POE < 0.01) for RBC on the FEF for 20 years (US Fish and Wildlife Service 2007). The POE would be even less during the 5-year period considered in this EIS.

No healthy butternut trees will be harvested in either action alternative. Historical reports and pollen records indicate that butternut has not occurred in abundance on the FEF or in eastern West Virginia. It is not likely to increase substantially due to the proposed mitigation. Shagbark hickory is not usually removed from the FEF and continuing that restriction would benefit the abundance of hickory in the overstory relative to other species. However, hickories are short-lived relative to many co-occurring species and in unmanaged stands the ratio of hickory may decline. Hickory species are generally considered adapted to fire and hickory reproduction may benefit from the proposed prescribed fires.

Herbaceous Layer

We do not expect either action alternative to significantly affect the herbaceous community with respect to composition or diversity. Research conducted on the FEF and elsewhere in the eastern United States suggests that the proposed treatments are not severe enough to have long-term impacts on this stratum of forest vegetation (Gilliam and Turrill 1993, Johnson et al. 1993, Elliott and Loftis 1993, Gilliam et al. 1995, Jenkins and Parker 1998, Jenkins and Parker 1999, Ford et al. 2000b). Jenkins and Parker (1999) speculate that disturbances associated with forest management are usually not severe enough to shift ground layer species composition. Ground layer species resiliency (i.e., the ability to recover to pre-disturbance characteristics following a disturbance) may also be a function of patch size and connectivity to patches of similar characteristics (Ford et al. 2000b). Gilliam (2007) asserts that the herbaceous layer plays a significant role in ecosystem structure and function despite its relatively minor contribution to total biomass. He points out that the herbaceous layer can contain 90 percent of the plant species, contribute 20 percent of the forest litter, influence development of forests after disturbance, and mitigate the loss of essential nutrients. The work by Royo et al. (2010) suggests that canopy gaps created through partial harvest may increase herbaceous species richness. However, the role of invasive species may alter this functionality (Huebner 2006). Minimizing disturbances in streamside management zones will further protect many sensitive plants.

Herbaceous-layer composition and plant species diversity were evaluated in watershed 3 and compared to several other watersheds. Continued application of fertilizer is proposed in watershed 3 for both action alternatives. Gilliam et al. (1995) found stinging nettle, violets, seedlings of striped maple, and several fern species were common on all of the watersheds, regardless of age or acidification treatment. The herbaceous layer of watershed 3 was quite similar to other watersheds evaluated. There were no significant differences with respect to percent cover, biomass, or species richness. Gilliam and Turrill (1993) also studied herbaceous communities of watershed 3 and concluded that species composition was most strongly influenced by soil characteristics early in stand development; however, as stands mature, they speculated that this linkage is less important. Based on this analysis, we expect no significant changes to the herbaceous layer from continued application of fertilizer to watershed 3.

General Effects

The effects on the vegetation due to the fertilizer application in watershed 3 and the LTSP study is an important research topic. Eventually, watershed and local site acidification could lead to base cation depletion and nitrogen saturation, negatively affecting individual tree health and reduce site productivity. Effects on site productivity on the FEF have been evaluated and no evidence was found that the fertilization/acidification treatments have altered site productivity (Adams et al. 2006). For the period from 1990/91 to 1996, productivity of the treated watershed

3, measured as stemwood cubic volume, actually exceeded the productivity of watershed 7, a nearby untreated watershed with similar stand age and characteristics. From 1996 to 2004, no treatment effect with regards to stemwood productivity was discernable between watersheds 3 and 7. Watersheds 3 and 7 also were compared in terms of biomass production. In most cases there were no statistically significant differences. However, in a comparison of plots with a high proportion of black cherry and yellow-poplar, biomass production on watershed 3 exceeded that of watershed 7. A comprehensive summary of research related to the Fernow watershed acidification study was published and addresses nutrient cycling, forest ecosystem sustainability, salamanders, vegetation, stream and soil water chemistry, and soil chemical response (Adams et al. 2006).

Using best management practices – i.e., closure of skid roads, reclaiming decks, and avoiding logging during wet periods - reduces soil compaction, erosion, and loss of productivity. All of these factors affect forest vegetation in that the potential productivity of the site is measured by the total primary productivity (i.e., the amount of forest vegetation that can capture solar energy and store it). Avoiding logging on wet soils and preventing erosion is a simple but effective way of preserving the productivity of the land and practicing good land stewardship.

Streamside management zones buffer and protect aquatic resources from sedimentation and stream water temperature increases, as well as other adverse effects. However, the relatively high levels of canopy cover required in these zones would have a long-term effect on the species composition of these areas. Without larger canopy openings, species composition would change, to include more shade tolerant species. Many of the nonperennial streams, including ephemeral streams, are also a part of the highly productive yellow-poplar – mixed hardwood cove sites. These sites are capable of producing the highest quality hardwoods with high monetary value. However, without larger canopy openings, species such as black cherry would no longer be able to compete successfully on these sites. Not cutting trees from stream banks would protect the channel and provide a structural barrier to trap large woody debris.

The prescribed fires proposed in the action alternatives would primarily effect smaller woody vegetation (less than 5 inches dbh). Past prescribed fires on the FEF have primarily reduced understory density of woody stems less than five inches dbh (Schuler et al. 2013). Prescribed fire in all compartments 13, 21, 45, and 48 would continue to reduce the number of stems that are in the lower canopy strata. Some trees not directly killed by fire may be prone to storm damage and/or attack by insects or disease. Two prescribed fires in compartment 49 (2002/03 and 2005) did result in small changes to the canopy. There was evidence that openness differed slightly between the burned and the unburned portions of the study in 2007 during the first year of hemispherical sampling ($p = 0.0261$). Mean openness was 8.9 and 7.2 percent for the burned and unburned portions of the study area, respectively. Maximum percent openness was 10.8 for the burned plots and 7.8 for the controls. Mean DSF, a measure of solar flux calculated from hemispherical imagery, was 17.8 and 12.0 percent for burned and unburned plots of the compartment, respectively. However, these differences were not statistically significant ($p = 0.1327$). Maximum DSF below the canopy was 35.2 percent for the burn area versus 15.5 percent in the unburned controls.

In compartment 45, a similar effect is anticipated if prescribed fires are continued. Reductions in overstory density from the use of past stem injection herbicides should promote the development of more understory stems overtime. The resulting stand structure would be more open and have more standing snags.

Alternative C – Modified Proposed Action

Species composition

The only difference between alternatives B and C is the addition of planting and herbicide treatments to compartments 7A, 7B, 9A, 9B, 17A, 17B, 18C, 19A, and 20A, watersheds 2A, 2B, and 5A. The purpose of these treatments is to attempt to increase tree species diversity in the understory/advanced reproduction layer. The areas chosen for this treatment are all in areas currently in a long-term study of cutting practices and will help us determine if management practices can maintain forest resiliency with changing climate.

Age Classes

Since the timber harvest and prescribed fire actions are the same as Alternative B, Alternative C has the effect on age classes as listed under effects for all action alternatives.

Threated, Endangered, and Sensitive Species

Since the timber harvest and prescribed fire actions are the same as Alternative B, Alternative C has the effect on age classes as listed under effects for all action alternatives.

Herbaceous Layer

There may be some short-term reductions in numbers of stems in those areas where herbicide is applied and understory planting of tree seedlings takes place. The treatments will be applied to 0.5-acre plots within the larger harvested areas, and total only 6 acres of disturbance over five years; the direct impacts should be short-term and limited in extent

All Alternatives

Two aspects of climate change are discussed below: 1) climate change effects on project area resources, and 2) project effects on climate change via changes in carbon storage. The scope of the analysis for direct and indirect effects of climate change on the project is the project area over the next 85 years. The timeframe was chosen because it aligns with a recent climate change vulnerability assessment for the Central Appalachians. The scope of the direct, indirect, and cumulative effects of the project on climate change is at a larger spatial scale because greenhouse gas emissions are mixed in the atmosphere and statistical confidence in carbon data is more robust at scales beyond the project level. We discuss carbon dynamics over the lifespan of the forests in in the project area.

Climate Change

Butler et al. (2015) describes the vulnerability of forested ecosystems in the Central Appalachians to anticipated changes in climate based on model predictions. This assessment is the source for the cumulative effects addressed here. Two climate models under two greenhouse gas emission scenarios (one low and one high) were used in this assessment with climate projected over the next century (2070-2099). These results were compared to averages over the last 30 years of the 20th century. Results from the models for temperature and precipitation were downscaled and then used as inputs into models that describe the impacts climate has on tree species (LINKAGES, LANDIS PRO, and Tree Atlas).

Under both high and low emission scenarios, average temperatures across the Central Appalachians are projected to increase; 1 to 4 °F under the low scenario and 4 to 12 °F under the high scenario. The models project a wide range of possible future precipitation trends, although

both agree that precipitation is projected to increase in winter and spring. Under the high emissions climate scenario this increase could be 1 to 3 inches over the 30-year trend. The timing of possible decreases in precipitation differs by model, occurring in either summer or fall, depending on scenario. The projected higher temperatures coupled with precipitation decreases in the growing season may cause greater moisture stress.

Based on projections from the two climate model-emissions scenario combinations and the three forest impact models, the evidence suggests that across the Central Appalachians fire risk will increase, tree reproduction will be vulnerable to changes in soil moisture patterns, suitability for southern tree species will increase, and suitability for northern species will likely decline. All of these stressors could also lead to greater threats from non-native invasive species, pests, and pathogens. Again, these projections are for the long-term, over the next 80 years or so.

The regional assessment identified nine forested ecosystems and described potential impacts in greater detail. The Dry/Mesic Oak Forest and Mixed Mesophytic and Cove Forest used in the assessment correspond to the forest types found on the FEF. In the Dry/Mesic Oak Forest, habitat suitability and growth for white oak are expected to remain stable. The projected response of red oak, one of the dominated species of this type on the FEF, is highly variable but models suggest a positive effect on regeneration potential where suitable habitat remains. For chestnut oak and scarlet oak, suitable habitat and growth are projected to decline.

For the Mixed Mesophyitc and Cove Forest, suitable habitat and growth of American beech, hemlock, and sugar maple are projected to remain stable under the low emission scenario but decline under the high emission scenario. These key species are likely to be susceptible to moisture stress as climate changes. Red maple, yellow-poplar, black cherry, and white ash show mixed responses to modeled climate change with loss of suitable habitat but maintenance of growth and volume. As in the other forest type, red oak shows highly variable response to projected changes, but models suggest a positive effect on regeneration potential where suitable habitat remains. Possible future stressors in both forest types include increased drought and increased susceptibility to insects and diseases. The diversity of both ecosystems and the complex topography on which they occur may buffer these ecosystems from future climate changes.

To the extent that experimental manipulations promote such species as sugar maple on the FEF, it is possible that the action alternatives would exacerbate future forest health issues. Conversely, by reducing stocking through planned harvests, the ability of the manipulated stands to adapt to climate change may improve. Prescribed fire often favors oak species over northern hardwood species that will not be as well adapted to a warming trend over the next century. More generally, forest management strategies to prepare forests for climate change often include stocking reductions to improve individual tree fitness and manipulation of species composition to retain diversity. Thus, the action alternatives may have both positive and negative impacts on forest health that are not realized until many decades later. However, understanding how forests change through time and with novel disturbance regimes, such as those brought about by climate change, is one of the underlying principles of our long-term forest management studies. Continuing these studies well into the future will enable researchers and scientists to better gauge the impacts of climate change and develop appropriate mitigation strategies.

The private land that is immediately adjacent to the FEF is forested and of the same forest types found on the FEF. There are no timber harvests currently occurring on private lands and no

apparent actions in preparation for timber harvest are taking place. The use of prescribed fire on private forest lands in West Virginia is not permitted by the State and therefore not likely to occur near the FEF in the next 5 years. If timber harvest were to occur on private lands surrounding the FEF, the harvest would likely be a partial harvest. With high first-entry yields and easy implementation, diameter-limit harvests occur on much of the privately owned forest in the northeastern United States (Nyland 1992, Fajvan et al. 1998). These partial harvests would result in uneven age class structure within the stands, and depending on the diameter limits employed they would favor the development of shade-tolerant tree species.

The portions of the Monongahela National Forest adjacent to and within 1 mile of the FEF are forested stands and grazing areas. Ecological land types and forest types are similar on the Monongahela National Forest as found on the FEF (Fig. 3-10). No timber harvest, herbicide, planting, or prescribed fire will occur on the Otter Creek Wilderness that borders the FEF to the east by the MNF. The mineral rights under the Otter Creek Wilderness are privately held and could be developed resulting in some land clearing. Other areas of the Monongahela National Forest within 1 mile of the FEF are suitable for timber harvest, but the management areas are not under consideration by the National Forest for any timber harvest, prescribed fire, or herbicide application for the foreseeable future.

Carbon Storage

The proposed action and alternatives would remove biomass as a result of timber harvesting and prescribed fire. This would temporarily reduce the amount of carbon stored in the treated areas. A portion of the carbon removed via harvest would remain stored for a period of time in wood products manufactured form the removed timber. The harvest of live trees and burning of vegetation, combined with the increase in down dead wood, would temporarily convert stands from a carbon sink that removes more carbon from the atmosphere than it emits, to a carbon source that emits more carbon through respiration than it absorbs. These areas would remain a source of carbon to the atmosphere until carbon uptake by new trees and other vegetation exceeds the emissions from decomposing dead organic material. The areas would likely remain a carbon source for several years depending on the amount of dead biomass left onsite and new trees' growth rates once reestablished. As the treated areas continue to develop, the carbon source would change to a carbon sink.

Recent scientific literature confirms this general pattern of changes in net ecosystem productivity (NEP) and carbon stocks over the period of forest stand development. The NEP is defined as gross primary productivity (GPP) minus ecosystem respiration (ER) (Chapin et al. 2006). This measure reflects the balance between (1) absorbing CO^2 from the atmosphere through photosynthesis (GPP) and (2) the release of carbon into the atmosphere through respiration by live plants, decomposition of dead organic matter, and burning of biomass (ER). When NEP is positive, carbon accumulates in biomass. Ecosystems with a positive NEP are referred to as a carbon sink. When NEP is negative, ecosystems emit more carbon than they absorb. Ecosystems with a negative NEP are referred to as a carbon source. Pregitzer and Euskirchen (2004) synthesized results from 120 separate studies of carbon stocks and carbon fluxes for boreal, temperate, and tropical biomes. They found that in temperate forests NEP is lowest, and most variable, in young forests (0-30 years), highest in forests 31-70 years, and declines thereafter as forests age. These studies also reveal a general pattern of total carbon stocks declining after disturbance and then increasing, rapidly during intermediate years and then at a declining rate.

Carbon stocks continue to decline over time until another significant disturbance (timber harvest or tree mortality resulting from drought, fire, insects, disease or other causes) kills large numbers of trees and again converts the area to a carbon source where carbon emissions from decay of dead biomass exceed that amount of carbon removed from the atmosphere by photosynthesis within the forest.

The impacts of the proposed action and alternatives on global carbon sequestration and atmospheric concentrations of CO^2 are very small. However, the forests of the United States significantly reduce atmospheric concentrations of CO^2 resulting from fossil fuel emissions. The carbon stored in forests of all ownerships in the contiguous United States and forest products harvested from those forests is estimated at 216–313 Tg C/yr (McKinley et al. 2011). This rate of carbon sequestration offsets approximately 10% of CO^2 emissions from burning fossil fuels (Birdsey et al. 2006). The short-term reduction in carbon stocks and sequestration rates resulting from the proposed timber harvest and prescribed fire are imperceptibly small on global and national scales, as are the potential long-term benefits in terms of carbon storage. The currently large carbon sink in US forests is a result of past land use changes, including the re-growth of forests on large areas of the eastern U.S. harvest in the 19-20th century, and 20th century fire suppression in the western U.S. (Birdsey et al. 2006). The continuation of this large carbon sink is uncertain because some of the processes promoting the current sink are likely to decline and projected increases in disturbance rates such as fire and large-scale insect mortality may release a significant fraction of existing carbon stocks (Canadell et al. 2007, Pacala et al. 2008).

Current available data on forest carbon is imprecise and statistically nonviable at the project level. What follows is an exercise to provide context for the magnitude of carbon impacts project to illustrate why the project is too small to warrant a more formal quantitative analysis. The MNF stores about 0.00023 Tg C/ha or about 84 Tg total (Heath et al. 2011). About half of the total carbon stored on the forest is aboveground in live and dead trees and herbaceous vegetation, while the remaining is stored belowground in soil and roots (Heath et al. 2011). The FEF is about 1,862 ha. Assuming that carbon density in the project area is similar to the MNF as a whole, then about 0.43 Tg C are stored in the FEF, or about 0.5 percent of the total carbon stored on the MNF.

From another assessment, the forested lands within the Central Appalachian broadleaf forests of Ohio, West Virginia, and Maryland are estimated to hold about 69.1 metric tons of carbon per acre with most of the carbon stored in oak/hickory and maple/beech/birch forests (Butler et al. 2015). With this estimate, the MNF stores about 63,641,100 metric tons of C (63.6 Tg) and the Fernow about 317,860 metric tons (0.32 Tg). These estimates – 84 Tg compared to 63.6 Tg for the MNF and 0.43 Tg and 0.32 Tg for the FEF – demonstrate the difficulty in estimating carbon storage. Thus, it is expected that long-term effects of the proposed action and alternatives on carbon storage and sequestration would be minimal. The no-action alternative would not result in an immediate release of carbon from prescribed burning or harvest.

When combined, the carbon emissions from this and past projects in the analysis area are expected to have a minimal cumulative effect. Since greenhouse gas emissions are thoroughly mixed in the atmosphere, the appropriate cumulative effects boundary would be the globe. However, to provide context, we examine the emissions at the scale of the state of West Virginia. In 2013, the state of West Virginia released 92.93 Tg of C from fossil fuel emissions (US EPA 2013). If all of the carbon currently stored aboveground of the Fernow was lost in one year, this would be equivalent to roughly 0.5 percent of total fossil fuel emissions in the state. However,

project activities are expected to take place over the course of 5 years and most of the management treatments proposed will retain a large proportion of aboveground biomass, thus emissions from this project in a given year are roughly equivalent to 0.001 percent of the fossil fuel emissions released from the state of West Virginia in one year. In addition, we have seen that managed stands with lower stocking levels grow faster and sequester carbon at a higher rate than unmanaged stands (Schuler 2004, Davis et al. 2009) which will offset the short-term loss of carbon due to our proposed treatments. Total C stored over a 55-year period was stimulated about 37 percent with partial harvesting relative to unmanaged forests on the Fernow. Perhaps of more importance than the rate of carbon uptake is maintaining healthy forests region-wide so that they continue to serve as carbon sinks and not become carbon sources due to declining health and widespread mortality. Science to inform managers how to best achieve healthy and resilient forests in the 21st century is a critical need and the primary focus of the Fernow Experimental Forest research activities.

Cumulative Effects

Alternative A – No Action

Species composition

Alternative A would allow the continual buildup of mesic species that is occurring throughout the eastern hardwood forest (Nowacki and Abrams 2008). This would negatively impact future forest health as environmental gradients favor other species. Moreover, understanding how forests change through time and with disturbance regimes, such as those brought about by climate change, is one of the underlying principles of our long-term forest management studies. Terminating these studies would make it more difficult for researchers and scientists to devise strategies to improve forest adaptation and resiliency to future climate change.

Age Classes

There would be no cumulative effects to forest age classes if Alternative A were implemented as no timber harvest will take place. Trees will continue to age and uneven-aged stand condition would develop.

Threated, Endangered, and Sensitive Species

Manipulative research on the FEF involving RBC would terminate if the No Action alternative was implemented beyond the five year life-cycle of this planning period. Discontinuing this research would make it more difficult to achieve the goals of the RBC recovery plan since this species depends upon disturbance. The Endangered Species Act is designed, in part, to prevent species from becoming imperiled and to recover species once they have become imperiled. Success in these endeavors requires more than protection, it requires new knowledge. This alternative would not be consistent with the Endangered Species Act.

Herbaceous Layer

Aside from RBC, Alternative A would not directly affect the herbaceous community with respect to composition or diversity. Physiographic features of different sites would be the dominant factor controlling ground layer composition (Gilliam and Turrill 1993, Gilliam et al. 1995, Jenkins and Parker 1998). Under this alternative there may be a reduced

chance of introducing invasive exotic floral species. Invasive exotics are most often introduced in disturbed areas, such as along roadsides (Bergelson et al. 1993).

Alternative B – Proposed Action

There are no cumulative effects to, species composition, age classes, or the herbaceous layer from Alternative B.

Threated, Endangered, and Sensitive Species

Populations of RBC on the FEF are critical to the recovery of the species. The RBC revised recovery plan (U.S. Fish and Wildlife Service 2007) delineated a goal of 34 self-sustaining populations before delisting this species as federally endangered. The FEF population is one of the largest populations on record, with distribution over about 2,000 acres. In the last Biological Opinion received from the US FWS regarding RBC, the staff at the Timber and Watershed Laboratory was directed to inform the US FWS if silvicultural manipulations were ceased due to concerns about insufficient disturbance for RBC sustainability. Continued silvicultural manipulations proposed under this alternative would provide additional opportunities to evaluate how this species responds to disturbance. The RBC Recovery Plan states that appropriate habitat management techniques are needed and should be evaluated experimentally. The proposed action would continue existing RBC research on the FEF approved by the US Fish and Wildlife Service.

Alternative C – Modified Proposed Action

There are no cumulative effects to age classes or the herbaceous layer from Alternative C.

Species Composition

The modifications made to the proposed action to create alternative C were made with climate change issues in mind. The proposed use of herbicide and under plantings in some areas already under long-term study and including overstory manipulation may show techniques for maintaining species diversity and resilience to anticipated climate change. Continuing these studies well into the future will enable researchers and scientists to better gauge the impacts of climate change, and develop appropriate mitigation strategies.

Threated, Endangered, and Sensitive Species

Cumulative effects for alternative C are the same as for alternative B, the proposed action.

3.8 Recreation Resources

Affected Environment

Tucker County is a noted outdoor recreation destination within the Allegheny Highlands. The FEF is used heavily for recreational purposes including hunting, fishing, hiking, mountain biking, and wildlife and scenic viewing. Hunting is allowed on the FEF including hunting for deer, bear (with and without dogs), and spring and fall wild turkey. Squirrel hunting and ruffed

grouse hunting also occur on the FEF. Fishing, primarily for brook trout, occurs in the main stem of Elklick Run.

The FEF also is routinely used for wildlife and scenic viewing, and is listed as a resource for the West Virginia Watchable Wildlife Program. Spring wildflowers and colorful fall foliage attract both local and out-of-region visitors to the FEF, and organized wildflower and birding tours occur regularly on the FEF. Camping is not permitted on the FEF, but is permitted on the adjacent lands of the Monongahela National Forest. Main roads on the FEF are open year-round, unless significant safety hazards leads to their temporary closure.

The FEF is surrounded on three sides by the Monongahela National Forest. To the west is the 1,977 acre Fork Mountain Area, of which 1,069 acre are National Forest land. To the southwest, is the McGowan Mountain Area (5,424 total acre, 4,987 federally owned). The McGowan Mountain Road (FR 324), which runs south from the FEF along the western edge of Otter Creek Wilderness Area ending at the Yellow Creek trail head, is open year-round and is routinely accessed by the public.

The FEF also shares a common boundary with the 20,000-ac Otter Creek Wilderness, managed by the Cheat Ranger District of the Monongahela National Forest. Set aside by Congressional action in 1975, this area now supports a second-growth mixed mesophytic forest at lower elevations and northern hardwood and red spruce forest types at higher elevations, with dense thickets of rhododendron and mountain laurel along mountain streams throughout. All recreational activities within Otter Creek are dispersed backcountry activities. No wheeled/motorized traffic is permitted. Hiking, camping, hunting and fishing are the main activities pursued by visitors to Otter Creek.

There are 45 miles of trails within Otter Creek, many following old railroad grades, remnants of early 20th century logging. On the FEF, there are two trailheads for the Otter Creek Wilderness trail system, Big Springs Gap and Turkey Run. Approximately 4,500 visitors hike through or camp in Otter Creek annually using these trailheads, the majority of those during the summer months, for an average of 8,768 visitor days (statistics provided from trailhead registers maintained by Cheat Ranger District). Approximately 40 percent of the visitors are local or from West Virginia, with most remaining visitors from surrounding areas (Ohio, Maryland, Pennsylvania, Virginia and the District of Columbia). The trailhead parking areas on the FEF for Big Springs Gap and Turkey Run often are near capacity during summer months, particularly on weekends.

Direct and Indirect Effects

Alternative A - No Action

Direct and indirect effects of the no action alternative on the recreational resource should be minimal. A cessation of logging and prescribed burning would reduce annual soft-mast production of species such as blackberry and blueberry and woody browse production that are important to many game species, such as white-tailed deer and black bear, which are valued by the hunting public. There would be no visible forest management activities that may deter some users or impair the recreational experience of those viewing scenic resources.

Alternative B – Proposed Action and Alternative C – Modified Proposed Action

Because of the small acreages and short duration of the prescribed burning treatments (14-20 days total during the next 5 years), the impact on the recreational resource would be minimal. However, it is expected that there would be temporary impacts to scenic views, day hikes, and wildlife watching on days when burning occurs. Spring burning could interfere with spring turkey season and fall burning could interfere for a short time with bow-hunting for white-tailed deer and squirrel hunting due to partial road closure or actual burning. The areas planned for the prescribed fire treatment would be closed to the general public during the activities. Recreational visitors would be informed of alternative areas open to their use, and of the nature and purpose of the research resulting in the closure.

There may be some temporary effects for visitors seeking a Wilderness experience hearing or seeing ongoing logging for research or by visiting recently harvested plots. However, the logging occurs during the winter dormant season, when visitor numbers to Otter Creek Wilderness are lowest, so impacts would be minimal.

Cumulative Effects

Alternative A - No Action

Cumulative effects of the no action alternative include the curtailment of logging and prescribed burning. This would accelerate the shift of forests on the FEF to older, shade-tolerant community types that provide less hard mast (acorns) and certain soft mast (black cherry and wild grape) in future forests critical for game species such as white-tailed deer, black bear, and wild turkey, and therefore, could reduce available hunting opportunities slightly.

Skid roads and landing decks that remain open and in an early successional stage are used heavily as travel corridors and foraging areas by wildlife. With the no action alternative, these would eventually revert to denser vegetation. Reduction of these areas would impact hunter access and diminish hunter success on the FEF, particularly for white-tailed deer and ruffed grouse. Similarly, abandonment of these skid roads also may reduce the access of some wildflower enthusiasts and birdwatchers to interior, off-road portions of the FEF.

Alternative B – Proposed Action and Alternative C – Modified Proposed Action

The FEF is located within an area of 26,056 acres of the Monongahela National Forest where no timber harvest or prescribed burning activities are planned within the foreseeable future. Therefore, the cumulative effects of the proposed activities on recreational resources would likely be insignificant or positive. By ensuring a diversity of habitat and forage for game species, hunting activities and wildlife viewing opportunities would be maintained or enhanced over the long-term through habitat changes as a result of research logging and prescribed burning as indicated in the section 3.6 Wildlife Resources**.** Additionally, treatment of invasive exotic plants would have positive impacts by rehabilitating degraded native wildlife habitat.

3.9 Heritage Resources

Affected Environment

The FEF consists of lands that were originally granted to Francis (or Frances) and William Deakon (or Deakins) in 1783. Deakon's heirs sold the land to Jonathan Arnold in 1856, and Arnold's son Thomas J. sold the timber rights to the Elk Lick Lumber Company in 1901. The Elk Lick Lumber Company built a logging railroad, and cut timber between 1903 and 1911 (Trimble 1977).

Arnold's holding of 7,123 acres was the first purchase unit of the Monongahela National Forest in November 1915. Within the area purchased was a 3,640 acre tract that in 1934 became the original experimental forest, named for Bernhard E. Fernow, a pioneering forester. Early maps show limited access into the area, and only one house location. Flat ground on the FEF is scarce, providing little arable land. Most ridge tops are narrow with steep slopes creating V-shaped valleys with little or no flat ground adjacent to streams. There are several flat dry benches on the western slopes of McGowan Mountain of limited size.

During the 1930s, the Civilian Conservation Corps built roads, bridges, culverts, a dam, and a water line. After World War II, forest research and experiments began in earnest.

For the purposes of this analysis, effect means the alteration to the characteristics of a historic property qualifying it for inclusion in, or eligibility for the National Register of Historic Places (NRHP) per the definition in 36 CFR 800.16(i). Historic property means any prehistoric or historic district, site, building, structure, object or historical/cultural landscape included in, or eligible for inclusion in the National Register of Historic Places maintained by the Secretary of the Interior. This term also applies to any cultural resource or property not yet evaluated to determine whether it is eligible for the NRHP. This term includes artifacts, features, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or native Hawaiian organization and that meet the National Register criteria per the definition in 36 CFR 800.16(l).

The historic properties within the FEF are under stewardship of the Heritage Resources Program of the MNF. As such, the proposed action and alternatives were reviewed in accordance with the programmatic agreement among the USDA Forest Service, Monongahela National Forest, The West Virginia Division of Culture and History, and the Advisory Council on Historic Preservation regarding the process for compliance with Section 106 of the National Historic Preservation Act, as amended.

The area of potential effects has been surveyed for the identification of historic properties multiple times. The Forest Service conducted an identification survey which included the current area during 2000, and then hired a qualified consultant, Northern Ecological Associates, Inc., during 2003 for additional identification and delineation of, as well as internal eligibility recommendations for, historic properties. Additional delineation efforts were made by the Forest Service to establish protection measures for the 2005 and 2010 EIS for the Fernow Experimental Forest. Also during 2004, the Forest Service contracted New South Associates to survey the

built environment of the MNF to assist in the development of a Historic Property Management Plan, which included the FEF. This analysis accounts for all of those previous surveys and recommendations. All sites found during surveys are confidential and specific locations will not be disclosed in this document.

Direct and Indirect Environmental Effects by Alternative

The proposed action and alternatives will have no adverse effects to historic properties. Standard protection measures will include avoidance or other appropriate forms of mitigation of all direct and indirect effects to historic properties, as stipulated in the MNF programmatic agreement. Heritage resources that have been previously evaluated and found to be not eligible for the National Register require no further consideration during project planning or implementation.

The adjacent Corricks Ford Battlefield will not be adversely affected by the proposed actions. The historic property is eligible for National Register under Criterion A because of the association with significant events or activities within the broad patterns of national history. The battlefield may also be eligible under Criterion B because of the association with the casualty of General R.S. Garnett, the first Confederate General to be killed in action during the Civil War. The battlefield may even be eligible under Criterion D because of the potential to yield important historic information. The proposed action and alternatives will not alter these characteristics. The Corricks Ford Battlefield would not be eligible under Criterion C because it is not an embodiment of distinctive physical type of period characteristic of design, construction, or form. In other words, the physical and visual integrity of the property is not a characteristic that contributes to the eligibility. Regardless, there is approximately 800 meters (~2,265 feet) of forested land that provides a visual buffer between the proposed action and the historic property boundary. The proposed action would also occur on the eastern side of Fork Mountain, further negating the effects to the visual integrity of the battlefield, which lies to the west of the Fork Mountain ridge.

All standard protection measures will avoid direct and indirect effects to historic properties and are in accordance with the MNF programmatic agreement.

Alternative A – No Action

Alternative A will have no adverse effect to historic properties. Routine maintenance of roads, wildlife openings and trails within the FEF would be implemented programmatically and reviewed by the MNF Heritage Program Manager on a case-by case-basis.

Environmental Effects Common to Alternatives B and C

All action alternatives have the same determination of no adverse effect to historic properties. All alternatives will adhere to the stipulations set forth by the MNF programmatic agreement.

Alternative B – Proposed Action

Alternative B will have no adverse effect on historic properties. Standard protection measures will be carried out for each undertaking in accordance with the programmatic agreement among the USDA Forest Service, Monongahela National Forest, The West Virginia Division of Culture

and History, and the Advisory Council on Historic Preservation regarding the process for compliance with Section 106 of the National Historic Preservation Act, as amended.

Commercial Timber Harvest

There are three historic properties within the proposed commercial timber harvest units. Standard avoidance measures will be implemented to eliminate or minimize adverse effects to historic properties. Activities within the boundaries of each property shall be prohibited with the exception of using developed Forest transportation system.

Application of Fertilizer

There are no historic properties within the proposed units for the application of fertilizer. Furthermore, the application of fertilizer is exempt from Section 106 review and consultation because it has limited-to-no potential to affect historic properties.

Prescribed Fire

Prescribed burns using previously existing fire lines, where no above ground historic properties will be affected, are exempt from Section 106 review and consultation.

Maintenance of Fernow Experimental Forest

Road maintenance activities within the FEF will be implemented programmatically as needed. There are three culverts and two bridges along FSR 701 that are designated as historic properties. Standard protection measures shall be implemented to avoid adverse effects to these five historic properties. Written approval from the MNF Heritage Program Manager is required before implementation of protection measures for these five historic properties on a case-by-case basis. If the MNF Heritage Program Manager determines that necessary maintenance cannot be carried out under the provisions of the MNF programmatic agreement, additional consultation with the West Virginia Division of Culture and History shall be initiated pursuant to 36 CFR 800.

The management activities such as seeding decks and landings, using herbicides to control the spread of invasive plants, and felling trees to maintain openings around weather stations are exempt from Section 106 review and consultation.

Alternative C - Modified Proposed Action

Alternative C will have no adverse effect to historic properties. Herbicide treatment and seedling planting are exempt from Section 106 review and consultation.

Cumulative Effects

The potential for cumulative effects is not significant for any alternative. The FEF and most of the surrounding area are under stewardship of the MNF heritage program. All present and future undertakings must be reviewed for effects to historic properties. The probability of impacts from adjacent private land to these historic properties is extremely low.

3.10 Economic Resources

Affected Environment

The analysis focuses on proposed actions occurring within the boundaries of the Fernow Experimental Forest (FEF), located in Tucker County, West Virginia. The time period of the analysis is for fiscal years 2016 through 2020. Timber values are based on the anticipated volumes to be harvested by fiscal year (Table 3-7), and the average bid price for timber sold on the FEF in 2014 ($0.30 per board foot). This price was close to the average stumpage price across all species for Region 3 in West Virginia (Appalachian Hardwood Center 2015), weighted by relative species volume in the sawtimber inventory of West Virginia (U.S. Forest Service, Forest Inventory and Analysis 2015), which was calculated to be $0.28 per board foot.

Costs for management activities were estimated by FEF staff based on prior experience. Since the exact years for the prescribed fires are unknown, they were spread between years 2, 3, and 4 of the analysis period for discounting purposes, with the largest analyzed as occurring in year 3 (2018) in the middle of the study period.

The standard discount rate of 4 percent for Forest Service projects (including use in the 2010 Final Environmental Impact Statement for the FEF) was used to determine the present values (*PV*) of future costs and benefits (*FV*), using the general formula for calculating present value: $PV = FV/(1+r)^n$, where r is the discount rate and n is the number of years in the future (Hyman 1993). All inputs and outputs used in the analysis are on file at the Timber and Watershed Laboratory, Parsons, West Virginia.

Direct/Indirect Effects

Alternative A – No Action

There are no estimable monetary costs or benefits associated with implementing the No-Action alternative; thus, the benefit/cost (B/C) ratios cannot be used to directly compare the proposed actions to this alternative. However, there are several other effects to consider. Silvicultural treatments in several existing long-term research studies would be terminated, along with long-term fertilization studies. A loss of new knowledge therefore would be associated with no action. Other treatments including invasive species control also would be discontinued. There would be no revenues generated in association with timber harvests.

Alternative B – Proposed Action and Alternative C – Modified Proposed Action

Under both alternative actions, approximately 2,213,060 board feet of timber will be harvested using conventional logging systems. The difference between the alternatives comes with the added costs that modify the proposed action.

Table 3-8 lists estimated cash flows for each transaction. The B/C ratio for the proposed action (Alternative B), calculated by dividing the sum of the discounted benefits by the sum of the discounted costs, is 12.2. The present values of the benefits and costs are $568,156 and $46,504, respectively.

For the modified proposed action (Alternative C), which adds the costs of herbicide and under plantings, the B/C ratio was reduced to 11.6 as the present value of the benefits remains the same but the discounted costs increase to $49,175.

These B/C measures can be used by the Responsible Official to determine how much costs could rise without making the projects economically unattractive (by dropping below 1.0). Since the ratios for both alternatives are greater than 1.0, it does inform the Responsible Official that both alternative actions provide economic benefit (Hyman 1993). Such analysis is informative even though the primary basis for the proposed actions is not purely economic, but rather achievement of research-based objectives. It should also be noted that costs, such as employee salaries and other administrative costs, are not part of this analysis as they would not be affected by any of the three alternatives.

Cumulative Effects

Alternative A

Silvicultural treatments in existing research studies would be terminated; thus, fewer professional and educational visitors would come to the FEF because the demonstration value of these studies would decrease in the absence of ongoing scientific activity. Recreational hunting opportunities would be reduced because dispersed early successional habitats would be diminished. Overall, fewer visitors to the FEF may negatively impact the small local economy. In addition, the new knowledge to be gained by continuation of long-term silvicultural experiments on the FEF would be impaired, which would reduce the long-term economic returns possible for landowners and managers locally and beyond.

Alternative B – Proposed Action and Alternative C – Modified Proposed Action

Tucker County, home to the FEF, has a small population that was estimated to be 6,927 in 2014 by the U.S. Census Bureau (2015). This figure represents a 3.0 percent decline in population in Tucker County from 2010, which is greater than the 0.1 percent decline for West Virginia as a whole. Nationally, population rose by 3.3 percent from 2010 to 2014. In 2013, there were 2,053 persons employed in nonfarm jobs in Tucker County. Median household income in Tucker County was $37,635 for the 2009-2013 period (i.e., the last period for which data were available), which is lower than both the West Virginia state-wide median ($41,043) and the overall U.S. median ($53,046). Persons living below the poverty level was 17.7 percent in Tucker County from 2009 to 2013, similar to the state-wide level for West Virginia (17.9 percent) but higher than the national figure (15.4 percent).

The above economic statistics notwithstanding, it is unlikely that either of the proposed actions considered in this analysis would have a measurable effect on county-wide employment over the time period considered. However, any decisions with measurable economic benefits would be positive toward helping sustain the local economy given the economic demographics of the region.

3.11 Effects on Consumers, Civil Rights, Minority Groups and Women

Forest Service activities must be conducted in a discrimination-free atmosphere. Contract work that may be generated from this document would include specific clauses offering civil rights protection. The Forest Service will make a concerted effort to enforce these policies. Executive Order 12898 of February 11, 1994, Environmental Justice as Part of the National Environmental Policy Act (NEPA), calls for consideration of the environmental, health and economic effects to minority and low-income areas including the consumption patterns for fish and wildlife. The alternatives were assessed to determine whether they would disproportionately impact minority or low income populations, in accordance with Executive Order 12898. No local minority or low income populations were identified during scoping or effects assessment. No alternatives considered in detail, including the no action alternative, will have a disproportionate impact on minority or low income populations. All affected communities have been involved in the public comment period of this project and will have an opportunity to comment on the FEIS. No minority or low income populations are expected to be impacted by implementation of any of the alternatives.

From 2009 to 2013, 17.7 percent of Tucker County's population consisted of persons living below the poverty, similar to the state-wide level for West Virginia (17.9 percent). Only 1.5 percent of the population in Tucker County identified as an ethnicity other than white, while West Virginia's population consists of 6.3 percent minority population (U.S. Census Bureau 2015). To qualify as an environmental justice community, the percent of low-income and minority populations much be at least twice that of the state of West Virginia (target of 34.8 percent low-income and 13.0 percent minority). Therefore, demographic information indicates that Tucker County does not qualify as an environmental justice community.

3.12 Irreversible and Irretrievable Commitment of Resources

Irreversible commitments of resources are actions that change either a nonrenewable resource (such as heritage resources or minerals) or a renewable resource to the point that it can be renewed only after 100 years or more. The construction of permanent roads for timber harvesting is an example of an irreversible action because of the time it takes for a constructed road to revert to natural conditions. There is no permanent (haul) road construction proposed in this FEIS.

Irretrievable commitment of resources includes lost production or lost use of renewable resources due to management decisions. Such decisions are reversible, but the production opportunities foregone are irretrievable. As an example, deferring treatments, including harvesting, at this time would be an irretrievable commitment of research activities that are on a prescribed schedule. The commitment is irretrievable rather than irreversible because future activities could treat those areas if they are still available.

Measures to protect resources that could be irreversibly affected by timber harvest have been incorporated in the mitigation measures developed in the action alternatives. These mitigation

measures protect site productivity, soil stability, endangered, threatened and sensitive species, riparian areas, water quality, and heritage resources from irreversible loss.

3.13 Adverse Effects Which Cannot Be Avoided Should the Proposal Be Implemented

The action alternatives incorporate mitigation measures to reduce adverse impacts to resources. In most cases adverse effects can be eliminated. For instance, avoiding sites identified in surveys would eliminate impacts to heritage resources. However, other adverse effects can only be reduced by the use of mitigation measures. Adverse sediment effects may occur to some streams, including Elklick Run, from implementing the preferred alternative (Alternative C – Modified Proposed Action). Mitigation measures can reduce adverse effects to water, riparian, and aquatic resources significantly but may not eliminate them; some sources of negative effects are inherent to the road system itself regardless of research activities proposed here. Mitigation measures have been used to reduce adverse effects to sensitive species to the point that there may be effects to individuals, but project work is not likely to cause a trend to federal listing or a loss of viability.

Adverse impacts to three federally listed species may occur as a result of implementing any of the proposed alternatives. For the northern long-eared bat a determination of may affect, likely to adversely affect was made based on the possibility of removal of roost trees and direct impacts to individuals. For Indiana bat, the probability of an adverse effect is low because of seasonal constraints of logging activities, but could occur due to felling trees which bats would use for roosting in the spring and summer. For running buffalo clover, the proposed actions will result in the taking of individual plants, but will provide the periodic disturbance needed to ensure the species' survival. Other adverse impacts may occur to soils, general wildlife species and wildlife habitat, vegetation, and air quality. However, the intensity and magnitude of these effects are limited in duration and area because these effects are occurring only on a small portion of the total area considered in the analysis.

3.14 Relationship between Short-term Uses of the Environment, and the Maintenance and Enhancement of Long-Term Productivity

The mission of the FEF is to study and explain the role of natural and human-induced factors in the sustainability of central Appalachian forest ecosystems, and to provide management guidelines. Additionally, the productivity and diversity of the soil, water, and other forest resources must be protected. Many of the research activities that quantify management practices on public and private lands as well as the related environmental effects have been ongoing since the late 1940s or early 1950s. These data are critical to future management in the central Appalachian region and beyond to maintain and enhance long-term productivity. The data and research collected improve our understanding of ecosystem processes and lead to better management practices that protect natural resources.

3.15 Possible Conflicts between the Proposed Actions and the Objectives of Federal, Regional, State, and Local Land Use Plans, Policies, and Controls for the Area Concerned

The FEF occurs within the boundary of the MNF. The USDA Forest Service manages system roads and lands. Direction for management of the FEF is found in the 2011 Revised Forest Plan, Monongahela National Forest. Management of the FEF is consistent with this management plan. A Biological Assessment was prepared for activities on the FEF, and has been provided to the US Fish and Wildlife Service. Formal consultation with the US Fish and Wildlife Service regarding impacts to threatened and endangered species will assure shared goals and understanding. Documentation of findings from consultation will be made part of the record prior to a final decision.

Chapter 4 – Supplemental Information

Figures and Tables

Figure 1-1. Map of West Virginia with locations of Monongahela National Forest and Fernow Experimental Forest.

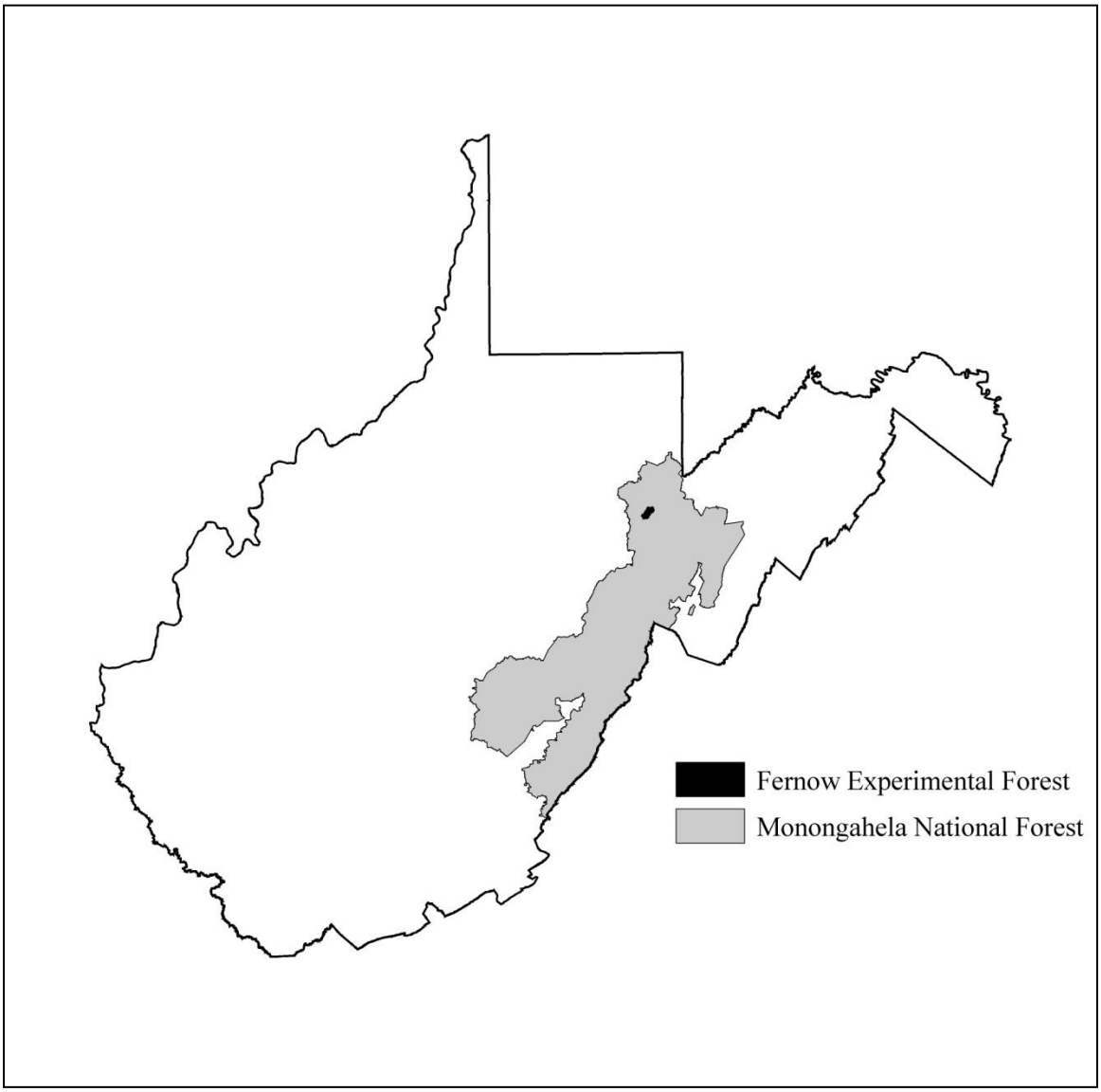


Figure 2-1. Locations of proposed actions listed in Alternatives B and C. The plot-based application of herbicide and underplanting in compartments 7A, 7B, 9B, 17A, 18C, 19A, 20A, and watersheds 2A, 2B, and 5A are not shown at this scale.

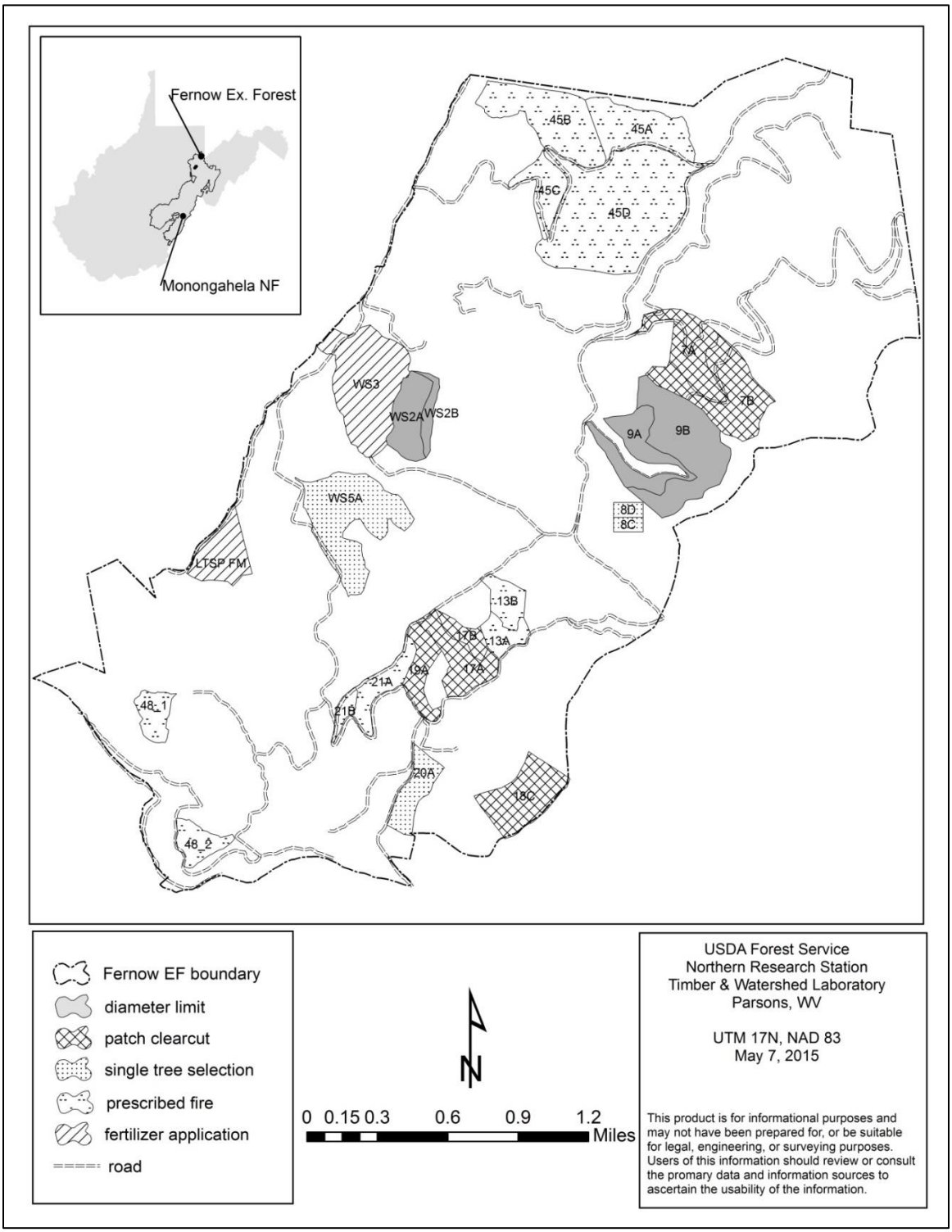


Figure 3-1. Drainages and subdrainages of the Fernow Experimental Forest.

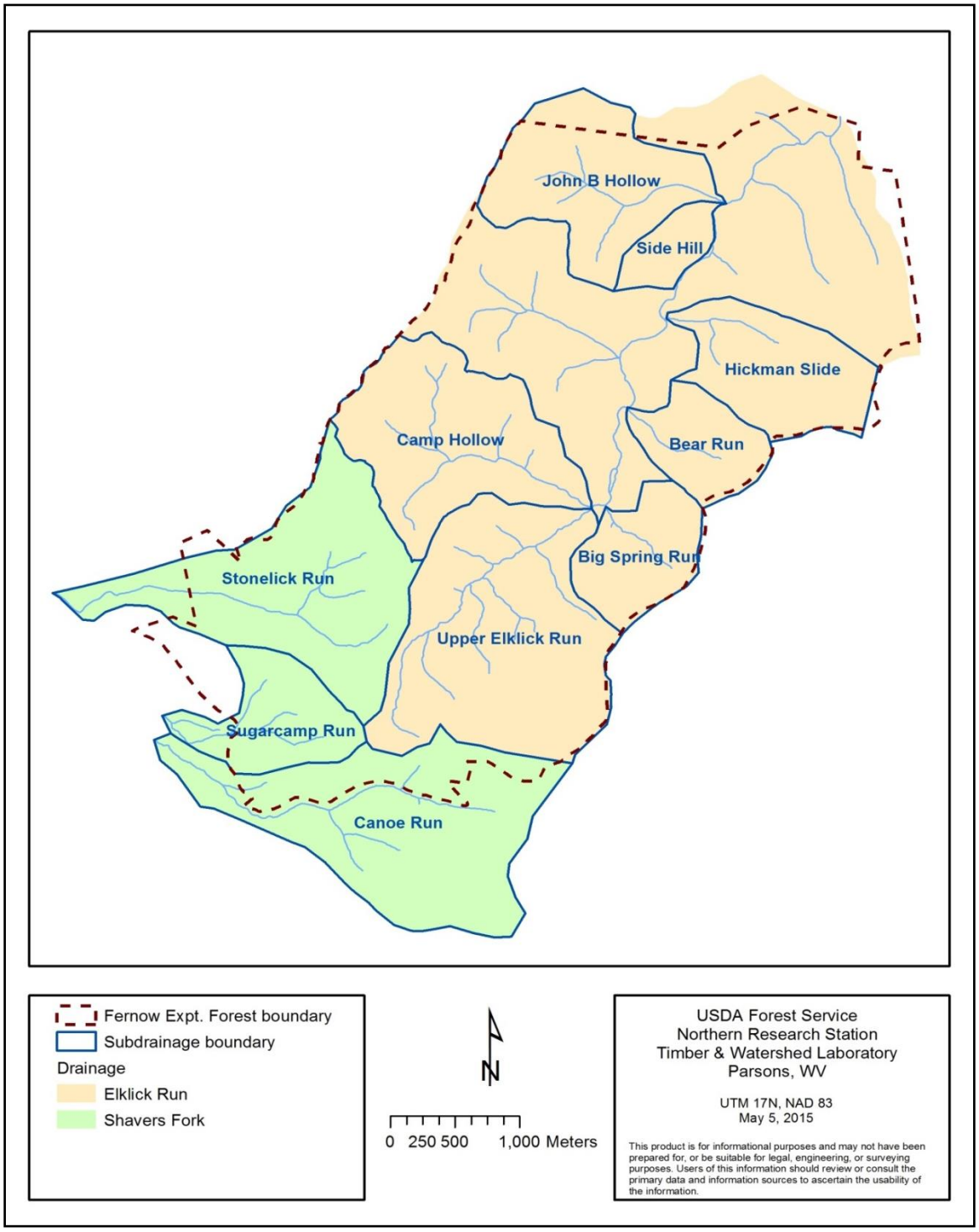
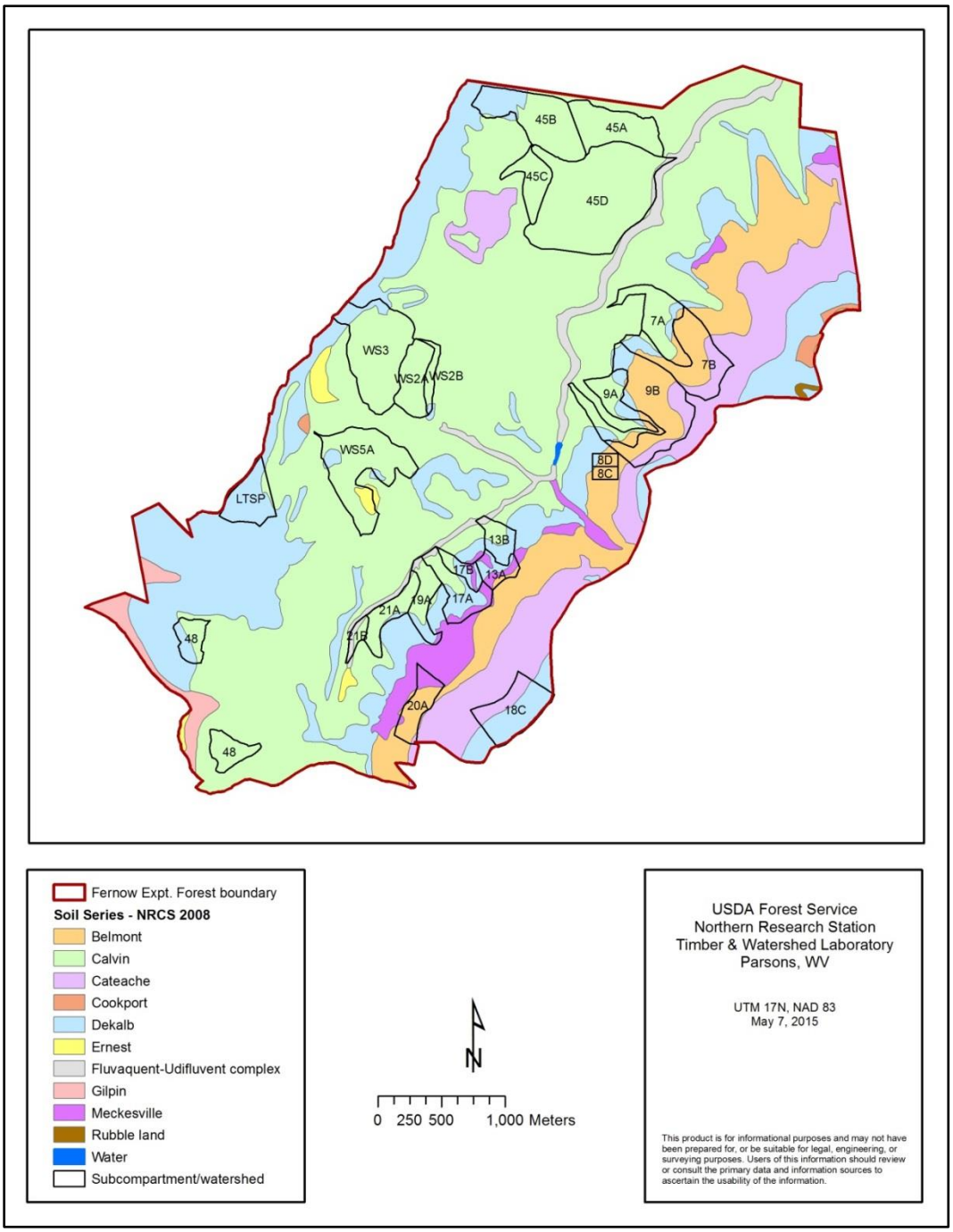
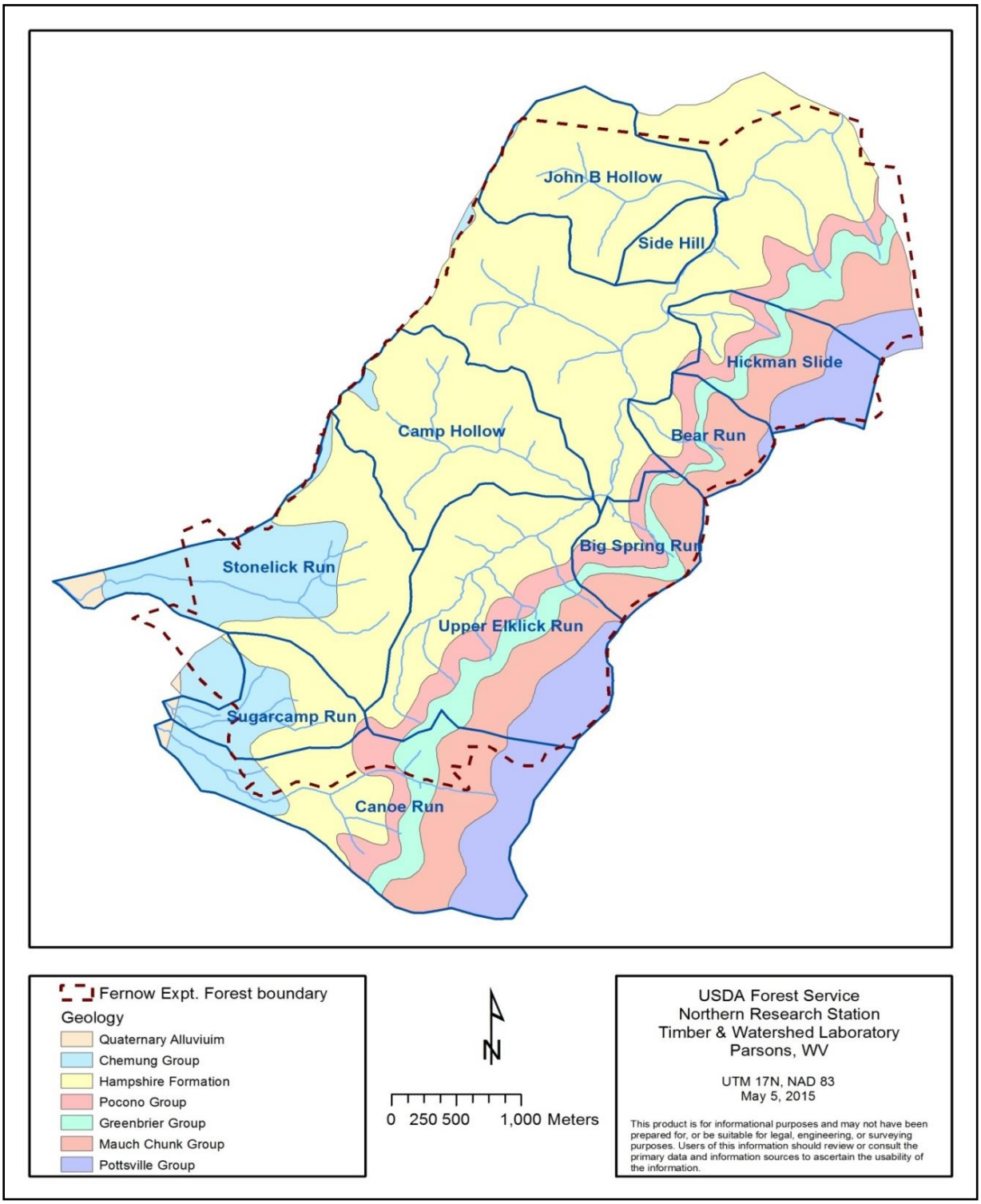


Figure 3-2. Soil series of the Fernow Experimental Forest, with locations of areas proposed for treatment under Alternatives B and C[1].



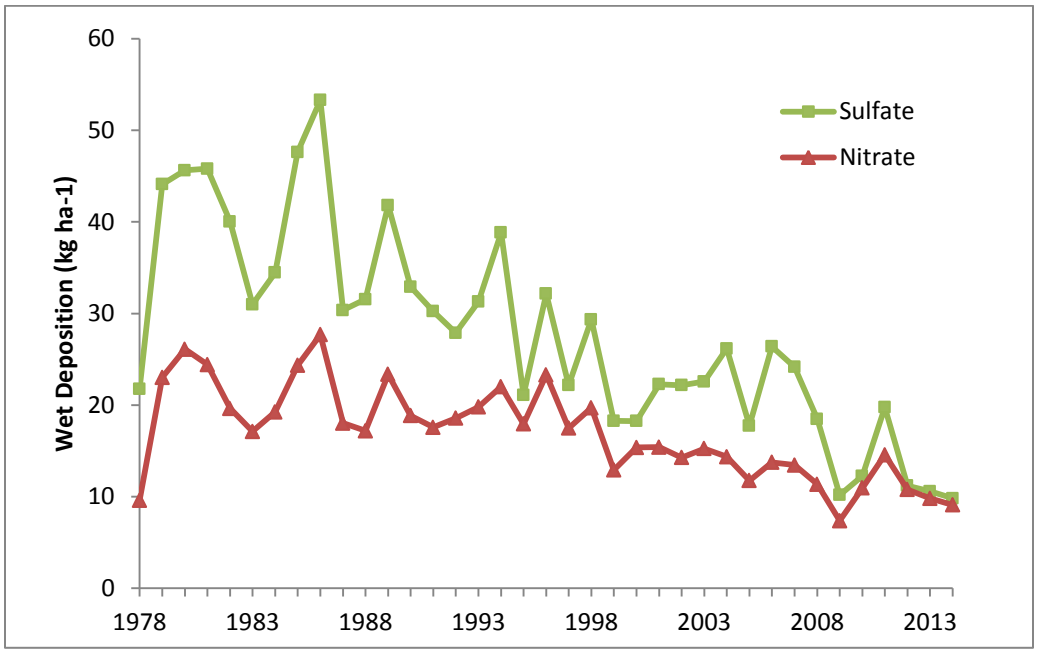
[1]See text for details of treatments and compartment descriptions. Soil series are from the 2008 soils data for the Monongahela National Forest based on NRCS county soil surveys.

Figure 3-3. Geology underlying the subdrainages of the Fernow Experimental Forest[1].



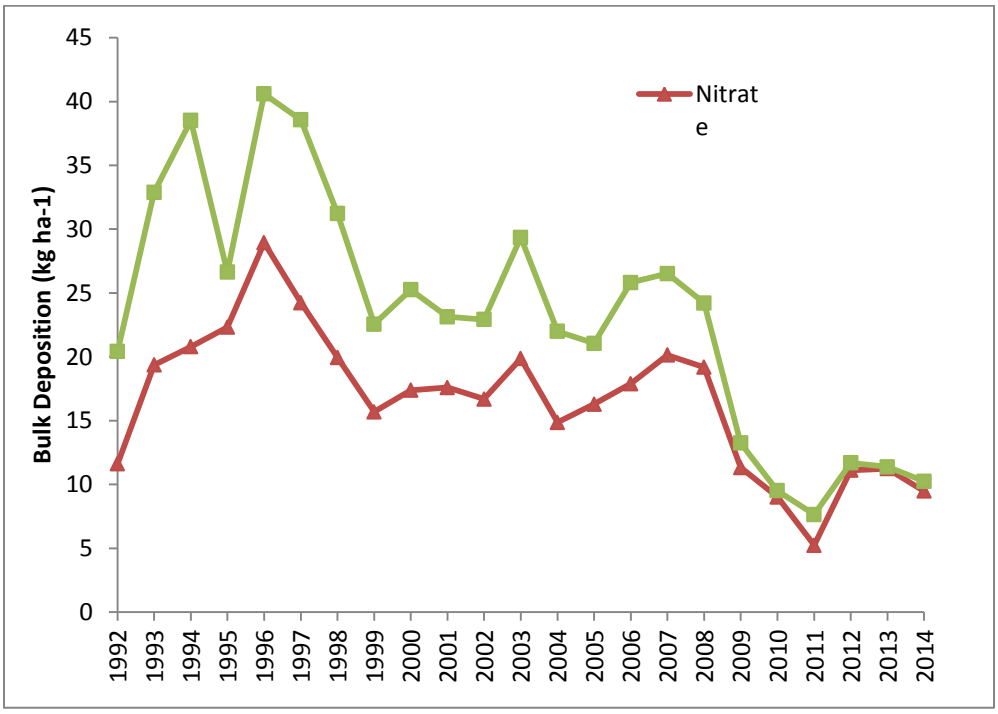
[1]Map based on Taylor and Kite 1998

Figure 3-4. Total wet deposition at the Nursery Bottom location in Parsons, WV[1].



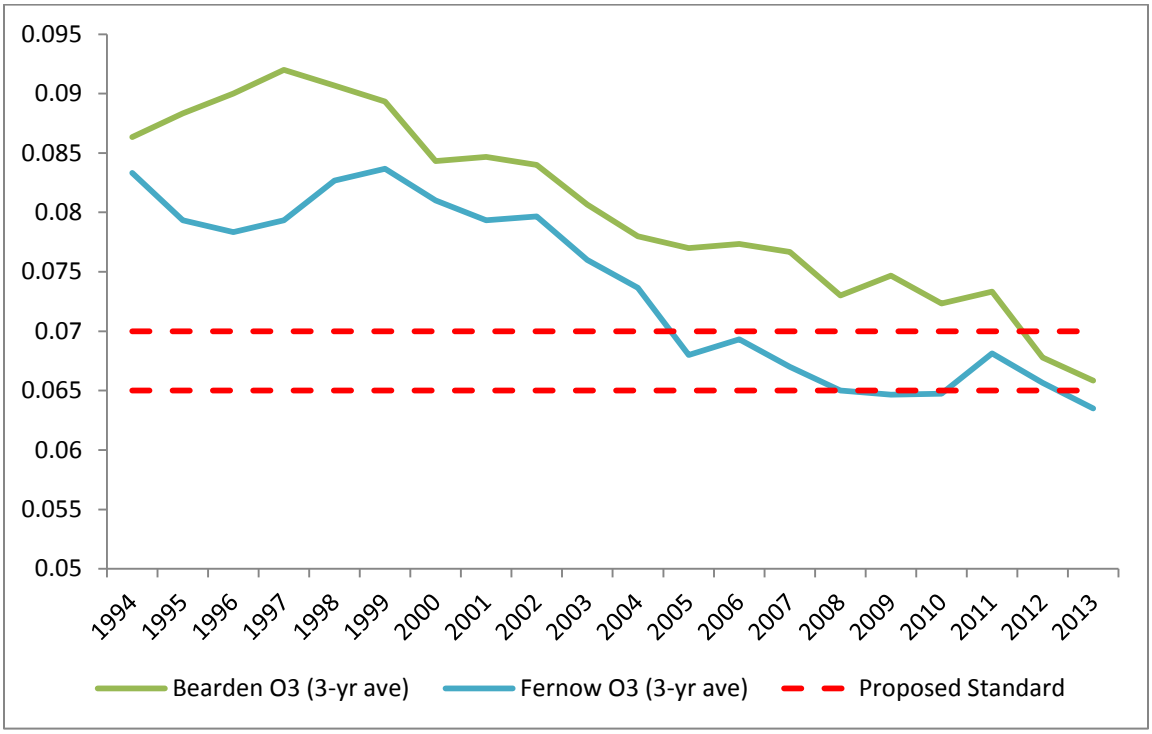
[1]Data from National Atmospheric Deposition Program (NRSP-3) 2015

Figure 3-5. Bulk deposition for sulfate and nitrate at Bearden Knob[1].



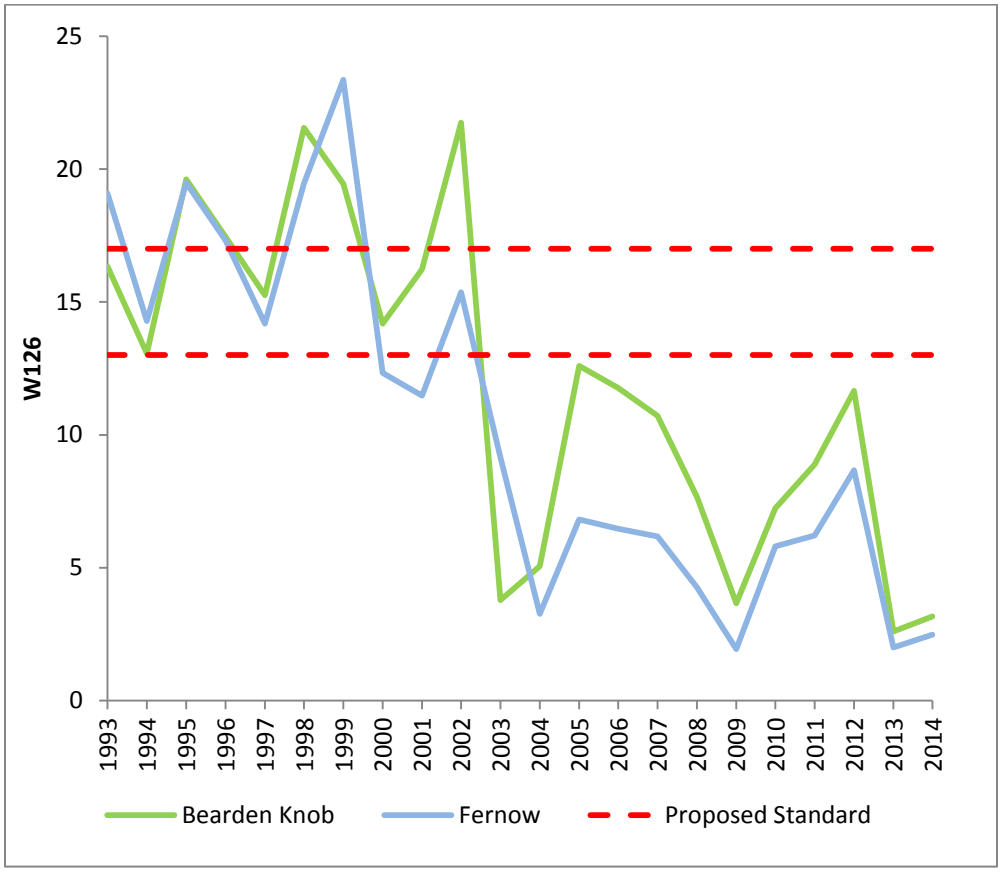
[1]Data from National Atmospheric Deposition Program (NRSP-3) 2015

Figure 3-6. Ozone design values[1] for the Bearden Knob and Nursery Bottom sites, for unofficial comparison with the proposed new primary standard.



[1]EPA defines design value as a statistic that describes the air quality status of a given location relative to the level of the National Ambient Air Quality Standards (NAAQS). Data from National Atmospheric Deposition Program (NRSP-3) 2015.

Figure 3-7. W126 index ozone values for the Bearden Knob and Nursery Bottom sites, compared with the proposed new secondary standard[1].



[1]Data from National Atmospheric Deposition Program (NRSP-3) 2015

Figure 3-8. Map of 2012 Annual PM2.5 Designations.

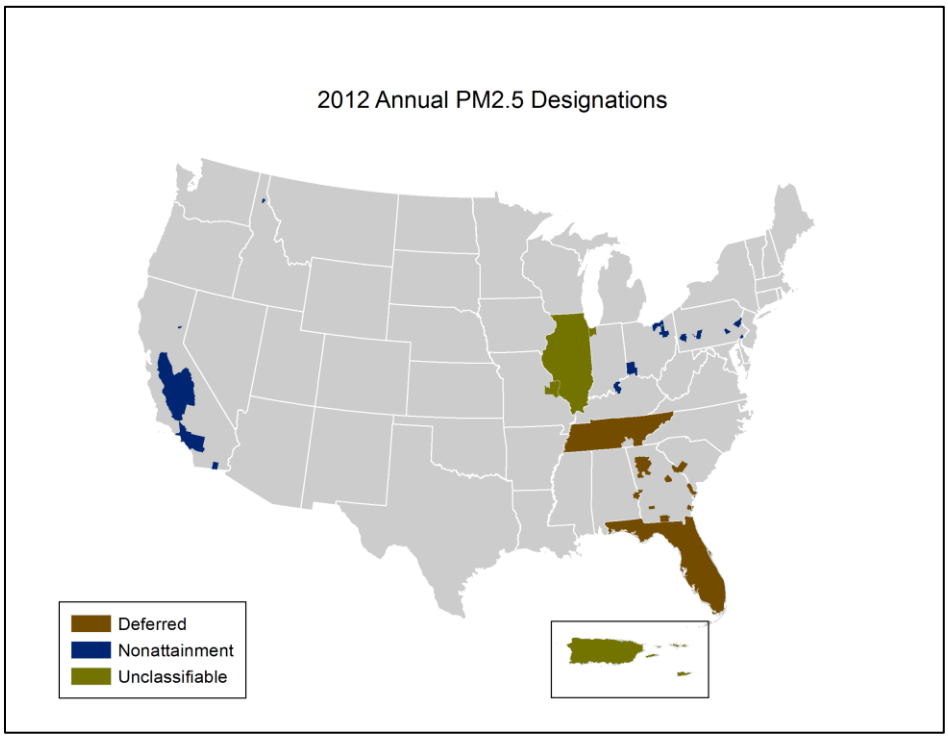
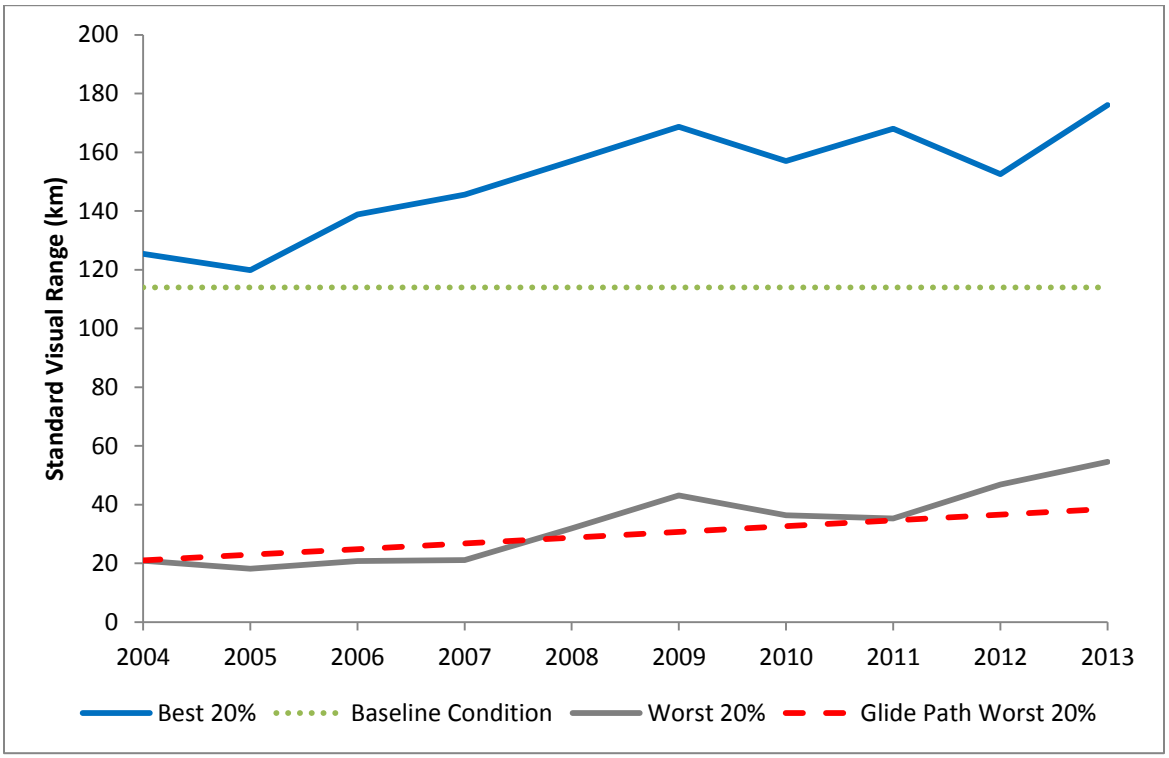
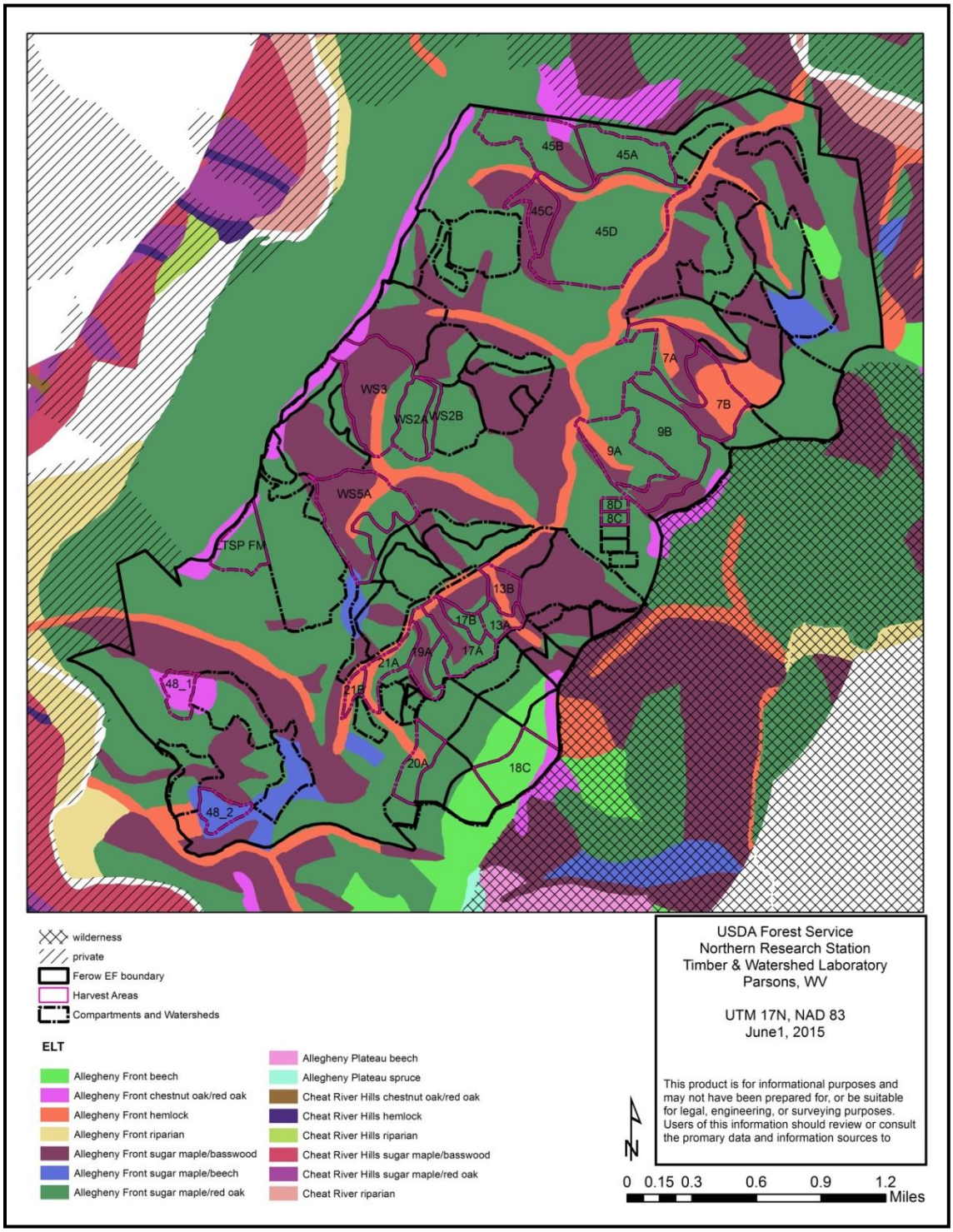


Figure 3-9. Visibility at the Bearden Knob IMPROVE monitoring site measured as Standard Visible Range (km). The top line represents the best 20 percent days for visibility and the bottom line represents the 20 percent worst visibility days[1].



[1]Data from National Atmospheric Deposition Program (NRSP-3) 2015

Figure 3-10. Existing ecological land types on the Fernow Experimental Forest and surrounding national forest and private land[1].



[1]Ecological land types are from DeMeo et al. 1995

Table 3-1. Subdrainages of the Fernow Experimental Forest, description and proposed treatments.

		Ownership		Compartment			Treatment			
Subdrainage	Area (ac)	Federal (%)	Private (%)	Name	Area (ac)	% Subdrainage	Type	Area (ac)	% Subdrainage	BA reduction[1] (%)
Side Hill	83.0	100.0	0.0	45	76.6	92.3	Prescribed fire	76.6	92.3	0
				Other	6.4	7.7		--	--	
				Total	83.0	100.0		76.6	92.3	
John B Hollow	395.5	96.2	3.8	45	224.4	56.7	Prescribed fire	224.4	56.7	0
				Other	171.1	43.3		--	--	
				Total	395.5	100.0		224.4	56.7	
Camp Hollow	489.2	100.0	0.0	WS3	84.7	17.3	Fertilizer additions	84.7	17.3	0
				WS2A	26.8	5.5	Diameter-limit; herbicide and plant	26.8	5.5	38
				WS2B	11.5	2.4	Diameter-limit; herbicide and plant	11.5	2.4	26
				WS5A	78.2	16.0	Single-tree selection; herbicide and plant	78.2	16.0	20
				Other	288.0	58.9		--	--	
				Total	489.2	100.0		201.2	41.1	
Hickman Slide	294.5	100.0	0.0	7A	37.1	12.6	Patch cutting; herbicide and plant	6.0	2.0	23
				7B	59.7	20.3	Patch cutting; herbicide and plant	10.0	3.4	23
				Other	197.7	67.1		--	--	
				Total	294.5	100.0		16.0	5.4	
Bear Run	167.0	100.0	0.0	9A	39.8	23.8	Diameter-limit; herbicide and plant	39.8	23.8	23
				9B	80.9	48.4	Diameter-limit; herbicide and plant	80.9	48.4	38
				Other	46.3	27.7		--	--	
				Total	167.0	100.0		120.7	72.3	
Big Spring Run	200.0	100.0	0.0	8C	5.0	2.5	Single-tree selection	5.0	2.5	19
				8D	5.0	2.5	Intensive single-tree selection	5.0	2.5	19
				Other	190.0	95.0		--	--	
				Total	200.0	100.0		10.0	5.0	

Table 3-1, continued.

Subdrainage	Area (ac)	Ownership		Compartment			Treatment			
		Federal (%)	Private (%)	Name	Area (ac)	% Subdrainage	Type	Area (ac)	% Subdrainage	BA reduction[1] (%)
Upper Elklick Run	736.1	100.0	0.0	13	31.3	4.3	Prescribed fire	31.3	4.3	0
				17A	31.4	4.3	Patch cutting; herbicide and plant	2.4	0.3	25
				17B	11.3	1.5	Patch cutting; herbicide and plant	2.0	0.3	25
				18C	44.5	6.0	Patch cutting; herbicide and plant	7.6	1.0	24
				19A	22.4	3.0	Patch cutting; herbicide and plant	2.8	0.4	23
				20A	18.8	2.6	Single-tree selection; herbicide and plant	18.8	2.6	25
				21	30.9	4.2	Prescribed fire	30.9	4.2	0
				Other	545.5	74.1		--	--	
				Total	736.1	100.0		98.0	13.3	
Stonelick Run	617.8	87.9	12.1	48	1.6	0.3	Prescribed fire	1.6	0.3	0
				LTSP	16.0	2.6	Fertilizer, lime additions	4.0	0.6	0
				Other	600.2	97.2		--	--	
				Total	617.8	100.0		5.6	0.9	
Canoe Run	691.5	100.0	0.0	18C	0.9	0.1	Patch cutting; herbicide and plant	0.4	0.1	24
				20A	6.4	0.9	Single-tree selection; herbicide and plant	6.4	0.9	25
				48	9.7	1.4	Prescribed fire	1.5	0.2	0
				Other	674.5	97.5		--	--	
				Total	691.5	100.0		8.8	1.3	
Sugarcamp Run	221.3	99.9	0.1	48	17.8	8.0	Prescribed fire	16.1	7.3	0
				Other	203.5	92.0		--	--	
				Total	221.3	100.0		16.1	7.3	

[1]Estimated basal area ($ft^2\ ac^{-1}$) reduction based on mean BA reduction for all previous treatments in compartment.

Table 3-2. Subdrainages of the Fernow Experimental Forest, length and area in roads and decks.

Subdrainage and area (ac)	Compartment	Haul roads			Skid roads			Decks		Total	
		Length (mi)	Area (ac)	% Subdrainage	Length (mi)	Area (ac)	% Subdrainage	Area (ac)	percent Subdrainage	Area (ac)	% Subdrainage
Side Hill	45	0.00	0.00	0.00	2.67	4.16	5.01	0.00	0.00	4.16	5.01
83.0	Other	0.00	0.00	0.00	0.47	0.74	0.89	0.00	0.00	0.74	0.89
	Total	0.00	0.00	0.00	3.14	4.90	5.91	0.00	0.00	4.90	5.91
John B Hollow	45	1.59	3.85	0.97	4.76	7.43	1.88	0.00	0.00	11.28	2.85
395.5	Other	0.96	2.32	0.59	1.65	2.58	0.65	0.00	0.00	4.90	1.24
	Total	2.55	6.17	1.56	6.41	10.01	2.53	0.00	0.00	16.18	4.09
Camp Hollow	WS3	0.13	0.32	0.07	2.22	3.46	0.71	0.00	0.00	3.79	0.77
489.2	WS2A	0.00	0.00	0.00	0.73	1.14	0.23	0.00	0.00	1.14	0.23
	WS2B	0.00	0.00	0.00	0.30	0.47	0.10	0.00	0.00	0.47	0.10
	WS5A	0.25	0.61	0.12	2.27	3.54	0.72	0.38	0.08	4.53	0.93
	Other	1.60	3.87	0.79	1.11	1.73	0.35	0.36	0.07	5.96	1.22
	Total	1.98	4.81	0.98	6.63	10.34	2.11	0.73	0.15	15.88	3.25
Hickman Slide	7A	0.68	1.64	0.56	0.70	1.08	0.37	0.07	0.03	2.80	0.95
294.5	7B	0.34	0.82	0.28	1.94	3.02	1.03	0.11	0.04	3.95	1.34
	Other	1.10	2.67	0.91	5.34	8.33	2.83	0.26	0.09	11.26	3.82
	Total	2.12	5.13	1.74	7.97	12.44	4.22	0.44	0.15	18.02	6.12
Bear Run	9A	0.69	1.67	1.00	1.21	1.89	1.13	0.00	0.00	3.56	2.13
167.0	9B	0.27	0.65	0.39	2.65	4.13	2.47	0.27	0.16	5.05	3.02
	Other	0.03	0.08	0.05	1.26	1.96	1.17	0.05	0.03	2.09	1.25
	Total	0.99	2.40	1.44	5.11	7.98	4.78	0.32	0.19	10.70	6.41
Big Spring Run	8C	0.00	0.00	0.00	0.29	0.46	0.23	0.00	0.00	0.46	0.23
200.0	8D	0.00	0.00	0.00	0.18	0.28	0.14	0.00	0.00	0.28	0.14
	Other	1.49	3.61	1.80	1.66	2.59	1.29	0.07	0.03	6.26	3.13
	Total	1.49	3.61	1.80	2.13	3.32	1.66	0.07	0.03	6.99	3.50

Table 3-2, continued.

Subdrainage and area (ac)	Compartment	Haul roads			Skid roads			Decks		Total	
		Length (mi)	Area (ac)	% Subdrainage	Length (mi)	Area (ac)	% Subdrainage	Area (ac)	% Subdrainage	Area (ac)	% Subdrainage
Upper Elklick Run	13	0.00	0.00	0.00	0.81	1.27	0.17	0.00	0.00	1.27	0.17
736.1	17A	0.00	0.00	0.00	0.81	1.26	0.17	0.17	0.02	1.43	0.19
	17B	0.00	0.00	0.00	0.31	0.49	0.07	0.00	0.00	0.49	0.07
	18C	0.00	0.00	0.00	0.97	1.51	0.20	0.00	0.00	1.51	0.20
	19A	0.00	0.00	0.00	0.99	1.54	0.21	0.09	0.01	1.62	0.22
	20A	0.00	0.00	0.00	0.77	1.21	0.16	0.15	0.02	1.36	0.19
	21	0.00	0.00	0.00	0.53	0.83	0.11	0.00	0.00	0.83	0.11
	Other	4.00	9.69	1.32	12.51	19.52	2.65	0.69	0.09	29.89	4.06
	Total	4.00	9.69	1.32	17.70	27.62	3.75	1.10	0.15	38.40	5.22
Stonelick Run	48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
617.8	LTSP	0.00	0.00	0.00	0.42	0.66	0.11	0.00	0.00	0.66	0.11
	Other	2.75	6.68	1.08	5.47	8.54	1.38	0.62	0.10	15.83	2.56
	Total	2.75	6.68	1.08	5.89	9.20	1.49	0.62	0.10	16.49	2.67
Canoe Run	18C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
691.5	20A	0.00	0.00	0.00	0.50	0.78	0.11	0.00	0.00	0.78	0.11
	48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Other	2.01	4.87	0.70	2.57	4.01	0.58	0.00	0.00	8.88	1.28
	Total	2.01	4.87	0.70	3.07	4.80	0.69	0.00	0.00	9.66	1.40
Sugarcamp Run	48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
221.3	Other	1.37	3.31	1.50	1.52	2.37	1.07	0.10	0.05	5.78	2.61
	Total	1.37	3.31	1.50	1.52	2.37	1.07	0.10	0.05	5.78	2.61

Table 3-3. Subdrainages of the Fernow Experimental Forest, length of perennial and nonperennial stream reaches.

Subdrainage	Compartment	Perennial		Nonperennial		Total	
		Length (mi)	% Subdrainage	Length (mi)	% Subdrainage	Length (mi)	% Subdrainage
Side Hill	45	0.00	0.0	0.00	0.0	0.00	0.0
	Other	0.00	0.0	0.00	0.0	0.00	0.0
	Total	0.00	0.0	0.00	0.0	0.00	0.0
John B Hollow	45	1.29	96.9	0.80	35.2	2.09	58.0
	Other	0.04	3.1	1.47	64.8	1.52	42.0
	Total	1.33	100.0	2.27	100.0	3.61	100.0
Camp Hollow	WS3	0.05	4.5	0.98	21.9	1.03	18.3
	WS2A	0.00	0.0	0.33	7.4	0.33	5.9
	WS2B	0.00	0.0	0.00	0.0	0.00	0.0
	WS5A	0.13	11.4	0.97	21.7	1.10	19.6
	Other	0.96	84.1	2.20	49.1	3.16	56.2
	Total	1.14	100.0	4.48	100.0	5.63	100.0
Hickman Slide	7A	0.32	37.5	0.48	34.8	0.80	35.8
	7B	0.00	0.0	0.23	16.8	0.23	10.4
	Other	0.53	62.5	0.67	48.4	1.21	53.8
	Total	0.85	100.0	1.39	100.0	2.24	100.0
Bear Run	9A	0.00	0.0	0.28	28.8	0.28	20.4
	9B	0.00	0.0	0.33	34.0	0.33	24.0
	Other	0.40	100.0	0.36	37.2	0.76	55.6
	Total	0.40	100.0	0.97	100.0	1.37	100.0
Big Spring Run	8C	0.00	0.0	<0.01	0.1	<0.01	0.1
	8D	0.00	0.0	0.03	2.3	0.03	1.6
	Other	0.58	100.0	1.27	97.6	1.85	98.3
	Total	0.58	100.0	1.30	100.0	1.88	100.0
Upper Elklick Run	13	0.05	2.9	0.44	7.3	0.49	6.2
	17A	0.06	3.0	0.77	12.7	0.83	10.4
	17B	0.00	0.0	0.00	0.0	0.00	0.0
	18C	0.00	0.0	0.00	0.0	0.00	0.0
	19A	0.03	1.5	0.55	9.1	0.58	7.3
	20A	0.00	0.0	0.00	0.0	0.00	0.0
	21	0.64	34.4	0.10	1.7	0.74	9.4
	Other	1.09	58.2	4.18	69.3	5.27	66.7
	Total	1.87	100.0	6.04	100.0	7.91	100.0
Stonelick Run	48	0.00	0.0	0.00	0.0	0.00	0.0
	LTSP	0.00	0.0	0.23	4.8	0.23	3.6
	Other	1.53	100.0	4.53	95.2	6.06	96.4
	Total	1.53	100.0	4.75	100.0	6.29	100.0
Canoe Run	18C	0.00	0.0	0.00	0.0	0.00	0.0
	20A	0.00	0.0	0.00	0.0	0.00	0.0
	48	0.00	0.0	0.14	5.7	0.14	3.0
	Other	2.25	100.0	2.32	94.3	4.56	97.0
	Total	2.25	100.0	2.46	100.0	4.70	100.0
Sugarcamp Run	48	0.00	0.0	0.01	0.6	0.01	0.4
	Other	0.65	100.0	2.11	99.4	2.76	99.6
	Total	0.65	100.0	2.12	100.0	2.77	100.0

Table 3-4. Emissions for Tucker and neighboring counties from EPA 2011 National Emissions Inventory.

County	2011 estimated emissions (tons)[1]						
	VOC	NOx	CO	SO2	PM10	PM2.5	NH3
Barbour	5,718	1,186	3,717	74	910	207	99
Grant	8,888	4,195	5,627	3,464	2,103	1,061	765
Pendleton	12,044	591	3,028	28	768	242	1,680
Preston	7,950	2,703	7,557	6,592	1,754	600	250
Randolph	11,254	2,846	9,457	144	1,473	432	145
Tucker	**5,820**	**432**	**3,151**	**47**	**580**	**224**	**38**
Garrett, MD	8,373	1,917	9,213	276	1,083	455	413

[1]VOC – volatile organic compounds, NOx – nitrous oxides, CO – carbon monoxide, SO2 – sulfur dioxide, PM10 – particulate matter < 10 microns in diameter, PM2.5 – particulate matter < 2.5 microns in diameter, NH3 – ammonia

Table 3-5. Comparison of emissions from proposed harvest activities with regional (Tucker and adjacent Counties) emissions.

Average Annual Comparison	NOx	VOC	PM10
Total annual regional emissions (TPY)	13,870	60,047	8,671
Total emission from average annual timber harvest activities (TPY)	0.31	0.37	0.02
Harvest emissions as a percent of total annual pollution load (%)	0.0022	0.00061	0.00023

Table 3-6. Comparison of emissions from proposed prescribed burns to regional emissions.

Comparison	NOx	PM10	PM2.5
Total annual regional emissions (TPY)	13,870	8,671	3,222
Total emissions from prescribed fire (tons)	10	66	56
Prescribed fire emissions as percent of total pollution load (%)	0.072	0.76	1.74

Table 3-7. Estimated harvest by year and compartment.

Harvest year	Compartment	Treatment	Estimated volume removed (board feet)
2016	9A	Diameter limit	281,000
	WS2B	Diameter limit	77,000
2017	9B	Diameter limit	550,000
2018	20A	Single-tree selection	155,000
	WS5A	Single-tree selection	308,000
2019	17A	Patch cut (2.4 ac)	92,000
	17B	Patch cut (2.0 ac)	49,000
	WS2A	Diameter limit	171,060
	19A	Patch cut (2.8 ac)	44,000
	8C	Single-tree selection	23,000
	8D	Single-tree selection	21,000
2020	7A	Patch cut (6.0 ac)	156,000
	7B	Patch cut (10.0 ac)	135,000
	18C	Patch cut (8.0 ac)	151,000

Table 3-8. Benefits and costs used in the 2015 Fernow Experimental Forest economic analysis for the proposed action (and modified proposed action) and their future and present values.

Fiscal Year	Description	Type	Value	Value (addition of mod. proposed action)	Present Value[1]	Present Value[1] (addition of mod. proposed action)
2016	Timber sale	Benefit	$107,400		$99,297	
2017	Timber sale	Benefit	$165,000		$146,684	
2018	Timber sale	Benefit	$138,900		$118,732	
2019	Timber sale	Benefit	$120,018		$98,646	
2020	Timber sale	Benefit	$132,600		$104,796	
2016	Fertilizer (Watershed 3 & LTSP)	Cost	$3,000		$2,885	
2017	Fertilizer (Watershed 3 & LTSP)	Cost	$3,000		$2,774	
2018	Fertilizer (Watershed 3 & LTSP)	Cost	$3,000		$2,667	
2019	Fertilizer (Watershed 3 & LTSP)	Cost	$3,000		$2,564	
2020	Fertilizer (Watershed 3 & LTSP)	Cost	$3,000		$2,466	
2016	Log deck/road repair	Cost	$1,000		$962	
2017	Log deck/road repair	Cost	$1,000		$925	
2018	Log deck/road repair	Cost	$1,000		$889	
2019	Log deck/road repair	Cost	$1,000		$855	
2020	Log deck/road repair	Cost	$1,000		$822	
2016	Invasive species control	Cost	$500		$481	
2017	Invasive species control	Cost	$500		$462	
2018	Invasive species control	Cost	$500		$444	
2019	Invasive species control	Cost	$500		$427	
2020	Invasive species control	Cost	$500		$411	
2016	Herbicide and plant	Cost		$600		$577
2017	Herbicide and plant	Cost		$600		$555
2018	Herbicide and plant	Cost		$600		$533
2019	Herbicide and plant	Cost		$600		$513
2020	Herbicide and plant	Cost		$600		$493
2017[2]	Prescribed fire	Cost	$2,625		$2,427	
2018	Prescribed fire	Cost	$22,575		$20,069	
2019	Prescribed fire	Cost	$2,325		$1,987	
2019	Prescribed fire	Cost	$2,325		$1,987	

[1] Based on a discount rate of 4 percent.
[2] Exact dates for prescribed fires are unknown but estimated for the analysis (with the largest placed in the middle of the study period).

List of Preparers

Mary Beth Adams, Research Soil Scientist, NRS
B.S.F. Forestry, Purdue University
M.S. Forestry, Purdue University
Ph.D. Soil Science and Forestry, North Carolina State University
Professional experience as Research Soil Scientist since 1990

Matthew Bumgardner, Research Forest Products Technologist, NRS
B.S. Forest Resources Management, Ohio State University
M.S./M.A. Natural Resources Policy/Public Administration, Ohio State University
Ph.D. Forestry and Forest Products (Forest Products Marketing), Virginia Tech
Professional experience as a Research Forest Products Technologist since 1999

Pamela J. Edwards, Research Hydrologist, NRS
B.S. Forest Science, Penn State University
M.S. Forest Hydrology, Penn State University
Ph.D. Forest Soils, North Carolina State University
Professional experience as Research Hydrologist since 1983

Theresa Evans, Wildlife Biologist, Cheat/Potomac Ranger District, Monongahela National Forest
B.S. Wildlife Biology, Penn State University
Professional experience as a wildlife biologist since 1988

J. Gavin Hale, Heritage Program Manager/Tribal Liaison, Monongahela National Forest
B.S. Anthropology (Archaeology), Middle Tennessee State University, TN,
M.S. Geosciences (Archaeological Information Systems), Murray State University, Kentucky, (pending)
Professional experience in archaeology since 2006

Chad M. Landress, Fisheries Biologist, Monongahela National Forest
B.S. Biology (Aquatic Ecology), Kennesaw State University, Georgia
Master of Natural Resources (Fisheries), Utah State University, Utah
Professional experience in fisheries/aquatic ecology since 2002

Claire O'Dea, Air Quality Specialist, Monongahela National Forest
A.B. Ecology and Evolutionary Biology, Princeton University
M.A. Ecology, Duke University
Ph.D. Ecology, Duke University
Professional experience in air resources since 2011

Thomas M. Schuler, Supervisory Research Forester, NRS
B.S.F. Forest Management, Purdue University
M.S. Silviculture, Colorado State University
Ph.D. Forest Biology, Purdue University

Professional experience as Research Forester since 1992

Melissa Thomas-Van Gundy, Research Forester, NRS
B.S. Pre-forestry, Davis and Elkins College
M.S. Resources Management, SUNY College of Environmental Science and Forestry
Ph.D. Forest Resource Sciences, West Virginia University
Professional experience as Research Forester since 2007

Frederica Wood, Information Technology Specialist, NRS
B.S. Natural Resources, University of the South
M.F. Forestry, North Carolina State University
Professional experience as Information Technology Specialist since 1987

Glossary

Acidification. The decrease of acid neutralizing capacity in water or base saturation in soil caused by natural or anthropogenic processes.

Acid deposition. Air pollution produced when acid chemicals are incorporated into rain, snow, fog, or mist, and are deposited on plants, soils, and other surfaces.

Aggrading stream. A stream which is accumulating more mineral material than it is removing (or eroding). It also may be described as depositional.

Air quality. The properties and degree of purity of air to which people and natural and heritage resources are exposed.

Bankfull. The stage or discharge that occurs approximately once every 1.5 to 2 years.

Basal area. The cross-sectional area of all or specified trees per unit area of land. It is often given as square feet per acre or square meters per hectare. It is a useful measure of stand characteristics and is related to stand volume and is a measure of stand density.

Biota. A group of animals and plants occupying a place together (e.g., terrestrial biota).

Carbon monoxide. A criteria air pollutant that is a colorless, odorless, poisonous gas produced by incomplete combustion; particularly, incomplete burning of carbon-based fuels, e.g., gasoline, oil, and wood.

Clean Air Act. Originally passed in 1963, our current national air pollution control program is based on the 1970 version of the law. Substantial revisions were made by the 1990 Clean Air Act Amendments.

Compartment. A compartment is an area of forest generally making up the experimental treatment area. This is the unit of land treated in the various experiments.

Diameter at breast high (often abbreviated as **dbh**). The diameter of a tree's main stem 4.5 feet above the ground level. For purposes of standardization, measurements of tree diameters are taken at the same height.

Diameter-limit. A partial harvest where all trees over a specific dbh are removed; this is not considered true uneven-aged silviculture as no consideration is given to the residual stand structure, typically. In the diameter-limit treatment on the Fernow, all trees 17.0 inches dbh and larger are cut and removed from the stand on a recurring basis: every 20 years on SI 60 sites, and every 15 years on SI 70 or 80 sites (See definition of Site Index below).

Dormant season. The period of the year when most plant processes are inactive and growth ceases, approximately mid-October through mid-April for the FEF.

Dry deposition. Delivery of air pollutants in the gaseous or particle phase to surfaces.

Forest floor. The forest floor is a layer of material above the mineral soil surface, consisting of organic material in various stages of decomposition, microorganisms, insects and other fauna, as well as living plants.

Growing season. The period of the year when plant processes are active and growth occurs, approximately mid-April through mid-October for the FEF. In temperate regions, this is often characterized by the period of frost-free days during the spring, summer and autumn. The FEF usually experiences about 145 frost-free days per year.

Haul roads. Haul roads are those that form the transportation network over which the logged material is hauled from landings.

Herpetofauna. Amphibians (salamanders, frogs and toads) and reptiles (lizards, snakes, and turtles).

Home range. The area within which an animal normally lives. The boundaries of the range may be marked (e.g., by scent marking), and may or may not be defended, depending on species.

Humus. The soil constituent known as humus is well-decayed organic matter remaining as a dark, incoherent, and heterogeneous colloidal mass.

Hydrograph. A hydrograph is a graph of stream or river water discharge or depth versus time.

Mast. Soft, fleshy fruits (e.g., blueberries) or hard, nut-like fruits (e.g. acorns) produced by woody vegetation and consumed by wildlife.

Nitrogen oxides. A criteria air pollutant that includes compounds NO, NO_2, NO_3, N_2O_5, alkyl nitrates, etc.

NTU. Nephelometric turbidity unit. A unit of turbidity measurement.

Ozone. A gas composed of 3 oxygen atoms (O_3) that is a criteria air pollutant and a major constituent of smog.

Patch cutting. The system of patch cutting was designed to replicate conditions needed for regeneration of shade-intolerant tree species, without creating large clearcuts. Each patch is 150 feet in diameter (0.4 acre). All stems 1.0 inch dbh and larger are felled. On lower site index sites (SI 60), patches are cut on a 15-year cycle, with an estimated rotation of 90 years. On sites with site index 70-80, patches are cut on a 10-year cutting cycle, with an estimated rotation of 70-80 years. The number of patches to be cut is based on rotation length, number of periodic cuts, and study area size.

Peakflow. The highest instantaneous discharge of a stream, generally during a storm event, is referred to as the peakflow.

pH. A pH value is the measure of acidity/neutrality/alkalinity of a solution. A value of 7 indicates neutrality; less than 7, acidity; greater than, 7 alkalinity.

Riparian. The riparian corridor encompasses the stream channel and surrounding land from the high water mark toward the uplands where vegetation may be influenced by elevated water tables or flooding and the ability of the soils to hold water.

Seral stage. A stage in plant succession.

Shade-intolerant. Shade-intolerance is the inability of some species to sustain themselves at lower light intensities. Black cherry, yellow-poplar, and black locust are tree species that are classified as shade-intolerant.

Shade-tolerant. Shade-tolerance is the ability of some species to survive at low light intensities. Sugar maple, eastern hemlock, American beech, and flowering dogwood are examples of species classified as shade-tolerant. These species can grow well in the understory of a forest canopy where light intensity is low. Most shade-tolerant trees also grow well in full sun conditions.

Shelterwood method/harvest. This method of regeneration involves the gradual removal of the entire stand in a series of partial cuttings which extend over a fraction of the rotation. Natural reproduction is secured under the shelter of a portion of the old stand, and released when it becomes desirable for the new regeneration to have full use of the growing space.

Single-tree selection. Single-tree selection is designed to promote an all-aged forest stand. The practice is based on a concept that such a stand continually yields benefit and regenerates itself steadily. In practice, such stands are created by marking individual trees for harvesting that meet specific criterion, which include specifying a residual basal area, the ratio of trees in smaller diameter classes (called the "Q" factor), and the largest diameter tree to retain in the stand.

Site index (SI). An indicator of site quality. Site index is the expected height of a dominant or co-dominant tree based on a given reference species and tree age. For example, SI 70 indicates that dominant trees will average 70 feet in height at 50 years of age. In the central Appalachians, SI 70 and above indicates good site quality, while SI 60 is considered poor site quality.

Source. Any place or object from which air pollutants are released. Sources that are fixed in space are stationary sources; sources that move are mobile sources.

Subdrainage. A smaller watershed within a larger one.

Sulfur dioxide. A gas (SO_2) consisting of one sulfur and two oxygen atoms. Of interest because sulfur dioxide converts to an aerosol, and is a criteria pollutant of the Clean Air Act.

Transpiration. Transpiration is the loss of water from a plant through its stomata, also called evapotranspiration.

Turbidity. Turbidity is the measure of scattering and absorption of light in water by dissolved or suspended material.

Water bar. A water bar is a ridge or ridge and channel constructed diagonally across a sloping road or utility right-of-way that is subject to erosion. It is used to prevent erosion on long, sloping routes by diverting runoff at short intervals.

Watershed. A watershed is the area above a specific point on a stream from which water drains toward the stream; sometimes referred to as a basin.

List of Abbreviations

BA	Biological Assessment
BMPs	Best Management Practices
CEQ	Council on Environmental Quality
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
FEF	Fernow Experimental Forest
FR	Forest Road
GIS	Geographic Information System
IDT	Interdisciplinary team
MNF	Monongahela National Forest
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NRS	Northern Research Station (USDA Forest Service)
ppm	Parts per million concentration
RWU	Research Work Unit
TES	Threatened, Endangered and Sensitive Species
WS	Watershed

Scientific and Common Names of Species Mentioned in this Document

Scientific Name	Common Name
Arthropods:	
Lymantria dispar	Gypsy moth
Other invertebrates:	
Stygobromus emarginatus	Greenbrier Cave amphipod
Fish:	
Cottus bairdi	Mottled sculpin
Catostomus commersonii	White sucker
Onchorynchus mykiss	Rainbow trout
Salmo trutta	Brown trout
Salvelinus fontinalis	Brook trout
Amphibians:	
Cryptobranchus alleganiensis	Hellbender
Plethodon nettingi	Cheat mountain salamander
Reptiles:	
Crotalus horridus	Timber rattlesnake
Birds:	
Accipiter gentiles	Northern goshawk
Bonasa umbellus	Ruffed grouse
Dryocopus pileatus	Pileated woodpecker
Hylocichla mustelina	Wood thrush
Meleagris gallopavo	Wild turkey
Melospiza melodia	Song sparrow
Passerina cyanea	Indigo bunting
Spizella passerina	Chipping sparrow
Mammals:	
Corynorhinus townsendii virginianus	Virginia big-eared bat
Cryptotis parva	Least shrew
Felis rufus	Bobcat
Glaucomys sabrinus coloratus	Northern flying squirrel
Glaucomys sabrinus fuscus	Virginia northern flying squirrel
Glaucomys volans	Southern flying squirrel
Lepus americanus	Snowshoe hare
Martes pennanti	Fisher
Microtus chrotorrhinus carolinensis	Southern rock vole
Myotis leibii	Eastern small-footed nyotis
Myotis septentrialis	Northern long-eared bat
Myotis sodalis	Indiana bat

Scientific Name	Common Name
Neotoma magister	Allegheny woodrat
Odocoileus virginianus	White-tailed deer
Peromyscus polionotus	Old-field mouse
Procyon lotor	Raccoon
Sorex palustris punctatus	Southern water shrew
Sylvilagus obscurus	Appalachian cottontail
Sylvilagus spp.	Rabbit species
Ursus americanus	Black bear
Fungi:	
Ceratocystis ulmi	Dutch elm disease
Cryphonectria parasitica	Chestnut blight
Nectria coccinea var. figinata	Beech bark disease
Plants:	
Abies balsamea	Balsam fir
Acer pensylvanicum	Striped maple
Acer rubrum	Red maple
Acer saccharum	Sugar maple
Aconitum reclinatum	White monkshood
Ailanthus altissima	Tree-of-heaven
Amelanchier sanguinea	Serviceberry
Amphicarpaea bracteata	Hog peanut
Betula lenta	Black birch
Carya cordiformis	Bitternut hickory
Carya glabra	Pignut hickory
Carya ovata	Shagbark hickory
Castanea dentata	American chestnut
Dryopteris goldiana	Shield fern
Eupatorium perfoliatum	White snakeroot
Fagus grandifolia	American beech
Fraxinus americana	White ash
Juglans cinerea	Butternut
Kalmia latifolia	Mountain laurel
Laportea canadensis	Wood nettle
Lindera benzoin	Spicebush
Liriodendron tulipifera	Yellow-poplar
Magnolia acuminata	Cucumbertree
Microstegium vimineum	Japanese stiltgrass
Ostrya virginiana	Eastern hophornbeam
Panicum spp.	Panicgrass
Picea abies	Norway spruce
Picea rubens	Red spruce
Pinus strobus	White pine
Polystichum acrostichoides	Christmas fern

Scientific Name	Common Name
Prunus serotina	Black cherry
Quercus alba	White oak
Quercus montana	Chestnut oak
Quercus rubra	Northern red oak
Quercus velutina	Black oak
Rhododendron maximum	Great rhododendron
Robinia pseudocacia	Black locust
Rosa multiflora	Multiflora rose
Rubus spp.	Blackberry
Sassafras albidum	Sassafras
Smilax spp.	Greenbrier
Tilia americana	Basswood
Trifolium stoloniferum	Running buffalo clover
Tsuga canadensis	Eastern hemlock
Ulmus rubra	Slippery elm
Urtica dioica	Stinging nettle
Vaccinium spp.	Blueberry
Viola spp.	Violet
Vitis spp.	Wild grape

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List of Agencies, Persons and Organizations to whom the DEIS was Sent

Federal:

U.S. Fish and Wildlife Service, Elkins Office
USDA-FS, Cheat District Ranger, Monongahela National Forest
USDA-FS, WO, Ecosystem Management Staff
USDA-FS, WO, Deputy Chief for Research Staff
USDA-FS, WO, Director of Environmental Coordination
USDA-FS, Eastern Region, Natural Resources Staff
USDA, National Library, Head, Acquisition and Serials Branch
USDA, Office of Civil Rights
USDI, Office of Environment Policy and Compliance
U.S. EPA, Region III
U.S. Army Corps of Engineers, Great Lakes and Ohio Division
Ohio River Basins Commission c/o University of Kentucky
Eastern Region Office of the Regional Director, Federal Aviation Administration
Federal Highways Administration, West Virginia Office
Chief of Naval Operations
U.S. Coast Guard, Commandant

State:

West Virginia Division of Forestry
West Virginia Division of Natural Resources
West Virginia Division of Culture and History

Organizations/Individuals:

West Virginia University
The Nature Conservancy
West Virginia Sierra Club
West Virginia Highlands Conservancy

Jean Public
W. Mark Ford
Jane L. Rodrigue
Thomas Ward

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Appendix A – Public Involvement

Comments received on Proposed Action, comment period ending January 31, 2015

Thomas Ward, letter dated December 17, 2014

> Comment - …"why there is included in the plan 24 acres of clearcut, which according to my readings is obsolete…"
>
> Response – The area in patch cuts is a total for approximately 70 individual ~0.4-acre patches over five years in five compartments and is not contiguous. These patch cuts, while small in size, are designed to allow regeneration of shade-intolerant and shade-tolerant tree species. Patch cutting, at this small scale and larger, is still considered a valid forest management practice if shade-intolerant tree species, such as oaks and black cherry, are desired. Also, this treatment is an integral part of a larger long-term study comparing different forest management practices.

W. Mark Ford and Jane L. Rodrigue, email dated December 17, 2014

> Comment – "…the EIS will have to be expanded substantially to address new environmental issues associated with research activities on the Fernow Experimental Forest, such as the potential additive impact on white-nose syndrome impacted bats, particularly the endangered Indiana bat and the proposed listed northern long-eared bat, along with opportunities to initiate new research on these and other wildlife species."
>
> Response – We will address the impact of our research activities on bats through the EIS and Biological Assessment, including the impacts of white-nose syndrome. As for opportunities for new research on bats and other species, this request is outside the scope of this analysis. Nothing in the proposed action of the EIS precludes adding new studies and we are not required to assess the impacts of possible studies with no specifics or unknown environmental impacts.
>
> Comment – "…there should be an increased emphasis on understanding ecological relationships and processes of a wider suite of biodiversity/wildlife on the Fernow Experimental Forest."
>
> Response – We agree, it would be great to do this, but we cannot analyze the environmental effects of unknown, possible studies. If and when those studies are developed, they will be subject to further review under NEPA outside of this proposed action and EIS.
>
> Comment – "…this action should more clearly identify which long-term studies continue to provide value-added benefit for managing Appalachian forests versus those studies that have had sufficient duration and conclusive outcomes that merit their conclusion and/or that prevent new manipulative work from being proposed (particularly work that can build on the long-term legacy of forest datasets and considerable in situ infrastructure)."

Response – The requested analysis is formally made through a review of the Research Work Unit Description (RWUD). This normally occurs every five years; the current RWUD is valid until July 2016.

Comment – "The Fernow Experimental Forest should not be reduced to harvest studies that no longer produce progressive or innovative results and publications."

Response – We agree, however, the proposed action includes those research activities with the potential to impact the environment. Studies that include silvicultural treatments are not the only research going on at the Fernow Experimental Forest; it may appear that way as those actions are the most visible and require the analysis of effects and documentation in an EIS.

Comment – "…development of a wider array of alternatives that better fit potential end-users and are matched to the skills of the employees of NRS-01 and its cooperators are needed."

Response - This request for alternatives to the proposed action is better suited to the RWUD process. We do not need to create new alternatives for research or studies we have no plan for over the next 5 years; the NEPA process is not the vehicle to develop new lines of research. Again, nothing in this EIS precludes other studies. This analysis of effects just allows for the continued research as proposed; however, if priorities change, we are not required to implement the proposed action. In the foreseeable future, the long-term silvicultural studies, watershed acidification studies, and prescribed fire studies included in the proposed action would continue. Other studies can be added and if needed additional analysis can be made under NEPA.

Comment – "Indeed, it would be appropriate for each proposed action (study) to have a clearly identified PI and actual expected outcomes in terms of publications, findings and technology transfer so that the public can assess if the project's costs (direct and indirect) are a worthwhile tradeoff for the information generated."

Response - Parts of this request are addressed in study plans and the RWUD, none are required by NEPA. The draft and final EIS will include the direct costs of implementing the proposed action and any alternatives which are the direct costs of implementing some of the research taking place on the Fernow Experimental Forest.

Comment – "Development of alternatives accordingly may change the amount of or type of area impacted/managed or subjected to activities such as road-building, culvert replacement, logging, burning, energy-extraction, etc."

Response - Our proposed action does not include road building; energy extraction is outside our control for privately-held mineral rights. Without knowing these proposed future studies it's impossible for us to analyze their effects or develop alternatives to them. The proposed action is to continue long-term studies – forest management and watershed acidification – already deemed important through other processes. Again, nothing in this proposed action/EIS will preclude new research studies.

Comment – "Efforts to better address cumulative impacts than have occurred in the past on the Fernow Experimental Forest and the surrounding national forest lands and private lands need to be considered."

Response - Analysis of cumulative effects is always difficult and we strive to make better analyses each planning cycle.

Comment – "…care will need to be taken to craft experiments and alternatives that can legitimately qualify for an incidental take permit from the U.S. Fish and Wildlife Service…"

Response - We continue to work closely with the U.S. Fish and Wildlife Service to ensure that our actions and their effects are considered and covered by any resulting incidental take permit.

Comment – "…proposed work and alternatives need to better address current notions about climate change impacts or the mechanisms overshadowing that…"

Response - CEQ guidelines on NEPA direct us to analyze the effects our actions will have on climate and climate change. Data from the long-term studies on the Fernow Experimental Forest can be used to address climate change impacts and are being used for that purpose. Again, if and when research studies involving climate change or other drivers of forest ecosystem change are developed by Fernow researchers or cooperators, those studies can be implemented and may or may not require inclusion in an EIS depending on anticipated effects.

Jean Public, email dated December 23, 2014

THE TAXPAYERS OF THIS COUNTRY HAVE BEEN SUPPORTING THIS RESEARCH FOR 50 YEARS. ITS TIME TO PULL THE PLUG. ESPECIALLY WHEN THE US FS IS INTENTLY LOGGING AND BURNING UP ALL THE FORESTS WE HAVEIN THIS COUNTRY, AND LETTIGN IN GRAZERS AND MINERS AND OIL DRILLERS. THIS RESEARCH IS NOT STOPPING ANY OF THOSE ACTIVITIES.THIS SITE SHOULD BE TURNED INTO A NTIONAL FOREST WITH LAW ENFORCEMENT TO KEEP IT TIDY AND FLOURISHING BUT THE ALLEGED "RESEARCH" HASNT PRODUCED ANYTHIGN NEW IN 30 YEARS. I THINK SOME OF OUR STATE AGENCIES, LIKE VERMONT, ARE ACCOMPLISHING MUCH MORE RESEARCH THAT HELPS AMERICA ON A LOT LESS MONEY THAN THIS FAT CAT BUREAUCRATIC MONSTER. TAXPAYERS DONT NEED TO SPEND MORE TO INVESTIGAGE BURNING. WE HAVE IT GOING ON IN ALMOST EVERY FOREST IN AMERICA DAILY, WEEKLY AND YEARLY. THERE ISNT MORE WE NEED TO KNOW. IT HARMS WILDLIFE AND TAKES AWAY THEIR FOOD AND HOME FOR UP TO TEN YEARS. WE KNOW THAT. TAXPAYERS ARE SUPPORTING TOO MUCH FAT CAT BUREAUCRACY. THIS IS AN EXAMPLE. SHUT IT DOWN AS AN ALLEGED "RESEARCH STATION". THIS COMMENT IS FOR THE PUBLIC RECORD. CUT THE BUDGET FOR "RESEARCH" TO ZERO. PLEASE RECEIPT.

Response – The Fernow Experimental Forest is administered as a special management prescription (MP 8.5) of the Monongahela National Forest. We contend that the forest is flourishing in many respects, but more importantly, the science developed from work done on the Fernow Experimental Forest is improving the management of millions of acres. These works include management guidelines for sustained harvesting of hardwood forests, findings on basic ecological and hydrologic processes in forests, and impacts of forest management on wildlife populations, among other things.

While much is known about the effects of prescribed fire in eastern hardwood forests, our proposed research involves the timing of burns for best results in terms of oak regeneration and the use of fire for creating wildlife habitat in mesic hardwood forests.

West Virginia Division of Natural Resources, Wildlife Resources Section, letter dated January 7, 2015

Comment – "…strongly supports the proposed actions needed for the ongoing forest-management-related research being conducted on the Fernow Experimental Forest…"

Response – Thank you for your support.

West Virginia Division of Culture and History, letter dated January 21, 2015

Comment – "…nine ca. 1930s architectural properties along National Forest Road 701 are within the boundaries of the proposed area of work…In order to comment further on any of the proposed actions and potential effects to these architectural properties, per your request, we ask that we continue to receive information about this proposed project via hard copy mail."

Response – We are aware of the architectural resources along forest road 701 and will continue to avoid impacts to these structures. We will keep you informed of the proposed projects by hard copy email.

Comment – "According to our records, there are no previously documented archaeological resources located within the proposed project area. However, our records indicate that only a small portion (approximately 1.3 acres) of the project area has undergone a Phase 1 archaeological survey. Portions of the project area are situated on archaeologically sensitive terrain. Also, there is the potential for CCC-era deposits to be present within the project area. Prior to initiating any ground disturbing activities, please submit project related information to this office for comment if the proposed actions are not covered under the current Programmatic Agreement between this office and the Monongahela National Forest."

Response – All proposed actions are occurring on ground that has had similar activities in the past, however, we are working with the Monongahela National Forest archeologist to make sure our actions do not impact historic or pre-historic resources on the Fernow Experimental Forest. As requested, we will keep in contact with the WV Division of Culture and History as the draft and final EIS are written and before ground-disturbing activities occur.

Comments received on Draft EIS, comment period ending October 19, 2015

Thomas Ward, Letter received September 8, 2015

Comments – "Thank you for the information, your selected approach seems best"

Response – Thank you for your support.

F. Joshua Simons, West Virginia Department of Natural Resources, website comment form dated September 8, 2015

Comment – "I agree with Alternative C being the preferred action to take to implement the important long term research studies on the Fernow Experimental Research Forest. Thank you for the information."

Response – Thank you for your support.

W. Mark Ford and Jane L. Rodrigue, email dated September 28, 2015

Comment – "Page 1-6 – In conveying to the public about what you want to achieve, it is necessary to provide some summary or link to webpages/publications that provide such on past research, findings of importance to the environment/forest management and some sense of the value-added and return on investment to the taxpayer (expanding on the idea of Table 3-8). As written, these actions (while undoubtedly positive and of interest to many), hardly are presented as a compelling use of government time and money."

Response –The purpose of and need for the actions proposed in the EIS are consistent with the mission of the USDA Forest Service, which is to sustain our nation's forests and grasslands, and the 2015-2020 Strategic Plan of the agency. The proposed research will contribute to resilient, adaptive ecosystems; provide abundant clean water; strengthen communities; and advance knowledge of science-based forest management, all part of the new Forest Service Strategic Plan. Moreover, past research on the Fernow Experimental Forest has influenced management on public and private lands throughout the region and the nation on millions of acres. The proposed research is tiered to the Monongahela National Forest Land and Resource Management Plan (updated 2011) and is consistent with the Research Work Unit Description of NRS-01.

Comment – "Page 2-1 – Considering the fact that the Fernow has the second highest number of documented northern long-eared bat maternity roosts identified in North American and considering their extremely high selectivity for live black locust across a wide variety of sizes and condition, why would those boles not be protected from harvest similar to shagbark hickory for Indiana bats? The protection measures of tailoring pre-hibernation harvesting by elevation and aspect is laudable. However, does past, current or projected cutting schedules follow this? It would seem the spatio-temporal cutting schedule could be presented and linked to Table3-7 showing for example the progression of how harvesting would proceed in compartment 9 and so forth throughout all the listed

areas over the years. If staff says this is an employed mitigation strategy to assuage USFWS, then there needs to be proof in this document that there is a plan. Otherwise, if this is not the case and knowing that USFWS is going to grant an incidental take permit, why not acknowledge the impact and harvest temporally and spatial by other constraints, i.e., weather, access…."

Response – All known roost trees will be protected, including black locust and shagbark hickory, as well as other species. The comment is correct that we do propose to protect shagbark hickory trees across the Fernow as mitigation to maintain high-quality roost trees within the Fernow Experimental Forest. However, black locust, unlike shagbark hickory, is an early successional species and is intolerant of shade and a short-lived species. Black locust also is known for prolific vegetative sprouting following harvesting. As such, to maintain the presence of black locust trees on the Fernow it is essential that we both harvest black locust, if not already serving as a roost tree, and provide the conditions for its competitive survival so that younger trees will be recruited to the overstory as older stems die. It has been shown on the Fernow that black locust abundance increased dramatically following harvesting in the past (Schuler and Gillespie 2000). Black locust silvics as well as historical data illustrate that black locust abundance in the overstory is dependent on silvicultural intervention and/or major disturbances. As such, we feel our approach will both protect black locust today and sustain it as an overstory component in the future.

As stated in the EIS and other documents related to this analysis, we will target cooler and more mesic compartments furthest from Big Springs Cave for pre-hibernation harvesting at the start of each silvicultural operating period (i.e., September 1 through March 30). The exact schedule for each year cannot be determined due to potential logistical constraints as stated in the EIS. However, given the proposed schedule of treatments, compartment 9A would be harvested before WS2B in FY 2016, Compartment 9B would be harvested before WS2B if WS2B is delayed until FY 2017, Compartment 20A and WS5A are both mesic but Compartment 20A is further from Big Springs caveso it would be prioritized for pre-hibernation harvesting in 2018, WS2A is furthest from the cave and not especially mesic so it would be the first unit treated in FY2019, and Compartment 18C would be the first unit treated in FY 2020 due to its high elevation. This mitigation strategy is also consistent with operational safety by prioritizing the units that will have the coldest temperatures and deepest snow in mid-winter to be harvested first before severe conditions materialize.

Comment – "Page 2-19 – Are known northern long-eared bat and Indiana bat day-roosts not buffered by any distance. For private landowners, at least during the maternity season, known roosts might require 0.25 mile buffer depending upon the final 4(d) rule for the northern long-eared bat. While the 4(d) rule is not applicable to public land managers per se, considering the Fernow has the second highest number of known northern long-eared bat roosts documented, it would seem prudent that staff, in consultation with USFWS, would go above and beyond the minimum required for managing this species. Current IMCOM guidance for the U.S. Army provide much larger buffering (3-5 miles in some instances) and/or careful consideration of land management actions both in the maternity and dormant season. As these forest management and

training activities would be considered essential whereas research on the Fernow would be considered non-essential, it is amazing that more consideration and analyses are not provided by staff. For example, data exists on the maximum and mean distances that northern long-eared bats move from point of capture to day-roosts (approximately 1000 m and 300 m, respectively from Johnson et al. 2009). Moreover, Johnson et al (2012) provides area extent of roost networks that could also be used as a basis for buffering, consideration or impacts and mitigation measures. Why did staff not analyze both day-roosts and acoustic "hits" of northern long-eared bats within some framework such as this? Also, probabilistic maps based on the Maximum Entropy and later Maximum Likelihood techniques have been created for northern long-eared bat day-roosting and foraging habitat. Why in preparation of this EIS did staff not use these to assign risk of take and/or opportunities for adaptive management for the northern long-eared bat?"

Response – Known roost trees for NLEB and Indiana bats will be retained if located in harvest units. Of the known NLEB day roost trees on the Fernow only WS5A has known day roost trees and is proposed for harvesting. As such, there is little intersection between proposed harvesting treatments and NLEB roost trees. In WS5A all known roost trees will be identified and protected from harvesting. Plus, mitigation is further provided by harvesting primarily during the bat's hibernation period. In addition to the other mitigations already proposed, the long-term treatment proposed for WS5A is uneven-aged management using single-tree selection. Unlike most harvesting used today on many ownerships, single-tree selection in WS5A will perpetuate a stand with trees in all size classes up to a maximum of 32 inches in diameter after each periodic harvest. All openings have been and will be small and mimic gap-phase dynamics of old-growth forests. This practice has been employed in WS5A for over a half-century and the resulting conditions continue to provide NLEB day roost trees. However, we are not assuming the risk of take is negligible across the Fernow Experimental Forest due to our proposed actions. We have acknowledged this in our Biological Assessment and will follow all guidance provided in the Biological Opinion issued by the USFWS and continue to work with wildlife scientists to advance knowledge related to tree roosting bats.

In summary, to minimize incidental take of IB and NLEB we will do the following:

1) We will retain all shagbark hickories on the FEF except where they would present a safety hazard.

2) Retain all known IB and NLEB roost trees on the FEF.

3) We will schedule harvest units based on their distance from the hibernacula, slope, and aspect to minimize conflict with fall roosting. The cooler, moister units with more north, northeast, and east facing slopes located farther from Big Springs Cave will be harvested first each year, while other scheduled units with more roost tree habitat will be harvested later in the season while the bats are in the hibernacula.

4) Conduct all harvest activities between September 1 and March 31.

5) Conduct all prescribed fires between October 1 and May 31.

6) Establish and maintain streamside management zones and restrict harvesting and other activities as proposed in the BA.

7) If new a maternity colony is discovered, the Forest Service will consult with the USFWS to establish any new habitat protection and monitoring not aforementioned.

8) Support and assist efforts to survey the hibernating bat populations in Big Springs Cave.

9) We will establish and monitor two long-term monitoring sites annually for bats using approved USFWS protocols.

10) We will provide the USFWS with annual monitoring reports of threatened and endangered species.

Comment – "Page 2-11 – Please explain how Monongahela National Forest personnel will be monitoring northern long-eared bats and/or Indiana bats. Does such monitoring following current USFWS guidelines (as listed on USFWS Region 3 website)? Does this monitoring have the ability to provide index/trend or quantitative occupancy data that can be linked to research actions on the Fernow? If this monitoring is part of the national forest's mist-netting effort, how will staff account for false negatives? As an important consideration, past efforts between staff and national forest to collaborate on bat monitoring and research were hampered by lack of QA/QC on the national forest's part. In fact, considerable data had to be thrown out in preparation of the Johnson et al. (2010) publication for that reason. How will staff ensure this is not the case? Currently there are 5 permanent acoustic stations that have been monitored during the summer by staff and in cooperation with the U.S. Geological Survey and Virginia Tech (Johnson et al. 2013). Moreover, these sites were included in a recently award/assignment to Clemson University, Virginia Tech, U.S. Geological Survey and U.S. Forest Service Southern Station by the USFWS to be monitored in the coming years in conjunction with other areas with pre- and post-White- nose Syndrome acoustic monitoring datasets. Please explain why these data, more matched to current USFWS monitoring guidelines and also linking the Fernow to Fort Drum, Fort Pickett, NPS National Capital Areas, Sumter National Forest, Savannah River Site and Chickamauga National Battlefield would not be relevant to staff's needs."

Response – We will use USFWS approved monitoring protocols in conjunction with contractual services provided to the Monongahela National Forest. Our approach to monitoring has been approved by the USFWS in their final Biological Opinion received in January 2016. However, we welcome collaboration in conjunction with the five monitoring stations you and others have been operating for numerous years. Only recently, we have been requested to provide vegetation data to assist tree roosting bat analysis by your team and will continue to cooperate and collaborate where possible and feasible. Given the new award related to monitoring on the Fernow and other locations, we would like to share in the analysis and interpretation of bat response to different forest management scenarios. We are excited that work will continue and hope that new opportunities for us to collaborate with you and your team on habitat analysis continue to materialize.

Comment – "3-81 – Northern long-eared bats prior to White-nose Syndrome constituted a significant portion of pre-hibernation swarm captures at Big Springs Cave. Because northern long-eared bats do not roost in aggregates or in cave areas readily accessed/surveyed, it is misleading to say the Big Springs Cave is not an important hibernacula for the species. Please correct. Also would reiterate the need to provide some assessment towards how staff will deal with black locust subject to harvest relative to potential impacts to the northern long-eared bat."

Response – You are correct that circumstantial evidence suggests that Big Springs Cave may be important hibernacula for the northern long-eared bats, although the extent of its use as hibernacula has not yet been determined. The language in the final EIS has been changed to reflect that more accurate assessment of Big Springs Cave. For our response to your second question about northern long-eared bats see response to comment from "Page 2-19" above.

Comment – "3-82 – Again, as referenced above, how will staff be dealing with acoustic "hits" indicating northern long-eared bat presence from the Ford et al. (2006) findings?"

Response – Wildlife scientists and others will continue to work on interpreting acoustic hits and the methods and data it yields can guide the scientific community in estimating NLEB and other tree roosting bat habitat use in general. The acoustic monitoring on the Fernow will undoubtedly play an important role in the larger effort across the southeast and mid-Atlantic regions. However, our focus will not be on refining acoustic methodology. Our opportunity to advance knowledge related to tree roosting bats and their habitat needs will be on providing data and interpretation of that data related to long-term changes in species composition and structural characteristics related to bat preferences on the landscape over time. We welcome the opportunity to collaborate in this effort and already are preparing data based on your request.

Comments from the US Environmental Protection Agency, letter dated October 19, 2015

Comment - If culverts are being repaired and replaced efforts should be made to accommodate passage for fish and wildlife.

Response – We will review the feasibility of aquatic organism passage as culverts are replaced. Current Forest Service policy states that - To the extent possible, design bridges, culverts, and low-water crossings to accommodate the natural passage of ice, woody debris, water, sediment, and aquatic species; accommodate passage of terrestrial species where such passage is necessary; provide for ecological connectivity; and meet the intent of applicable laws and regulations (FS Handbook 7709.56b, 60.3).

Comment - Methods other that herbicides should be considered for controlling invasive

Response - We have used hand pulling in the past in conjunction with volunteer and public assistance to slow the spread of garlic mustard. We also minimize ground disturbing activities during our silvicultural treatments to avoid creating new sites of invasive species establishment. We are always looking for new invasive species that

might be in the initial phase of establishment and either spot treat or hand pull individual plants. Our research also has examined how best to establish new ground cover on newly established rights-of-way to avoid invasive species establishment and the subsequent need for herbicide use or other control measures.

Comment - Coordinate with the U.S. Fish and Wildlife Service and other appropriate state and federal agencies about listed species, migratory birds and other species of concern. This would also include time of year restrictions for clearing and burning activities.

Response – All of our activities related to threatened and endangered species are reviewed by the US Fish and Wildlife Service through formal and informal consultation. Guidance is provided in the Biological Opinion issued by the US Fish and Wildlife Service. We also work closely with biologists from the agency and academia to mitigate our impacts on other species of concern. We have proposed restrictions to our harvesting and prescribed burning operations to mitigate migratory bird impacts during nesting season. This change was established in a previous agreement with the US Fish and Wildlife Service and we will continue with these guidelines as we move forward.

Comment - Additional information should be provided about who the responsible official is (who will be making decisions on the project alternative). Is this a Forest Service employee?

Response - This was given in the cover letter, but, will be added to the final EIS. It will also be stated in the Record of Decision. The responsible official is the Project Leader of NRS-01, Northern Research Station, Forest Service.

Comment - Native non-invasive species should be used for revegetation efforts.

Response – Speedy reclamation of disturbed ground helps us avoid establishment of non-native invasive species. However, we will continue to refine our seed mixture to have more reliance on native species that reduce sedimentation, occupy the site quickly, are cost effective, and commercially available. One of the ground covers we promote through our activities is the native and federally endangered running buffalo clover. In the past, the US Fish and Wildlife Service has asked us to consult with them if we change our practices because the frequency and intensity of disturbance we are using is correlated with long-term sustainability of this federally protected species.

Comment - Page 1-4 it is unclear if the Watershed acidification study is new or ongoing. Additional information should be provided about this study as well as the others describing the length of the study, purpose, monitoring, and adaptive management.

Response – As stated in the EIS Summary and in Chapter 1, the watershed acidification study is ongoing. This study was initiated in 1989 with the EPA as a partner. We continue to collaborate with others on this study including West Virginia University and it is partially funded by the National Science Foundation's Long Term Research in Environmental Biology program.

Comment - Page 2-2 rationale should be provided for the buffers and crown closure values around streams. How were these values determined?

Response – These values are from the MNF Forest Plan and are Forest-wide management direction for protection of soil and water resources, standard SW37 (page II-12 of the Forest Plan). The justification for these values is found in the Final EIS for the MNF Forest Plan.

Comment - Page 2-2 the discussion for "patch cutting harvest areas" is confusing. Additional information should be provided describing this process.

Response – Thank you for pointing this out. We have clarified our description regarding the patch cutting in the EIS. Please see page 2-2 for the changes.

Comment - Page 2-2 states that logging equipment could be restricted within the stream channel or off the stream banks except in designated areas. How were these areas determined? Impacts to aquatic habitats should be avoided.

Response – Logging equipment is restricted to crossing stream channels at designated crossing sites. No new skid trails are planned; stream crossing have all been previously designated to minimize impacts to the stream channel. If conditions warrant, we will use temporary bridges and culverts where needed to cross intermittent and perennial streams as we have done in the past. However, all stream crossings are minimized by using alternative log decking areas and skid trails to avoid impacts.

Comment - Page 2-8 it is unclear if these Mitigation Measures identified will be implemented or are only suggested. We suggest these actions are implemented. Is there mitigation proposed for aquatic impacts if any occur? All impacts should be mitigated. Commitments to mitigation and description of mitigation activities should be included in the Final EIS and Record of Decision.

Response - The mitigations common to all alternatives starting on page 2-1 in the final EIS will be implemented. Plus, we have changed the language of Table 2-2 to indicate the additional mitigations will also be implemented, not just recommended. And while all impacts cannot be mitigated, our intent is to mitigate where feasible and disclose our impacts so that a reasonable decision can be made regarding implementation.

Comment - Monitoring activities for species of concern should be coordinated with the appropriate agencies.

Response – We will continue to work with the US Fish and Wildlife Service, West Virginia Department of Natural Resources, and the Monongahela National Forest to identify and track species of concern in concert with our partners and collaborators.

Comment - EPA is concerned about anticipated air emissions for the proposed project. As stated in the cover letter, we recommend consideration of CEQ draft guidance to direct discussion of potential issues associated with the GHG emissions and climate change. Page 2-11: how will monitoring of fine particulate matter be determined? How will coordination with the public take place regarding burning at the Forest? Estimation

of emissions should be included in the NEPA analysis. Offset mitigation should be considered. Implications of removal of forest cover should be included in overall impact assessment.

Response - In considering when to disclose projected quantitative GHG emissions, the CEQ reference point is 25,000 metric tons of CO2-e emissions on an annual basis. The calculated GHG emissions for prescribed fire are estimated at 9732.78 tons CO2e over the full project lifespan, therefore, annual emissions would be far less than 25,000 metric tons. We also added a qualitative assessment of carbon sequestration to the Final EIS (starts on page 3-94, under the Forest Vegetation section). Estimates of emissions were included in the Draft and Final EIS; see Tables 3-5 and 3-6 for estimates of NOx, PM2.5, VOC. Table 3-4 shows emissions from neighboring counties for comparison.

We will continue to monitor air quality, including visibility impairing pollutants, at the nearby IMPROVE site. At the IMPROVE site, concentrations of ammonium sulfate, ammonium nitrate, organic matter, elemental carbon, fine soil, coarse mass, and sea salt in the air are monitored. We may use PM2.5 E-Samplers when conducting our prescribed fires if the samplers are available, however, this monitoring will not be required.

Based on the small-scale of the proposed actions, approximately 273 acres of timber harvest and 398 acres of prescribed burning over five years in a forested landscape, we feel that mitigation to offset greenhouse gas emissions from our actions is not appropriate or feasible. Patch cuts on 31 acres (non-contiguous) will create young forest with rapid growth and carbon uptake. Under single-tree selection and diameter limit forest management, our long-term records show increasing volume growth with the reduction in stocking levels. In these low-intensity partial harvest areas, carbon uptake is continuing and carbon stocks are maintained or even enhanced (Davis et al. 2009, McKinley et al. 2011). The proposed actions and alternatives do not include conversion of forest land to non-forest land.

Comment - It is unclear what will be done to monitor species succession and determine changes in species that may be associated with climate change. It would be of interest to monitor and assess this information as part of the studies done.

Response – Data on vegetation – size, species, growth, etc. – are collected as part of research conducted on the FEF using over 200 permanent growth plots and 100 percent inventories by species and size class in all of our treated and reference compartments. This long-term record dates back to 1949 in Compartments 8 and nearly as long in Watershed 5 and Compartment 20. We have also extended our assessment of relative species abundance further back in time using establishment surveys and land survey records. We have published the results and interpretation of this data in conjunction with how management has altered successional trajectories via numerous outlets. The long-term record of how species composition changes through time is one the greatest values of long-term forestry research on the Fernow and we will continue our work in light of new perturbations related to climate change.

Comment - Is there an adaptive management plan in place for the activities evaluated in the DEIS? We suggest that one be developed.

Response - Our research related to ecosystem function and management guidelines is designed to test hypotheses and be scalable to larger landscapes so that it may guide others as well as our own actions. Adaptive management is a feedback loop for site specific actions. As research scientists our work is designed to go beyond that scope of interpretation. We are also engaged in activities to test the long-term consequences of some management actions. At times, these do not represent the best stewardship for a particular site but are part of a larger comparison to compare the effects of different management or treatment actions. We strive to maintain the integrity of the original study design, but in some cases modifications are necessary. When we do make changes, we document them in the study files, which are maintained at the Timber and Watershed Laboratory in Parsons, WV. Any needed adjustment to an experimental treatment is determined by the senior scientist in charge of the study in conjunction with the Project Leader of NRS-01. Although adaptive management is not as appropriate for use with the rigors of experimental design, we do use adaptive management concepts for actions such as controlling invasive species and maintaining the road and skid trail system.

Comment - Page 3-3 sediment contributions to Elklick Run are believed to be due to the presence of Forest Service Road 701. Are there any plans to fix the issues with this road? We suggest that this be done.

Response - FR 701 is maintained on a routine basis and repaired as needed and as funds are available in an effort to minimize impacts to Elklick Run. Road maintenance is coordinated through the Monongahela National Forest Engineering staff. We receive excellent support from the Monongahela National staff in this regard. Given its high use, maintenance of FR 701 is an ongoing endeavor.

Comment - Page 3-10 describes a non-perennial stream channel in watershed 2. What type of channel is this?

Response – As stated at the beginning of Section 3.1. nonperennial channels are those which have the streambed below the groundwater table only part of the year (i.e., intermittent channels) or where the streambed is always above the groundwater level (i.e., ephemeral channels). True distinction between these types of channels is not simple or necessarily constant from year to year depending upon local water table conditions within a given year. Therefore our analysis uses non-perennial to account for both ephemeral and intermittent stream channels.

Comment - Page 3-11 states that “the percentage of disturbed soils and harvested basal area in Camp Hollow sub drainage would be less that levels that would be needed to change the hydrology, channel morphology, or sediment budgets on a sub drainage scale.” What are these levels? Additional information and threshold rationale should be provided in the FEIS.

Response – Additional information has been included in the FEIS to clarify this statement. The following was added to the FEIS – “Soil disturbance must exceed 15

percent for ditched roads to result in changes to channel morphology (Verry 2000). Streamflow is not affected by timber harvest until approximately 25 percent of the basal area is removed from a stand (Hornbeck et al. 1993)."

Comment - Page 3-12 discusses sediment from haul roads reaching streams. Efforts should be made to correct problems in this area and other watersheds where needed.

Response - Haul road and skid road conditions are reviewed on a routine basis and problems corrected as needed and as funds are available. Road maintenance is coordinated through the Monongahela National Forest Engineering staff.

Comment - Page 3-23 it's unclear what is meant by "compaction and result in short-term (until litter layer is restored) increase in soil erosion and sediment delivery." Additional clarification should be provided. It seems that the litter layer would be on top of the compacted soil.

Response – This refers to the No Action alternative. Compaction can result from high intensity rain on exposed mineral soil. The litter layer deposited each year on old skid roads provides further protection of mineral soil from direct impact by such events.

Comment - Page 3-26 additional information should be provided about weir ponds and sediment. Who is responsible for cleaning these ponds? What is the purpose for returning the sediment to the streams?

Response - Forest Service employees clean the weir ponds annually by draining each pond and removing accumulated sediment manually. The accumulated sediment is a component of the watershed's sediment budget. Removing the sediment entirely from the stream would alter the sediment budget to an even greater extent than the presence of the weir ponds does already. The sediment is placed downstream from the weir pond where it can be distributed throughout the stream system.

Comment - Page 3-46 states that carbon cycling on the ecosystem scale will not be included in this analysis. Why?

Response: We have added a qualitative assessment related to carbon cycling to the final EIS starting on page 3-94.

Comment - Page 3-52 "repeated burning resulting in the removal of a significant portion of the forest floor could result in changes in soil temperature…. Unless the canopy is significantly altered, however…" it is unclear how the canopy will not be significantly altered from burning. Additional information should be provided.

Response – Unlike high intensity, crown fires in western States, the prescribed fires used in our research are ground fires where the main fuel is leaf litter. Occasionally, shrubs may carry fire short distances. The expected effects of the prescribed fires are described on page 3-93 of the final EIS. Significant effects to the canopy have not occurred in the past and are not likely in the future.

Comment - Page 3-53 "Although we may predict small changes in soil temperature as a result of prescribed fires, the extent of those effects are not known, nor are we confident of our ability to monitor very small changes in soil temperature. Thus, direct and indirect effects on soil are likely to be unmeasurable and negligible." Additional information should be provided to support this conclusion.

Response – The statement has been re-worded for clarity and citations added to support the conclusion. The statement now reads - "Although we may predict small changes in surface soil temperature as a result of prescribed fires, the extent of those effects are likely limited to a few centimeters depth (Gonçalves et al. 2012). It is difficult to measure such small changes in soil temperature (Certini 2005). Thus, direct and indirect effects on soil temperature are likely to be unmeasurable and negligible."

Comment – Impacts and avoidance of impacts to migratory birds should be addressed in the FEIS.

Response – We have reviewed the 2008 list of Birds of Conservation Concern and concluded that about two-thirds of them would not find suitable habitat on the Fernow Experimental Forest. Conducting timber harvest during the winter months protects birds from direct impacts during nesting season. This information has been added to the FEIS on page 3-83 in the Threatened, Endangered, and Sensitive Wildlife section. Moreover, beginning in 2012, we moved to stop tree felling activities in the month of May to avoid impacting tree roosting bats in poor condition after the winter hibernation period. This move also helps us avoid impacting migratory birds because all tree felling is completed by the end of March at the latest.

Comment - Children' Environmental Health does not appear to have been included in the DEIS. The Forest Service should address Executive Order 13045 for the Protection of Children from Environmental Health Risks and Safety Risks. Without analysis or documentation on this topic, it cannot be assumed that there is no potential risk associated with the proposed project that may adversely affect children's health. EPA recommends that the EIS include an evaluation of potential direct, indirect and cumulative health impacts of the project on children' health.

Response – Executive Order (E.O.) 13045 - Protection of Children from Environmental Health Risks and Safety Risks - was issued in 1997 and applies to <u>economically significant rules</u> under consideration by the E.P.A. that concern an environmental health or safety risk that may disproportionately affect children. We are not proposing any rule changes plus our economic analysis concludes the benefits of our preferred alternative can be measured in the hundreds of thousands of dollars, not the 100 million dollar threshold for economic significance prescribed in E.O. 13045. Moreover, our efforts are designed to maintain and foster resilient forests that will continue to provide the full range of ecosystem services and products that children have benefited from since before the Fernow Experimental Forest was established. We are not affecting the food, water, and air that children of the region rely on for survival and health. Therefore, we have concluded that E.O. 13045 does not apply to the environmental analysis we are conducting.

US Department of the Interior, letter dated October 20, 2015

Comment – "The Department of the Interior (Department) had no comment on the USDA Forest Service's Draft Environmental Impact Statement (DEIS) for the 2016-2020 Fernow Experimental Forest, located in Tucker County, West Virginia."

West Virginia Division of Culture and History, letter dated October 27, 2015

Comment – "We note that the Draft Environmental Impact Statement references the programmatic agreement signed by our office and the Monongahela National Forest. Please ensure that the stipulations of that agreement are enforced, including standard protection measures such as avoidance or other appropriate forms of mitigation of all direct and indirect effects to historic resources."

Response – We will continue to protect the historic resources found on the FEF through continued cooperation between the Archeologist on the MNF and staff at the Division of Culture and History.