Final Environmental Impact Statement
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: Janice K. Wiedenbeck
Project Leader
Timber and Watershed Laboratory
P.O. Box 404
Parsons, WV 26287

For Further Information Contact: Mary Beth Adams
NEPA Coordinator
Timber and Watershed Laboratory
P.O. Box 404
Parsons, WV 26287

Summary:

The USDA Forest Service, Northern Research Station 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 analyzed in this Environmental Impact Statement is designed to implement directions contained in the General Plan for the Fernow Experimental Forest, the 2006 Revised Forest Plan for the Monongahela National Forest, the Research Work Unit Description of NRS-01, and the individual research study plans. The purpose and need for this project is to continue important long-term research studies, and to manage the Fernow Experimental Forest for long-term research. The proposed action involves using the following silvicultural treatments in existing research studies: diameter-limit cutting treatment on 93.9 acres, single-tree selection on 114.3 acres, financial maturity harvesting method on 214.5 acres, group selection on 7.9 acres, 12.0 acres of patch clearcutting, and prescribed fire treatment of 420.4 acres. Other treatments include fertilization of 96.7 acres with ammonium sulfate fertilizer (and additions of dolomitic lime to 4 of those acres), treatments of invasive exotic plants (approximately 12 acres total), and maintenance of roads, decks, and other infrastructure.

The EIS discloses direct, indirect, and cumulative effects of the proposed action and a no-action alternative. In the EIS, we have reviewed, evaluated and responded to substantive comments provided during project scoping, and comments on the Draft EIS. In addition,

we have evaluated the effects of the proposed action, and the no action alternative upon water, air, soil, and geologic resources, as well as evaluating the effects on vegetation, old-growth, forest fragmentation, wildlife, recreation and heritage resources, and have evaluated the economic impacts, and the effects on consumers, civil rights, minority groups and women.

Table of Contents

Chapter 1 – Purpose and Need 1-1
Introduction 1-1
Project Area 1-1
Relationship to Planning Documents 1-2
Legislation and Executive Orders Related to this EIS 1-3
What do we want to achieve? 1-4
Public Involvement 1-5
Issues 1-5
Issue 1 – Threatened, Endangered, and Sensitive Species (TES) 1-5
Issue 2 – Hydrologic and Sediment Impacts to Streams 1-6
Decisions to be Made 1-6

Chapter 2 – Alternatives 2-1
Development of Alternatives 2-1
Items Common to All Alternatives 2-1
Alternatives Considered In Detail 2-3
Alternative A: No Action 2-3
Alternative B: Proposed Action 2-3
Comparison of Alternatives 2-5
Table 2-1. Comparison of alternatives 2-6
Table 2-2. Subdrainages and acres of treatment by alternative 2-6
Mitigation Measures 2-7
Table 2-3. Measures to protect threatened, endangered and sensitive species 2-7
Table 2-4. Measures to reduce sediment impacts 2-8
Monitoring Activities 2-8

Chapter 3 – Affected Environment and Environmental Effects 3-1
3.1 Water and Riparian Resources 3-1
3.2 Air Resources 3-56
3.3 Soil Resources 3-64
3.4 Geology and Minerals 3-79
3.5 Aquatic Resources 3-83
3.6 Wildlife Resources 3-87
3.7 Old Growth 3-97
3.8 Forest Fragmentation 3-99
3.9 Forest Vegetation 3-104
3.10 Recreation Resources 3-118
3.11 Heritage Resources 3-121
3.12 Economic Resources 3-124
3.13 Effects on Consumers, Civil Rights, Minority Groups and Women 3-126
3.14 Research Program and Implications 3-127
3.15 Irreversible and Irretrievable Commitment of Resources 3-130
3.16 Adverse Effects Which Cannot Be Avoided Should the Proposal Be Implemented 3-131

3.17 Relationship Between Short-term Uses of the Environment, and the Maintenance and Enhancement of Long-Term Productivity 3-132
3.18 Possible Conflicts Between the Proposed Action and the Objectives of Federal, Regional, State, and Local Land Use Plans, Policies, and Controls for the Area Concerned 3-133
Chapter 4 – Supplemental Information.. 4-1
Figures and Tables 4-1
Figure 1-1. Map of West Virginia with locations of Monongahela National Forest and Fernow Experiment Forest.. 4-1
Figure 2-1. Fernow Experimental Forest, with locations of areas proposed for treatment. See text for details of treatments and compartment descriptions. 4-2
Figure 3-1. Watersheds and subdrainages of the Fernow Experimental Forest, as used in analyses in section 3.1. See text for details.. 4-3
Figure 3-2. Geology underlying the subdrainages of the Fernow Experimental Forest as used in analyses in section 3.1. See text (Section 3.4) for descriptions.............. 4-4
Figure 3-3. Total wet deposition at the Parsons WV NADP location. 4-5
Figure 3-4. Bulk deposition for sulfate and nitrate at Bearden Knob......................... 4-6
Figure 3-5. 2007 and 2008 hourly ozone data from Bearden Knob and the Nursery Bottom summarized with 24-hour and 30-day moving averages. 4-7
Figure 3-6. Map of West Virginia showing areas designated in nonattainment of the 2006 $PM_{2.5}$ standard. 4-8
Figure 3-7. Visibility at the Bearden Knob IMPROVE monitoring site measured as Standard Visual Range (km). The top line represents the visibility on the best 20 percent days for visibility and the bottom line represents the 20 percent worst visibility days. 4-9
Figure 3-8. Japanese stiltgrass occurrence within the proposed action study areas of the Fernow Experimental Forest.. 4-10
Table 3-1. Subdrainages of the Fernow Experimental Forest, description and proposed treatments 4-11
Table 3-2. Subdrainages of the Fernow Experimental Forest, length and area in roads and decks.. 4-13
Table 3-3. Subdrainages of the Fernow Experimental Forest, length of perennial and nonperennial stream reaches 4-16
Table 3-4. Subdrainages of the Fernow Experimental Forest, geologic formations . 4-18
Table 3-5. Emissions estimated by the regional planning organization (VISTAS – Visibility Improvement State and Tribal Association of the Southeast) 4-20
Table 3-6. Comparison of emissions from proposed harvest activities with regional (Tucker and adjacent Counties) emissions 4-20
Table 3-7. Comparison of emissions from proposed prescribed burns to regional emissions.. 4-21
Table 3-8. Current fragmentation of forest within five mile radius of Big Spring Cave 4-21
Table 3-9. Proposed project areas with archaeological sites present, eligibility status, and management recommendations.. 4-22
Table 3-10. Costs and benefits used in the 2010 Fernow Experimental Forest economic analysis and their discounted present value based on a 4 percent discount rate

(NRS and EXT denote Northern Research Station and unknown external partner, respectively) ... 4-23
List of Preparers ... 4-24
Glossary ... 4-25
List of Abbreviations ... 4-29
Scientific and Common Names of Species ... 4-30
Literature Cited ... 4-34
List of Agencies, Persons and Organizations to whom the EIS was Sent ... 4-65
Index ... 4-66
Appendix A – Public Involvement ... 1
Summary of Scoping Comments ... 1
Summary of Draft EIS Comments ... 3

Chapter 1 – Purpose and Need

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 Environmental Impact Statement (EIS) on the potential effects of silvicultural and ecological research in the Fernow Experimental Forest. This document provides information on research projects proposed for implementation in the Fernow Experimental Forest (FEF) over the next several years.

This EIS 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 and need for the proposed actions, discusses the relationship of the proposed actions to various planning documents, and identifies the significant issues driving the EIS analysis. Chapter 2 describes the proposed actions, alternatives to the proposed actions, and compares these. Chapter 3 describes the physical, biological, and social environments that could be potentially affected by the proposed actions and alternatives. It also discloses the environmental effects of each of the alternatives being considered. Chapter 4 contains tables and figures, the list of preparers, the EIS distribution list, literature cited, a glossary, a list of scientific and common names of plants and animals found on the FEF and an index. The Appendix contains a summary of comments received during the scoping and DEIS comment periods 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 to it, estimate the environmental effects and prepare this EIS. The planning process complies with NEPA and CEQ regulations. Planning was coordinated with the appropriate Federal, state and local agencies.

Project Area

The 4,615-acre FEF is located south of Parsons, WV, and is administered by the Northern Research Station of the USDA Forest Service (Figure 1-1). The ecological land type of the FEF is referred to as the Allegheny Mountains Section of the Central Appalachian Broadleaf Forest (M221) according to the Forest Service National Hierarchical Framework of Ecological Units (McNab and Avers 1994). The land type association has been designated as the Allegheny Front Side Slopes (Ba10) (DeMeo et al. 1995). 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 ft 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 ranging from 20 to 50 percent cover most of the area. The soils are predominantly from 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. Belmont soils formed from weathered limestone, that are less acid than the Calvin and Dekalb, also are found on the FEF.

The Elklick watershed (later to become 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. Most of the watershed was not 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 1933. 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 that time fire and grazing have been excluded. Chestnut blight was the next major disturbance. 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). Closed during World War II, silviculture and watershed research began again in 1948 and has continued to date without interruption.

The FEF also 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 Shaver's Fork River. These two rivers join to form the Cheat River just north of Parsons.

<u>Relationship to Planning Documents</u>

This document describes research projects proposed for the FEF over the next several years. This action is consistent with the 2006 Revised Forest Plan, Monongahela National Forest, Management Prescription 8.5 (Chapter III, p. 64-65).

Projects proposed here also are consistent with the General Plan for the Fernow Experimental Forest, the Research Work Unit Description, and individual study plans. The Research Work Unit Description (RWUD), the guiding document for Research Work Unit (RWU) activities, was updated and approved in 2009. 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:

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 will deliver tools and recommendations to help our partners and customers better sustain forests for a variety of outcomes, products and uses.
3. Inform the decisions made by foresters, forest land owners, and forest products industries that utilize the wood resource so that the full range of benefits derived from the region's forests may be sustained for future generations.

This RWU also has responsibility of managing the FEF for long-term silvicultural, hydrologic and ecological research. It is necessary for us to conduct experimental manipulations in order 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 the long-term research is not impaired, which requires maintenance of roads and structures, control of non-native invasive species, and other management activities.

Legislation and Executive Orders Related to this EIS

Shown below is a list of laws pertaining to project-specific planning and environmental analysis on Federal lands.

- National Historic Preservation Act of 1966 (as amended)
- Endangered Species Act of 1973 (as amended)
- Archaeological and Historic Preservation Act
- Wild and Scenic Rivers Act of 1986, amended 1986
- Wilderness Act of 1964
- Clean Air Act of 1963 (as amended)
- National Environmental Policy Act of 1969 (as amended)
- Executive Order 11990-Protection of Wetlands
- Executive Order 11988-Protection of Floodplains

Approximately 960 acres or just greater than 20 percent of the FEF would be affected by this proposal during the next five-year period. The kinds of environmental effects expected from the proposal would include changes in vegetation in both the overstory and understory plant communities. Associated with the proposal would be effects to the following natural resources: soil; water; air; aquatic; wildlife; and, threatened, endangered, and sensitive species.

A portion of the public would consider this proposal to have significant impacts to the physical, biological, and social environments within the scope of the FEF and the region as a whole. This is based on past projects of a similar nature conducted on the Monongahela National Forest and initial scoping for this proposal.

The effects of the proposal are not likely to compound environmental effects because of the use of mitigation measures, including those covered under the Forest Plan, West Virginia's Best Management Practices (BMPs), and those developed for site specific projects.

Environmental Assessments have been prepared on a yearly basis on the Monongahela National Forest for similar types of projects involving timber harvest. A determination was made that the effects of timber harvesting and connected actions from those projects were not significant.

Monitoring the effects of projects is the nature of the research activities. Impacts to natural resources would be documented as part of scientific studies. This information would help us to better understand the impacts of managing the timber resource and the impacts on other forest values. This information would be used to better describe and disclose the effects of projects in future NEPA documents. In addition, a monitoring plan has been developed to assess impacts to resources identified as issues in this EIS.

What do we want to achieve?

Most of the proposed actions are to continue ongoing research studies, and some of these are 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 glean information about the effects of various silvicultural practices 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.

We also want to maintain the integrity of the FEF for long-term research. 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 that we manage the FEF to ensure availability for collaborative research, and to ensure safety for all visitors to the FEF. Management 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 to control the spread of Japanese stiltgrass on approximately 12 acres, and other invasives such as tree-of-heaven on an individual tree basis, as needed.

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 18, 2009, when it was decided that an EIS was to be completed for the project.

Public Mailing: In December 2009, a letter providing information and seeking public comment (scoping document) was mailed to approximately 100 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.

Local News Media: A legal announcement about the project was printed in the December 16 and December 23, 2009 editions of the *Parsons Advocate.*

A copy of the Draft EIS was mailed to agencies, organizations and interested individuals on April 2, 2010 for comment.

Comments from the Draft EIS were reviewed, analyzed and evaluated and response to comments is contained in the appendix of the Final EIS. The Notice of Decision will be published 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, 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, although not yet on the FEF. 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 *Geomyces destructans*. Scientists estimate as many as 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. Affected bats have been documented in caves in CT, DE, MA, MD, MO, NH, NJ, NY, OK, PA, TN, VA, VT, and WV. 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 EIS 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.

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 EIS. All comments can be found in the Appendix of this EIS.

Decisions to be Made

The EIS will evaluate site-specific effects and the issues as related to the proposed action and alternatives. The Responsible Official, NRS-01 Project Leader, will make a decision based on a review of the EIS. 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 October 20, 2010, in the *Parsons Advocate*. The Notice of Decision will also detail requirements and timelines to appeal the decision.

Chapter 2 – Alternatives

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 B 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 Effects." Chapter 3 discusses the scientific 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

The proposed action and each alternative presented in this EIS provide a different response to the significant issues for the FEF research program. 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 design phase of a research project. The following items are listed to highlight some of the measures of processes that are common to alternatives; this is not a complete list.

Actions common to all studies:

Wildlife Habitat

> Tree felling would be conducted only between October 1 and May 31, and would not take place during April.
>
> Tree species to be removed is dependent upon the specific silvicultural prescription. However, no butternut trees would be cut, and shagbark hickory trees would be left where possible without compromising the integrity of the research studies.

Units higher in elevation and more northerly in aspect, and generally *farthest* from the cave would be harvested first, moving closer to the cave as winter progressed to avoid interfering with the fall swarming period of bats.

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.

Trees would be felled and winched to the landing using a truck crane or tractor and cable, to minimize soil disturbance. Logs would be skidded using a rubber tired skidder or 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 closed, and water control devices such as water bars and dips constructed to control the movement of water.

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

All BMPs, as defined by the West Virginia Logging Sediment Control Act of 1992, would be followed during and after logging.

Riparian Habitat

Perennial streams would be protected with a 100-foot-wide vegetative strip, as described in the Forest Plan. 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 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.

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

Heritage Resources

Keeping with standard Forest Service practice, all unevaluated sites will be avoided during project planning or implementation.

Alternatives Considered In Detail

The proposed action and a no action alternative are considered in detail. The alternatives are defined as: Alternative A – No Action; Alternative B – 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. Alternative B satisfies the Purpose and Need, while still responding to the issues discussed in Chapter 1. Alternative B is the Preferred Alternative. Definitions of technical terms and abbreviations are provided in the Glossary.

Alternative A: No Action

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, 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. This would prematurely end important long-term research and seriously impair development of new knowledge. The utility of the FEF for collaborative research would be impaired.

Alternative B: Proposed Action

The proposed action includes many projects that are repeat treatments in ongoing long-term research studies (Figure 2-1). The proposed action involves using the following silvicultural treatments in existing research studies: diameter-limit cutting treatment on 93.9 acres, single-tree selection on 114.3 acres, financial maturity harvesting method on 214.5 acres, group selection on 7.9 acres, 12.0 acres of patch clearcutting, and prescribed fire treatment of 420.4 acres. Other treatments include fertilization of 96.7 acres with ammonium sulfate fertilizer, (and additions of dolomitic lime to 4 of those acres), treatments of invasive exotic plants (approximately 12 acres total), and maintenance of roads, decks, and other infrastructure.

The studies are described below:

<u>Large area comparisons of forest management practices</u> was initiated in 1950. The objective of this study is to determine the effects of three uneven-aged silvicultural practices (single-tree selection, diameter-limit, patch clearcuts) on yield and stand growth in board feet, cubic feet, and basal area, replicated two times 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.

Financial rate of return areas on the Fernow Experimental Forest was initiated in 1971. The objective of this study is to determine the effects of financial rate of return harvests on growth and yield of hardwood stands, species composition and hardwood stand quality. The financial rate of return method is a selection system that incorporates economic guidelines for selecting trees to harvest. Two study areas are being utilized for each of the following estimated rates of return: 3, 4 and 6 percent, as a test of the utility and accuracy of these criteria for selection, and to evaluate the effects on stand characteristics over time.

Evaluating prescribed fire as a silvicultural tool to promote oak regeneration in the central Appalachians. The principal objective of this research is to determine the effectiveness of using prescribed fire and fencing in conjunction with a shelterwood regeneration method to regenerate oak. Secondary objectives include evaluating treatment effects on coarse woody debris, forest floor and litter characteristics, seed bank composition and abundance, spring ephemeral wildflowers, herpetofauna, and acorn predation by weevils. The study is intended to develop a silvicultural technique related to the use of prescribed fire, but also will examine changes in ecosystem properties that can be considered at the stand or subwatershed scale.

Artificial acidification of several small watersheds at or near the Fernow Experimental Forest and The effect 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 will be applied to 85-acre watershed 3 and the effects on ecosystem parameters will be determined. The study results will quantify the susceptibility of watersheds in the central Appalachians to acidification by acid deposition. Also, the data will be useful for testing watershed acidification models. This whole system manipulation approach will 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 object of this research is to address, in the short-term, the habitat needs for tree-roosting bats, (e.g. *Myotis* spp.), and in the longer term, to create a mosaic of sites where oak regeneration is an eventual surety. Through a series of prescribed burning and periodic overstory mortality treatments (herbicides and/or girdling), we will be assessing in the short term, improvements in bat roosting and forage habitat. Over the longer period, overstory mortality treatments will focus on non-oaks such that over time all remaining live overstory trees will be oak; and only oak seedlings/saplings (or other fire tolerant species) will be present for future accession into the overstory. Unlike previous oak-fire-light studies, this will not have timber management as an immediate management goal. Such information would be useful for those managers that wish to manage specifically for bats and other important wildlife species, and restore high-graded stands over longer time periods. This study would take place on 6 compartments (6 replicates): 4 subareas of compartment 45 located within the John B. Hollow watershed, and compartments 13 and 21 (total of 363.2 acres).

Applying group selection in the central Appalachian hardwoods. This study was established in 1990. The objective was to develop practical guidelines for using the group selection method on a sustained yield basis to develop an uneven-age stand using small openings to regenerate portions of the stand on about a 20-year cutting cycle. Opening size varies from just a few trees to whatever size meets acceptable aesthetic and ecological requirements for the forest type being regenerated. In this study, maximum opening size is approximately 1 acre. Species composition and regeneration quality in new openings is of particular concern. Demonstration and the development of new guidelines for use of this practice are also objectives.

Evaluating forest responses to three ecological disturbance regimes. Current forests are considered to exist under very different conditions than pre-European contact forests, with higher deer densities in many places and changed 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 underlie 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 (LTSP). 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.

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, including Japanese stiltgrass on approximately 12 acres, and tree-of-heaven on an individual tree basis, as needed.

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 2-1 summarizes the proposed activities by the general categories of silvicultural treatment, prescribed fire, fertilization, and herbicide use.

Table 2-1. Comparison of alternatives

Criteria	Alternative A	Alternative B
Total silvicultural treatment area (acres)	0	442.6
Volume (board feet removed)	0	2,700,000
Miles of skid road[1]	0	19.1
Area in logging decks (acres)	0	2.1
Area treated with prescribed fire (acres)	0	420.4
Miles of fire break	0	6.2
Area treated with fertilizers (acres)	0	96.7
Area controlled for invasive exotic plant species (acres)	0	12.0
Total area to be treated (acres)[2]	0	959.7
Benefit/Cost ratio	NA	14.47

[1] No new skid roads would be created.

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

The issues raised in the EIS concern impacts of research activities on threatened, endangered, and sensitive plant and animal species; and adverse sediment impacts. The FEF was divided into 14 subdrainages (Table 2-2) for analysis of effects on water and riparian resources. Projects are proposed in 10 of those subdrainages.

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

Subdrainage	Total area	Alternative A	Alternative B
	----------------------------	acres	----------------------------
Side Hill	83.0	0	76.6
John B. Hollow	395.5	0	224.4
Lower Elklick Run	856.9	0	0
Bear Run	167.0	0	31.9
Hickman Slide	294.5	0	19.6
Tippy Toe Run	164.9	0	0
Wilson Hollow	326.3	0	31.0
Camp Hollow	489.2	0	96.5
Big Spring Run	200.0	0	0
Upper Elklick Run	736.1	0	266.4
Stonelick Run	617.8	0	137.8
Canoe Run	691.5	0	20.6
Sugarcamp Run	221.3	0	54.9
Fire Run	55.2	0	0
Total	5299.2	0	959.7

Mitigation Measures

Many of the resource concerns raised during scoping, interagency discussions, and subsequent analysis did not become significant issues driving alternative development. Some of these concerns were addressed by design and implementation of the proposed activities.

Many mitigation measures are described in the section Items Common to All Alternatives. Issue-specific mitigation measures are detailed in Tables 2-3 and 2-4.

Table 2-3. Measures to protect threatened, endangered and sensitive species

Protection measure	Alternative A	Alternative B
1. Tree felling would be conducted only between October 1 and May 31, with no felling occurring in April to reduce direct impacts to TES bat species.	NA	X
2. Shagbark hickory trees would be not be cut, to protect potential habitat for endangered Indiana bats.	NA	X
3. Streamside management zones would be established along perennial and nonperennial streams/riparian areas providing protection to TES species that use this habitat.	NA	X
3. Populations of TES species will be monitored regularly to assure viability of populations.	NA	X
4. Scheduling of harvesting units each year will be planned and conducted so that those units that are cooler, and more mesic will be harvested first, while those with more roost tree habitat are harvested later to minimize the possible impacts to Indiana bats.	NA	X
4. Monitoring of Indiana bat activity and habitat use will continue.	NA	X
5. Silvicultural systems employed in research would benefit certain TES species.	NA	X

Table 2-4. Measures to reduce sediment impacts

Protection measure	Alternative A	Alternative B
1. Forest Plan standards and guidelines would be employed to reduce sediment impacts.	NA	X
2. BMPs (Best Management Practices) would be employed to reduce sediment impacts.	NA	X
3. Streamside management zones would be employed for identified perennial and nonperennial streams.	NA	X
4. Ditches and culverts would be cleaned, and gravel applied to Bear Run and Hickman Slide Roads to reduce sediment impacts.	NA	X
5. Ditches along Fork Mountain Rd. in compartment watershed 5B would be graveled or have temporary culverts installed where equipment must cross the road to reduce sediment impacts.	NA	X

Monitoring Activities

Because many of the proposed actions are continuing treatments on ongoing research studies, their measurement and monitoring would continue. 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 EIS and relative to other resources on the FEF. Details of monitoring and experimental design can be found in individual study plans. This information would be put into annual monitoring reports, and published in scientific journals.

1. Winter hibernacula surveys of Big Springs cave will take place 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. (Issue 1)

2. Radio transmitters will be placed on Indiana bats outside of the hibernacula during the spring, summer, and/or fall months to monitor roost tree habitat on the FEF. Procedures for catching and handling bats will follow the "West Virginia summer bat research guidelines addressing white-nose syndrome" (draft edition). The goal is to place 2 transmitters on Indiana bats between August 15 and September 15, 2 transmitters on Indiana bats between May 15 and June 15, and any non-pregnant adult Indiana bats captured in the prescribed fire areas during summer mist netting will also received transmitters. However, the frequency and

timing of these surveys will be dependent upon the presence of white-nose syndrome and advice from the U.S. Fish and Wildlife Service. (Issue 1)

3. Limited mist net surveys will take place during the spring, summer, and/or fall months as part of an on-going roost tree selection study. However the frequency and timing of these surveys will be dependent upon white-nose syndrome and the concurrent U.S. Fish and Wildlife Service regulations that are developed as a result of the spread of this disease. (Issue 1)

4. All known running buffalo clover (RBC) populations on the FEF have been physically monumented, located using GPS devices, and added to the geographical information system for the FEF in the past five years. RBC monitoring on the FEF has been on-going since 1994 and will continue (Issue 1). Because it has become impractical to monitor all of the 5,000 to 6,000 individual RBC plants on the FEF annually, we will

    a. monitor each population at least once every two years during the next 5 years.
    b. improve physical monuments and spatial information of known RBC locations.

5. Channel cross sections would be established on selected stream channels to monitor changes in channel morphology. (Issue 2)

6. Substrate in some perennial stream reaches would be periodically measured to assess changes in quality. (Issue 2)

7. Effects of vegetation manipulation treatments, including changes in species composition, productivity, tree quality, and regeneration, would continue to be evaluated per the study plan design.

8. Air quality monitoring would continue as currently conducted.

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

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

Chapter 3 – Affected Environment and Environmental Effects

3.1 Water and Riparian Resources

Affected Environment

Effects to water and riparian resources are discussed in terms of the 10 subdrainages in which the compartments or watersheds occur (Figure 3-1). In terms of areas proposed for treatment, Upper Elklick subdrainage includes all of the area for compartments 13, 16B, 16C, 18A, 18B, 19B, 21, 26A, 26B, 27A, 27B, 30, and 31, and 9.9 acres of compartment 20C. Camp Hollow subdrainage contains all of watershed 3 and watershed 5B. John B. Hollow subdrainage contains 224.5 acres of compartment 45. Side Hill subdrainage contains 76.6 acres of compartment 45D. Hickman Slide Run subdrainage contains all of compartment 7C. Bear Run subdrainage contains all of compartment 9C. Wilson Hollow subdrainage contains all of compartment 60. Stonelick subdrainage contains all of compartment 61, 1.6 acres of compartment 48_1, 8.8 acres of compartment 49_1, 3.0 acres of compartment 90, and 16 acres of LTSP. Canoe Run subdrainage contains 17.8 acres of compartment 20C, 9.7 acres of compartment 48_2, and 5.0 acres of compartment 90. Sugarcamp Run subdrainage contains 9.6 acres of compartment 48_1, 8.2 acres of compartment 48_2, 38.2 acres of compartment 49_1, 27.6 acres of compartment 49_2, and 23.0 acres of compartment 90. The Sugarcamp Run, Canoe Run, and Stonelick Run subdrainages are located in the Shaver's Fork watershed. All other subdrainages are in the Elklick Run watershed. Cumulative effects are described in terms of the individual subdrainages, as well as Elklick Run and Shaver's Fork watersheds.

Based on on-the-ground geologic mapping of the FEF, these 10 subdrainages contain 7 bedrock geologic formations (Figure 3-2): Alluvium, Chemung, Pocono, Mauch Chunk, Hampshire, Greenbrier, and Pottsville.

Soil series delineation was determined from the June 2008 NRCS-updated soil survey for the Monongahela National Forest. The major soil series for the FEF for the compartments and watersheds in the alternatives are Belmont, Calvin, Cateache, Dekalb, Ernest, Gilpin, and Meckesville. 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.

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 done 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 6.09 miles, and nonperennial channel length is approximately 18.12 miles. Perennial channel length in the subdrainages of the Shaver's Fork watershed included in these analyses is approximately 4.43 miles. Nonperennial channel length in those subdrainages of the Shaver's Fork watershed is approximately 9.33 miles.

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 70-75 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 25-30 percent of the time. Stormflow contributions to flow in Calvin soils originate from shallow soil water contributions (Edwards et al. 2002), 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 < 5 NTU (e.g., Edwards 2008, Edwards et al. 2009). Turbidity increases during stormflows but the degree of turbidity change varies greatly among sites and across storms. Some streams may experience turbidity increases during smaller less intense stormflow. 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). On a paired watershed, 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 measured from a spring and in a stream on the FEF 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, or 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 calculations have been completed annually for approximately the past 10 years (monitoring done in conjunction with the 2000 EIS and 2005 EIS for the FEF). These measurements have shown that Elklick Run is an aggrading stream. As a result it is retaining more sediment than it is transporting. The substantial lengths of bedrock streambed in Elklick Run 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 this excess sediment is substantially shorter than the entire channel length. As the channel aggrades, aquatic habitat diversity decreases, and pools and riffles become less distinct.

Aggradation in Elklick Run is attributed primarily to the presence of Forest 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 and stream at the same elevation. At other places where the road is at a higher elevation than the stream, hanging culverts exist which erode fill below 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 of the 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 of its tributaries, since its construction. Causes contributing to the sediment inputs are: its intersection with Elklick Run by 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 is still visible during storm events. FR 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. FR 709 (Fork Mountain Road) appears to have little impact on water resources because of its ridge top location. 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 because of 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 collected in fulfillment of the 2000 and 2005 EIS monitoring requirements at nine permanent locations in Elklick Run (where bedrock was not present in the bed in 2000) show that the channel overall does not appear to be widening or deepening. Two of the cross sections in middle Elklick show some change, but these are from local morphological changes at those specific transects. The upper most cross section in middle Elklick now contains a root wad in the channel that was transported from upstream. The mid-reach cross section in middle Elklick shows loss of a pool between 2003 and 2004. This was due to rotting and washout of a log and debris dam present in that transect; after the dam washed out, the pool in front of the dam filled in. This change is due to the normal cycle of dam creation and loss in this channel.

The instability of Elklick Run appears to be expressed in the short-term by streambed fining (smaller particles filling the spaces or interstices around larger particles). However, visual observations during pebble counts and other monitoring efforts do suggest that there has been a substantial loss of and complete filling of large pools during the past two years in middle sections of Elklick Run. This includes some pools that previously had bedrock substrate for the first 8 years of monitoring. The cause of this drastic pool filling is believed to be the result of 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 exacerbates the chronic habitat loss from sediment accumulation in the channel.

The cross sections in Camp Hollow indicate no obvious trends or changes in channel width or depth. While there has been little direct forest management activity along Camp Hollow during the 10 years of monitoring, this stream receives flow from watershed 2 and watershed 5 that have undergone harvesting during the past 10 years. Local cross section measurements in watershed 2 show no substantial changes during the past 10 years. Wolman pebble counts in watershed 2 have varied little through time, though the percentages of substrate fragments in smaller sizes (especially 16 mm and smaller) were elevated in 2002. This difference does not seem to be linked directly to management practices in the watershed, because harvesting was done 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 fines 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, which overlapped with harvesting done in that subwatershed 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 (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.

Potential Effects

Harvesting and road construction can alter streamflow; studies throughout the East confirm this finding. However, it should be noted that most studies, including most of those described in this section, that have examined the effects of forestry-related disturbances in the United States have been performed on relatively small catchments or basins. The science involved in scaling these findings up to the landscape level is in its infancy and is currently most typically accomplished through modeling.

The most consistent finding across studies of forestry-related effects is that annual water yields are increased by harvesting (Hornbeck et al. 1993, Kochenderfer et al. 1990). The more trees removed, the greater the increase in streamflow. Annual streamflow increases become statistically measurable when about 23-25 percent of the basal area within a watershed is harvested (Reinhart and Trimble 1962, Hornbeck et al. 1993). Vegetative reductions do not have to be restricted to overstory components to increase annual yields. Removal of a thick understory of mountain laurel and rhododendron that accounted for 22 percent of the basal area of a watershed has been shown to result in significant short-term increases in annual water yields (Johnson and Kovner 1956, Meginnis 1959). On basins larger than 5,000 acres, 25 percent removal of vegetation using partial cuts resulted in a 66 percent increase in annual daily maximum discharge (Burton 1997).

For clearcuts in the central Appalachians, maximum annual water yield increases typically range from 5 to 7 inches and usually occur during the year of harvesting or the year after harvesting has been completed (Edwards and Troendle in press). However, increases in annual yields are relatively short-lived. In response to the favorable growing conditions, evapotranspiration is restored to approximately pretreatment levels within 5-10 years after clearcutting (Hornbeck and Kochenderfer 2001, Hornbeck et al. 1993). In some cases, following forest recovery, annual stream discharge can fall below that of the previous uncut stand due to changes in species composition, which changes canopy architecture and leaf area index (Swank et al. 2001).

Most of the augmentation of annual streamflow occurs during the growing season and during baseflow (Kochenderfer et al. 1990, Lynch et al. 1972, Reinhart et al. 1963, Douglass and Swank 1975). Significant dormant season increases can occur after clearcutting, but the increases tend to be of lower magnitude than those during the growing season (Edwards and Troendle in press); however, the dormant season increases are expressed for more years than growing season increases (Kochenderfer et al. 1990). Low-intensity thinnings on the FEF significantly increased growing season discharges, but these seasonal increases lasted only about 2 years. By contrast, increases in growing season flows for clearcuts on the FEF last about 5-7 years (Kochenderfer et al. 1990). Clearcutting and partial harvests on the FEF decreased the number of days that streamflow was less than 0.05 ft^3 s^{-1} mi^{-2} (Troendle 1970). Analysis of flow duration curves from the FEF also suggests that clearcutting augments low flows for a longer period than the time during which annual water yields are increased (Patric and Reinhart 1971, Bates 2000). The greatest change in flow durations occurred for the lowest discharges. Low flow augmentation is beneficial to aquatic biota (Patric 1976b).

Bates (2000) provides an analysis of long-term hydrograph records from the FEF gauged watersheds. Data were examined for the entire post-treatment period, which was up to 40 years in some cases. In addition to verifying previous results of increased water yields during the growing season after harvesting, no dramatic changes in hydrograph responses except those related to snowmelt and where logging roads contributed excessively to runoff were observed. Time to peak on clearcut watersheds was not significantly different than the control (Bates 2000), even when herbiciding was involved (Edwards and Wood 1994). Because the spring hydrograph in the central Appalachians generally is not dominated by long-term melt of accumulated snowpacks, harvesting and opening up stands to increased insolation does not have a substantial effect on changing the timing or shape of the spring hydrograph in this region.

Hydrographic responses to periods of intense rainfall also changed after a watershed was clearcut to 1-inch dbh employing no BMPs. Storm hydrographs associated with these events showed sharp, rapid peaks indicating the presence of a much quicker flow component than was present for similar storms before harvesting. This change occurred only during and directly after harvesting, but was present during both the dormant and growing seasons. A greater change was observed for smaller storm events. The hydrologic spikes were attributed to the numerous skid roads, particularly those that were poorly located and acted as channel extensions (Bates 2000).

Reported changes to peakflows due to forest harvesting and related activities (e.g., road construction) have not been universal. In some studies in the eastern United States, peakflow increases from 1/4 to 2 times in magnitude have been observed, but they generally last only 5-10 years (Reinhart et al. 1963, Hewlett and Helvey 1970, Lynch et al. 1972, Hornbeck 1973, Verry et al. 1983), while other studies have found little or no changes in peakflow (Hewlett and Hibbert 1967, Harris 1973, Rothacher 1973, Harr et al. 1975, Harr and McCorison 1979, Settergren et al. 1980, and Hornbeck et al. 1993). Analyses of watersheds on the FEF have shown no peakflow increases after harvesting, including clearcutting (Bates 2000). When peakflow increases have been observed, the majority of the increased discharge typically has been attributed to smaller runoff events with short recurrence intervals, suggesting that forestry activities have little effect on large floods (Swindel and Douglass 1984, Patric and Reinhart 1971, Lynch et al. 1972, Thomas and Megahan 1998, Troendle et al. 2010, Hewlett 1982).

Most of these peakflow analyses have been performed using paired watershed studies in which the response of a managed watershed (e.g., some level of harvesting and perhaps road construction) has been compared to that of an undisturbed or unmanaged watershed during pretreatment and posttreatment periods using analysis of variance or analysis of covariance procedures. However, the results of these types of analyses recently have been challenged because peakflow inherently includes both frequency-of-occurrence and magnitude components, which cannot be analyzed simultaneously using these techniques (Alila et al. 2009). Instead flood frequency analyses using the series of annual peakflows while adjusting for hydrologic recovery (following harvesting) have been presented as the correct procedure for interpretation of peakflow analyses, as frequency curves consider both the size of the event (magnitude) and the recurrence interval (frequency) (Alila et al. 2009). This follows the approach used for examining the effects of urbanization on peakflows in engineering literature (McCuen 1998). Frequency analysis results adjusted for recovery have been described for data from only two harvested watersheds in the western U.S. (Alila et al. 2009) for which traditional paired watershed analyses of peakflows had been performed (Jones and Grant 1996, Troendle and King 1985, Elder et al. 2006). The frequency analyses showed increases in peak flows across all range of recurrence intervals, including large flows with long recurrence intervals. As a result of the shift in the frequency curves, the recurrence interval of all sized storms had shifted to become more frequent (i.e., the recurrence interval had shortened). In addition, the duration of these changes was quite long, and was much longer than that described with more conventional analysis of variance or analysis of covariance.

Flood frequency analysis performed following harvesting in small watersheds in Minnesota found most of the divergence between frequency curves for unharvested and harvested conditions was for events with recurrence intervals less than 10 years, and the effects on large floods were negligible (Lu 1994). However, this analysis did not include adjustments for hydrologic recovery, which Alila et al. (2009) indicate must be done because of the departure from stationarity that likely exists which in turn leads to misinterpretations about the duration of harvesting effects.

While changes in streamflow regimes during storm events can be attributable to harvesting alone, they often are attributable, at least in part to the influence of roads within the watershed (e.g., Swank et al. 1988, Reinhart et al. 1963, Jones and Grant 1996). Roads hasten the delivery of water to streams through a number of processes, including: channel extension from cross drains; interception of subsurface flows and conversion to surface drainage; and intentional concentration of water on roads containing drainage structures (i.e., drainage is not solely by outsloping) (Edwards and Evans 2004).

Changes to stormflow can alter channel morphology and stability if they are extreme enough to shorten the recurrence interval of discharges that equal or exceed the channel maintenance flow. Channel maintenance flows in gravel and cobble bottom streams are bankfull or near-bankfull flows (Dury 1969, Dunne and Leopold 1978). More extreme flood flows also may be important for channel maintenance in small mountainous channels that lack floodplains (Verry 2000). Changes in channel maintenance flows change a stream's ability to produce and carry sediment (Verry 2000); sediment deposition, retention, transport, and erosion are the processes that control channel stability and dimensions.

Bankfull stage occurs about once every 1.5 years for perennial channels in the U.S. (Dunne and Leopold 1978, Leopold 1994). Because bankfull is a concept developed for perennial channels, the level of flow needed for maintenance of nonperennial channels is not known, but the concept of bankfull (analogous to that for perennials) likely is applicable to intermittent channels since they have water tables above their streambed bottom for at least part of the year. The frequency of bankfull in intermittent channels on the FEF or more broadly through the forested eastern U.S. is not known, but based upon results from Coweeta Experimental Forest in North Carolina, bankfull in headwater channels probably is more frequent than once per year, though most bankfull occurrences are short lived (Henson 1994). Initial analyses of multiple pieces of data collected at the FEF suggest the concept of bankfull is not applicable to ephemeral channels. Nonapplicability to ephemeral channels probably is due to two factors: (1) the water table is always below an ephemeral channel streambed, and (2) bankfull flows are driven by storm events, i.e. precipitation-contributed water. As such, both discharge and stage at any position in an ephemeral stream may vary significantly from one storm to another based upon antecedent soil moisture, source areas and flow paths, storm characteristics, etc. If channel maintenance flows are applicable to ephemeral channels, the frequency of these flows is less and undoubtedly much less consistent than for intermittent and perennial channels.

Channel morphology studies related to land use on the FEF, as well as much of the East, are in their infancy. Of all the components of channel morphology that are measured to determine stream stability, bankfull width is the most easily measured and most consistent diagnostic parameter of channel condition. This is because it is strongly correlated to flow parameters (Dunne and Leopold 1978) – for example, bankfull width will double in a stream where the bankfull discharge (volume) is doubled (Verry 2000). An analysis of stream cross sections on the Monongahela National Forest showed no significant changes in channel bankfull width or depth due to newly constructed culverted stream crossings, but channel substrate showed marked increases in fines (Bill 2005). In Minnesota, clearcutting an aspen stand increased bankfull flow volume by 150 percent even though 25- to 100-year flood flows did not change. This bankfull increase widened the bankfull width (Lu 1994). Data from the north central states also showed that cutting young vegetation from more than 2/3 of a watershed increased annual peakflows, which again are the effective channel maintenance flows (Verry 1997). Headcutting is one of the most visually obvious changes in channel morphology and is an upslope erosional extension of the channel. It may be the consequence of many different types of actions, including down-cutting in downstream reaches or channels, channel straightening, locating roads along stream channels, removing wood and other roughness features from the channel, and changing channel maintenance flows via land use, such as extensive clearing, grazing, or development (Verry 2000). The ditched road area should remain at less than 15 percent of the basin area to protect against increasing storm runoff and streamflow to levels that could alter channel morphology (Harr et al. 1975; Verry 2000). However, bankfull can sometimes decrease in response to disturbances in a watershed (Faustini et al. 2009), presumably disturbances often result in increased sediment delivery to stream channels causing them to aggrade and fill.

Bankfull width was measured at transects demarcating 70-acre contributing areas on three intermittent channels on the FEF (Edwards et al. 1999). One watershed had been clearcut to 1-inch diameter using no BMPs in 1958. A second watershed was clearcut using BMPs and all the woody debris in the channel was removed in 1972. In both cases no riparian buffer strip was retained. The third watershed was a control that had no harvesting or major disturbance since about 1905. Bankfull width was substantially greater on the two harvested watersheds (~12 feet and ~10 feet, respectively) compared to the control (~5.25 feet). On the clearcut watershed with no BMPs, channel widening was attributed to the extensive and poorly planned skid road system that acted as channel extensions and resulted in concentrated streamflows. Widening resulted from a change in bankfull flows. Channel widening on the clearcut watershed with channel cleaning was attributed primarily to the significant reduction in channel roughness, though increased streamflow initially (~0-5 years) after harvesting may have further encouraged channel changes. Drainage densities (ft of stream channel per acre) in the two harvested watersheds were 1.7 and 1.3 times greater than the control watershed, suggesting headcutting, which was visibly evident. Where no BMPs were employed, the channel network was extended up to almost the catchment ridge top.

How erosion and sediment delivery change with forest management is inherently tied to how surface runoff is changed. Water is responsible for the majority of erosion and sedimentation that occurs in the humid East. Erosion is a natural process and critical for streams and rivers to preserve their morphology and stability. By contrast, anthropogenically-elevated erosion and sediment transport can deleteriously affect water quality, aquatic habitat, and channel condition.

Stream sedimentation risks increase as litter and soil disturbance and soil compaction increase. The litter layer acts to protect soil particles from direct impact and detachment by raindrops (Stuart and Edwards 2006). The litter layer also plays a major role in maintaining high soil infiltration rates (Patric 1977) so precipitation can infiltrate quickly or overland flow has a greater chance to infiltrate and deposit any sediment it may be transporting. Sediment transport from hillsides to streams is almost entirely a surface phenomenon primarily through rill (including gullies) flow and transport, which occurs when overland flow concentrates and builds up energy (Rauws and Govers 1988, Torri et al. 1987, Römkens et al. 1997, Bryan 1990). Therefore, by retaining litter on the surface and avoiding soil compaction, sediment transport to streams above natural climate-driven levels is eliminated or largely controlled.

Not surprisingly because of the degree of soil disturbance involved in their construction and existence, forest roads, not the removal of timber, are the major source of sediment made available for delivery to streams (Megahan 1972, Patric 1976a). If water is not controlled properly, it can become concentrated and build up sufficient energy to erode and transport soil particles. Sediment can be eroded from a road and delivered directly at stream crossings if the road is not properly designed and the water not properly controlled. Water discharge points on roads, such as cross-drainage culverts, dips, wing ditches, etc. concentrate water, which can result in substantial energy and erosion at the point of discharge (i.e., the culvert, dip, or wing ditch outlets); eventually erosion and channel extension from the outlet to the stream can result. To avoid these problems, water must be moved off of roads and from ditch lines in small parcels; this is achieved by frequent placement and proper sizing of road drainage structures. These requirements apply to both system and nonsystem roads (e.g., skid roads), since both provide sources of sediment that can be vulnerable to transport to streams.

Substantial research on road construction techniques and placement, with respect to erosion and sedimentation issues, has been done by scientists working on and near the FEF. Their findings are consistent with those in the literature: when haul roads, skid roads, and landings are properly located and appropriate mitigation measures, such as graveling, are employed, watershed exports of sediment show minor increases (Kochenderfer 1970, Patric 1978, Kochenderfer and Helvey 1987, Kochenderfer et al. 1997). Gravelling provides protection from erosion and subsequent sedimentation.

Kochenderfer and Helvey (1987) measured 47.2 tons of sediment generated off of each acre of ungraveled road surface (annual mean). Roads with limestone gravel had mean annual exports of between 5.7 and 10.1 tons per acre of road surface, depending upon the size and composition of the gravel material.

Only a portion of sediment generated from roads is delivered to stream channels. The amount depends upon many things, including but not limited to road characteristics and condition (including the placement of BMPs), soil erodibility between the road and stream, proximity of the road to the stream, susceptibility to landslides, and climate. Research on an 82-acre watershed on the Cheat District of the Monongahela National Forest, showed that stream crossings were the most vulnerable locations on the road for sediment delivery, and this was particularly true during the construction period. Three crossings yielded more than 2,522 pounds of sediment during construction, compared to minor contributions from the rest of the 2,526 feet of road length in the watershed (Stedman 2008). Sediment delivery to the stream primarily was due to mechanical additions of soil during fillslope construction in the approaches to the crossings. Once the fillslopes were revegetated and stabilized, soil losses to the stream diminished substantially. While most forested headwater streams are sediment limited, during the period from stream crossing construction to fillslope stabilization, there was sufficient sediment delivery from the crossings that the streams temporarily changed from being source limited to energy limited (unpublished data) – that is, sediment was transported to and within the stream as long as energy was available.

While measurements of in-channel sediment yields are not equivalent to hillside delivery of sediment (Edwards 2003), the former can provide some insight into the effects of roads on soil delivery. Kochenderfer et al. (1987) quantified sediment deposited in the Elklick Reservoir on the FEF over an 18-year period and compared it to sediment yield on three forested watersheds, which were much smaller in area and contained much shorter road lengths. The reservoir is at the mouth of an intensively managed 1,600-acre watershed containing 8 miles of graveled roads, many of which are located within 50 feet of perennial stream channels (including Elklick Run). Annual sediment yields from Elklick Run were 463 lb acre^{-1} compared to 33 lb acre^{-1} from an undisturbed watershed, 166 lb acre^{-1} from a watershed which was partially harvested 10 years earlier, and 253 lb acre^{-1} on a watershed that had been a mountain farm 50 years earlier. They also reported that 87 and 96 percent of the sediment was exported during stormflows, for the latter two watersheds.

Providing vegetated riparian zones is a common technique used to control sediment delivery and protect streams. The presence of vegetation, particularly forest trees, helps bind soil in place to reduce erosion. Riparian and upland trees also provide the sources of litter critical for maintaining soil infiltration. By maintaining sufficient distance between roads or other sediment sources, vegetated riparian zones are also meant to encourage infiltration of concentrated flow and deposition of eroded soil. However, riparian areas may not provide these functions fully or effectively for concentrated runoff from road cross drains (culverts, broad-based dips, water bars, etc.) if too much is discharged onto the surface at a single location (Edwards and Evans 2004). As a consequence, these discharge points can become direct extensions of the channel during storm events, thereby affecting the runoff volume and timing, and quality of flow in the channel below those points.

In addition to providing benefits associated with runoff and erosion, streamside zones also provide temperature protection and moderation (Barton et al. 1985). Partial harvesting in the riparian zone can be done and aquatic resources can remain protected if sufficient shading is left (Kochenderfer and Edwards 1991). Greatly reducing stream vegetation can increase summer temperatures and decrease winter temperatures, thereby affecting aquatic organisms (Swift 1983).

Fire is another disturbance that can affect soil erosion and sediment delivery. Fire severity plays an important role in how susceptible soil becomes to erosion following the burn. Erosion occurs when the organic layers are fully combusted and mineral soil is exposed (Van Lear and Danielovich 1988). In the humid Appalachians, controlled burning, or prescribed fire, usually has little effect on erosion and sedimentation because the severity of fires may remain light, thereby retaining organic material on the surface, even when the burn is high intensity (Van Lear and Kapeluck 1989). Soil infiltration does not seem to be affected much as long as surface organic layers are not combusted fully (Mohering et al. 1966). Swift et al. (1993) captured insignificant levels of mineral material in sediment traps following a burn. Approximately 30 percent of the humus layer was unburned and the rest was charred. Soil movement occurred only where the soil had been exposed before the fire occurred, such as from windthrow root wads. No sediment moved off site. Controlled fires in the East also are not hot enough to create hydrophobic soils; hydrophobicity is a primary cause of loss of infiltration and the concentration of overland flows where severe wildfires burn (e.g., western U.S.). Only one record of hydrophobicity was found for eastern soils in the literature, and its occurrence lasted only 5-10 minutes (Shahlaee et al. 1991).

Direct and Indirect Effects of Alternative B: Proposed Action

The following discussion relates to **Issue 2 – Hydrologic and Sediment Impacts to Streams.**

Silvicultural or other types of research projects that could affect hydrology or alter sediment delivery or in-channel sediment regimes are proposed for ten subdrainages. One new log deck, but no new haul roads or skid roads are proposed in Alternative B. Effects to water and riparian resources are described in terms of size, geology, soil sensitivity (erodibility), miles of perennial streams and nonperennial streams (i.e., intermittent and ephemeral), skid roads, truck/haul roads, and decks of the compartments and subdrainages, which are summarized in Tables 3-1, 3-2, 3-3, and 3-4 (Chapter 4).

Allowed harvesting and crown closure levels for riparian or buffer strip areas on the FEF are different from those applicable to the larger Monongahela National Forest (described in the 2006 Forest Plan, in effect at the time this EIS was written). On the FEF, any harvesting in the streamside area of treated compartments or watersheds would retain at least 60 percent crown closure along the entire length of all nonperennial channels and would retain at least 75 percent crown closure along the entire length of all perennial channels. Based on research in other areas, this level of shade would provide stream shading for alternatives at a level sufficient to protect stream water from temperature increases that potentially could affect aquatic organisms or not be recoverable within a short distance (Burton and Likens 1973, Zwieniecki and Newton 1999). Therefore, stream shading and temperature are not discussed further in this document.

For purposes of quantifying and describing effects in this EIS, bulldozed skid road width has been assumed to be 13 ft and haul road width 20 ft. No new skid or haul road construction is planned in any alternative, so all roads included in the discussion are existing roads.

A study involving prescribed fire is included in the proposed actions for Alternative B. This study will include compartment 45 in Side Hill subdrainage and John B. Hollow subdrainage, and compartments 13 and 21 in Upper Elklick Run subdrainage. Fire breaks will be required for this study, and haul roads and skid roads that are in place at this time will be used as fire breaks when possible; however, additional fire breaks also will be needed. While in reality most of these breaks probably will be constructed manually by raking or blowing leaves out of a corridor, some fire breaks will be constructed using a bulldozer. Because the exact locations/numbers/miles of constructed bulldozed fire breaks is unknown, in this analysis all of the constructed fire breaks are treated as and described in terms of 13-feet wide bulldozed skid roads, and total no more than 3.8 miles.

Effects of Mitigation for Alternative B: Proposed Action

Stream sedimentation, channel morphology changes, and streamflow regime changes all are interrelated and are controlled by the 8 physical factors that dictate stream stability and behavior (Dunne and Leopold 1978). Significant changes in streamflow, sediment, or channel morphology are either accompanied by or driven by changes in the other two. Because of this interdependence, sediment is used as a surrogate for all three parameters in mitigation measures. Thus, mitigation described to control or reduce sediment problems likewise would effectively mitigate potential channel morphology and streamflow changes/problems.

Mitigation actions that are common to all activities in Alternative B that affect water and riparian resources are listed in Chapter 2.

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 issue 2) 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 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 water bars and dips, and on log landings with liming, seeding, and mulching similarly would help reduce to-stream sedimentation. Matching harvesting equipment and methods to the site conditions would reduce soil disturbance and erosion. For example, using a truck crane would limit soil exposure and erosion in steep terrain. Restricting logging equipment from riparian areas would help avoid erosion in these near-stream areas and subsequent in-stream sediment deposition. These mitigations, 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 West Virginia's BMPs 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 Alternative B on water and riparian resources over what would be experienced otherwise. These mitigations also work toward reducing cumulative effects.

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 Forest Road 701. There are 2.44 miles of skid roads in the subdrainage, which occupy 4.63 percent of the subdrainage area. There are no perennial or nonperennial streams in the subdrainage, but ditch lines of Forest Road 701 contribute directly into perennial Elklick Run.

Compartment 45D 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 701 on the east side of the subdrainage is a Fluvaquent, which is highly erodible. In Alternative B, all of compartment 45D in the Side Hill subdrainage would be subjected to prescribed fire to create endangered bat habitat.

Prescribed burning in Side Hill subdrainage would be moderate intensity but fairly rapid 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 from the surface of about 2.34 miles of existing skid roads using a bulldozer which would help reduce hot spots and humus layer combustion. A fire line to mineral soil would be bulldozed around the ridges of Side Hill subdrainage to control the fire. The fire lines would be constructed within a day or two of the burn. Because litter would become re-established on the fire lines relatively quickly from wind redistributing leaves from outside the burned area, no additional water control 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 or streamflow, particularly since there are no streams in compartment 45D in the Side Hill subdrainage. The lack of channels within the subdrainage coupled with little mineral soil exposure would 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 2.51 miles of haul roads, and 5.01 miles of skid roads. These comprise almost 14 acres, or 3.53 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 the 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 all of compartment 45 is a prescribed fire to create endangered bat habitat, primarily in the lower two-thirds of the subdrainage. The prescribed burn would be moderate intensity but fairly rapid 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. A fire line to mineral soil would be bulldozed around the compartment boundary to control the fire. Additional fire lines to mineral soil would be constructed by hand and would be approximately 2 ft wide. No fire lines would be constructed near stream channels. The fire lines would be constructed within a day or two of the burn.

The prescribed fire would have little effect on soil moisture or streamflow. The bulldozed fire lines 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 effects. Consequently, the treatments proposed for John B. Hollow subdrainage would not directly or indirectly affect hydrology or sedimentation.

Camp Hollow Subdrainage

Camp Hollow subdrainage is 489.2 acres. It includes 1.98 miles of haul roads, about half of which is Fork Mountain Road and runs along the ridge top in the head of Camp Hollow subdrainage. The other half is Camp Hollow Road which is adjacent to perennial Camp Hollow Run. Camp Hollow Road crosses Camp Hollow Run about 6 times and crosses an additional intermittent channel near the end of Camp Hollow Road. There are 5.81 miles of skid roads in Camp Hollow subdrainage within watersheds 2, 3, and 5. There are 3 decks along Camp Hollow Road that are very near the perennial stream channel and 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 14.61 acres, or 2.99 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 shared with Upper Elklick subdrainage. Calvin soil is moderately erodible and Dekalb has low erodibility.

There are two areas that are proposed for treatment in Camp Hollow subdrainage under Alternative B. Watershed 3 would continued to be treated aerially 3 times a year with ammonium sulfate fertilizer to study the effects of soil acidification on watershed processes; the entire watershed area would receive fertilizer applications. Compartment B in watershed 5 would be harvested using single-tree selection.

Watershed 3 is 84.7 acres in area, which is 17.3 percent of Camp Hollow subdrainage. It contains 0.14 miles of haul road on the ridge along Fork Mountain. Increased haul road use would not be expected from the proposed treatment. 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 would not be expected from this treatment.

There are 2.20 miles of skid roads in watershed 3. These were constructed before 1973, and remain mostly unused by vehicles since 1972. As a result, they have developed a protective vegetation and litter layer on them, and trees now grow within some of the skid roads. Four-tenths of a mile of a skid road is used monthly by light all-terrain vehicles to retrieve soil water samples from November to April each year. 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 on watershed 3 would not increase erosion or in-stream sedimentation since the application of fertilizer would not increase soil disturbance. ATV use on the currently used skid roads would continue even if the fertilization was not applied because soil water samples would continue to be collected.

Changes in hydrology would not be expected. Therefore, channel morphology, in-channel sediment storage and routing, and sediment budgets would not change in response to ammonium sulfate applications or site access.

Watershed 5 is 90 acres and includes two sections – 5A and 5B. Treatment is proposed only for watershed 5B. Watershed 5B comprises 11.8 acres in watershed 5, and 2.4 percent of the area in Camp Hollow subdrainage. In Alternative B, watershed 5B would receive a single-tree selection harvest spread over its entire area. Basal area would be reduced by approximately 34 percent. Because of the small area involved and the harvested trees being dispersed, insufficient basal area would be removed to increase streamflow in watershed 5 or in the Camp Hollow subdrainage.

Watershed 5B has no haul roads and no decks within its boundaries. The deck that would be used in this proposed treatment is one of those located along Fork Mountain Road, on the ridge top. There are 0.22 miles of skid roads in watershed 5B, constituting 0.35 acres, which is 0.07 percent of the subdrainage area. Most of the soils in watershed 5B are moderately erodible.

There are no perennial or nonperennial stream channels in watershed 5B. Most of the area in watershed 5B is on or near a ridge top or on topographic divides within watershed 5. However, the skid trail that would be used to reach the landing on Fork Mountain Road crosses the headwaters of one nonperennial tributary and passes uphill but near the start of another nonperennial tributary. The stream crossing has a culvert in place.

Erosion from the skid roads in watershed 5B would be expected to increase as the result of their re-opening and re-use. However, sediment transport from them would not be expected to reach streams since most of the sections of skid road that would be used are away from stream channels. Outside of watershed 5B, sediment contributions to the nonperennial stream channel could increase in the area around the crossing. However, since only one crossing is involved and it is in the very headwaters of that channel, sediment increases would not be expected to be substantial if BMPs were followed, and it is unlikely that sediment inputs would be at a level that could alter sediment routing or sediment budgets measurably in the subdrainage. Cross section measurements made in upper, middle, and lower reaches of Camp Hollow Run over approximately the past 10 years showed no meaningful changes in channel morphology when more-intensive harvesting was done on larger areas (watersheds 2 and 5A) in the subdrainage. Overall, 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.

Wilson Hollow Subdrainage

Wilson Hollow subdrainage is 326.3 acres. The subdrainage has 2.27 miles of haul roads and 2.76 miles of skid roads. These comprise slightly less than 10 acres of the subdrainage area. There is also one deck in the subdrainage, which is 0.06 acres. Haul roads, skid roads, and decks are 3.04 percent of the subdrainage area. There are 0.48

miles of perennial channel and 2.97 miles of nonperennial channel within the subdrainage.

In Alternative B, compartment 60 in the Wilson Hollow subdrainage would receive a 4 percent financial maturity harvest. No other areas are proposed for treatment in the subdrainage. Compartment 60 is located in the headwaters of the subdrainage, and is 31 acres in size, which is 9.5 percent of the subdrainage area. The harvest would result in a removal of 21 percent of the basal area in the compartment, and as a financial maturity harvest, selected trees would be dispersed throughout the compartment. Given the size and position of the compartment within the subdrainage, the amount of basal area removed would be insufficient to increase streamflow within the subdrainage.

Skid roads and log landings occupy about 0.82 ac of compartment 60. No haul roads exist in the compartment. The skid roads are located primarily along the contour and do not cross stream channels. The log deck is on the ridge top. Soils in this compartment are mapped as Dekalb, which has low erodibility.

No perennial or nonperennial streams exist in compartment 60. The closest stream channel, which is nonperennial and runs parallel to the compartment's southeastern boundary, is approximately 40-85 ft downslope.

Harvesting in compartment 60 would have a negligible effect on water and riparian resources. Because of the lack of stream channels and stream channel crossings in the compartment, channel stability and channel morphology changes would not be expected. Sediment transport downstream would not be expected due to the substantial distance between the compartment and the nearest stream. Sediment delivery downslope from the log landing would not affect streams because the log landing is on the ridge top, far from any stream channels.

Consequently, at the subdrainage level changes to streamflow, sediment delivery, or channel morphology would not be expected from treatments in Wilson Hollow subdrainage.

Hickman Slide Subdrainage

Hickman Slide subdrainage is 294.5 acres. There are 2.02 miles of a cut-and-fill haul road that is open to low-density traffic year round. Both dips and culverts are employed as cross drainage features. There are another 7.60 miles of skid roads in the subdrainage that are closed and water barred when not in use. Log decks occupy another 0.44 acres of the subdrainage. Total area in haul roads, skid roads, and decks in the subdrainage is 17.31 acres.

Hickman Slide subdrainage has a total of approximately 2.26 miles of stream channel within its boundaries. Approximately 0.87 miles are perennial and 1.39 miles are nonperennial. The perennial stream is crossed by the haul road in Hickman Slide subdrainage in 6 locations and nonperennial tributaries are crossed at 10 locations by the haul road and skid roads.

Single-tree selection harvesting is proposed in a single compartment, 7C, in Hickman Slide subdrainage. The compartment is 19.6 acres and comprises 6.7 percent of the subdrainage area. Approximately 28 percent of the compartment's basal area would be removed. Harvesting would occur in the upper-most portion of the subdrainage along the ridge where no stream channels exist.

Approximately 0.50 miles of skid roads would be re-opened in compartment 7C. Another 0.70 miles of skid road also would be re-opened outside of the compartment in Hickman Slide subdrainage to access the log landing located within the subdrainage but outside compartment 7C. The total area of re-opened skid roads and decks in Hickman Slide subdrainage would be less than 1 percent of the total subdrainage acreage. The deck is located on Hickman Slide Road, so 0.92 miles of haul road (outside of compartment 7C) would be used by log trucks during the harvesting period; therefore, the traffic on the haul road during this period would increase both in terms of frequency of use and equipment weight.

The re-opened skid road used to access the landing includes two culverted crossings on nonperennial streams. The haul road includes 3 culverted crossings – 2 perennial streams and 1 nonperennial stream. Compartment 7C does not have streams within its boundaries and is not close to any streams.

Compartment 7C is composed of small portions of Dekalb soils immediately along the ridge, and Cateache soils in the rest of the compartment. Cateache soils are highly erodible and Dekalb soils have low erodibility. The soils present in the re-opened portion of skid road outside of compartment 7C are Cateache and Belmont and are highly erodible. While highly erodible soils dominate in and along the proposed harvesting and skid road use areas, the area they would include would cover slightly less than 20 percent of the area in Hickman Slide subdrainage.

Because harvesting would occur on less than 7 percent of the subdrainage area, would be limited to the ridge top area and would be accomplished by single tree selection, streamflow changes in the subdrainage would not be detectable. The vegetation adjacent to the harvested trees would quickly exploit additional soil moisture that may be produced by single-tree selection. Furthermore, the thick Cateache soils in subcompartment 7C would provide a reservoir for storing excess moisture so any release to streamflow would be slow. Consequently, hydrologically-driven changes would not occur.

Erosion from harvesting would be negligible in the compartment, even with highly erodible soils, because tree felling results in little soil disturbance. Winching logs and skidding within the compartment could expose, disturb, and compact soils because the dominant soil in the compartment is highly erodible. However, sediment transport originating from erosion within the compartment would be negligible because of the ridge top position of the compartment and the lack of nearby stream channels. By contrast, direct entry of sediment into stream channels would be possible from skid road re-blading and use outside of the compartment during log transport to decks. There would be opportunities for stream sedimentation near the stream crossings given the high erodibility of the soils in these crossings, particularly since harvesting would occur during the wetter months of the year.

Log-truck use of the haul road also would be expected to contribute sediment to the perennial portions of Hickman Slide Run. This haul road currently delivers high amounts of discharge directly to the stream; even with the improvements associated with re-graveling the road in 2009, sediment losses remain visible during storms from this road. Heavy truck traffic could exacerbate this problem by kicking off gravel and moving soil to the surface as gravel becomes more embedded. Sediment from the haul road could reach the stream channel through ditches and culverts, dips, other water control features, as well as the stream crossings. Ditch line and cross drain outlet erosion could lengthen and extend the active stream channel up to the cross drain outfalls due to the high erodibility of these soils.

Turbidity increases in stream water likely would be visible at some times during skidding and hauling operations, particularly during storm events, and these effects probably would result even if those operations were suspended during wet periods because road sediments were exposed and available. Sediment additions to the channel from the skid roads should decrease when their use is terminated because the skid roads would be water barred; however, some sediment resulting from skid road use could be stored in the stream channel, which might take years or decades to be flushed from the subdrainage. However, the chronic sediment and turbidity conditions during storms in Hickman Slide Run are primarily due to the presence of Hickman Slide Road, and much of the current problems would continue even if the road was closed to any traffic.

Actions proposed in Alternative B would be expected to result in additions of sediment to the stream channel from the road system. Because Hickman Slide Run already suffers from elevated sediment inputs from the presence of Hickman Slide Road, any additions of sediment to the stream would be undesirable and would contribute to an already altered sediment budget.

Bear Run Subdrainage

Bear Run subdrainage is 167.0 acres. There are 0.95 miles of haul road that is open year-round and has low-volume traffic. Haul road drainage is accomplished through culverts, open-top culverts, and dips. There are also 4.73 miles of skid roads in Bear Run subdrainage; these are closed and water barred when not in use. There are 3 log decks in Bear Run, and these are seeded, limed, and mulched after closure. The total area in haul roads, skid roads, and decks in the subdrainage is 10.08 acres, or 6.03 percent of the subdrainage area.

Bear Run subdrainage has 0.4 miles of perennial stream channel and 0.97 miles of nonperennial stream channel. The haul road does not cross the perennial stream channel, but does cross nonperennial reaches at two locations in the subdrainage. There are approximately 9 locations where skid roads cross nonperennial tributaries and most of these are in the lower half of the subdrainage.

Diameter-limit harvesting is proposed in compartment 9C of Bear Run subdrainage. This compartment is 31.9 acres and is located in the upper portion of the subdrainage, along the ridge top. Within compartment 9C, the dominant soil series are Cateache and Dekalb, which have high and low erodibilities, respectively. Compartment 9C comprises 19.1 percent of the subdrainage area. Approximately 43 percent of the basal area in compartment 9C would be removed under Alternative B.

Within compartment 9C, there are no haul roads and 0.76 miles of skid roads. There are only 0.14 miles of nonperennial stream length in compartment 9C and the skid roads do not cross any streams within the compartment. There are no decks within the compartment, and the single deck that would be used for this harvesting is located in the lower half of the subdrainage; thus, logs would be skidded along an additional 1.0 miles of skid road located outside of the compartment to reach the deck. At most, two nonperennial streams would be crossed by the skid roads used to access this deck. This deck is 0.19 acres and occupies 0.1 percent of the subdrainage.

Because harvesting is proposed for only 19.1 percent of the subdrainage area and would remove less than half of the basal area in that ridge top position, measurable streamflow increases would not result. Local, short-term increases in soil moisture may occur, but the thick Cateache soils would be able to store this moisture, which would either be released slowly or would be exploited by the remaining overstory and understory vegetation.

There are no stream channel crossings by haul or skid roads in compartment 9C, but just outside of the compartment, there are two crossings of nonperennial channels on a skid road that would be used for the proposed harvesting. Additionally, there are several undersized cross drain culverts and some ineffective dips on the haul road that would be used to transport logs. Erosion from dips is evident, and there is minor washing and erosion on the haul road where the undersized culverts are present. The channels extend very far upslope in the subdrainage, and some channel incision was observed during past EIS monitoring. Undersized culverts and perhaps improper culvert slopes are likely causes of these problems. The potential for continued channel extension and elevated erosion inputs exists with the use of the skid road at the crossings and increased haul road traffic because of the high erodibility of these soils, but the impact is probably more influenced by existing conditions than by increased levels of use.

Re-opening and use of the deck will result in soil disturbance and exposure, but there are no stream channels near it, so increased sediment delivery to streams would not be expected from the deck. Soil stabilization (seeding, liming, mulching) after deck closure will limit the duration of soil exposure, reducing overall erosion.

Upper Elklick Run 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 FEF.

Total haul road length is 4.20 miles, which is almost entirely FR 701. There are 16.38 miles of skid roads. Approximately 36 acres of roads exist in Upper Elklick Run subdrainage. Twenty-six decks and one gas well pad cover an additional 1.27 acres. Roads, decks, and the well pad comprise 5.06 percent of the area of Upper Elklick Run subdrainage.

Upper Elklick Run subdrainage has 1.86 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 Elklick Run.

FR 701 parallels Elklick Run's main channel and is within 50 ft or less of the channel for most of the entire stream length in Upper Elklick Run subdrainage. All of 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.

Upper Elklick Run subdrainage includes 14 compartments proposed for treatment in Alternative B. Compartments 13 and 21 would be subjected to prescribed fire; compartments 16B, 16C, 19B, and 27B would have single-tree selection harvests; compartments 18A, 18B, and 30 would have patch clearcuts; compartments 20C and 27A would have diameter-limit harvests; compartments 26A and 26B would have 6 percent financial maturity harvests; and compartment 31 would have a 3 percent financial maturity harvest.

Compartment 13 is 31.3 acres and is located near the mouth of Upper Elklick Run subdrainage. The compartment contains no haul roads and 0.80 miles of skid roads. Approximately 0.44 miles of nonperennial tributary to Elklick Run longitudinally bisects compartment 13.

A fire line will be 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 constructed within a day or two of the burn.

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.

The proposed prescribed fire would be moderate and quick and primarily 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.

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 not be great.

Compartment 21 (30.9 acres), which is located more in the headwaters of Upper Elklick Run subdrainage, would be treated in essentially the same way as compartment 13. Compartment 21 contains 0.64 miles of perennial stream channel, and 0.1 miles 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 miles of skid road 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 creation 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 constructed within a day or two of the burn.

The proposed prescribed fire would be moderately intense with part of the objective for the burn to kill some of the overstory trees. It would not have a significant effect on reducing evapotranspirational rates within the compartment or increasing soil moisture sufficiently to increase streamflow or stream energy. Channel morphology or sediment relationships attributable to hydrologic changes also would not be changed by prescribed fire.

The constructed 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 not be great. Continued chronic inputs of sediment from FR 701 into Elklick Run would continue, but the fire would not increase those inputs.

Compartments 16B and 16C are adjacent units and occupy 30.3 and 17.0 acres, or 6.4 percent, of the Upper Elklick subdrainage. In Alternative B, these compartments would be harvested using single-tree selection. Approximately 36 percent of the basal area would be harvested from compartment 16B and 33 percent from 16C.

Compartment 16B is comprised of a small portion of Belmont soil but primarily Cateache soil; both are highly erodible. The lower half of compartment 16C also contains Cateache soil, while the upper half along the ridge is Dekalb, which has low erodibility.

There are no haul roads in compartments 16B and 16C, but there are 0.69 and 0.48 miles of skid roads, respectively, which occupy a total of 1.85 acres. Approximately half of the skid road length in compartment 16C is in Dekalb soil. The skid road system in compartment 16B includes one stream crossing of a nonperennial tributary of Elklick Run. The majority of the logs harvested in compartments 16B and 16C would not involve transport across that stream crossing.

There are no perennial streams in compartments 16B and 16C, and only 0.05 miles of nonperennial stream channel in a corner of compartment 16B. Because of the position of the channel, most of the harvesting operations would be away from streams, so the single skid road crossing would be the primary influence on surface waters.

Harvesting in this compartment would not remove enough trees to affect transpiration and soil moisture sufficiently to increase streamflow measurably in the compartment or in the subdrainage. Furthermore, since harvesting would be single-tree selection, moisture effects would be dispersed. Little stream channel length exists in compartment 16B and none in 16C, and Belmont and Cateache soils dominate. These two factors would further reduce and disperse effects. During the growing season, when soil moisture increases would occur from harvesting, the thick Belmont and Cateache soils would store excess soil moisture, and adjacent trees would exploit it quickly.

Compartments 16B and 16C currently contain some skid roads and skid road sections on which water is poorly controlled and evidence of road surface erosion exists. These compartments have a large number of small springs emerging at the soil surface, and these enhance skid road drainage and erosion control problems. The result is that sediment transport could occur and extend beyond what would be encountered in other soils where overland springflow is absent. Therefore, even though there is little channel length present in either compartment, there is an elevated risk to stream sedimentation compared to most other compartments in the FEF. Skid roads in compartment 16C would have less potential for influencing sediment delivery and channel stability than those in compartment 16B, because of the less erodible soils in the upper half of 16C, the greater distance from streams, and the rockier soil surface. In compartment 16B, where the soils are all highly erodible, re-blading and using skid roads would have a high probability for increasing stream sedimentation, especially near the stream crossing. Channel instability in the form of channel widening and incision are evident at some locations in the nonperennial stream downstream of compartment 16B, so additional use of this area likely would further enhance erosion, sedimentation, and possibly, channel morphology changes. Water barring at 50-ft intervals following harvesting would help reduce runoff and sedimentation problems, but the springs would continue to test water control and erosion structures over time. The lack of mulching on the skid roads coupled with overland flow on the roads would increase the duration that they would be susceptible to elevated erosion rates. Limiting harvesting to single tree selection would help alleviate some of the problems of skid road erosion because residual overstory trees would be available to provide inputs of litter to the skid road surfaces within the first year after harvesting.

Compartment 19B occupies 10.8 acres, or 1.5 percent of Upper Elklick Run subdrainage. A single tree harvest that would remove 20 percent of the compartment's basal area is proposed in Alternative B. The compartment is located in a mid-slope position and is dominated by Dekalb soil, with a small strip of Calvin soil along the northwestern compartment boundary and a small strip of Meckesville soil along the southeastern boundary.

There are no haul roads and 0.36 miles of skid roads in compartment 19B. There are no decks in the compartment, but two decks outside the compartment's boundaries would be used for this harvesting operation. Both are located along FR 701; one is located on the upslope side and just outside of the compartment and the second is located down slope of the compartment. Most of the compartment area has Dekalb soil, but the skid road length outside of the compartment leading to the lower deck is located in Calvin soil.

There is little stream channel length in compartment 19B, only 0.04 miles of nonperennial stream. However, there is one stream channel crossing on one of the skid roads. The skid road leading to the lower deck also follows along and within 50 to 100 ft of a nonperennial stream for most of its length.

Since harvesting in compartment 19B would be single-tree selection, any resulting increased soil moisture from decreased transpiration would be dispersed throughout the compartment. Harvesting would not remove enough trees to increase soil moisture sufficiently to augment streamflow in the subdrainage, particularly since the channel length in the compartment is so short. Local increases in soil moisture would be short-term and exploited quickly by residual trees.

The general placement of skid roads away from the short channel length that exists in compartment 19B reduces the potential for sediment delivery and road runoff to reach streams. However, because the sections of skid roads that would be repeatedly traveled to reach the lower deck run beside a stream in moderately erodible soil, there is some potential for soil erosion and sediment delivery. Therefore, re-opening and use of this skid road could increase stream sedimentation in the tributary downstream of the compartment. It is unlikely that these losses will be large enough to significantly disrupt sediment regimes in Elklick Run. Water barring the skid road soon after its use is no longer needed would help reduce the duration and degree of soil loss. Once litter cover is restored to the skid roads, sediment losses would be reduced further.

Compartment 27B occupies 24.8 ac, or 3.4 percent of the Upper Elklick Run subdrainage. In Alternative B a single-tree selection harvest is proposed, in which 29 percent of the basal area in the compartment would be removed. The entire compartment lies along the upper ridge top.

There are no haul roads in compartment 27B, but there are 0.98 miles of skid roads constituting 1.54 acres. There are no decks in the compartment, and harvested logs would be transported out of the compartment over the ridge and to a deck near the ridge in Camp Hollow Run subdrainage.

There are no perennial stream channels in compartment 27B and only 0.07 miles of nonperennial streams. There are no stream crossings in the compartment, and most of the skid road length is along the ridge top, away from the stream channels. The soil in this compartment is Dekalb, which has low erodibility.

Since harvesting in compartment 27B would be single-tree selection, moisture effects would be dispersed. Harvesting in compartment 27B would not remove enough trees to increase soil moisture sufficiently to augment streamflow. Local increases in soil moisture would be short-term, and they would be retained by these drier ridge top soils and exploited by residual trees.

The placement of skid roads away from the short channel length that exists in compartment 27B and drier ridge top soils would mean that erosion from skid road re-commissioning and use would have little opportunity to reach streams. The low erodibility of soils in this compartment would further control erosion from harvesting and road use. Therefore, single-tree harvesting at this level in compartment 27B would not have significant effects on stream channel morphology or sediment routing in the receiving tributaries.

Compartments 18A and 18B occupy 28.6 and 41.6 acres, respectively, or a total of 9.6 percent of Upper Elklick Run subdrainage. In Alternative B, both compartments would receive patch cuttings that would involve 4.0 and 5.0 acres, respectively, of compartments 18A and 18B. These treated areas constitute 1.2 percent of the subdrainage area. The patch cuttings would remove approximately 26 percent of the basal area in each compartment.

There are 0.41 miles of haul road and 0.33 miles of skid road in compartment 18A. FR 701 lies adjacent to the northwestern boundary of compartment 18A. There are 1.14 miles of skid road in compartment 18B. There is one log deck in compartment 18B occupying 0.13 acres and another which would be constructed at the bottom corner of compartment 18A to replace one just outside of compartment 18A that was obliterated by a gas well access road constructed in 2007. The deck in 18A would be similar in area to the one in compartment 18B.

Skid roads generally are located well away from stream channels except at stream crossings. There are four stream crossings in compartment 18A: three are haul road crossings and one is a skid road crossing. In all cases, the crossings are over nonperennial tributaries, of which there are 0.41 miles in compartment 18A. There are no stream crossings in compartment 18B and only 0.04 miles of nonperennial stream length. Even though the channels are nonperennial, the intermittent reaches carry a significant amount of water throughout much of the year, probably due to hydrologic influences from the underlying geology. Surface wetness, apparently from numerous small emergent springs also is obvious at many locations that are not connected to stream channels.

Soil in compartment 18A is all Meckesville. In compartment 18B, only a narrow strip along the lower slope boundary is Meckesville. Most of the lower one-third of compartment 18B is Belmont soil, and the upper two-thirds are Cateache. All of these soils are highly erodible.

Even though harvesting would be in concentrated units as patch clearcuts, enough trees would not be removed within the subdrainage to alter transpiration and soil moisture sufficiently to increase streamflow significantly. Local increases in soil moisture might result in the short term within patches, but moisture would not be released to streamflow quickly because the thick Cateache, Belmont, and Meckesville soils would store excess soil moisture. Therefore, direct and indirect changes in water resources would not result from changes in flow or stream energy.

Because of the high levels of soil wetness and high potential soil erodibility in compartment 18A, re-commissioning and use of the skid roads in this compartment would be expected to increase erosion and stream sedimentation. The relatively high number of stream crossings in highly erodible soil makes this compartment particularly susceptible to elevated in-stream sediment loading and changes to sediment budgets. The presence of substantial moisture at the soil surface in both compartments 18A and 18B makes erosion control particularly difficult, and this is exacerbated by the presence of roads. Road use within compartment 18A would be expected to result in significant direct and indirect changes to sediment delivery and sediment routing regimes within the receiving tributaries within and downstream of the compartment. Sediment delivery to streams from road use in compartment 18B would be a lower risk due to the relative lack of stream channels within the area. However, the presence of dispersed overland flow during at least wetter parts of the year (when the roads would be used) increases the chance for long-distance transport of some sediment. Therefore, there is some potential that it could be routed to and intercepted by stream channels down slope.

Compartment 30 occupies 23 acres, or 3.1 percent of the Upper Elklick Run subdrainage. It is located at the mouth of the subdrainage. About 3 acres of the compartment would be patch clearcut under the proposed action alternative. This represents 0.4 percent of the area within the Upper Elklick Run subdrainage. Approximately 20 percent of the basal area in compartment 30 would be removed.

Within compartment 30, there are no haul roads, but there are 0.44 miles of skid roads. There is one deck (0.33 acres) present along FR 701. Elklick Run is the northwestern boundary of compartment 30, and about one-half of the skid road length in the compartment parallels this perennial stream. The average distance between the skid road and stream is approximately 95 ft. There are no other streams in the compartment.

Dekalb is the dominant soil in the upper half of compartment 30 and Calvin dominates in the lower half. There also is a narrow band of erodible alluvium along Elklick Run.

Even though harvesting would be in concentrated units as patch clearcuts, an insufficient amount of basal area would be removed to alter streamflow significantly in the subdrainage. Therefore, direct and indirect changes in streamflow and stream energy would not result from harvesting.

Increased sedimentation to the streams may occur from skid road use, because the perennial stream and skid road are separated by only 95 feet for approximately 800 feet. However, the effects should be short term since only 3 total acres would be logged, and that could be accomplished in a short time period. Water barring immediately after use would limit the duration of runoff and erosion problems. While sediment inputs may increase to Elklick Run in the short term from a small portion of skid road, changes likely would not be sufficient to significantly change channel morphology locally or downstream, particularly since streamflow/energy changes would not accompany sedimentation. Within-stream sedimentation from the more erodible alluvium along Elklick would be unlikely because the skid roads do not traverse this material and harvesting activities would not occur in this area.

Compartment 20C in Upper Elklick Run subdrainage is 9.9 acres. The compartment lies along the ridge top. The proposed harvest treatment is a diameter-limit harvest, which would be spread across the entire acreage in the compartment. Approximately 37 percent of the compartment's basal area would be harvested.

There are no perennial or nonperennial streams in compartments 20C. There also are no haul roads. Logs would be decked in compartment 18B. There are 0.31 miles of skid roads in the compartment.

The soil in compartment 20C is dominated by Cateache which has high erodibility. The upper one-quarter of the compartment has a small amount of Dekalb soil which is on the ridge top.

Although erosion on the skid roads could occur in compartment 20C due to the high erodibility of the soil, sediment delivery to streams would not be expected because there are no streams in or near the subcompartment. Streamflow changes also would not occur due to the relatively low basal area removed from the entire compartment and the lack of channels in and near the compartment. Any small increases in soil moisture that might occur locally from losses to evapotranspirational demands would occur during the growing season, and would be easily retained by the relatively thick Cateache soils, particularly in this dry ridge top area. Consequently, hydrologic changes and hydrologically-driven changes, such as channel morphology and sediment budgets would not occur within the subdrainage due to harvesting in compartment 20C.

Compartment 27A in Upper Elklick Run subdrainage also would have a diameter-limit harvest spread over its 34.3 acres in Alternative B. Approximately 32 percent of the compartment's basal area would be removed. Most of compartment 27A is located in low and mid-slope positions in the subdrainage.

There are no perennial streams in the compartment, but there are 0.48 miles of nonperennial channel. There are no haul roads in the compartment, but there are 0.95 miles of skid roads. One of the skid roads follows beside and lies within 95 ft of about half the channel length, and there are four stream crossings by skid roads in the compartment. There are no decks in the compartment, and logs would be skidded along contour skid roads into a compartment on the ridge top of the Stonelick subdrainage.

Almost all of the soil in compartment 27A is Calvin, though there is a thin strip of Dekalb present in the western portion of the compartment. This section of Dekalb contains very little skid road length and no stream channels.

Harvesting in this compartment would not remove enough basal area to increase streamflow measurably. Due to the close proximity of one skid road to a large section of stream channel and the stream crossings, increased stream sedimentation may occur. Water barring the skid road immediately after use would limit the duration of runoff and erosion problems. Residual trees will provide leaf litter to the skid road surfaces within the first year after road closure, but with no mulching or seeding probably at least 3 years would be needed to develop a more stable and fuller cover of the soil. Turbidity increases could be visible locally within the channel during storms from skid road erosion, but it is unlikely that they would be visible far downstream or in Elklick Run. Consequently, sediment inputs probably would not be sufficient to significantly change channel morphology locally or downstream, particularly since streamflow/energy changes would not accompany sedimentation.

Compartments 26A and 26B occupy 32.1 and 14.2 acres, respectively, or a total of 6.3 percent of the Upper Elklick Run subdrainage. Most of compartment 26B is along a ridge top, while 26A occupies mid slope and lower slope positions. In Alternative B, a 6 percent financial maturity harvest is proposed for both compartments. Approximately 29 percent and 33 percent of the basal area would be harvested in each, respectively.

There are no haul roads or decks in compartments 26A or 26B. There are 1.06 and 0.87 miles of skid roads, respectively, in the compartments. Logs would be skidded to a deck on the ridge top of Stonelick Run subdrainage. The skid roads in both compartments run primarily along the contour, and there are three nonperennial stream crossings in compartment 26A. Most of the 0.41 miles of nonperennial channel in compartment 26A has skid roads within 35 to 140 feet. There are no perennial streams in either compartment, and only 0.01 miles of nonperennial stream channel length in compartment 26B. The soil in both compartments is Calvin.

Insufficient basal area would be removed within both compartments to alter streamflow in Elklick Run subdrainage significantly. Therefore, direct and indirect changes in streamflow and stream energy would not result from harvesting in these compartments.

Sediment inputs to the tributaries in compartment 26A probably have already been elevated by the proximity of the skid roads to the stream and the numerous stream crossings. Re-opening the skid roads in that compartment would likely increase the amount of sediment delivered to the receiving tributaries, at least in the short term until a stable and complete litter layer became re-established on the road surface. Channel widening and incision are possible though these effects are probably more chronic and occur simply due to the skid road presence. By contrast, streambed fining may be the more direct result of skid road use in compartment 26A, particularly originating at the crossings. The degree of potential problems depends upon the amount of sediment actually reaching the channel, but it is likely that visible turbidity changes during storm events would occur.

Increased water and sediment delivery to streams from harvesting and skid road use in compartment 26B would not be expected due to the lack of stream channels in the compartment and the distance between roads in the compartment and the nearest streams. Concentrated road runoff would be expected to become infiltrated by the soil before reaching a channel, and sediment would settle out as the result of infiltration and surface roughness.

A 3 percent financial maturity harvest is proposed for compartment 31 in Alternative B. This compartment occupies 18.8 ac, or 2.6 percent of the Upper Elklick Run subdrainage. Approximately 17 percent of the basal area in compartment 31 would be harvested.

There are no haul roads in compartment 31, but there is a 0.26-mile-long skid road that runs diagonally through the compartment. FR 701 lies adjacent to the northwestern boundary of the compartment, where there are also two decks that would be used for this harvesting. These occupy a total of 0.25 acres. There are no stream channels in compartment 31.

The lower half of compartment 31 is primarily Calvin soil, and the upper half is primarily Dekalb. There is a narrow strip of Meckesville along the upper boundary and a narrow strip of alluvium in the lower boundary along FR 701, including the area where the decks are located.

Insufficient basal area would be removed in the compartment to increase streamflow in the subdrainage. Therefore, direct and indirect hydrologic effects would not result from changes in flow or energy. Increased runoff or sedimentation to the streams would not occur from skid road use because the skid road is not close to any stream. Use of decks located in the erodible alluvium may increase erosion, but since the road and a wooded buffer exist between the decks and Elklick Run, there is little chance that sediment will reach the stream. Immediate reseeding and mulching of the decks after use would contribute to limiting any potential water quality effects. Impacts to water resources from logging and skidding in compartment 31 would be negligible.

Stonelick Run Subdrainage

Stonelick Run subdrainage is 617.8 acres. It has 2.73 miles of haul roads that comprise 6.62 acres, all of which run along the ridge tops in the subdrainage. Nine decks totaling 0.62 acres are present along the haul roads. There are 5.0 miles of skid road in Stonelick

Run subdrainage, which are confined primarily to the upland areas in the northeastern portion of the subdrainage. A total of 2.45 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 4.76 miles of side channel tributaries are nonperennial.

There are four compartments and one other research area within Stonelick Run subdrainage proposed for treatment. In compartments 48_1 and 49_1, a low intensity prescribed fire is proposed. In compartment 61 a 3 percent financial maturity harvest is proposed and in compartment 90 group selection is proposed. Fertilizer and lime additions are proposed for the long term soil productivity research area (LTSP). All of these areas are in the uplands of the subdrainage.

Compartments 48_1 and 49_1 occupy 1.6 and 8.8 acres, respectively of the ridge top, or 1.7 percent of the subdrainage area. While the entire 1.6 acres of compartment 48_1 would be burned, only 5.0 acres of compartment 49_1 would be burned. No basal area reduction is planned for these compartments.

There are 0.39 miles of haul road adjacent to the lower boundary of compartment 49_1 Additionally, there is a 0.09-mile-long skid road running from the ridge top to this haul road in approximately the middle of the compartment. The haul road along the lower boundary would be used as a fire line for the prescribed fire and approximately 300 ft of fire line would be created within the compartment from the haul road to the ridge top. A bulldozed fire line would be constructed around the lower boundary of 48_1 which would remove litter, slash, and the humus layer.

No stream channels occur in compartments 48_1 and 49_1 in Stonelick Run subdrainage, and no tributaries in the subdrainage come close to the compartments. Moderately-erodible Calvin soil is present in both compartments.

These low intensity burns would combust only the litter layer, so the humus layer would be retained to protect the soil from erosion. The bulldozed fire line in 48_1 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 fires on compartments 48_1 and 49_1.

Harvesting is proposed in compartments 61 and 90. Compartment 61 occupies 118.4 acres in Stonelick Run subdrainage, or 19.2 percent of the area. It lies in the headwaters of the subdrainage, predominantly on flat ridge and knob areas. The proposed 3 percent financial maturity harvest would remove approximately 18 percent of the basal area within compartment 61. Compartment 90 occupies 3 acres in Stonelick Run subdrainage, or 0.5 percent of the subdrainage area. It lies along the ridge top in the southern portion of the subdrainage. Group selection is proposed on only 0.8 acres within compartment 90 in this subdrainage.

There is a haul road upslope from and running along much of the boundary of compartment 61, but it does not enter the compartment. Six of the 9 decks in Stonelick Run subdrainage are on or near the ridge top in compartment 61, on the edge of the haul road. The area in decks in compartment 61 is 0.09 acres. Skid roads occupy 3.22 miles, or 5.07 acres and generally run along the contour parallel to the 1.85 miles of nonperennial stream channels in the compartment. Total disturbed area in decks and skid roads in compartment 61 is 5.16 acres, which is 0.84 percent of the Stonelick Run subdrainage.

There are no perennial channels in compartment 61, but the nonperennial channels constitute approximately 39 percent of the total nonperennial channel length and 29 percent of total overall channel length in Stonelick Run subdrainage. Approximately 20 percent of the soils in compartment 61 are Dekalb, which have low erodibility. They lie primarily in the lower elevations of the compartment. Upslope from the Dekalb soil is Calvin soil, which is moderately erodible.

There are no haul roads or skid roads in compartment 90 in Stonelick Run subdrainage. There also are no decks present in the compartment. However, there is a haul road just down slope from and running along about half of the compartment boundary within the subdrainage. Logs removed from compartment 90 would be delivered to a deck on the ridge top just outside of the compartment boundary. The haul road would be used to truck logs from the subdrainage and it includes two stream crossings positioned near the head of two nonperennial tributaries of Stonelick Run. The soil in compartment 90 in this subdrainage is Calvin, which is moderately erodible.

The total amount of harvesting proposed in compartments 61 and 90 would be insufficient to increase streamflow on a subdrainage basis. Streamflow energy also would not be affected sufficiently to change sediment relationships or channel morphology in Stonelick Run subdrainage.

Runoff from the decks should have no effect on altering streamflow regimes or sediment delivery to channels because all of the decks are located in flat areas on the ridge top. Skid roads in compartment 61, however, could influence sediment delivery to the stream channels due to the density of skid roads and the proximity of several to stream channels. Many of the skid roads parallel the channels and several extend fairly close to the streams. Sediment contributions from two skid roads in particular could be substantial because the lower end of the roads lies between and uphill from confluences; this location would increase the opportunity of channel interception of sediment if erosion and downhill transport begin. Overall, due to the density and proximity of all the skid roads there is a moderate to moderately high potential that some sediment would reach the stream channels if these skid roads would be re-opened for use. If sediment would be transported to the stream channels, there could be a delay between the time it is captured and the time it is transported downstream because these channels are nonperennial, and several are largely ephemeral. Transport downstream would not occur until sufficient flow and energy became available to carry the particles present, and if that period is long enough the added soils could become stabilized within the stream channel and resist detachment. Increased sediment in the channel could visually increase turbidity in the upstream reaches near and just downstream from the proposed activities during storms if surface flow is present or develops; however, increased turbidities would be unlikely at the mouth of the Stonelick Run subdrainage.

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 miles that comprise 0.66 acres. Only one of the skid roads in the area continues to be used and has no stream crossings. The unused skid road has a single stream crossing; in the research area, the stream is ephemeral and is 0.23 miles 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, fertilizer and/or lime are applied to various treatments plots (12 total) 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 to the degree of increasing sediment delivery to the ephemeral channel is not expected. In addition, changes in streamflow would not occur, so there would be no direct or indirect hydrologic or sedimentation effects from continuing these treatments.

Canoe Run Subdrainage

Canoe Run subdrainage is 691.5 acres. There are 2.01 miles of haul road and 1.54 miles of skid road in the subdrainage. All roads constitute 7.30 acres or 1.06 percent of the subdrainage area. There are no decks located in Canoe Run subdrainage. 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 of the miles of skid roads are located in the head of the subdrainage, primarily near the ridge.

Canoe Run subdrainage includes 2.25 miles of perennial stream, which reaches almost to the top of the watershed. There also are 2.45 miles of nonperennial stream channel.

Canoe Run subdrainage includes three different proposed treatments that all would be along the northern ridge top of the catchment: a diameter-limit harvest (compartment 20C), group selection harvest (compartment 90), and a prescribed fire with no basal area removal (compartment 48_2). Compartment 20C is 17.8 acres, compartment 90 is 5.0 acres, and compartment 48_2 is 9.7 acres. The treatments would be spread across the entire acreage in compartment 20C. The actual harvesting would involve only 1.3 acres in compartment 90 and the controlled burn in compartment 48_2 would occur on only 1.5 acres. The basal area that would be removed from compartments 20C and 90 would be 37 percent and 34 percent, respectively.

There are no perennial streams in these three compartments in Canoe Run subdrainage. There are no nonperennial channels in compartment 20C, but there are 0.14 miles of nonperennial channel length in compartment 48_2.

There also are no haul roads or decks in any of the compartments, but there is a haul road just outside and down slope from a portion of the boundary of compartment 90, and another similarly placed haul road outside of compartment 48_2. The haul road will serve as part of the boundary fire line for compartment 48_2. There are 0.54 miles of skid roads in compartment 20C and 0.06 miles in compartment 90. There are no skid roads in compartment 48_2, but a fire line would be constructed around the compartment by bulldozing down to mineral soil along the remaining boundary where no haul road exists. The soils in all three compartments are Calvin, which are moderately erodible.

The proposed harvesting in compartments 20C and 90 would remove less basal area in the subdrainage than is needed to influence streamflow or stream energy. Furthermore, the harvests would be along ridge top areas on south-facing aspects that are generally drier than the rest of the catchment. 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_2 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 20C and 90 would not be expected because there are no streams in those compartments. The nonperennial channel beginning at the edge of compartment 90 should not be affected by the operations since only 1.3 acres would be harvested and the area of harvest is not near the channel.

The prescribed fire in compartment 48_2 would be applied to only 15 percent of the compartment area, and 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.

Sugarcamp Run Subdrainage

Sugarcamp Run subdrainage is 221.3 acres. It contains 1.37 miles of haul roads, 1.08 miles of skid roads, and 0.09 acres of decks. The total area in roads and decks is 5.11 acres, or 2.31 percent of the subdrainage area.

There are 0.65 miles 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 are two proposed treatments in Sugarcamp Run subdrainage in Alternative B. Compartments 48_1, 48_2, 49_1, and 49_2 would receive prescribed fire treatment with no accompanying basal area removals, and compartment 90 would receive a group selection harvest.

Compartments 48_1, 48_2, 49_1, and 49_2 comprise 9.6, 8.2, 38.2, and 27.6 acres, respectively of Sugarcamp Run subdrainage. Except for compartment 49_2, all other compartments are confined to ridge top and mid-slope positions. Compartment 49_2 extends from the ridge top down into the riparian area of the subdrainage. It is the only portion of any compartment proposed for treatment that includes perennial channel length within its boundaries. In total, compartment 49_2 includes 0.17 miles of perennial streams and 0.22 miles of nonperennial stream length. There are no stream channels in any of the other compartments proposed for prescribed burning.

There are no roads or decks in compartment 48 and no haul roads in compartment 49. However, most of compartment 49_2 is bordered by haul roads located just outside the compartment. On the haul roads there are one perennial and three nonperennial stream crossings. There also are 0.14 miles of skid road in compartment 49_2 and 0.36 miles of skid road and one deck in compartment 49_1. Skid roads are not near channels in any of the compartments with proposed burns.

The soils in compartments 48_1, 48_2, 49_1, and 49_2 are predominantly Calvin, but about half of compartment 49_2 is Gilpin and a small strip along the southwestern compartment boundary is Ernest. Calvin and Gilpin soils are moderately erodible and Ernest is highly erodible.

Almost all of the area of compartments 48_1 and 48_2 and about half of the area of compartments 49_1 and 49_2 in Sugarcamp Run subdrainage are proposed to be burned in Alternative B. Total burned acreage would comprise about 49 acres, or 22 percent of the subdrainage. In compartments 49_1 and 49_2, burning would be done in vertical strips with bulldozer-created fire lines separating burned and unburned strips. Burning would be excluded from the riparian area where the perennial and nonperennial channels are present in compartment 49_2. In compartments 48_1 and 48_2, just over half (59 and 53 percent, respectively) of each area would be burned. Bulldozer-created fire lines also would be used in compartment 48. All bulldozed fire lines would involve removing the downed wood, litter layer, and humus, thereby exposing mineral soil.

The burn in both compartments would 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 construction 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 burn from surrounding, unburned areas. The lack of streams in compartments 48_1, 48_2, and 49_1 along with excluding burning or fire lines in the near-stream areas of compartment 49_2 would further ensure that even if some erosion occurred, there would be very little chance of sediment reaching any stream channels.

The remaining treatment in Sugarcamp Run subdrainage would be a group selection harvest in compartment 90. Compartment 90 in Sugarcamp Run subdrainage is 23 acres and is located along the eastern ridge top. The harvest would be restricted to a total of only 5.8 acres (2.6 percent of the subdrainage) spread in small blocks throughout the compartment. Approximately 34 percent of the basal area of the compartment would be removed.

There are no haul roads in compartment 90 in the Sugarcamp Run subdrainage, but there is a haul road that runs just outside and along the western border of the compartment. There are 0.54 miles of skid roads in the compartment. The skid roads and haul road run primarily along the contour. While there are no decks in compartment 90, there is one adjacent to the compartment, inside compartment 49_1, which would be used for logs removed from compartment 90. There also are no stream channels in compartment 90.

The soils in compartment 90 in Sugarcamp Run subdrainage are predominantly Calvin with a narrow section of Dekalb soil on the ridge top on the eastern border. Calvin is moderately erodible and Dekalb has low erodibility.

The harvest would not remove sufficient basal area in the subdrainage to increase streamflow in Sugarcamp Run subdrainage. Because the harvest would be multiple units spread across the compartment, local increases in soil moisture, would be small if they occur, and would last only a short time. The lack of streams in the compartment and the compartment's location on the ridge top would effectively eliminate sediment delivery to headwater tributaries. Sediment losses would be limited further by the lack of stream crossings by either the skid roads or the haul road that would be used to transport logs to the deck.

<u>Cumulative Effects of Alternative B: Proposed Action</u>

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 Shaver's 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 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 additional cumulative effects in Side Hill subdrainage above those direct and indirect effects described for this 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 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) would be the primary chronic cause and source of altered hydrologic regimes and channel morphology and increased sediment delivery to the perennial and nonperennial stream reaches. The advent of manipulation of compartment 45 has resulted in increased road use, but 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, but erosion and sediment losses may have increased a small amount. However, undersized and improperly sloped stream crossing culverts along the entire road remain the largest problems and provide the causes for channel incision and headcutting. Therefore, there are additional cumulative effects above those attributable to the proposed treatments due to the long-term presence of the haul road in this subdrainage.

Camp Hollow Subdrainage

Camp Hollow subdrainage includes other areas that have been treated in the past for which there are no proposed treatments in this EIS. One of these is watershed 2, which 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 a control watershed) from watershed 2 have been documented for most water years since treatment began in 1958. 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 (1952-57). Virtually all of the years with significant flow increases since the calibration period had streamflows on both the control and watershed 2 that were above those observed during calibration (unpublished data). These values lie outside of 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 given year support that increased streamflow on watershed 2 is not fully 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.

In addition, almost 15 percent of the area of watershed 2 is in skid roads. This is approaching the level of disturbance for which channel morphology changes have been documented (Verry 2000). Because these roads have been in place for many years, any changes to channel morphology, such as channel widening and headcutting, that might occur from concentrating effects of runoff and sediment delivery likely already have occurred or have been on-going for some time. 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 2004 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. Therefore, past activities in watershed 2 probably changed sediment budgets within the local nonperennial stream. 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.

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 a year or two. Sediment contributions to the stream in watershed 5 may have been significant due to the close proximity of the skid roads to the stream and the number of stream crossings present. While the proposed harvesting in watershed 5B is not predicted to result in hydrologic alterations alone, residual effects from the 2007 harvest probably still exist, so additional harvesting during the next 5 year cycle could cumulatively contribute to effects, either increasing the magnitude of those effects and/or increasing the duration of hydrologic changes.

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 about a 200 foot reach. So it is likely that removing the overstory increased stream temperatures in this portion of the channel, particularly since summer baseflows in this watershed are very low and slow velocity.

Past harvesting also occurred in watershed 3. In 1958-59, a single-tree selection treatment was applied. Selected trees ≥ 5 inches dbh 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 of 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. Consequently, past harvesting in watershed 3 would not contribute to cumulative streamflow increases in Camp Hollow subdrainage.

The skid roads in watershed 3 are well healed and do not appear to provide a significant sediment source to the channel. There is visible evidence of active headcutting in the main stem of watershed 3, which is elevating 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, headcutting may decrease through time.

Because of the probable increases to in-stream sedimentation that occurred from treatments and road presence in watersheds 2, 3, and 5, these watersheds contribute to the cumulative sediment effects in Camp Hollow subdrainage. However, they also contribute to cumulative sediment effects in another way, as does watershed 4 in this subdrainage, which is a control watershed that has been unharvested and unroaded for 85 years. All of these watersheds are gauged with weirs. 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 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 slugs 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.

Overall, skid roads, haul roads, and log landings constitute only 3.16 percent of the Camp Hollow subdrainage area. This figure is well below the 15 percent figure 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.

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 elevate effects associated with the proposed treatments.

Wilson Hollow Run Subdrainage

In addition to compartment 60, Wilson Hollow Run subdrainage includes a number of areas for which no treatments are proposed in this EIS. They are watersheds 6, 7, and 13, and compartment 38.

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 effects in Wilson Hollow Run subdrainage.

Watershed 13 is a control watershed that has not received any treatments and has no roads within its boundaries, so it is not contributing to cumulative effects in the subdrainage.

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 determine whether 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 of species conversion on streamflow quantity and quality.

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 have been 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 has 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). The watershed soils are well covered with a thick needle layer, which appears to have reduced terrestrial erosion processes and sediment delivery. This treatment has resulted in long-term reductions in streamflow to Wilson Hollow Run.

On watershed 7, streamflow augmentation occurred until about 1989. While about 15-20 years was needed for the watershed to become fully reoccupied by hardwoods due to the herbicide treatments, it now has interception and evaporative losses similar to other hardwood stands that fully occupy their catchments. However, dormant season discharges remain significantly elevated, with about 1 inch more streamflow per season being exported from the watershed than predicted. This increase is likely to continue into the foreseeable future because it is probably due to changes in interception losses (by different canopy architecture) associated with 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 phase 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 rather than an increase in sediment transport.

A more apparent sediment effect from watersheds 6 and 7 is the same effect described for Camp Hollow Run from 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 is not changed, but the timing of delivery significantly alters the sediment regime of the stream and possibly translates to measurable changes downstream in Elklick Run, particularly if considered cumulatively with other inputs in the watershed. Watershed 13 is gauged with a flume, so it does not have a settling pond or the associated effects.

Previously, compartment 60 has 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 treatments during the next 5 years.

Overall, roads, skid roads, and decks comprise only 5.82 ac, or 1.5 percent of the subdrainage area. This figure is well below the 15 percent figure given for ditched roads (Verry 2000) that should be maintained to avoid streamflow changes that in turn can change channel morphology. Consequently, there would be no additional cumulative effects from roads in Wilson Hollow subdrainage above that from those described previously.

Hickman Slide Subdrainage

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 has removed less than 20 percent of the basal area within the subdrainage at any one time, so hydrologic effects would have been unlikely. Within the last 5 years, only 30 percent of the basal area on 25 percent of the area of the Hickman Slide subdrainage was harvested, which also would not have been expected to increase streamflow. Consequently, these harvests would not be expected to contribute to cumulative effects.

Within Hickman Slide subdrainage, there are 17.14 acres of roads, skid roads, and decks, which constitutes 5.82 percent of the subdrainage area. This figure is well below the 15 percent figure 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 over the past several years, sediment delivery to the stream remains elevated. Sediment from this road results in visible turbidity levels in the stream and contributes to cumulative effects within the subdrainage. These road effects would be expected even without any other treatments in the subdrainage as there are no plans on closing the road or implementing practices that would substantially decrease sediment inputs.

Bear Run Subdrainage

Compartment 9 (A, B, and C) comprises almost the entire 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 and 2002. Those 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 that harvesting. Since hydrologic effects of clearcutting generally disappear within 5-7 years, the effects of these much less intensive harvests would have been of much shorter duration; therefore, these past harvests would not contribute to cumulative effects in the proposed alternative.

Residual sedimentation effects from skid road use approximately 10 years ago 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. Consequently, the cumulative effects in Bear Run subdrainage are the same as the direct and indirect effects described previously for Alternative B.

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 EIS.

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 of 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, and 2005. 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 2005 removed only 17 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 that treatment (FEF 2000 EIS). 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 have received single-tree selection harvests in 1951, 1961, 1971, 1982 (16B only), 1991, and 2003. Harvesting prior to 2003 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 2003 harvests removed about one-third of the basal area from compartments 16A and 16B about 7 years ago, and the area involved was less than 7 percent of the subdrainage area. Therefore, there should be no residual 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 2003 also was predicted to increase sediment delivery to the stream channels (FEF 2000 EIS). These past inputs could exacerbate sedimentation problems beyond those predicted as direct and indirect effects in these compartments, 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, and 1999, and compartment 27B received single-tree selection harvests in 1951, 1970, 1991, and 2003/2004. The areas, respectively, comprise 4.7 and 3.4 percent of Upper Elklick Run subdrainage. No residual streamflow increases from harvests in either compartment would be expected to exist. Likewise 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 in the compartment, and sedimentation effects from past skid road use in compartment 27 were predicted in the FEF 2000 EIS. Assuming stream sedimentation occurred, the associated effects could continue to be expressed in the stream channels for years or decades. Consequently, cumulative effects greater than those described earlier for direct and indirect effects in these compartments are possible.

Compartment 30 has been subjected to 0.4-ac patch clearcuts 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 a short 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 2000 EIS. It is possible that some sediment did reach the stream during the 2005 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.

Compartment 17 is separated into two sections, 17A and 17B. Small patch clearcuts (0.4 acres) have been applied to compartment 17A approximately every 10 years since 1957 and to compartment 17B in 1957, 1971, 1987, and 2003. Reductions in transpiration would have been insufficient to increase streamflow, so no residual effects would be expected. Even local increases in soil moisture within the openings that may have occurred in compartment 17A in 2007, would not be expected to be measurable any longer due to exploitation of the moisture in the ensuing 3 years by residual and re-growing vegetation in the small openings. 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 clearcuts applied on approximately 10- or 15-year intervals since 1952. The most recent patch clearcuts in all sections were in 2004 or 2005. 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.

Compartment 26 (26A and 26B) has 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 it would not contribute to cumulative streamflow effects. 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 above those describe for direct and indirect effects in compartments 26A and 26B.

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 clearcuts every 10 years since then. Compartment 19B has received single tree selection harvests in 1957/1958, 1967, 1982, and 1997. 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. While this could contribute to cumulative sediment and channel effects at this time, the small amount of sediment expected to have been delivered presents little impact to current effects beyond those described as direct and indirect effects for compartment 19B in this analysis.

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 compartments 13 or 21 above those described for direct and indirect effects.

Compartment 20 includes three sections, 20A, 20B, and 20C. There was a single-tree selection 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. Only three diameter-limit harvests were applied to 20C, in 1952, 1970, and 1990. There was not enough basal area removed in the harvests during the last 10-15 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 has decreased dramatically.

Changing subsurface flows to surface flows has altered the hydrology of the subdrainage. However, since the water is now generally recharged to the soil, the effects have probably lessened. Past erosion losses delivered to the sink hole are unknown because the delivery point is not known.

The well pad access road crossed several small streams, and some of these have evidence of erosion above and below the crossings. Headcutting 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 is probably stabilizing because most of the disturbed area has been re-vegetated and the road surface and some of the ditchline has been surfaced with large non-friable 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 2008-2009. 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 is being monitored, and erosion levels have decreased dramatically since vegetation became re-established on it (unpublished data). 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 36.24 acres of roads, skid roads, and decks, which constitute 4.92 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 figure 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 provides access to Otter Creek Wilderness.

Combined, the harvesting treatments proposed for the next 5 years in Upper Elklick Run subdrainage involve about 33 percent of the subdrainage area. About 25 percent of the basal area from these harvested areas (i.e., not 25 percent of the total subdrainage) would be removed. It is unlikely that streamflow would be cumulatively affected by these harvests, particularly since they would be spread across 5 years.

<u>Stonelick Run Subdrainage</u>

There are six research areas in Stonelick Run subdrainage: compartments 39, 48_1, 49_1, 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_1 was treated with prescribed fire in spring 2001. Compartment 49_1 was prescribed burned in 2002, 2003, and 2005. 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, and 2006. Residual road use 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 insufficient basal area was removed to 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 involved 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 road use in compartment 90.

A 2-acre site was cleared on the ridge top of Stonelick Run subdrainage in 2005 for use as a 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 ability to recover, as well as its small area and ridge top location.

Overall, there are 15.12 acres of roads and decks in Stonelick Run subdrainage. This constitutes 2.45 percent of the subdrainage. This figure is well below the 15 percent figure 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 beyond those described for direct and indirect effects.

Canoe Run Subdrainage

Canoe Run subdrainage contains compartments 20, 43, 48_2, 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, and 2006. 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 this compartment and the area of highly erodible soils is small. Consequently, no 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 cumulative effects would be expected from treatments that are more than 30 years old.

Compartment 48_2 received a low intensity controlled burn 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 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 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 or to have a continued effect now, and since almost 40 years have passed, residual effects should not be present. Consequently, there are no cumulative effects related to these harvests in the Canoe Run subdrainage.

There are 7.30 acres of Canoe Run subdrainage in roads and decks. This comprises 1.06 percent of the acreage in Canoe Run subdrainage. This figure is well below the 15 percent figure 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 five research compartments in Sugarcamp Run subdrainage that have had previous treatments: 48_1, 48_2, 49_1, 49_2, and 90.

Compartments 48_1 and 48_2 were treated with low intensity prescribed fire in spring 2001. Compartments 49_1 and 49_2 were treated with low intensity prescribed fires in 2002, 2003, and 2005. The humus layer in these compartments remained intact, thereby protecting mineral soil. The bulldozed fire lines also 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_2. Consequently, the past burning in these compartments would not contribute to cumulative 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 cumulative effects would be expected from this past treatment.

There are 5.11 acres in roads and decks in Sugarcamp Run subdrainage. These comprise 2.31 percent of the acreage in Sugarcamp Run subdrainage. This figure is well below the 15 percent figure 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 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 Forest Service land 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 10 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.

Past and potential future treatments, activities, or structures that have not been described previously in the descriptions of direct, indirect, or cumulative effects for the individual subdrainages are described in detail in this section.

One of the greatest impacts to cumulative effects in Elklick Run watershed is FR 701. As described in the 'Affected Environment' section of this portion of the EIS, FR 701 provides a chronic source of fine sediment and coarse fragments from road wash to Elklick Run. Many of the cross drain culverts 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.

Overall, haul roads, skid roads, and decks comprise 3 percent of the area in the Elklick Run watershed. This is well below the 15 percent required to affect runoff, so contributions of discharge originating only from the density of roads would not be expected to be sufficient to alter channel morphology.

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.

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 FEF would help reduce the effects that would 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, 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 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- to 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 downslope 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.

Other wells could be drilled in the next 5 years within the FEF. The total potential number is unknown, but given the time required for planning, excavation, and drilling, the maximum number probably would not exceed 2 or 3 wells within the next 5 year cycle. 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.

Additional 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 effects of treatments proposed for Alternative B have cumulative effects that would be measurable at their subdrainage level. But because only 672 acres, or 18.1 percent, of the Elklick Run watershed area would be included in the proposed activities, cumulative effects at the 3,713-acre Elklick Run watershed scale from the treatments alone probably would not be measurable. Cumulative effects at the Elklick Run watershed level would be primarily from the presence of 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, bankfull (i.e., flow with ~1.5-year recurrence interval) could shift to 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. 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.

<u>Cumulative Effects on Shaver's Fork Watershed of Alternative B: Proposed Action</u>

The Shaver's Fork watershed drains approximately 119,700 acres at the confluence with

Stonelick Run and neighboring FEF 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), rural residential, and a small percentage of area in municipal developments. The Monongahela National Forest has had no major activities in the upper Shaver's Fork watershed (where most of its holdings exist) during the past 10 years. The Monongahela National Forest also has targeted the Shaver's Fork watershed for watershed restoration projects to improve watershed health. 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 Shaver's Fork watershed.

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 (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. 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, if they result, would ubiquitously apply to all streams and rivers within the watershed, regardless of whether they were in managed or unmanaged subdrainages.

Direct, Indirect, and Cumulative Effects of Alternative A: No Action

Alternative A is the no action alternative. 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 roads would remain open, and their use would remain near current levels. Forest Service and other researchers would continue to use the 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 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 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 Alternative A, and the probability of these occurrences increases over time. As a result, culverts could plug and roads and trails could wash out and become substantial contributors to sediment in both tributaries and perennial streams as well as in Elklick Run, thereby changing some relatively minor sediment contributions to inputs that would be large enough 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 improvement in the Shaver's Fork watershed or Shaver's Fork River would be expected from no action because the contributing area and corresponding sediment loads of Stonelick Run, Canoe Run, and Sugarcamp Run subdrainages would be extremely small relative to the rest of the contributing upstream areas of the Shaver's Fork River.

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 (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. 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, if they result, would ubiquitously apply to all streams and rivers within the watershed, regardless of whether they were in managed or unmanaged subdrainages.

3.2 Air Resources

Affected Environment

The FEF is affected primarily by air masses from the west and southwest, although weather does 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 through the area, 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 3-5).

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, and the secondary purpose is to protect human welfare and the environment. An area that is found to be 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.

Air quality has been the subject of research and monitoring at the FEF for a number of years (Adams et al. 1994). Monitoring of air quality for the FEF has been conducted on the Nursery Bottom, located approximately 2 air miles from the FEF boundary at the Timber and Watershed Laboratory; on the FEF itself and at locations more distant: Clover Run (8 miles northwest of the FEF) and Bearden Knob (approximately 13 miles east of the FEF). Data from all of these locations are used in the characterization below.

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 weak acids in the atmosphere and return to earth as acidic deposition in the form of rain, fog, cloud and dry particles. 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 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 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 11-15 kg nitrate ha^{-1} yr^{-1} and 18-30 kg sulfate ha^{-1} yr^{-1} (NADP 2010; Figure 3-3). Dry deposition is estimated to be approximately the same as wet deposition. The greatest deposition occurs during the growing season (Gilliam and Adams 1996).

Stream water pH of most streams draining the FEF ranges from 6.24 to 8.04 (Williard et al. 1999). 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 even 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 show a statistically significant increase between 1988 and 1993. (Lawrey 1993).

Recently, deposition has been changing in Tucker County. Sulfate deposition at the Nursery Bottom has declined (NADP 2010; Figure 3-3), and this change is attributed to the 1990 Clean Air Act Amendments. Nitrogen deposition trends are not as clear, but appear to be decreasing. Deposition of basic elements (Ca, Mg) has decreased since the late 1970s as fly ash and particulate emissions have decreased (NADP/NTTN data; http://nadp.sws.uiuc.edu). Similar trends in sulfate and nitrate deposition are observed in the bulk data collected at Bearden Knob (Figure 3-4).

Ozone

Ozone concentrations have been monitored at the Nursery Bottom site (1673 ft elevation), 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. Ozone data from the two sites in 2007 and 2008 show high variability but maintain the trend of lower average ozone levels at the Nursery Bottom site than on Bearden Knob (Figure 3-5).

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. 2004a). 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 somewhere between 0.060 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. 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 7 and 15 ppm-hours. Exposure levels in 2008 ranged from 12 to 24 ppm-hours on the FEF. Past exposure levels ranged from 12 to 46 ppm-hours, were lowest in 2004 (between 12 and 13 ppm-hours) and greatest in 2001 (approx. 46 ppm-hours). There is no obvious trend in ozone exposure. The US EPA indicates that both Tucker County, in which the FEF is located, and nearby Garret County, Maryland would not meet the secondary ozone standard if it is set at the lower level of 7 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 $PM_{2.5}$ standard requires concentrations of $PM_{2.5}$ not to exceed a 24-hr average of 35 $\mu g\ m^{-3}$ (micrograms per cubic meter). This standard was changed from the previous 65 $\mu g\ m^{-3}$ by the EPA on Dec. 17, 2006 (http://www.epa.gov/particles/fs20061006.html). Average annual arithmetic $PM_{2.5}$ concentrations are not to exceed 15 $\mu g\ m^{-3}$.

The fine particulate standard was lowered in 2006 and the resulting nonattainment designations were made at the end of 2008 and again at the end of 2009. In West Virginia, Kanawha and Putnam counties around Charleston and Brooke and Hancock counties north of Wheeling were in nonattainment of the 2006 $PM_{2.5}$ standard in December 2009 (Figure 3-6). It is important for forest managers to know where nonattainment areas are located. By definition the US EPA is declaring the air as unhealthy in these areas. Activities by any entity (government or private) that emit air pollution into these areas (e.g. prescribed burning) will likely come under increased scrutiny by US EPA and/or state air quality regulators.

Visibility

Visibility is strongly affected by light scattering and absorption by fine particulate matter (<2.5 microns in diameter). Among the constituents of the fine particle 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 the Bearden Knob site were found to be among the highest in the eastern U.S., but sulfate deposition and ammonium sulfate concentrations are decreasing (NAPAP 2001, NADP 2010). Visibility throughout the eastern U.S. is generally estimated to be less than 10 miles (http://vista.cira.colostate.edu/views/). The FEF participates in the IMPROVE (Interagency Monitoring of Protected Visual Environments) network, designed to monitor visibility and aerosols and particulates in air, as they affect visibility. Trend plots from the IMPROVE monitoring site at Bearden Knob show that for the 20 percent worst visibility days, the light extinction values are decreasing and visibility is improving. The 20 percent best visibility days also are showing recent improvements (http://vista.cira.colostate.edu/views/; Figure 3-7).

Potential Effects

Vehicular and equipment use associated with timber harvest and transporting logs would produce some air pollutants, mainly nitrogen oxides, hydrocarbons and particulate matter. Particulate matter, also know as fugitive dust, associated with harvest is produced primarily during periods when unpaved roads are dry.

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 but this pollutant rapidly dilutes in the atmosphere and is only a concern to personnel in close proximity to the fire (typically only the firefighters working on the fire). Prescribed burning may also produce emissions of hydrocarbons, some of which may pose health problems to personnel in close proximity to the fire.

Direct and Indirect Effects of the Alternative B: Proposed Action

Under the action alternative, a total of just under 2.7 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 Environmental Protection Agency emission factors (US EPA 1997, 1999 and 2002) and basic operations assumptions for a "typical" logging operation in mountainous areas. Nitrogen oxides (NO_X), 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 VISTAS 2002 emissions inventory (Stella and Jackson, emissions tool), 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 3-6). 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.

A total of approximately 420 acres would be treated with prescribed burning over a five-year period. Of those acres, two blocks (unit 48 – 35 acres and unit 49 - 77 acres) are designed to study the effects of burning on oak regeneration so only approximately half of those units would be burned. The other three units are larger, totaling approximately 363 total acres. The latter three units are proposed to be burned in 2012 and the former two units are proposed to be burned in 2013. That said, with weather and administrative delays there is a possibility that all units could be burned in the same year. That scenario will be used in this analysis to consider a "worse case" scenario for smoke emissions and effects. It is expected that burning would be completed over a period of several days on each of the units, so total emissions produced from prescribed burning activities will not all be emitted in one day. The prescribed fire would be conducted in the spring, and would be a slow-moving (1-5 ft min^{-1}) fire that produces high amounts of heat (2-4 ft flame lengths). It is expected that only the leaf litter and some of the 1 hour fuels will burn at these sites.

Suitable burning conditions would be determined based on fuel characteristics and local weather conditions. The two units in the oak study would be burned at a moderate intensity to top kill the vegetation to promote oak regeneration. These units currently have heavy fuel loads including logging slash, but they would be burned when the fuel moisture of the slash (100-hour (1 to 3 inches in diameter) fuels and larger) is great enough to keep these fuels from burning and producing smoldering emissions. The three larger units would be burned at a higher intensity but these units do not have high fuel loadings. Again, the larger fuels would be moist enough to keep them from being burned and producing smoldering emissions. The burn plan will be written, and prescribed fires will be conducted, according to state regulations administered by the West Virginia Division of Forestry. The most recent smoke management guidelines would be followed (Hardy et al. 2001). Caution will be taken to ensure that emissions from prescribed fires would not significantly contribute to an exceedance of NAAQS. The effects of smoke on the Class I Wilderness areas can be mitigated by burning under prescribed conditions that avoid putting smoke in those areas.

During burning it is estimated that a total of 50 tons of particulate matter (PM_{10}), 43 tons of fine particulate matter ($PM_{2.5}$) and 4 tons of nitrogen oxides (NO_X) would be released to the atmosphere (FOFEM 5.7 model run results). The PM and NO_X emissions estimates were compared to regional emissions (in tons per year) from all source sectors. Regional emissions estimates come from the VISTAS 2002 emissions inventory (Stella and Jackson, emissions tool), 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 3-7).

Prescribed fire emissions represent less than 1.8 percent of the emissions for the region on an annual basis assuming all burns occur on the same day. Since conducting prescribed burns is highly dependent on weather conditions and resource availability, exact dates of prescribed fire events could not be included in this comparison analysis. It is important to note that the prescribed fire emissions presented here represent the total that will be emitted on 1 to 5 or more days over 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.

Nitrogen losses were estimated at 300-500 kg ha^{-1} (455 lbs ac^{-1}) from a hot understory fire in North Carolina (Vose et al. 1993). Emissions would be less from a cooler fire with lower fuel loadings (estimated at 13-22 tons ac^{-1} for FEF, compared to 60-90 tons ac^{-1} in

North Carolina). NO_X emissions are estimated at 30 lbs ac^{-1} (R. Ottmar, USDA Forest Service, Pacific Northwest Research Station, personal communication), or less than 0.02 percent of the emissions in the county. Losses of nitrogen from the forest floor would be estimated as part of the proposed research to determine the significance of nitrogen losses.

Cumulative Effects of Alternative B: Proposed Action

The FEF is located within an area of the Monongahela National Forest of 26,056 acres that would not experience prescribed burning or timber harvest 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 completion of such a road. Emissions from the Kingsford Charcoal Plant, which is currently in compliance with state and federal emissions regulations, are not expected to increase in the future. 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 area. 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 and the short duration of the prescribed burning, the incremental impact on the air resource would be insignificant.

Effects of Mitigation on Alternative B: Proposed Action

Proposed mitigations would have minimal effect on air resources. Only the proposed road gravel and maintenance would impact air resources. The addition of gravel would result in short-term, localized increases in particulate matter during dumping and long-term localized reductions in particulate matter, fugitive dust, by limiting dust kicked up and entrained by vehicle travel. Road grading typically brings up smaller particles and could result in increases in long-term, localized particulate matter kicked and entrained by vehicle traffic. It is only long-term in that the potential to continue having fugitive dust kicked up will exist for a longer period of time. However, the fugitive dust is only entrained for seconds to a couple minutes. These effects are very minor and localized to only immediately adjacent to the roads

Direct and Indirect Effects of Alternative A: No Action

Because there would be no logging or burning, there would be no emissions. Thus**,** there would be no direct or indirect effects on air quality as a result of this alternative.

Cumulative Effects of Alternative A: No Action

As there are no direct or indirect effects on air resources there are no real cumulative effects of the no action alternative. That said, local emissions particularly of nitrogen dioxide, 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 completion of such a road. Emissions from the Kingsford Charcoal Plant, which is currently in compliance with state and federal emissions regulations, are not expected to increase in the future. Deposition of sulfate is expected to continue to decrease, and deposition of N is expected to stay level over the long run.

3.3 Soil Resources

Affected Environment

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 drainages where the series are found are identified in the individual soil series descriptions below.

FLUVAQUENTS-UDIFLUVENTS COMPLEX: (Bear Run, Camp Hollow, Hickman Slide, Side Hill, Upper Elklick Run, Wilson Hollow) This 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.

BELMONT SERIES: (Bear Run, Canoe Run, Hickman Slide, Upper Elklick Run) 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.

CALVIN SERIES: (Bear Run, Camp Hollow, Canoe Run, Hickman Slide, John B. Hollow, Side Hill, Stonelick Run, Sugarcamp Run, Upper Elklick Run, Wilson Hollow) 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.

CATEACHE SERIES: (Bear Run, Canoe Run, Hickman Slide, Upper Elklick Run) 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.

COOKPORT SERIES: (Camp Hollow, Hickman Slide) The Cookport series consists of moderately deep to deep, moderately well-drained soils that developed on uplands in acid, gray material weathered from sandstone and shale. A firm, mottled fragipan is generally at a depth of about 20 inches. In most places these nearly level or gently sloping soils are on concave ridge tops or benches. Generally they do not extend over large areas, and are only found in minor amounts on the FEF.

DEKALB SERIES: (Bear Run, Camp Hollow, Canoe Run, Hickman Slide, John B. Hollow, Stonelick Run, Sugarcamp Run, Upper Elklick Run, Wilson Hollow) 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.

ERNEST SERIES: (Camp Hollow, Sugarcamp Run, Upper Elklick Run) 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. Unlimed soils are strongly acid or very strongly acid throughout. It is found in minor amounts on the FEF in or near riparian areas.

GILPIN SERIES: (Canoe Run, Stonelick Run, Sugarcamp Run) The Gilpin series are medium-textured, moderately deep to deep well drained soils that developed on uplands in acid material weathered from shale and sandstone. These soils are moderately permeable and have moderately low natural fertility. Most of these soils occur on steep ridges and lie west of McGowan Mountain and Backbone Mountain. The acreage of Gilpin soils on the FEF is fairly minor. The soils normally occur on ridges too steep for road construction.

MECKESVILLE SERIES: (Canoe Run, Upper Elklick Run) The Meckesville series 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 type is found in minor amounts in the FEF.

Potential Effects

Potential effects on soils from research activities and connected 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) nutrient leaching, and 7) changes in soil fertility.

Soil disturbance disrupts an orderly process of litter accumulation and decomposition. However, this disturbance would take place, to some extent, regardless of human interference. Natural disturbances (windthrow and fire) to the organic layer are common in forested areas (Lyford 1973). 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. Exposure of bare soil can be caused by equipment losing traction (spinning wheels) and from road maintenance (road grader "blading" roads). 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, and the extent of forest floor disturbed is proportional to the intensity of the fire (Groeschl et al. 1990). A single prescribed burn may remove only a small percentage of the total forest floor depth and weight, whereas a high intensity fire may remove the entire forest floor, thereby exposing the mineral soil and possibly increasing infiltration and water holding capacity. Generally, prescribed fires seldom remove more than 50 percent 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 and truck 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 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 increase 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. 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.

Increased soil movement, through mass wasting or erosion, can result in nutrient loss from a site, sediment inputs into drainage waters, and decreased productivity. Effects on sediment are discussed in Section 3.1, “Water and Riparian Resources”. Roads are the major source of eroded sediment, not removal of timber (Patric 1976a, 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 moisture and soil temperature are relatively unaffected by harvesting activities unless the forest canopy is disturbed considerably, as in a clearcut. The tree canopy and forest floor moderate extremes in soil temperature. There is little evidence to suggest changes in soil moisture and temperature with intermediate cuts. Streamflow is not affected by cutting 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 (soil heating) with negative effects on soil biota, soil erosion and nutrient 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 growing season. 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 is found to 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).

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. 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, 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 documented 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 diameter and greater are removed, removes more biomass than a stem-only harvest, where stems smaller than 8 inches diameter 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) ac^{-1} compared to 97 lbs N ac^{-1} 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 affects nutrient leaching, 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 (both microbial and mineral), 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 (l977) 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). Unlike nitrate, sulfate (SO_4) is absorbed reasonably strongly by clay and organic matter within the soil (Edwards et al. 2002b). 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).

Direct and Indirect Effects of Alternative B: Proposed Action

Soil Disturbance

Soil disturbance was calculated as the percentage of the area affected as a result of management activities. Long-term impacts to soils are associated with skid trail construction and reconstruction, log landings, and bulldozing of fire lines. Therefore only the area in skid roads, decks and fire lines was used in this calculation because disturbance of mineral soil rarely occurs except under repeated passes. Based on this assumption, a maximum of 3.8 percent of the treatment area or 42 acres would experience soil disturbance. This corresponds to less than 1 percent of the total FEF area.

The majority of the soil disturbance would be associated with the use and reconstruction of skid trails in the treatment areas. Use of existing skid roads could increase erosion rates above what occurs naturally. However, the effects would be short-lived because skid trails would be smoothed out, and water barred after use is completed. Reconstruction of skid roads would expose soil on the cut and fill slopes. There could be short-term erosion of these surfaces while they are being actively used, but effects would be short-lived, due to water barring after closure.

Soil disturbance from prescribed, low-intensity fires can be variable, 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). Wendel and Smith (1986) estimated that a low to medium intensity fire burned only about 56 percent of the litter fuel. Controlled low intensity burns are not expected to result in significant soil disturbance, or large areas of bare soil (Dissmeyer and Stump 1978). Revegetation after burning is expected to be rapid (Swift et al. 1993). The overstory trees would generally not be killed by the fire and the tree canopy would serve to protect the soil from raindrop impact after leaf out. 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 we may assume that the prescribed fires will remove approximately 50 percent of the forest floor, but that the spatial extent will be relatively small and patchy in distribution and soil disturbance will likewise be limited in extent.

Soil disturbance from the proposed activities would be minimal and limited to skid trails, logging decks, and fire lines or about 3.8 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.

Soil Compaction

Compaction from logging equipment can increase soil bulk density. This 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. Bulldozed fire lines are probably less of a concern. Therefore only about 2.9 percent of the areas to be treated would likely be affected by compaction, or less than 1 percent of the entire FEF under Alternative B.

Skid roads and log decks would be closed after logging is complete. As part of the mitigation, 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 any new use would result in negligible additional impacts.

Soil Movement

Soil movement could occur on long unimpeded slopes with moderate to steep grades where mineral soil is exposed to rain drop impact. Overland water flow can occur in these circumstances. Soil movement is more likely to occur on skid trails, haul roads and log landings. Soils in the Belmont, Cateache, Ernest, and Meckesville series have high erodibility, but occupy less than 20 percent of the area. Dekalb soils are characterized by low erodibility, and occupy about 22 percent of the FEF. Soils of the Calvin series, which have moderate erodibility, make up 30 percent of the area of the FEF. Thus the majority of the soils represent low to moderate erosion hazard. A small portion of the FEF is found in skid roads and decks. Because skid roads and decks are closed and mitigated after use, and BMPs followed during logging, erosion would be minimized.

Approximately 420 acres would be burned during the period covered in this analysis, using a low intensity ground fire. 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. Moderate to light burns expose almost no mineral soil (Dissmeyer and Stump 1978). Swift et al. (1993) found no movement of soil from a controlled burn in North Carolina. Following prescribed burns in Stonelick subdrainage of the FEF in 2000, there were no areas of bare soil reported in a survey to determine the extent of forest floor removal (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.

A risk rating system was developed by the Monongahela National Forest to address the risk of slope collapse and/or mass wasting. The rating system is similar to risk rating systems applied in the western U.S. The factors considered include the: soil/rock complex, slope gradient, soil depth, aspect, roads and skid trails, slope position, ecosystem land type, rainfall amounts, and angle of rock dip to the slope (Jacobson et al. 1993). Based on this risk assessment model, there is little risk of mass wasting on the FEF because there would be no construction of roads on particularly sensitive soils (Cateache) with this alternative. There would be no 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. All BMPs would be met to further reduce the potential loss of soil from these areas. Effects on soil resources through soil movement would be negligible. Consequences of erosion and sediment transfer are addressed further in Section 3.1.

Soil Moisture

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 clearcuts, due to complete canopy removal and resulting decreases in transpiration. However, these are relatively small areas, ranging from 0.4 to 1.4 acres in size and totaling only 12.2 acres, or less than 0.1 percent of the total FEF area. In these small openings, the effects are likely to be minimized due to edge effects, which provide shade and decrease the effect. 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, effects on soil moisture would be insignificant.

Repeated burning that results in 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 most prescribed fires, evapotranspiration is found to decrease, due to removal of competing vegetation, but soil moisture increases. Increases in soil moisture of 6 to 10 percent following fires have been reported (Klock and Helvey 1976). Thus, while we may see changes in soil moisture as a result of the study, “Prescribed burning and variable intensity overstory mortality for enhanced wildlife habitat structure and long-term oak restoration”, the direction and extent of those effects are not known, but are expected to be relatively small. The study design will include monitoring to evaluate the effects on soil moisture and temperature.

Soil Temperature

An increase in surface soil temperature is expected to occur for a period of time following clear cutting. 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 are expected to be lower than normal during the winter months.

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 that results in 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. Thus, although we may predict small changes in soil temperature as a result of the research, "Prescribed burning and variable intensity overstory mortality for enhanced wildlife habitat structure and long-term oak restoration", the extent of those effects are not known, nor are we confident of our ability to monitor very small changes in soil temperature.

We conclude it is unlikely that significant adverse effects on soil temperature are expected from the proposed actions.

Nutrient Cycling

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 effects of 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), 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 soil moisture, surface soil temperatures, and increased organic matter that have been observed after clear cutting produce ideal conditions for rapid decomposition of the organic matter available on the site. Soil organisms responsible for decomposition would benefit from this surge in organic materials. Mineralization of organic compounds, and nitrification have been shown to increase after clear cutting. Such effects would be short-lived in the patch clearcuts because of rapid revegetation of the site by nutrient-demanding young vegetation. However, effects on nutrient cycling in intermediate cuts (diameter-limit, financial maturity, 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 has relatively little, if any, effect on microclimate and thus on nutrient cycling processes. Also, because the rates of these 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 removals are not expected to be significant, 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 clearcuts, 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, increase volatile losses of N (see Section 3.2), increase leaching of nutrients, and alter rates of important processes such as mineralization and nitrification. However, only about 420 acres would be burned during the five-year period of the analyses (9.1 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.

The study "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 (Adams et al. 1993, Adams et al. 1995, Edwards et al. 2002a, Edwards et al. 2002b, Adams et al. 2006) have been published by FEF scientists and show that nutrient cycling on watershed 3 has been affected by the fertilization treatment. 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 have been 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. Experimental design calls for continued monitoring to evaluate the extent of this process, and documentation of other changes in soil chemistry.

Soil Fertility

Fertility may be expected to increase from pre-harvest levels as increases in soil moisture and soil temperature from timber harvest and controlled burns 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 as well as benefiting many soil-borne organisms. On roads and landings, where soils have been disturbed, additions of limestone and fertilizer prior to revegetation would 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 not been reported in eastern hardwood forests (Adams 1999). Therefore, no adverse impacts to soil fertility are expected from the proposed harvesting treatments.

Productivity loss for trees on bladed roads is considered to be a long-term impact and is considered significant when roads cover 15 percent or more of a project area. Skid roads and decks cover less than 4 percent of the total treatment area and little more than 1 percent of the FEF area. Prior research on the FEF has shown that skid roads do not significantly impact the long-term soil fertility, if properly managed (Kochenderfer et al. l987).

The study "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. Although numerous papers (Adams et al. 1993, Adams et al. 1995, Edwards et al. 2002a, Edwards et al. 2002b, Adams et al. 2006) have been published by FEF scientists which show that nutrient cycling has been affected by the fertilization treatment, 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). 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. Experimental design calls for continued monitoring to evaluate the extent of this process, and documentation of other changes in soil chemistry.

We conclude that with the exception of the two studies mentioned above, direct and indirect effects of the proposed action on soil resources of the FEF would not be significant. As the objective of these two studies is to evaluate the effects of nutrient amendments on ecosystem processes, the study design will allow us to evaluate the significance of the hypothesized effects.

Cumulative Effects of Alternative B: Proposed Action

Logging early in the 20th century, 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. Nonetheless, it is believed that erosion was significant from turn of the century logging, and there may have been post-logging fires, which 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. 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.

Aggradation in Elklick Run is attributed primarily to the presence of 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 who use this road for recreation access. FR 701 has many undersized culverts that create road washout problems during high flows. This eroded road material is transported directly into Elklick Run. FR 701 also provides sediment source to Elklick in many places along its length because the gravel surface has largely been worn from the surface.

Past federal activities have consisted mainly of system road construction/reconstruction and timber harvesting. Controlled low intensity burns would affect relatively few acres of the FEF and recovery from burning is rapid with little or no long-term adverse environmental effects (Sykes l971). The repeated burning proposed under the study "Prescribed burning and variable intensity overstory mortality for enhanced wildlife habitat structure and long-term oak restoration" would affect a very small proportion of the FEF, a portion that 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. Proposed harvesting activities would affect less than 12 percent of the FEF land area with no significant adverse impacts to forest soils.

The FEF is located within an area of 26,056 acres of the Monongahela National Forest where no cutting or burning activities are planned within the foreseeable future. There is also 1,345 acres of private land within this area. Timber harvesting in general on private land has caused more disturbance to the soil due to a much less carefully designed standard road system (steeper grades, fewer drainage structures, no road surfacing material used). Grazing and farming practices on private land within the general area cause periodic erosion.

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. Downstream 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.

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 cumulative effects are difficult to quantify (see Chapter 3.1), but 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. Temperature may increase and precipitation may also increase. 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.

Direct and Indirect Effects of Alternative A: No Action

Soil Disturbance

There would be no new soil disturbance beyond natural levels.

Soil Compaction

There would be no effects on soil compaction because there would be no new deck construction and no vehicular use of existing skid roads.

Soil Movement

Under this alternative, no new deck construction would occur, and existing skid roads would not be re-opened and used. Soil erosion would continue from system roads (mainly FR 701) in the FEF. Since these roads are open to the public year-round, the road surface would continue to deteriorate.

Soil Moisture

There would be no significant changes in soil moisture.

Soil Temperature

There would be no clearings created and no changes in vegetation cover, other than natural gaps. So, except for within natural gaps, there would be no changes in soil temperature.

Nutrient Cycling

Acidic deposition and resulting inputs of N are expected to remain high. Deposition of SO_4 is decreasing (http://nadp.sws.uiuc.edu/Default.aspx). Some of the stands on the FEF may already be N-saturated as a result of ambient deposition (Peterjohn et al. 1996). Thus although effects of ambient deposition (approx. 14 lb N ac^{-1} yr^{-1} or 15 kg N ha^{-1} yr^{-1}) would continue, they would not be accelerated or ameliorated by harvesting or burning. Over the long-term, leaching of base cations may increase (Adams 1999).

Soil Fertility

Effects on soil fertility would be limited to factors, such as acidic deposition and climate change related impacts. Detectable changes in soil fertility from these factors are not likely to occur within the timeframe of this document. Long-term increases in base cation leaching could lead to nutrient imbalances or deficiencies, however, with no forest removals it is not expected to be detectable.

Cumulative Effects of Alternative A: No Action

The logging early in the 20th century, in all probability, had an effect on the soil resource. The railroad used to log the FEF area was located along or sometimes in Elklick Run. Much of the harvesting involved removal of all timber, although there were residual trees along ridge tops that were not cut because they were of little commercial value or were inaccessible. Nonetheless, it is believed that erosion was significant at that time, and there may have been considerable burning. 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. Additional effects on the soil resource from the no action alternative are likely to be negligible.

Aggradation in Elklick Run is attributed primarily to the presence of 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 NRS01 personnel and the general public who use this road for recreation access. FR 701 has many undersized culverts that create road washout problems during high flows. This eroded road material is transported directly into Elklick Run. FR 701 also provides sediment to Elklick in many places along its length because the gravel surface has largely been worn from the surface. With no actions, erosion is expected to continue.

The FEF is located within an area of 26,056 acres of the Monongahela National Forest where no cutting or burning activities are planned within the foreseeable future. There is also 1,345 acres of private land within this area. In general, timber harvesting on private land has caused more disturbance to the soil due to a much less carefully designed standard road system (steeper grades, fewer drainage structures, no road surfacing material used). Grazing and farming practices on private land within the general area cause periodic erosion.

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 no action alternative will not affect the area of disturbed soil.

At present, reliable well-accepted predictions for climate change in the area of the FEF do not exist. Temperature may increase and precipitation may also increase. While such changes in climate could affect soils over the longer term, we cannot predict any cumulative effects on the soil resources due to climate change at this point in time.

Under this alternative, there are no future manipulations planned on the FEF. Erosion would continue from existing roads and private land. Cumulative effects would not change significantly from the present, but over the long term, erosion would continue.

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 (Figure 3-2).

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 also is a resistant sandstone but of nonmarine 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). Detailed descriptions of the formations are given in 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. Big Spring Cave is within the 102-acre Biological Control Area. The cave is a winter hibernaculum for the federally-endangered Indiana bat. Two small inaccessible caves exist below the Hickman Slide Road: Fish Trough Cave and Hickman Slide Pit Cave. Neither are 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 20 m 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. And several small sinkholes were discovered in compartment 16 during develop of a natural gas well site in 2008, with one larger, deep sinkhole located above FR 701 which is about 7-8 feet deep.

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).

Colonies of the southern rock vole, a USDA Forest Service Region 9 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 begun. 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.

Direct, Indirect and Cumulative Effects of Alternative B: Proposed Action

The potential effects of the proposed alternative would include changes in groundwater flow or introduction of sediment to caves from logging, or prescribed burning. Potential effects also could include changes to groundwater quality in karst systems from run-off of herbicides, or the fertilization treatments.

Compartments or areas watershed 3, watershed 5, LTSP, 19, 21, 26, 27, 30, 31, 45, 48, 49, 60, 61 and 90

The proposed actions within these compartments 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 are formed 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 or have subsurface hydrologic connections to the area proposed for fertilizer additions.

<u>Compartments or areas 7, 9, 13, 18, 19 and 20</u>

The proposed actions within these compartments are not likely to substantially affect caves or cave ecosystems.

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 clearcuts, and prescribed burning. The proposed activities involve logging utilizing both ground-based and cable logging systems, 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, which avoids substantial changes to water flow direction, and minimizes its 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, and mitigating measures that require karst features, such as sinkhole or cave openings, to be protected as if they were live streams, 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 cumulative effects on the geologic resources of the proposed alternative.

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.

Direct, Indirect and Cumulative Effects of Alternative A: No Action

There would be no changes in geologic or mineral resources due to this alternative.

3.5 Aquatic Resources

Affected Environment

The major perennial stream on the FEF is Elklick Run. This stream drains nearly 3,530 acres of the FEF or about 75 percent of the area. This subwatershed contains numerous other 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 empties into the Black Fork River about two miles southeast of Parsons, West Virginia. See Section 3.1 for more details.

Bedrock geologies account for variances in water chemistry in the area. The Hampshire formation is comprised of nonmarine sandstone and shale and the Greenbrier group is made up of marine limestones and calcareous shales. Limestone derived material results in pH of streams closer to neutral, which is optimum for aquatic life, relative to more acidic streams characteristic of bedrock of shales and sandstones. Brook trout and mottled sculpins are present in low numbers in Elklick Run, Camp Hollow, Canoe Run and Stonelick Run, and are mostly restricted to plunge pools (Angradi 1996, Hartman and Cox 2001). In addition, black nosed dace are common in Elklick Run and white suckers are occasionally collected whereas brown trout have been reported in the lower reaches of Canoe Run (Hartman and Cox 2001).

Numerous studies conducted on the FEF have evaluated macroinvertebrates abundance, diversity and response to disturbances (Angradi 1996, 1997, 1999, Angradi and Hood 1998, Meegan and Perry 1996, Kaller and Hartman 2004). Elklick Run is one of the participating streams in the long-term project "Assessment of Spatial and Temporal Variability in Stream Habitat and its Influence on Brook Trout Population Dynamics" (Sweka and Hartman 2008) and monitoring of macroinvertebrates is part of this project.

Potential Effects

Potential adverse impacts on aquatic resources related to forest management practices include changes in sedimentation rates, large woody debris occurrence, stream organic matter, extent of overhead canopy, stream water temperature, stream productivity, flow regimes, and changes in water quality. Of these, Filipek (1993) and Dissmeyer (1994) suggested that sedimentation has the highest potential to negatively impact aquatic systems and their communities. Many authors have investigated fine sediment effects on salmonids. In these studies, fine sediment has been variously defined as size fractions < 0.063 mm, < 0.83 mm, < 1 mm, < 2 mm, < 3.5 mm, or < 6.5 mm. Early research has suggested that when fine sediment (< 6.5 mm) in spawning gravels reaches 30 percent, trout fry emergence is reduced to 40 percent (Everest and Harr 1982). Cederholm and Reid (1987) reported decreases in salmonid fry survival up to 3.4 percent for each 1 percent increase in fine sediment. Fine sediment in the spawning gravels suffocates trout eggs and reduces macroinvertebrate populations (Cordone and Kelley 1961, Hall and

Lantz 1969, Bjornn and Reiser 1991). Fine sediment (< 6.5 mm) levels above 40 percent can effectively eliminate a trout fishery (Everest and Harr 1982) as well as many macroinvertebrates species (Kaller and Hartman 2004, Hartman and Hakala 2006). More recently, Hakala (2000) found that when fine sediment < 0.063 mm exceeded 1 percent in spawning gravels, the resulting year class of brook trout was reduced to 20 percent of that in unimpacted streams. The size fraction and percentage of sediment composition at which severe reproductive impairment of brook trout and alteration of macroinvertebrate communities occur varies across studies. Hakala (2000) summarized brook trout – sediment relationships for brook trout recruitment and suggested that since most spawning substrate in the Monongahela National Forest was < 4 mm in diameter (~ 27 percent) that it was smaller particles, particularly < 0.063 mm that negatively affected recruitment. Based on this research, he suggested that the 5 to 7 percent level for fine sediment less than 1.0 mm be the accepted threshold above which brook trout experience substantially impaired reproductive success.

In addition to impacts to spawning gravels and macroinvertebrates populations, fine sediment also impacts trout by decreasing available habitat and suspended sediment may reduce foraging efficiency. Fine sediment fills in pool habitat and spaces surrounding cobble/rock within riffle areas. These habitat areas are important to the life cycle of salmonids. Pools provide adult salmonid habitat and the spaces in the riffle substrate are important for both winter and summer survival. In the winter, resident salmonids burrow down into the spaces in the substrate to escape harsh winter conditions. In extreme low flow conditions in the summer, resident salmonids enter spaces within the substrate to maintain contact with water as headwater streams dry. Suspended sediments reduce water clarity. Increases in suspended sediments have been shown to lead to reduced growth of brook trout, even with unlimited food as fish expend more effort actively searching for prey (Sweka and Hartman 2001). Thus, suspended and deposited sediments can work interactively to alter the production of trout and their prey base in streams.

Current sources of sediment associated with research on the FEF come from system roads, skid roads, and log landings. Additional information on erosion and sedimentation processes can be found in Section 3.1, “Water and Riparian Resources”.

Effects Without Mitigation: If the action alternative were implemented without the use of mitigation measures, there could be increased stream sedimentation, reduction in water quality, and loss of aquatic habitats for fish and macroinvertebrates species. These would result from erosion of skid trails and erosion of upland areas, and continued erosion from FR 701. Poorly designed or improperly placed stream crossings, as well as insufficient or lack of stream filter strips, could contribute to degradation of aquatic habitat and reduced water quality. Loss of stream shade from uncontrolled timber harvests within the riparian area could result in increased water temperatures that would adversely affect trout. Improper design of stream crossings for permanent and temporary roads and trails could result in migration barriers -- preventing fish from reaching spawning habitat. This could lead to lower fish production and genetic fragmentation of the fish population.

Effects With Mitigation: With appropriate mitigation measures for the action alternative as described in Chapter 2, sediment delivery to the streams within the project areas would generally be minimal and short term, stream shade would be maintained by controlling the amount of harvest adjacent to streams, and stream crossings would be properly designed to allow fish passage.

<u>Direct, Indirect and Cumulative Effects of Alternative B: Proposed Action</u>

The proposed action would not yield any direct adverse effects to perennial or intermittent aquatic resources within the project area because the streams would be protected from direct impacts by streamside protection zones from harvesting or burning. However, there would be potential for indirect and cumulative effects to aquatic ecosystems from sediment inputs. Sediment delivery to intermittent and perennial streams starts with disturbances in smaller ephemeral channels. These channels begin high in the drainage in the same areas proposed for timber harvesting. Skid trail reconstruction, landings, system road reconstruction and maintenance all increase the risk of sediment delivery to streams. Sediment from these small ephemeral channels could adversely affect trout fisheries downstream. Erosion from FR 701 would continue to contribute sediment to Elklick Run, with possible cumulative effects on brook trout habitat. Mitigation activities associated with Alternative B would significantly reduce sediment inputs to Elklick Run.

The FEF is located within an area of 26,056 acres of the Monongahela National Forest where no cutting or burning activities are planned within the foreseeable future. There is also 1,345 acres of private land within this area. In general, timber harvesting on private land has caused more disturbance to the soil due to a much less carefully designed standard road system (steeper grades, fewer drainage structures, no road surfacing material used). Grazing and farming practices on private land within the general area cause periodic erosion. However, most of these areas do not drain into the FEF, so the cumulative effects on the aquatic resources of the FEF are unlikely.

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. Although future gas wells could be developed during the next 5 year period, their contribution to cumulative effects on aquatic resources depends on their placement, and timing of development. If they are located near water bodies or within karst topography, there could be cumulative effects, based on cumulative sediment effects. If drilling is contained on or near ridge tops, the potential for additional effects on aquatic resources becomes much less.

At present, reliable well-accepted predictions for climate change in the area of the FEF do not exist. Temperature may increase and precipitation may also increase. While such changes in climate could affect aquatic resources over the longer term, we cannot predict any changes due to climate change at this point in time.

The proposed action will not greatly affect the area of disturbed soil, nor contribute to current low levels of sediment to streams, and the effects on aquatic resources are unknown, but believed to be minimal.

Direct, Indirect and Cumulative Effects of Alternative A: No Action

There would be no direct or indirect adverse effects of the no action alternative because there would be no use of skid roads and log landings. However, continued erosion from FR 701 would continue to contribute sediment to Elklick Run, with possible negative cumulative effects on brook trout habitat.

The FEF is located within an area of 26,056 acres of the Monongahela National Forest where no cutting or burning activities are planned within the foreseeable future. There is also 1,345 acres of private land within this area. In general, timber harvesting on private land has caused more disturbance to the soil due to a much less carefully designed standard road system (steeper grades, fewer drainage structures, no road surfacing material used). Grazing and farming practices on private land within the general area cause periodic erosion. However, most of these other ownerships do not drain into the FEF, so cumulative effects on the aquatic resources of the FEF are unlikely.

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. Other wells could be drilled in the next 5 years within the FEF. The effects of future well pad construction and drilling upon aquatic resources 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 effects deriving from sediment effects. If drilling is contained on or near ridge tops, the potential for additional effects on aquatic resources is much less.

At present, reliable well-accepted predictions for climate change in the area of the FEF do not exist. Temperature may increase and precipitation may also increase. While such changes in climate could affect aquatic resources over the longer term, we cannot predict any changes due to climate change at this point in time.

The no action alternative will not affect the area of disturbed soil, nor significantly change current levels of sediment to streams. Therefore while cumulative effects of the no-action alternative on aquatic resources are unknown, they are believed to be negligible.

3.6 Wildlife Resources

Introduction

Classification of vegetation into forest cover types, size classes, communities, upland habitat, wetland habitat, aquatic habitat, and relict habitats provides a partial basis for determining existing or potential habitat for wildlife species. The combination of physiography, soils, climate, successional pathways and patterns, as well as past or historic land use practices have produced a variety of habitat niches within the FEF.

Wildlife species utilizing the FEF can be categorized into subgroups based on habitat preferences and niche function. These subgroups can broadly be defined as generalist species, intermediate species, and specialist species. Species in the generalist category are those that use the widest array of habitat types (forested or nonforested) and communities within those types. In addition to these factors, specialist utilization is dependent upon physical variables such as elevation, karst formations, emergent rock, springs, seeps, and standing water, 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. These variables when considered with minimum home range requirements (minimum space required for food resource acquisition, intraspecific interaction, and appropriate denning/shelter areas), are all factors used to place species into subgroups.

Examples of each wildlife subgroup occur on the FEF. Additionally, some species also are placed into administrative rather than biological categories. These include species dealt with in the Biological Assessment that are categorized as Threatened or Endangered by the Federal government, or species considered sensitive on the USDA Forest Service Region 9 Sensitive Species list.

Affected Environment

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 beginning 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 cutting that has favored the establishment, maintenance, and growth of shade tolerant overstory vegetation such as red and sugar maple, as opposed to mast producing oaks and black cherry that are highly valuable for regional wildlife species. Additionally, steep slopes and a mixed ownership pattern have limited the extent of conventional logging across the oak and Allegheny hardwood types. In contrast, research-related harvesting activities on the FEF have consisted mostly of intermediate and 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 temporal basis without fragmenting and/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 experiments 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 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 dependent upon early successional forest types have been declining in numbers throughout recent years. Therefore, it is important to understand that forests can be readily manipulated to meet disturbance-dependent wildlife species needs.

Studies on wildlife response to silvicultural activities have been conducted over the last several years 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. 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), 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), 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. 2009), small rodents (Healy and Brooks 1988), Allegheny woodrats (Castleberry 2000a, Castleberry 2000b, Castleberry et al. 2002), tree 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), fisher (Gehring 1997), raccoons (Ford et al. 1999a, Owen 2003, Owen et al. 2004a), black bear (Rieffenberger et al. 2000) and white-tailed deer (Miller et al. 1999, Campbell 2003, Laseter et al. 2004). Results of these studies indicate a lack of response or completely beneficial impacts to these species and/or their habitat as so much of the surrounding landscape remains in mature forest.

Nonforested Lands

Approximately 53 acres of nonforested openings (slightly more than 1percent of the FEF) exist as logging decks, weir sites, skid roads, parking areas, fields, and a natural gas well. 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

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 Monongahela National Forest are 1.3 miles per square mile of land areas. Some roads on the FEF, (FR 701, FR 704, FR 705) are open to year-round public use, or are open in part of the year (FR 324) 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.

Threatened and Endangered Wildlife Species

Appendix 1 of the Biological Assessment contains the "Likelihood of Occurrence Table" for the FEF. It contains all threatened, endangered and sensitive species currently found on the Region 9 Sensitive Species list, which may be found on the FEF. This table was developed to take an overall look at the FEF and 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, Indiana bat, and Virginia big-eared bat.

Direct and Indirect Effects of Alternative B: Proposed Action

Forested Lands

Under this alternative over the next five years, regeneration harvests (patch clearcutting) are proposed on 12.0 acres (0.3 percent of the FEF). Light overstory thinning, including single-tree selection and diameter-limit harvests are proposed for 208.2 acres (4.5 percent of the FEF). Moderate overstory thinning, including group selection and heavy diameter-limit harvests are proposed for 222.4 acres (4.8 percent of the FEF). Prescribed burning is proposed on 420 acres (9.1 percent of the FEF).

It is possible that wildlife species occupying cut trees at the time of harvest could be temporarily impacted. Seasonal harvesting (October 1 – May 31) would eliminate the direct impacts to nesting birds and roosting bats as logging would occur in the months outside of the nesting season. The open understory available immediately after harvesting 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. Thinning of the overstory as a result of shelterwood harvests and diameter-limit harvests has 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.

Regeneration harvesting such as patch clearcutting greatly increases the amount of soft mast (*Rubus* spp., *Vaccinium* spp., and *Smilax* spp.) 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 clearcutting 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 disturbance would not greatly exceed that of uncut stands, the utility of single-tree selection and diameter-limit harvest thinnings to early successional wildlife species would be less than those from regeneration harvests. However, diameter-limit harvests produce complex multi-layered stand structures thought to benefit many interior and interior-edge songbird species (Weakland 2000). Shrews are as abundant or more abundant in stands subjected to diameter-limit harvests as 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 Monongahela National Forest 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 and cowbird parasitism did not appear to be a biological concern in this heavily forested portion of the central Appalachians (DeMeo 1999, Weakland 2000). Percent core area on the FEF is high (83.8 percent core area with edges buffered at 100 ft and 73.3 percent core area with edges buffered at 325 ft; see section 3.8 for detailed description) - far above threshold levels where cowbird parasitism and mammalian predation would affect songbird nesting success.

After the first growing season post-harvest, regeneration cutting 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 occurs in regenerating stands in the central Appalachians (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).

Within regeneration harvests, high exposed perches for raptors and scavengers would remain after logging (Smith 2003). Low exposed perches would be found in harvested areas important for singing perches, insect-hawking perches and nesting sites for edge, interior-edge, ground-nesting, and shrub-nesting songbirds. Reductions in the number of cavity trees could impact roost and nest site availability for bats, squirrels, raccoons, owls, woodpeckers, nuthatches and other cavity-nesting birds. Conversely, in the affected environment black locust is abundant in regeneration areas and quickly becomes overtopped by other overstory tree species, developing into snags readily used as bat roosts (Menzel et al. 2002, Owen et al. 2002, Johnson et al. 2009). Bear den sites in felled cavity trees could be impacted. However, bears in the Allegheny Highlands often tend to den in rock outcrops and slash piles (which would be abundant in regeneration areas) rather than in tree cavities (Joe Rieffenberger, West Virginia Division of Natural Resources, personal communication). Where practical, mitigation measures would be implemented to leave cull trees and snags for wildlife.

Shelterwood harvests provide structural diversity that benefits songbirds across all habitat preferences and nesting guilds in the central Appalachians (Miller et al. 1995, Weakland 2000). Furthermore, retention of overstory trees in shelterwood harvests provides future sources of large standing snags and large woody debris useful to wildlife as in the course of stand development and study progression, some residual overstory trees would die and provide large coarse woody debris important to wildlife within the stand (Loeb 1993). None of the proposed harvests would remove large, dense patches of conifer. These patches, primarily eastern hemlock, are valuable to wildlife for escape and winter thermal cover in the central Appalachians.

Prescribed burning impacts to wildlife from the three proposed burning studies 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. 2009). 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. These species also provide high quality live roosts for many bat (Dickinson et al. 2009) and bird species. 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 consumption by burning is high (Ash 1995). 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 fertilization would not be applied in high enough density and is not toxic to fauna at this low concentration. Results from these studies have shown no change in the soil chemical properties, salamander capture rates and body condition, and shrew capture rates (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 be species-specific on the FEF; application would be applied directly to targeted plants. Tatum (2003) stated that most commonly used herbicides degrade quickly once they enter the environment, and therefore are neither cumulative nor bioaccumulative. Additionally, modern herbicides have been designed to target biochemical processes unique to plants, thus having a low level of direct toxicity to animals. Because herbicide application would be species-specific, there would be no direct or indirect effects to wildlife. Some additional snag trees may be created, thus providing additional roost trees to bats and other species that utilize decadent trees and tree cavities.

Nonforested Land

No additional permanently nonforested land would be created or maintained by the proposed action; therefore effects would not be significant.

Roads

Roads can represent barriers to dispersal and survival to some wildlife species whereas roads represent 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 Anurans 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 oldfield 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.

Threatened and Endangered Species

Direct and indirect impacts of regeneration harvests, partial harvests, and thinning and prescribed burning on threatened and endangered species that occur or could possibly occur on the FEF are possible, but unlikely. Federally listed species that occur or could potentially occur on the FEF include: running buffalo clover, Indiana bat, and Virginia big-eared bat. See section 3.9 for discussion on running buffalo clover.

For the Indiana bat, a finding of "may affect, likely to adversely affect" was delivered. Although felling trees could possibly impact individuals of the population, seasonal logging (October 1 – May 31, with no tree felling to occur during April) reduces this to an extremely low probability. Monitoring of bat activity on the FEF has revealed that bats are entering Big Spring Cave hibernacula as late as mid-October and departing in the spring in mid-April; therefore there is a minimum amount of overlap in the fall and spring when tree felling will occur while bats will be out on the landscape. Under the proposed action, potential Indiana bat roost trees could be lost through tree removal via harvesting and prescribed burning. It is possible that an Indiana bat may be directly affected by prescribed burning; however, research has shown that bats in general have demonstrated the ability to escape fire without direct harm (Rodrigue et al. 2001, Dickinson et al. 2009). Prescribed burning will be conducted early in the spring to prevent harming non-volant young and in late fall when the young are volant. For the Virginia big-eared bat, findings of "no effect" were made for all proposed alternatives. For a more detailed discussion, see the Biological Assessment.

For sensitive animal species known to occur on the FEF, including the southern water shrew, southern rock vole, northern flying squirrel, 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 small-footed myotis had a finding of "no impacts" for the proposed action. For details see the Biological Assessment.

<u>Cumulative Effects of Alternative B: Proposed Action</u>

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 actually 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 an area of Monongahela National Forest of 26,506 acres that would not be burned or logged in the foreseeable future. No significant changes are expected on area private lands or the adjacent Otter Creek Wilderness Area on the Monongahela National Forest. 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.

Global climate change could potentially alter wildlife habitat in the Appalachian Mountains, although the extent of habitat alteration remains unknown. 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, this forest type is not the predominate forest type on the FEF, 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, and bats will benefit from the abundance of live roost trees available, as these provide long-term roost sources. The amphibian guild would become slightly less diverse as those 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.

An emerging threat to bat species on the FEF is white-nose syndrome (WNS), a fungus that affects bats in their winter hibernacula. 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 Wildilfe 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 Spring Cave on the FEF is currently gated and closed to recreational spelunking in an effort to prevent the spread of WNS via humans; 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 the fact that many species aggregate in dense clusters during hibernation. Additionally, Big Spring Cave is located in the Biological Control Area of the FEF where no silvicultural or fertilization treatments will occur, so the area around this cave is protected. 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 is not likely to contribute to the cumulative effects of WNS on bats.

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.

Direct and Indirect Effects of Alternative A: No Action

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.

This alternative would not affect threatened and endangered species directly, as no trees would be felled.

Cumulative Effects of Alternative A: No Action

Timber management on private lands in the surrounding area would remove the most 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-masting 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. However, in the long term, hard mast capability would decline as the stand moved towards a shade tolerant composition. From a wildlife perspective, the loss of mast producing overstory species would be devastating to the large number of species including squirrels, bears, turkeys and woodrats that depend on these mast resources. 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 Monongahela National Forest. 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.

3.7 Old Growth

Affected Environment

Old growth forests are those with: large, mature or overmature trees (both healthy and decadent) comprising a plurality of stocking; a multi-layered canopy in trees of various age classes; and, dead trees and relatively large amounts of decaying material on the forest floor (USDA Forest Service 1989, Muller and Liu 1991, Greenberg et al. 1997, Hardt and Swank 1997). Attributes that need to be considered in managing old growth at a landscape level or ecosystem context include: patch size, structural diversity, overstory and understory species composition, standing snags, downed coarse woody debris, land type association, slope, soil type, aspect, ownership patterns, disturbance factors, and spatial arrangements to other areas containing similar or additional attributes (Greenberg et al. 1997).

Mature stands on the FEF, notably the Biological Control Area, watersheds 4, 10, and 13, and compartment 8E are beginning to develop attributes that make them desirable for consideration in management of future old growth habitat. These areas would be classified as being in the understory re-initiation stage, with the main cohort emanating from first logging that occurred circa 1905 to 1912, although some of the trees in the stands predate that period.

These stands total 250.5 acres, about 5 percent of the FEF. None of the alternatives within this EIS would change the status of these areas as unmanaged areas used to make comparisons to managed areas. Recent research using these compartments documented conditions with respect to productivity and woody species diversity (Schuler 2004), coarse woody debris (Adams et al. 2003), and individual tree characteristics (Wiemann et al. 2004). While these stands exhibit some traits of old-growth, they are not considered old-growth from either a process or a structural perspective (Oliver and Larson 1996).

Direct, Indirect, and Cumulative Effects of Alternative B: Proposed Action

Because no old growth exists on the FEF, no direct effects would result from this proposed alternative. No management activities are proposed in this alternative in the Biological Control Area, watersheds 4, 10, and 13, and compartment 8E. These unharvested areas would continue to develop based on the attributes of existing tree species and gain more structural attributes of old-growth forests through time. The proposed action does allow for the control of invasive exotic species on the FEF. Anthropogenic disturbances can facilitate the spread of invasive species through several means, including the physical movement of seeds and alteration of environments more suitable to exotic species establishment (Meffe et al. 1994, Miller 2003). While this alternative directly affects only managed compartments, which will not develop old-growth attributes, the managed compartments could become sources of exotic species that spread throughout the FEF to unmanaged compartments. Thus, indirectly this alternative could increase the potential for invasive species to spread to potential old-growth stands. Also, like all other forests in the study area and beyond, the unmanaged stands will be impacted by climate change. A warming climate is predicted to shift tree species habitat and distributions to the north over the long term (Iverson et al. 1999). A changing climate may change the composition of these forests, however it is not likely that climate will change such that forests are no longer the dominate vegetation of the FEF and surrounding region.

<u>Direct, Indirect, and Cumulative Effects of Alternative A: No Action</u>

Because no old growth stands exist on the FEF, no direct effects would result from this alternative. Unharvested areas such as those noted above would continue to develop according to patterns of stand development and gain more structural attributes of old-growth forests through time (e.g., several more decades). However, there are risks associated with the development of future old-growth stands and the no action alternative. One of the greatest risks is the potential for invasive exotic species to displace indigenous species in both the overstory and herbaceous strata (Meffe et al. 1994, Miller 2003). The no action alternative does not allow for the control of invasive exotic species on the FEF. Species such as Japanese stiltgrass and tree-of-heaven have the potential to become abundant on the FEF, invading managed and unmanaged areas as disturbances, both natural and anthropogenic, facilitate. Potential old-growth stands with significant amounts of either of these species would be less useful as reference areas and the invasives would likely alter functional characteristics of these stands as well. Also, like all other forests in the study area and beyond, the unmanaged stands will be impacted by climate change. A warming climate is predicted to shift tree species habitat and distributions to the north over the long term (Iverson et al. 1999). A changing climate may change the composition of these forests; however it is not likely that climate will change such that forests are no longer the dominant vegetation of the FEF and surrounding region.

3.8 Forest Fragmentation

Affected Environment

The FEF occurs in a heavily forested portion of the central Appalachians where open and early successional habitats, rather than closed, mature forest, are limited on the landscape. Forest fragmentation issues common to other portions of the country such as the conversion of forest land to agriculture or the continuation of urban sprawl into forested areas (Robbins 1988, Rich et al. 1994, Donovan et al. 1995, Marini et al. 1995, Robinson et al. 1995, Rosenblatt 1999, Freeman et al. 2003) are not serious issues threatening the forested areas around the FEF in West Virginia (Weakland 2000). Despite the recent changes in forests across the United States, areas around the FEF have remained virtually unchanged over the past 25 years. Most of the FEF and surrounding land continues to be dominated by closed, mature forest.

For this EIS the affected environment for forest fragmentation analysis is the area within a 5 mile radius of Big Spring Cave on the FEF. This area includes all of the FEF, MNF land, and privately-owned land. The cave provides winter habitat for the federally endangered Indiana bat and the area within 5 miles of the cave is considered primary habitat for the Indiana bat (USDA Forest Service 2006). To calculate fragmentation, roads, permanent openings (including rivers), and forests less than 10 years of age were buffered by 100 feet. In ArcMap™, the Landscape Fragmentation Tool v2.0 (University of Connecticut, Center for Land Use Education and Research 2009) was used to calculate the amount of area in patch, edge, perforated, and core forest (Vogt et al. 2007). Forested areas categorized as patch are those completely surrounded by area considered edge, in this case within 100 feet of a fragmenting element. Edge is assigned to those forested areas within the given buffer width along the outside edge of a non-patch area. The area of perforated forest was calculated by identifying those forested areas along the inside edge of openings within the core forested area. Core areas are those forested areas not directly affected by edge, patch, or perforation. Three classes of core area were calculated: small (less than 250 acres), medium (250 to 500 acres), and large (greater than 500 acres).

The current condition for the 5-mile affected area is a landscape of 83.8 percent core forest, with most of that (79.3 percent) as large core forests (Table 3-8). Even a liberal buffering of 325 ft, 243 ft beyond the distance where biologically relevant effects were detected for songbirds on the Monongahela National Forest (DeMeo 1999), produces a core area of 73.3 percent closed forest for the five miles around the cave (Table 3-8). Only about 108 acres of the 5-mile area is considered patch that is completely surrounded by edge. Edge habitat currently makes up about 5 percent (2,473.5 acres) of the area. About 337.4 acres (0.7 percent) of the area is classified as perforated. About 10 percent of the area (5,248.5 ac) is in open condition, both permanent (roads, home sites) and temporary (regenerating forest).

Potential Effects

Fragmentation occurs when openings create breaks in continuous forest blocks. Openings are caused by natural disturbances such as blowdown and fire or anthropogenic factors including farm fields, home sites, wildlife openings, roads, power lines, timber harvests (regeneration cuts such as clearcuts, seed-tree harvests, and shelterwood harvests), recreational areas (ski resorts), wind turbines and surface mining (Faaborg et al. 1993, Osborn et al. 2000, Weakland 2000, Hadley and Wilson 2004a, 2004b). Prescribed fire has the potential to create temporary fragmentation of the forest.

Single-tree selection and diameter-limit harvesting are not considered fragmentation events at the landscape level. Timber harvesting effects are transitory because the new stand develops and openings disappear. From a wildlife perspective, research has shown that timber harvest techniques such as diameter-limit harvesting and single-tree selection have actually improved wildlife habitat (particularly songbird habitat) and do not fragment the landscape from a wildlife perspective (Weakland et al. 2002).

The amount and impact of fragmentation depends on the configuration and spatial dispersal of the openings in the forest. Because of the “edge effect”, the more irregular in shape and the more dispersed openings are, the larger the fragmented area (Franklin and Forman 1987). Fragmentation changes light and moisture regimes at the microsite level. Additionally, site conditions can be altered enough to affect populations of wildlife and vegetation dependent on conditions produced by intact, interior forest stands. It is important to understand that interior habitat conditions take time to develop and fragmentation cannot only result in habitat loss but also ineffective habitat as well (Jules 1998).

Interior habitat is an important consideration because some faunal and floral species are documented interior-obligates (Harris 1984, Robbins 1988, Donovan et al. 1995, Jules 1998). Donovan et al. (1995) hypothesized that 40 percent core area represented a threshold where there was no difference between source and sink habitats for neotropical migratory songbirds in the landscape. Research on the Monongahela National Forest confirms that no adverse effects occur to songbird nesting, reproduction, and survivorship in areas with as little as 42 percent core area (DeMeo 1999). The majority of the Monongahela National Forest that surrounds most of the FEF boundary has core area in excess of 75 percent, with some large blocks in the adjacent Otter Creek Wilderness Area in excess of 90 percent core area.

Species favored by fragmentation are those associated with edge and habitat diversity within patches (Forman and Gordon 1986). Species that can be adversely affected by fragmentation are those requiring interior conditions for at least part of their life cycle (Forman and Gordon 1986). Of the 126 neotropical migratory songbird species that breed in the central Appalachians and northeastern United States, 74 species are associated with edge conditions and 52 are interior species (Smith et al. 1993, Costello et al. 2000). Breeding bird survey trends from 1980 to 2007 for West Virginia show eighteen neotropical migratory songbird species declining with 5 of those considered forest interior sensitive (Sauer et al. 2008). The other thirteen species with declining trends over this time are associated with edges, grasslands, or shrub habitat. In western Virginia, Conner and Adkisson (1975) noted that interior species such as the wood thrush returned to clearcut areas when the stand reached pole-stage (about 20 years on the FEF). Across landscapes with 42 to 81 percent forested core area on the Monongahela National Forest, fragmentation effects on songbirds were only apparent at very localized scales within 75 to 100 ft of edge, with no pervasive landscape-scale effects noted (DeMeo 1999). Edge type (hard vs. soft) effects were noted, with overall nesting success higher at the edge of regenerating clearcuts than along road edges. The same study noted that the wood thrush is associated with diverse forest understories resulting from edge creation on the Monongahela National Forest. In fact, numbers of other interior species such as worm-eating warbler, cerulean warbler, scarlet tanager, and eastern wood peewee were not significantly related to forest fragmentation within the aforementioned ranges. For interior species on the intensively managed Mead-Westvaco Ecosystem Research Forest (MWERF), only ovenbird numbers were positively correlated with increasing percent core area of intact forest (Weakland 2000).

Some mammal species such as bats and deer have also been found to benefit from the mosaic of forest conditions created by forest fragmentation. Research on the Monongahela National Forest and MWERF has shown that bat species such as hoary bats and silver-haired bats had higher activity levels in clearcuts and deferment cuts than other forest stands with more intact forest conditions (Owen 2000, Owen et al. 2004b). A white-tailed deer study on the MWERF showed that clearcuts were an important component of browsing habitat for deer during the summer (Campbell et al. 2004).

Conversely, some mammalian species are adversely affected by forest fragmentation. Smaller more maneuverable bat species like the northern myotis, eastern pipistrelle and the Indiana bat are probably negatively affected by fragmentation. Research has shown that these smaller bat species have higher activity levels in interior forests than more open habitats (Owen 2000, Owen et al. 2004b). Additionally, research has shown that salamanders are adversely affected by forest fragmentation due to the changing conditions of the forest floor after timber harvest (Knapp 1999, Knapp et al. 2003).

The question of "How much fragmentation is acceptable?" must therefore consider both edge and interior species. Given that 3 times as many edge songbird species as interior species are showing population declines, the key challenge of land management might be to provide for edge species concurrent with protecting sufficient interior habitat (Ambuel and Temple 1983, Blake and Karr 1984, Askins 1993, Litvaitis 1993, Costello et al. 2000). Many songbird species are associated with shrub-scrub habitats that are best provided in the central Appalachians by regenerating timber harvest areas (Conner and Adkisson 1975).

Direct, Indirect, and Cumulative Effects of Alternative B: Proposed Action

Overall the impact of the proposed actions to the continuity of forest cover on the FEF would be minor. Because the area to be treated in the proposed action is small relative to the entire FEF and the landscape within a 5 mile radius of the FEF, there would be no direct, indirect, or cumulative effects on forest fragmentation of this alternative.

Patch clearcutting in compartments 18A, 18B, and 30 will likely not add to forest area considered perforated. These temporary openings already exist in these compartments from past timber harvest and as these patches regenerate to forest the newly created patches become the fragmenting element. These areas will remain perforated; however the total area in temporary openings will not change as older patches of forest age and are replaced by new openings. As these patch cuttings are part of a long-term study on the FEF, this fragmenting action is expected to continue in the future.

Prescribed fire treatments in compartments 48, 49, 13, 21, and 45 have the potential to create temporary openings in the forest. These openings are considered temporary as the forest is expected to regenerate. Small openings were created in compartments 21 and 45 from previous prescribed fires. While the intent is for these treatments to be low to moderate in intensity, openings larger than 0.1 ac could be created by the proposed prescribed fire treatments. Two prescribed fires have already taken place in compartments 13, 21, 45, and 49 and one fire has taken place in compartment 48. The need for prescribed fires beyond those proposed this planning period will be re-assessed at the start of the next planning cycle. Unlike long-term research involving periodic timber harvest, the prescribed fire treatments themselves are not likely to continue indefinitely although these studies are long-term.

Direct, Indirect, and Cumulative Effects of Alternative A: No Action

Percent core area of closed forest would realize a small gain from the no action alternative as planned timber harvests and disturbance events do not proceed. Overall, however, there would be no significant impact to forest fragmentation from this alternative.

Cumulative Effects Common to Both Alternatives

In 2008 and 2009, openings for a gas well and pipeline were created on the FEF. These canopy removals are considered permanent fragmenting effects and were included in the calculations of fragmentation described above. The rights to mineral resources under the FEF are privately owned. There are no known additional gas wells or pipelines currently planned for the FEF; however energy development is very speculative. There is a possibility that additional fragmentation will occur in the future if the gas-bearing formation under the FEF proves economical. Clearing of forested areas for gas wells or pipelines could occur on private land within the affected area as well.

Also, the FEF and region will likely be impacted by climate change. A warming climate is predicted to shift tree species habitat and distributions to the north over the long term (Iverson et al. 1999). A changing climate may change the composition of these forests, however it is not likely that climate will change such that forests are no longer the dominant vegetation of the FEF and surrounding region. A highly fragmented forest could be a barrier to some tree and shrub species as seeds may not be transported across nonforest areas.

Activities that temporarily and permanently fragment the forest will likely occur on private land within the area of the affected environment. Timber harvest has occurred in the past on private land and is likely in the future; this would temporarily increase the amount of open area and edge within the area. The area has seen little commercial development or conversion of forest land to house sites in recent years, although this is possible at any time. We know of no plans for land conversion within the affected area at this time.

3.9 Forest Vegetation

Affected Environment

In this section of the analysis, the affected forest vegetation is described within a context of hierarchical ecological units as described by McNab and Avers (1994) and plant associations described by Braun (1950) and Barrett (1995). Although such units incorporate both physical and biological components, the analysis in this section focuses on floral characteristics.

The FEF is a small part of the Central Appalachian Broadleaf Forest (Province M221) as designated by McNab and Avers (1994), which includes parts of Georgia, North and South Carolina, Virginia, Maryland, Pennsylvania, and West Virginia. The area of this province is about 68,000 square miles and represents almost 2 percent of the total area of the United States. This area represents the largest contiguous, temperate hardwood forest in the world (Barrett 1995).

The Central Appalachian Broadleaf Forest is divided into four sections known as the Ridge and Valley, the Allegheny Mountains, the Northern Cumberland Mountains, and the Blue Ridge Mountains (McNab and Avers 1994). The affected environment addressed in this EIS is entirely within the Allegheny Mountains section (M221B). The potential natural vegetation of M221B is strongly influenced by elevation and aspect and includes northern hardwoods, red spruce, mixed mesophytic, and oak communities.

The FEF is part of the Allegheny Front Sideslopes (M221Ba10) land type association (LTA), which is the next level of ecological unit. LTAs are differentiated by landforms, natural overstory communities, and soil associations and often are thousands of acres in size. M221Ba10 represents over 99,000 acres on the Monongahela National Forest alone. This LTA contains some of the best examples of the highly productive mixed mesophytic vegetation type (DeMeo et al. 1995).

The ecological land type (ELT) is the next lower level of ecological unit (McNab and Avers 1994) and integrates landform, soils, and natural vegetative communities and often ranges from tens to hundreds of acres. The FEF encompasses 30 ELTs and most of these would be within the affected environment of the proposed action. The broad range of areas affected is due to experiments that are designed to measure the response of treatments across a range of ecological conditions. 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).

Before proceeding with a description of the forest vegetation it should be noted that vegetative communities rarely achieve stasis. The groups described here do not represent stable or climax communities. 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 yr B.P.), and the past disturbances – both natural and anthropogenic. Pollen analysis of sediment cores from Big Run Bog in Tucker County, West Virginia reveals dramatic changes in species composition from tundra-associated sedges and grasses (17,000 yr B.P. to 13,860 yr B.P.), to red spruce and balsam fir domination (13,860 yr B.P. to 10,500 yr B.P.), to a mixed conifer - northern hardwood forest (10,500 yr 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 on the 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 density and the accidental introduction of exotic pathogens (e.g., gypsy moth, Dutch elm disease, beech bark disease, chestnut blight, hemlock woolly adelgid, and potentially sudden oak death syndrome) 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. Replacing indigenous species with exotics represents a loss of ecosystem integrity. Timber harvesting also can influence species composition in different ways. In a recent study, 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, in this same study, it was also shown 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. Some regeneration 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 seed or sprout. Predicted climate change over the next century may also alter the geographical range of species distributions. Iverson et al. (1999) predict ongoing warming would shift species distributions to the north. For example, sugar maple, an important species in the central Appalachians today, would not be widely distributed in 50 to 100 years if warming trends continue. Thus, while it is feasible to make some generalizations regarding plant associations, it should not be construed that these groups are static and would remain as they are today if either the proposed action or the no action alternative is adopted.

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). Recognition of and concern for inadequate oak regeneration has been the prelude to several major conferences (Clark 1993). Much of the research reported at these meetings has been based on attempts at manipulating current stand conditions using silvicultural techniques. 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 protecting 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. Intermediate cuttings, such as thinnings, often accelerate the trend to more shade-tolerant species (Schuler and Gillespie 2000). Nevertheless, certain forest types are still widely recognized. Some of the characteristics of these commonly defined types follow.

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 is 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 exposures 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 great 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, for oak site $index_{50}$ 70 and 80, respectively (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. The studies described in the proposed action alternative do not incorporate any entire compartments of this productivity class; however, it does exist within some study areas on smaller scales. Even-aged regeneration methods in this forest type usually result in the continued dominance of yellow-poplar because of its capability for rapid height growth (Brashears et al. 2004).

Herbaceous Layer

There are two plant species listed as sensitive 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 on the sensitive species.

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 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, species of blackberry, Christmas fern and shield fern. Species composition could not be correlated with stand age or management history. The investigators found little difference between watersheds. Species diversity appeared to be predominantly related to physiographic properties of the individual watersheds. 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 panic-grass, white snakeroot and hog peanut. In contrast to the findings of Gilliam et al. (1995), running buffalo clover does seem to be correlated with management history. A complete list of species found on the FEF was completed by Madarish et al. (2002).

Running buffalo clover has a high affinity for calcium-rich soil, which is abundant in the eastern portion of FEF. It is most often found in locations underlain by limestone or other calcareous bedrock and research has shown that it does not 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 72, 5, 7, 9, 8, 13, 17, 16, 18, 20, and recently in 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 6,802 during the 2009 monitoring season (June – August), which was the greatest number recorded since monitoring began in 1994. Monitoring has recorded over 5,000 RBC rooted crowns since 2003 on the FEF . RBC is most commonly found on skid roads on the FEF and it has clearly been shown that the use of these skid roads for logging purposes diminishes the number of plants temporarily, but that population densities recover in about 3 to 5 years (Madarish and Schuler 2002). RBC may need periodic disturbances to persist in forested understory environments. 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). See Biological Assessment for further details.

Elsewhere in similar forest types, Ford et al. (2000b) found little difference among understory herbaceous communities of different ages in the southern Appalachian mountains of northern Georgia. In southern Indiana, aspect was the dominant factor determining ground layer species distributions when stands of different ages and management histories were evaluated (Jenkins and Parker 1999). 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 predisturbance 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. However, the role of invasive species may alter this functionality (Huebner 2006).

The effect of clearcutting on herbaceous composition has been the subject of some controversy (Duffy and Meier 1992, Johnson et al. 1993, Elliott and Loftis 1993). However, the importance of assessing the entire disturbance history, not just the forest management history, has been emphasized (Johnson et al. 1993). Jenkins and Parker (1998) found that stands that originated after subsistence agriculture were notably different from stands of a similar age that were not farmed or grazed.

Direct and Indirect Effects of Alternative B: Proposed Action

Silvicultural treatments which include some level of harvesting would be applied to about 547 acres. However, the actual area harvested using group selection and patch cutting is less than the compartment sizes. The adjusted total would be about 443 acres when the actual acres harvested using group selection and patch cutting is taken into consideration. The adjusted total is as follows: single-tree selection – 114.7 acres, diameter-limit – 94 acres, patch cuts (0.4 acres) – 11.7, financial maturity – 214.4 acres, and group selection – 7.8 acres. An 84.7-ac watershed would be treated with ammonium sulfate fertilizer to continue the ongoing atmospheric deposition study, and approximately 12 acres would be treated with lime and fertilizer in the long term soil productivity (LTSP) study. Prescribed fire would be applied to a maximum of 420 acres in all three studies using fire as a disturbance mechanism.

The silvicultural treatments in this alternative are not to be construed as optimal with respect to timber resources or the herbaceous layer. The purpose of the proposed actions is to conduct research that compares a range of silvicultural systems that are currently being utilized throughout the central Appalachian region. Indeed, research has shown that some uneven-aged regeneration systems, such as single-tree selection, tend to accelerate the dominance of more shade tolerant species and reduce diversity (Schuler and Gillespie 2000, Schuler 2004, Schuler and McGill 2007). However, clearcutting can also reduce diversity on high-quality sites when fast-growing species such as yellow-poplar eliminate or subordinate other species incapable of tolerating shade or sustaining rapid height growth (Brashears et al. 2004), but harvesting alone is not the major factor in composition change. Fire is considered by many to be a critical missing element of the contemporary forest disturbance regime (Brose et al. 2001, Hutchinson et al. 2008, Nowacki and Abrams 2008). Eastern forests, in the absence of fire, are increasingly dominated by shade-tolerant, fire-sensitive species. The role of fire in maintaining structural and compositional complexity is addressed in this alternative in three studies.

Other studies comparing changes in diversity of woody species related to silvicultural or management activities have documented significant changes with respect to treatment effects. In comparing diversity of plant species on two watersheds in New Hampshire ten years after perturbation, Gove et al. (1992) found that harvesting regime is a significant consideration. Similar results were reported 10 years after harvesting in northern Georgia (McMinn 1992). To assess changes over longer periods, others have compared species diversity in second-growth forests with old-growth forests or older second-growth forests on similar sites (Swindel and Grosenbaugh 1988, Gilliam et al. 1995). Studies of temporal changes in old-growth forests in the eastern United States have revealed a decline in many oak species with concomitant increases in sugar maple, red maple, or other shade tolerant species (Parker et al. 1985, Abrams and Downs 1990, Abrams and Nowacki 1992, Mikan et al. 1994). The decline of oak may portend other significant changes not yet fully understood.

Although uneven-age regeneration methods 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 and only possible when intensive management practices are utilized. The composition and growth rates of the newly established regeneration are of principal interest. Deviations from expected trends may represent the effect of changes in the biotic and abiotic factors influencing the forest environment.

Logging damage to residual trees would occur during various stages of the logging operation. This impacts residual trees directly. Skid trails and temporary haul roads are needed to access timber. Mitigation measures described in Chapter 2 would reduce these impacts. However, it is one of the goals of research proposed in this alternative to evaluate such effects over time with respect to different forest management practices. We expect some differences in residual stand quality with respect to silvicultural treatments.

Overstory removal that creates 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 do not expect this alternative to significantly influence the herbaceous community with respect to composition or diversity. The 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). Use of streamside management zones will further protect many sensitive plants.

Individual RBC plants would be crushed as a result of harvesting. However, the overall effects of the proposed action would benefit RBC because of its apparent requirement for periodic disturbance. In such cases as this, a determination of “may affect, is likely to adversely affect” is made. (See the Biological Assessment for details). However, it should be noted that although individual RBC plants would be destroyed following the adoption of this alternative, 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 during the next 20 years. The POE would be even less during the 5 year period considered in this EIS.

The prescribed fires proposed in this alternative would primarily effect smaller woody vegetation (less than 5 inches dbh). During the past 5 years on the FEF, prescribed fires have primarily reduced understory density of woody stems less than five inches in dbh.

Stem reduction of saplings (1 to 5 inches dbh) has been less consistent. Prescribed fire in all compartments 13, 21, 45, 48, and 49 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 during the past decade 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 our 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 comparing the burned and unburned plots from 2006 in compartment 49, the ratio of northern red oak to red maple was about 1 to 3 in the unburned area and about 4 to 1 in the burned area with about 20,000 northern red oak seedlings per hectare. These results are promising but are not expected to continue as many species overtop the newly established oak seedlings. In compartment 49, the post-shelterwood prescribed fire would be evaluated for its potential to release these oak seedlings from vigorous competition similar to work conducted in Virginia (Brose and Van Lear 1998).

In compartment 45, a similar effect is anticipated if the understory prescribed fires are continued. Reductions in overstory density from the use of past stem injection herbicides would promote the development of more understory stems. The resulting stand structure would be more open and have more standing dead snags. Such a structure may be more favorable for the endangered Indiana bat during the summer months for roosting and foraging. In recent research, northern myotis, an interior forest bat species, readily exploited alterations to forest structure created by the reintroduction of fire (Johnson et al. 2009). Bats used snags created by fire and herbicides for day roosts and temperatures in those roosts were higher than roost trees in areas not affected by prescribed fire treatments. It is not clear if structural changes associated with prescribed fire treatments will increase fitness among forest dwelling bats. However, structural changes brought about by prescribed fire are not anticipated to ameliorate bat population declines due to white nose syndrome, anticipated to arrive at the FEF during the assessment period of this EIS.

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, nitrogen saturation, negatively affect individual tree health, and reduce site productivity. Effects on site productivity on the FEF were recently evaluated and no evidence was found that the fertilization/acidification treatments have altered site productivity (Adams et al. 2006). In fact, 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).

Herbaceous-layer composition and plant species diversity were evaluated in watershed 3 and compared to several other watersheds. 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.

Cumulative Effects of Alternative B: Proposed Action

With respect to the herbaceous layer, populations of running buffalo clover (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. Only 13 small populations were known to exist when the first recovery plan was written. Currently, over 100 populations or elemental occurrences (EO) have been documented (Harman 1996). More than 30 populations have been tracked for more than 5 years. Recent PVA analysis in the revised recovery plan using the diffusion approximation approach predicted a very low probability of RBC extinction. The FEF population is one of the largest populations on record, although it is widely distributed over about 2,000 acres. Most of the FEF RBC plants are found in managed areas underlain by limestone parent material. This species is moving towards reclassification to threatened from endangered, in part due to the research and monitoring conducted on the FEF. Continued silvicultural manipulations proposed under this alternative would provide additional opportunities to evaluate how this species responds to disturbance.

Anecdotal evidence suggests periodic disturbance is necessary to maintain viable populations of RBC in mesic woodlands. This may result from the relief of competition from more invasive herbaceous species. As with many species, RBC appears to be disturbance-dependent in most forested ecosystems. 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.

Effects of Mitigation for Alternative B: Proposed Action

The effects of mitigation refer to the actions common to all studies delineated in Chapter 2 of this document and pertain to the effects on forest vegetation only.

By limiting logging operations from October through May, we are potentially increasing the percentage of yellow-poplar in even-aged regeneration systems. Season of logging, though not of critical importance, does have some effect on establishment and growth of yellow-poplar seedlings (Trimble and Tyron 1969). In West Virginia, Ohio, and Indiana, summer logging produced fewer seedlings than logging at other times of the year. Apparently, in summer-logged stands most of the seeds did not germinate until the following year, and these small seedlings were not able to compete as well with the vegetation that started the previous year. Nevertheless, harvesting in summer months usually has produced sufficient seedlings where a good seed source previously was present.

Butternut would benefit by not being removed by timber harvesting. However, 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 would usually not be removed from the FEF. This would benefit the abundance of hickory in the overstory relative to other species. However, hickories are short-lived relative to many sympatric species and in stands that are not cut, the ratio of hickory may decline. Perhaps more important for maintaining hickory in stands where it has been present historically, is to determine the means for achieving reliable natural regeneration protocols. This has not been a focus of past research, partially due to the relatively low commercial value of the species. However, the importance of hickory as a source of mast and as a roost tree for the endangered Indiana bat suggests an increased research focus is warranted.

The preferred logging systems would be chosen to minimize soil disturbance. With respect to forest vegetation, soil disturbance can be either positive or negative depending on the autecological characteristics of the species. RBC seems to benefit, at least indirectly from some measure of soil disturbance, perhaps because it inhibits the competing vegetation more than it does RBC. Also, because of its stoloniferous character, RBC may benefit from the scraping away of some vegetation because it becomes easier for its stolons to become rooted as they advance over the surface of the soil.

Using best management practices, closure of skid roads, reclaiming decks, and avoiding logging during wet periods minimizes 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 - photosynthesis). 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.

The streamside management zones are proposed to buffer and protect aquatic resources from sedimentation and increases in stream water temperature, among other issues. 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, which also include 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 with high monetary value hardwoods. 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. Streamside management zones would also protect certain sensitive plant species which are commonly found in riparian areas, by eliminating vehicular traffic in these areas. However, many of these species protecting stream channels today are shade intolerant species. They would be replaced by more shade tolerant species as the existing trees die or are blown down during storm events.

The proposed action includes the control of primarily two invasive species – Japanese stiltgrass and tree-of-heaven. Tree-of-heaven is not common on the FEF but can be found in a few locations. Stem injection of herbicide is most effective for control of larger woody stems of this species because it prevents sprouting from the roots and root collar. A control program using stem injection of herbicides would likely prevent tree-of-heaven from becoming a management problem on the FEF. All herbicides would be applied under the supervision of a Certified Public Applicator as sanctioned by the State of West Virginia or the USDA Forest Service. Glypro® Plus (EPA Reg. No. 62719-322) or similar glyphosate-based product would be used for the herbicide stem injection treatments using a 50 percent solution of concentrate and water. Stem injection would be accomplished using one incision per inch of diameter at breast height evenly spaced around the stem using 1.5 ml of solution per incision. Injections would not be made during periods of high sap flow (March, April, May) and will terminate before November. All handling and directions of the product (Glypro® Plus) label would be followed.

Japanese stiltgrass is present on much of the FEF, primarily along truck and skid roads, but is beginning to expand into other disturbed areas as well (Figure 3-8). 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 should be repeated until Japanese stiltgrass is largely controlled. To control Japanese stiltgrass in the seed bank, a pre-emergent herbicide would also be used. Applications would not occur more frequently than on an annual basis for the next five years. Some non-target species would likely be affected. However, this can be minimized by waiting until later in the growing season to apply the foliar herbicide. As with the stem injection treatments, Glypro® Plus or similar glyphosate-based product would be used as the foliar spray using a 2 percent solution of the product with water. Glypro® Plus contains a surfactant so none would be added. During application, the foliage would be completely wetted during a rain-free period. All directions on the product label would be strictly followed. Oust® would be used as the pre-emergent to treat dormant Japanese stiltgrass seed in the seed bank. This is necessary in situations where Japanese stiltgrass is present prior to logging activities to prevent the spread of viable seed from the roadside to the interior of the forest. All label instructions for forestry use would be strictly followed. It is recognized that use of a pre-emergent herbicide would also affect some native plants; however, it has been shown that when Japanese stiltgrass is left untreated, native forb cover and diversity decline significantly (Flory and Clay 2009). Hand pulling of weeds can be useful in some situations, but is impractical when Japanese stiltgrass is extensive and has already set seed as is the case on much of the FEF (Figure 3-8).

<u>Cumulative Effects of Alternative B: Proposed Action</u>

In 2008 and 2009, a natural gas well site and accompanying pipeline were developed on the FEF by means of the private mineral rights that underlie the federal surface ownership, requiring an area slightly less than 7.5 acres. All natural forest vegetation was removed from these areas, and mostly revegetated to grass where road access and well head infrastructure was not needed.

Such disturbances may provide opportunities for the spread of invasive species; Japanese stiltgrass has been noted in some locations along the pipeline, especially along the Fork Mountain Road near the southwestern boundary of the experimental forest. Additional disturbances from the proposed actions may facilitate the spread of Japanese stiltgrass.

Predicted climate change over the next century may alter the geographical range of tree species. Iverson et al. (1999) predict ongoing warming would shift species distributions to the north. For example, sugar maple, an important species in the central Appalachians today, would not be widely distributed in 50 to 100 years if warming trends continue. To the extent that experimental manipulations promote such species as sugar maple on the FEF, it is possible that the proposed actions would be exacerbating future forest health issues. Conversely, by reducing stocking through planned harvests and prescribed fires, the fitness of the manipulated stands to adapt to climate change may improve. Prescribed fire often favors oak species over northern hardwood species, which 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. Thus, the proposed action 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 that now exceed 60 years in length in some cases. 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.

Direct and Indirect Effects of Alternative A: No Action

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 these trees would invariably die and ultimately become dead standing trees and large woody debris 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. This would create opportunities for some shade intolerant species to persist. The percentage of oak would continue to decline.

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

RBC would persist for the time period considered within this EIS but may decline in some compartments where sunlight and competition form other species begins to displace RBC. RBC needs periodic (e.g., 10 to 15 years), moderate level ground and canopy disturbance to thrive and this alternative does not include any scheduled disturbances.

Cumulative Effects of Alternative A: No Action

The no action alternative does not change the overall landscape patterns from either the current conditions or from the action alternative. The percent of the canopy that is classified as open would not change materially at either the scale of the FEF or the larger scale assessed.

Manipulative research on the FEF regarding RBC would terminate. No other research entity is conducting such research on wild populations of RBC. Discontinuing this research would make it more difficult to achieve the goals of the RBC recovery plan. The Endangered Species Act is designed, in part, to prevent species from becoming imperiled and to recover species once they have. Success in these endeavors requires more than protection, it requires new knowledge. This alternative would not be consistent with the Endangered Species Act.

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).

Predicted climate change over the next century may alter the geographical range of species distributions. Iverson et al. (1999) predict ongoing warming would shift species distributions to the north. For example, sugar maple, an important species in the central Appalachians today, would not be widely distributed in 50 to 100 years if warming trends continue. Alternative A would allow the continual build up 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 novel disturbance regimes, such as those brought about by climate change, is one of the underlying principles of our long-term forest management studies that now exceed 60 years in length in some cases. Terminating these studies would make it more difficult for researchers and scientists to devise strategies to adapt to future climate change, and mitigate its impacts.

Effects of Mitigation for Alternative A: No Action

There are no mitigations to this alternative. Measurements of existing forest vegetation likely would continue. Trends from past disturbances would be evaluated.

3.10 Recreation Resources

Affected Environment

Tucker County is a noted outdoor recreation destination within the Allegheny Highlands. The FEF is used heavily for recreational purposes, i.e., hunting, fishing, hiking, and wildlife and scenic viewing. However, on the FEF deer hunting as well as bear hunting with and without dogs, and spring and fall wild turkey hunting are the most popular outdoor activities. In 2009, 2,030 white-tailed deer were harvested in Tucker County during bow, rifle, and muzzleloader seasons as well as 88 bears. Additionally a total of 99 wild turkey gobblers were taken during spring and fall turkey season in Tucker County. Because white-tailed deer populations in northeastern West Virginia are at or approaching "sociological" carry-capacity thresholds, the West Virginia Division of Natural Resources has liberalized bag limits to increase white-tailed deer harvest in the region. Squirrel hunting and ruffed grouse hunting also occur on the FEF. Fishing, primarily for brook trout, occurs along 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. Spectacular 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 fire hazard 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 Opportunity Area (OA), of which 1,069 ac are National Forest land. To the southwest, is the McGowan Mountain OA (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, and through the McGowan Mountain OA, ending at the Yellow Creek trail head, is gated April 15- August 15 to minimize disturbance to wildlife. When the road is open to the public, it is routinely accessed by hunters and campers, and for non-consumptive wildlife and scenic viewing.

The FEF also shares a common boundary with the 20,000-acre Otter Creek Wilderness Area, 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 rosebay 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 the turn of the century logging. On the FEF, there are 2 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 per year 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 states (Ohio, Maryland, Pennsylvania, Virginia and the District of Columbia). The trailhead parking areas at Big Springs Gap and Turkey Run often are near capacity during summer months, particularly on weekends.

Direct and Indirect Effects of Alternative B: 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 secured from 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.

Research logging has been conducted on the FEF since 1949, during which white-tailed deer, black bear and wild turkey numbers in Tucker County and on the FEF have either increased or remained constant. The number of recreational visitors (both hunting and fishing and scenic and wildlife viewing) has not decreased during the interim. 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 research logging occurs during the winter dormant season, when visitor numbers to the adjacent Otter Creek Wilderness Area are lowest, so impacts would be minimal. The number of visitors to Otter Creek using the FEF trailheads has not decreased during the last five years, so there is no evidence to suggest that research logging would have any direct or indirect effect on recreational resources in the Otter Creek Wilderness area.

Cumulative Effects of Alternative B: Proposed Action

The FEF is located within an area of 26,056 acres of the Monongahela National Forest, where no cutting or 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.

Direct and Indirect Effects of 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 immediately 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 that 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.

Cumulative Effects of 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, shad-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.

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 harvest opportunities. Similarly, abandonment of these skid roads also would prevent the access of many wildflower enthusiasts and birdwatchers to interior, off-road portions of the FEF.

3.11 Heritage Resources

The FEF has importance for heritage resources in several areas: prehistoric, historic, and as an experimental forest. Heritage resource surveys were conducted on the FEF during the spring of 2000, involving 4,615 acres. All sites found during surveys are confidential and specific locations will not be disclosed in this document.

Background Information

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 holdings of 7,123 acres were the first purchase unit of the Monongahela National Forest. The sale took place in November 1915. Within the area purchased was a 3,640 acre tract that became in 1934 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.

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.

Affected Environment

The FEF is located south of Parsons, West Virginia, and lies between the Black Fork and the Shaver's Fork, both forks of the Cheat River. The original FEF was limited to the watershed of Elklick Run and its tributaries. With the southwestern addition, a portion of the Shaver's Fork watershed was added. Elklick Run flows into the Black Fork across from the town of Hambleton. The Elklick watershed lies between Fork Mountain on the west, and McGowan Mountain on the south and east. The Elklick has eleven tributaries, and provides abundant water to the area. However, limestone on McGowan Mountain creates a karst area of sinkholes, with sinking and rising streams, which make parts of McGowan Mountain quite dry. This same limestone contains inclusions of chert used as a raw material by prehistoric peoples to make tools.

Flat ground on the Fernow 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.

Survey Methods

The FEF consists of a wide variety of landforms, ranging from steep slopes, to benches, saddles, and low-lying narrow flats. The model of site location probability and survey methodology agreed to between the Monongahela NF and the WV Division of Culture and History was used during this survey (Ruth Brinker, personal communication). High probability areas, consisting of relatively level areas close to water, as well as unique landforms and features such as rock shelters, were visually examined and shovel-probed. Medium probability areas, consisting of moderately steep slopes large upland benches, were visually examined. Low probability areas include steep slopes without overhangs. These areas were simply observed at a distance to locate roads, overhangs, or other disturbed areas that would indicate human use. Shovel probes are small holes dug with a standard shovel with contents screened through ¼ inch hardware cloth. Standard distance between probes is 20 meters, but when a probe is positive for cultural remains, the distance was reduced to 10 meters.

The archaeological survey work referenced here meets the requirements set forth in the Programmatic Agreement entered into between the West Virginia Division of Culture and History and the Monongahela National Forest, as well as all federal laws, regulations, and agency standards. The archaeological and historic resources of the FEF are under the stewardship of the Heritage Resources program on the MNF. Any future archaeological site protection, consisting of coordination during project implementation to ensure avoidance of unevaluated or eligible cultural resources, will be conducted by the MNF Heritage Resources program in cooperation with the FEF.

Results

A total of 25 sites were located by the survey. Fourteen of these are historic and eleven prehistoric. Eight sites have been evaluated as not eligible for the National Register of Historic Places; the remaining 17 have not been evaluated. The 14 historic sites include 5 culverts, 2 farmsteads, 2 lumber camps, 2 bridges, a quarry, a railroad, and a reservoir. All prehistoric sites are lithic concentrations or scatters.

All results of survey work on the FEF have been sent to the State Historic Preservation Office (SHPO), as have the Forest Service's findings of eligibility. The SHPO has concurred with these findings.

Those sites that have been found to be not eligible need no further consideration and effects to them do not have to be taken into consideration during project planning or implementation. Keeping with standard Forest Service practice, all unevaluated sites will be avoided during all project actions. The presence of sites within proposed timber compartments, and their National Register status and recommended management is shown in Table 3-9. The majority of compartments on the FEF do not contain historic or prehistoric sites.

Direct, Indirect, and Cumulative Effects of Alternative B: Proposed Action

Log skidding has the greatest potential to disturb prehistoric sites identified in the surveys. Skidding disturbs the ground surface and has the ability to undermine the integrity of archaeological and historic sites and therefore have adverse effects upon their research potential. No unevaluated sites are located within any of the compartments proposed for skidding (Table 3-9). Therefore there would be no direct effects to archaeological or historic sites as part of the proposed actions under Alternative B.

The potential for cumulative adverse impacts would be the same as that described for the no action alternative.

Direct, Indirect, and Cumulative Effects of Alternative A: No Action

Under this alternative, there would be no adverse impacts to identified heritage resource sites. All areas surveyed are located on or surrounded by National Forest lands. Future management actions on federal lands would require that these sites either be evaluated as to their National Register eligibility or avoided. Areas that have not been surveyed and have the potential for site disturbing activities in the future would also have to be surveyed in order to identify archaeological or historic resources prior to the beginning of project work. Since a majority of the land in the area is in federal ownership the probability of impacts from adjacent private land to these sites is extremely low. The potential for cumulative adverse effects is therefore not significant under Alternative A.

3.12 Economic Resources

Introduction

This investment analysis focuses on the financial and economic consequences of the action alternative since the no action alternative does not include quantifiable monetary costs or benefits. This analysis includes timber revenues anticipated to occur in each fiscal year from 2011 through 2015, annual costs of the watershed 3 acidification treatment, annual fertilizer costs for the long term soil productivity study (LTSP), prescribed fire costs for three different studies, annual log deck rehabilitation costs, and annual control of invasive species. Table 3-10 lists the estimated cash flows for each transaction and their discounted values. We used the standard discount rate of 4 percent for Forest Service projects to determine the present value of future costs and benefits. We also categorized costs and benefits by those that would be incurred by the federal government and those that would be incurred by an external partner. The intent of this analysis is to provide the Responsible Official with a review of the monetary costs and benefits of choosing between the proposed action and no action alternatives.

Timber values are based on bid prices for timber sold from the FEF in 2009 and anticipated volumes for the fiscal years in this analysis. Recent market values for timber are depressed due to the severe economic downturn of 2009. No attempt was made to inflate the future prices of timber that may occur in association with an economic recovery. Therefore, discounted values of future cash flows from timber revenue may be conservative.

We used Quick-Silver version 6.0 for financial and economic analysis. Quick-Silver is commonly used for resource management and capital improvement projects and has been in use since 1984 by government agencies, forestry consultants, and private industry to aid in decision making. Program inputs and outputs used in this analysis are on file at the Timber and Watershed Laboratory, Parsons, West Virginia.

Direct, Indirect, and Cumulative Effects of Alternative B: Proposed Action

This alternative harvests about 2.7 million board feet of timber using conventional logging systems.

The benefit/cost (B/C) ratio for this alternative is 14.47. The benefit/cost ratio is a commonly used investment metric which equals the sum of the discounted benefits divided by the sum of the discounted costs. The present values of the benefits and costs used in this calculation were $484,452 and $33,491, respectively. When the costs for the watershed 3 acidification were included, the benefit/cost ratio was reduced to 3.35. The estimated present value of the acidification treatments for the 5 year investment period is $111,296. These costs have been born by West Virginia University through a grant from the National Science Foundation in the recent past. The B/C cost ratio can be used in some cases to rank alternative projects for achieving similar outcomes. In this sense it does not inform the Responsible Official whether or not to choose the proposed action or the no action alternative because the outcomes are not similar. However, the B/C ratio also is used to determine how much costs could rise without making the project economically unattractive (i.e., when the ratio is less than 1). Since the benefit/cost ratios for both the Northern Research Station only and for all partners are greater than 1.0, it does inform the Responsible Official that both alternatives produce economic benefit.

The Final Environmental Impact Statement for the Forest Plan Revision of the Monongahela National Forest (USDA Forest Service 2006) provides an economic and social overview of the 10 counties within the National Forest proclamation boundary. In short, Tucker County has a small population (7,321 residents) coupled with a small economic base (3,911 full and part-time jobs) based on the most recent census data. In 2000, West Virginia ranked last among all states for median household income and Tucker County was below the statewide median. In Parsons, where the Timber and Watershed Laboratory is located, about 40 percent of the households have annual incomes less than $20,000 and about 85 percent have annual incomes less than $50,000. Employment is largely in the Services sector, but Government is the second largest contributor to the local economy.

Notwithstanding the small local economy, it is unlikely that either the proposed action or the no action alternative considered in this analysis would have a measurable effect on county-wide employment in the next five years. However, considering the extremely low income demographics of the region, any economic decisions with measurable economic benefits would be positive and help to sustain the local economy.

<u>Direct, Indirect, and Cumulative Effects of Alternative A: No Action</u>

There are no estimable monetary costs or revenues associated with implementing this alternative. Much of the long-term research pertaining to the effects of acidic deposition on forest ecosystems would be terminated. No timber revenues would be produced and no wood products would be transported, processed, or sold. No invasive plant control measures would be initiated. Fewer scientific, professional, and educational visitors would come to the FEF because the demonstration value of the long-term manipulative studies would decrease because the differences among treatments would be diminished. No prescribed fires would be conducted and this would reduce the number of firefighters visiting the local area. Recreational hunting opportunities would be reduced because dispersed early successional habitat, most often used by game species, would be diminished. As fewer visitors come to the FEF, impacts to the small local economy would be negative.

3.13 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 NFMA and scoping portions of this project and will have an opportunity to comment on the EIS. No minority or low income populations are expected to be impacted by implementation of any of the alternatives.

Tucker County's population consists of 15.9 percent low-income and 1.5 percent minority. West Virginia population consists of 17.4 percent low-income and 6.5 percent minority population (U.S. Census Bureau 2008). To qualify as an environmental justice community, the percent of low-income and minority population 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.

3.14 Research Program and Implications

Forestry research has been conducted at the FEF since 1933. Current silviculture and watershed research programs began in 1948 and have continued without interruption to date. Treatments over the years have included a wide variety of disturbances: even-aged, uneven-aged and two-aged management systems, fertilization, prescribed fire, herbicides, and liming. To accomplish research objectives, about 500,000 board feet (International ¼ inch rule) of timber has been harvested annually since 1949 from the FEF. Watershed research traditionally focused on the effects of forest management activities and implications for water resources. More recently, air pollution effects analyses have been added to watershed level studies and a larger wildlife component has been added to the silviculture research. Overall, there is a concerted focus on more process-oriented, ecosystem-level research. Federal, state and university scientists continue to broaden research areas to include aquatic ecology, avian ecology, amphibian ecology, small mammal ecology, and landscape ecology.

Research conducted on the FEF and by project staff has been used to develop best management practices for the State of West Virginia, and to provide input into management decisions of many land owners, including state, private and federal land owners. More than 1,040 publications have been produced and distributed nation- and world-wide describing FEF research activities and outcomes (Godwin et al. 1993, http://www.nrs.fs.fed.us/units/appalachian/pubs/). The FEF is also part of other national research and monitoring programs, including the Long-Term Soil Productivity Program, the National Atmospheric Deposition Program, the Clean Air Status and Trends Network, the Interagency Monitoring of Protected Visual Environments (IMPROVE) network, the EcoTrends network (http://www.ecotrends.info/EcoTrends/) and international networks such as the Global Terrestrial Observing System/Terrestrial Ecosystem Monitoring Sites network. Cooperators in the research program include numerous federal and state research agencies, colleges and universities, private land management companies, and not-for profit conservation groups. Existing long-term studies on the FEF are unique. Such studies are a valuable national resource, which could not be replicated within the span of several generations.

The FEF also functions as an outdoor classroom, hosting 1,000 or more visitors per year for educational programs ranging from a few hours to several days. These visitors range from elementary school children to university students to professional foresters, wildlife biologists and land managers to scientists from the United States and around the world. Programs use research areas of the FEF to demonstrate basic ecological principles, sound forest management, and basic nature study.

Research is also being conducted on the ecology of running buffalo clover and the Indiana bat, both federally listed species. This research will be an important part of the recovery plan for both species. No other such research on running buffalo clover is being conducted anywhere in the United States. The planned research activities would benefit running buffalo clover populations throughout its range, and are necessary for understanding how to restore this species. Moreover, Indiana bat research at the FEF addresses a subset of questions particular to populations within the Appalachian Mountains that are currently not addressed in the core of its distribution to the west in the lower Ohio Valley and mid-Mississippi Valley.

Direct and Indirect Effects of Alternative B: Proposed Action

The proposed action would continue important long-term research studies that are among the oldest forest experiments in eastern North America. Because trees are long-lived organisms, and because forests are complex ecosystems, the long-term, larger-scale research that is conducted on the FEF is critical to improving our understanding of forest ecosystems and to providing information for sound management decisions on both public and private lands. The proposed action would allow the continuation of existing long-term studies that evaluate productivity, log quality, species composition, and regeneration, as well as forest management effects on other biota or facets of the forest system. These studies are a valuable national resource, which could not be replicated in the span of two generations if suspended, even temporarily. The proposed action also would benefit and help restore running buffalo clover and Indiana bat populations.

The proposed action would have a positive effect on the research program of the FEF, and on forestry and ecological research in general.

Cumulative Effects of Alternatives B: Proposed Action

The research program would be strengthened through the continued treatment and monitoring of these long-term experiments, and FEF scientists would continue to provide research leadership regionally, nationally and internationally. Other new research by cooperators at academic institutions, government research facilities, and non-governmental conservation organizations would further enhance the research program and the knowledge that is produced. The FEF would continue to participate in experiments with scientists from other parts of the United States and from other counties.

Direct and Indirect Effects of Alternative A: No Action

The no action alternative would halt all manipulative research on the FEF, and effectively end several important long-term research studies. Monitoring of the vegetation, water flow and chemistry, atmosphere, and wildlife would continue, but the results would only be narrowly applicable and without the strength of full inference, lessening in importance over time. Important new research on effects of fire on hardwood ecosystems linked to Indiana bats would not be continued, and this important gap in our knowledge would not be addressed by the research program at the FEF.

Cumulative Effects of Alternative A: No Action

Important long-term research would be discontinued, and would no longer be a resource, and a catalyst for other research. Scientists in West Virginia and the central Appalachians would find their research opportunities curtailed as a result of the change in the research program of the FEF. This would impair the ability to develop sound land management guidelines for a variety of land owners, and would also slow the growth of ecological knowledge about this resource.

3.15 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 EIS.

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

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

The action alternative incorporates 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 proposed action. Mitigation measures can reduce adverse effects to water, riparian and aquatic resources significantly but may not eliminate them. 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 effects on two federally listed species may occur. 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, wildlife and its 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.

3.17 Relationship Between Short-term Uses of the Environment, and the Maintenance and Enhancement of Long-Term Productivity

The mission of the FEF is to explain the role of natural and human-induced factors in the sustainability of central Appalachian forest ecosystems and to provide management guidelines therein. Additionally, the productivity and diversity of the soil, water, and other forest resources must be protected. Many of the research activities have been ongoing since the 1950s, quantifying management practices on public and private land and environmental effects. These data are critical to future management in the central Appalachian region and beyond for the maintenance and enhancement of long-term productivity. The data and research collected would improve our understanding of ecosystem processes and lead to better management practices that protect natural resources.

3.18 Possible Conflicts Between the Proposed Action 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 Monongahela National Forest. The USDA Forest Service manages system roads and lands. Direction for its management is found in the 2006 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

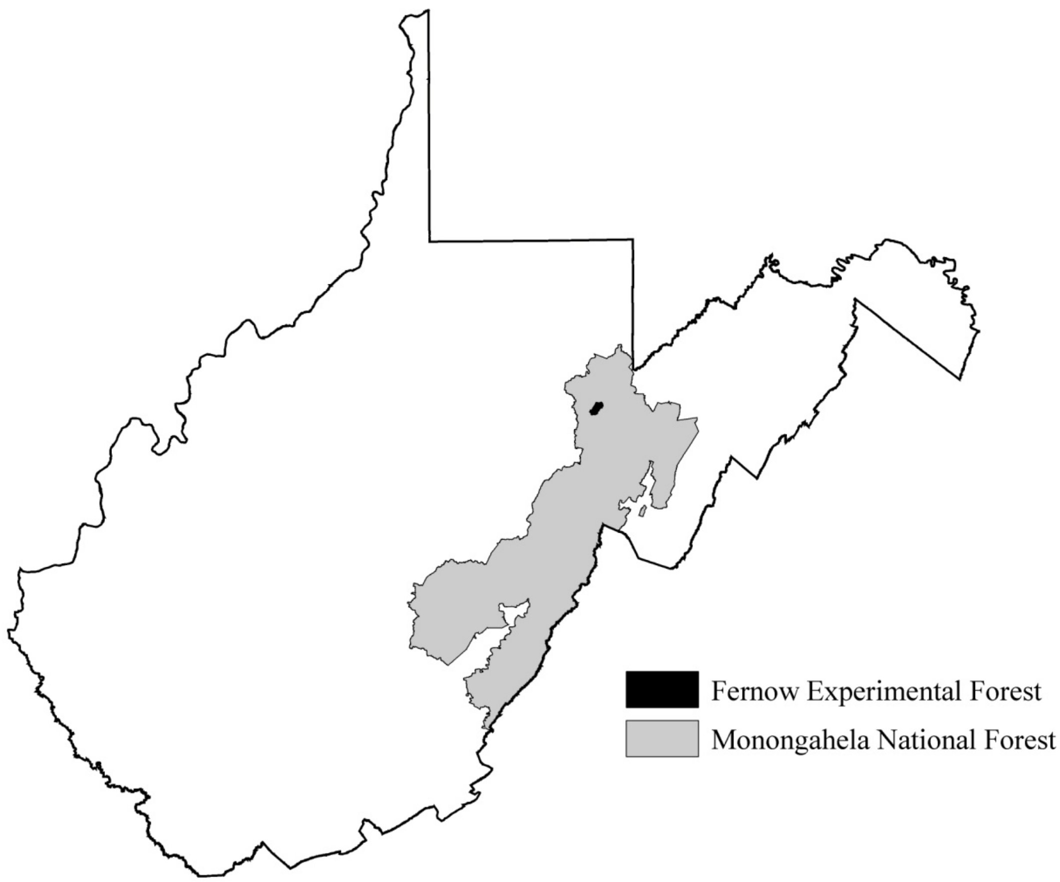

Figure 1-1. Map of West Virginia with locations of Monongahela National Forest and Fernow Experiment Forest.

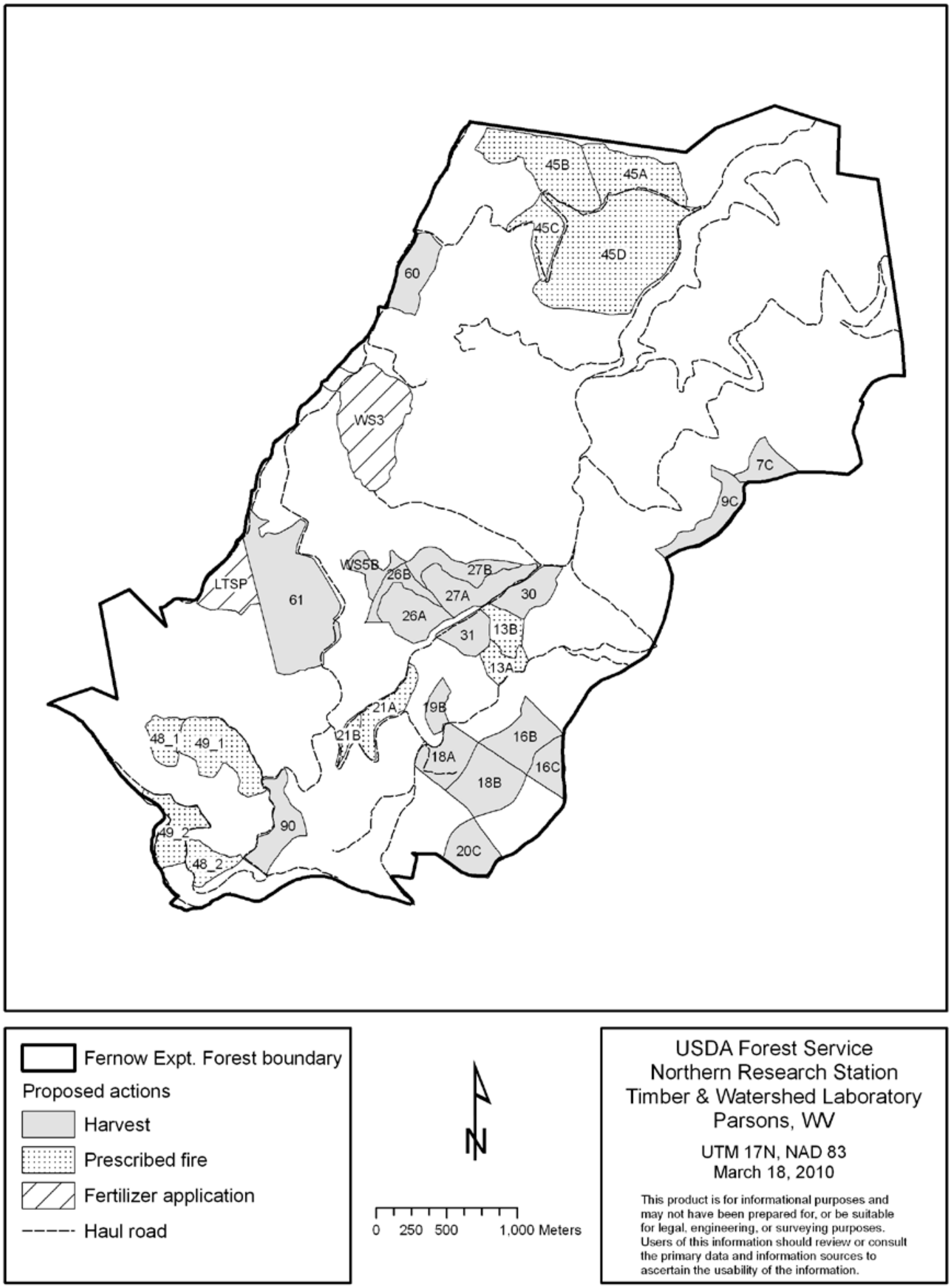

Figure 2-1. Fernow Experimental Forest, with locations of areas proposed for treatment. See text for details of treatments and compartment descriptions.

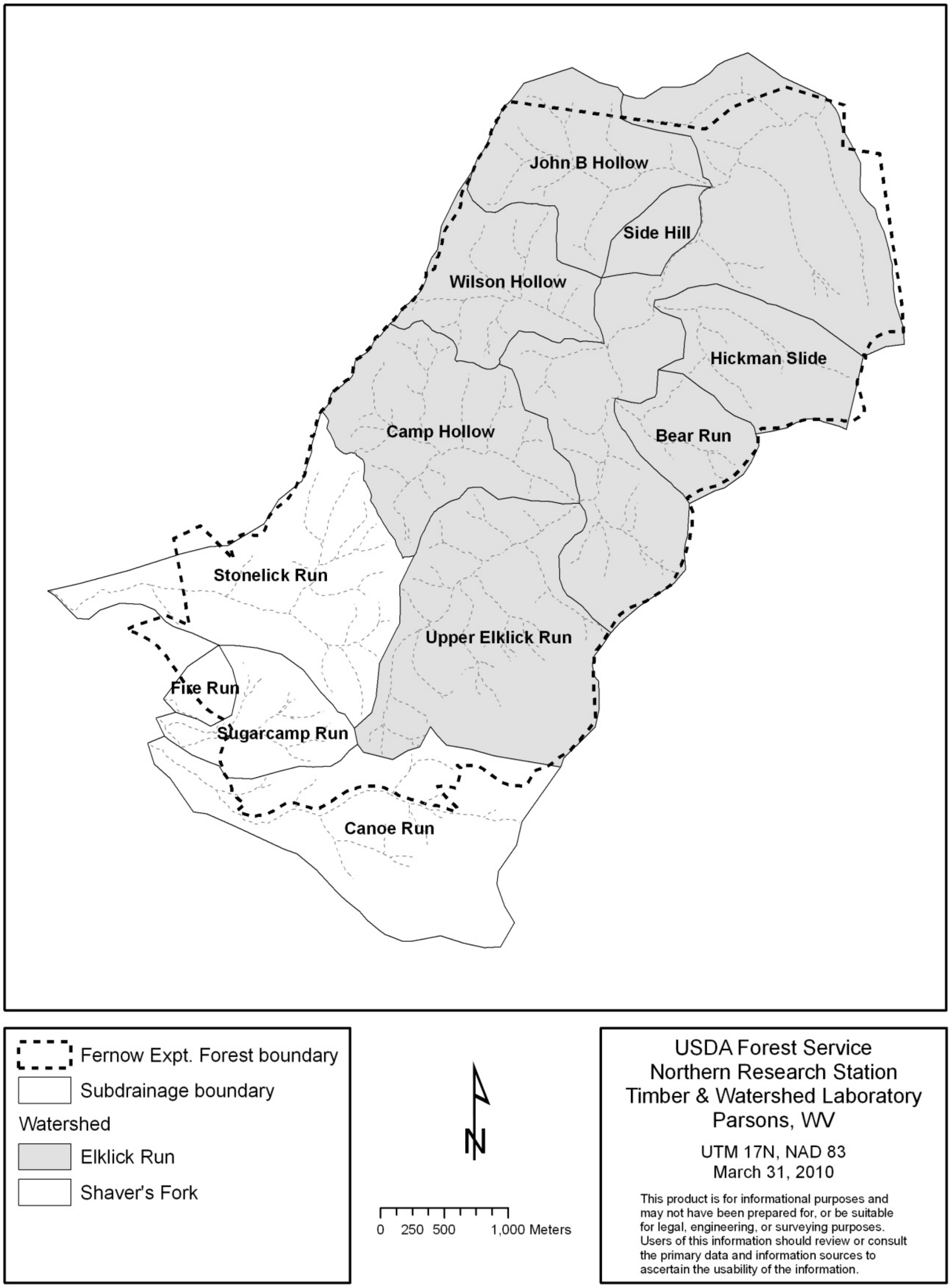

Figure 3-1. Watersheds and subdrainages of the Fernow Experimental Forest, as used in analyses in section 3.1. See text for details.

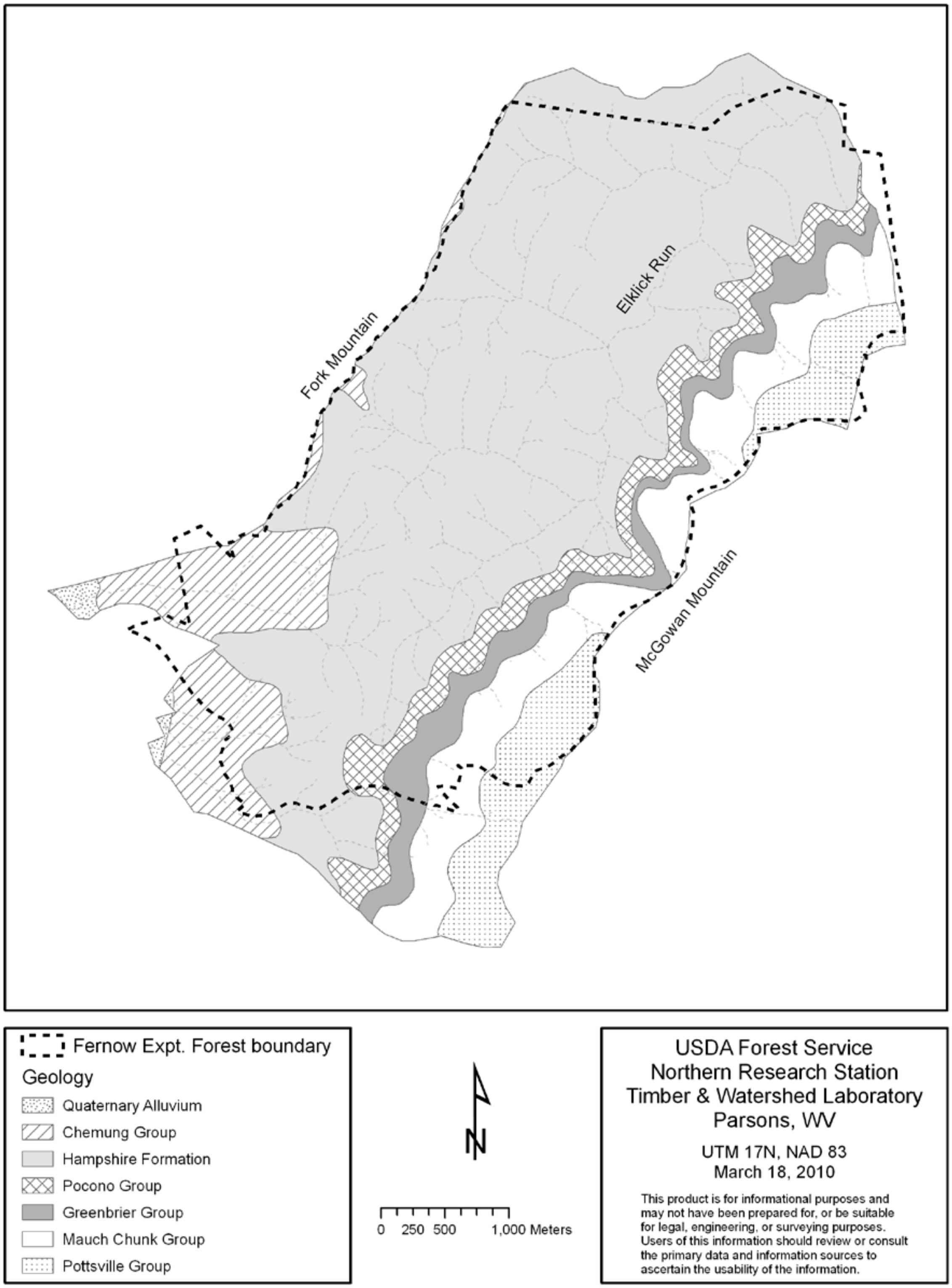

Figure 3-2. Geology underlying the subdrainages of the Fernow Experimental Forest as used in analyses in section 3.1. See text (Section 3.4) for descriptions.

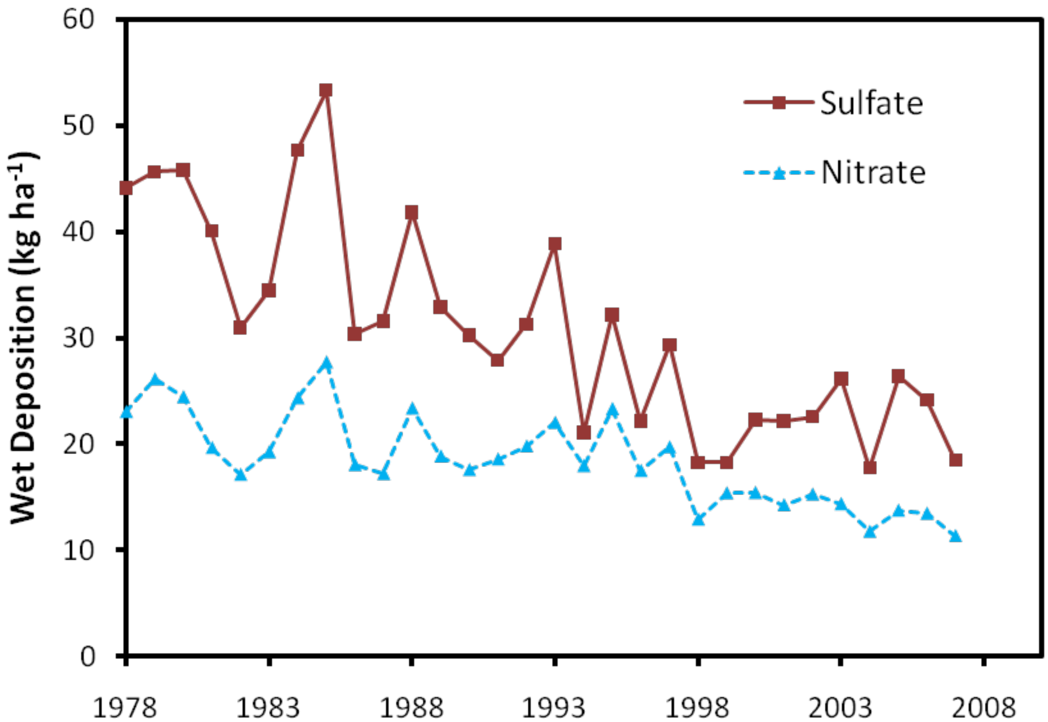

Figure 3-3. Total wet deposition at the Parsons WV NADP location.

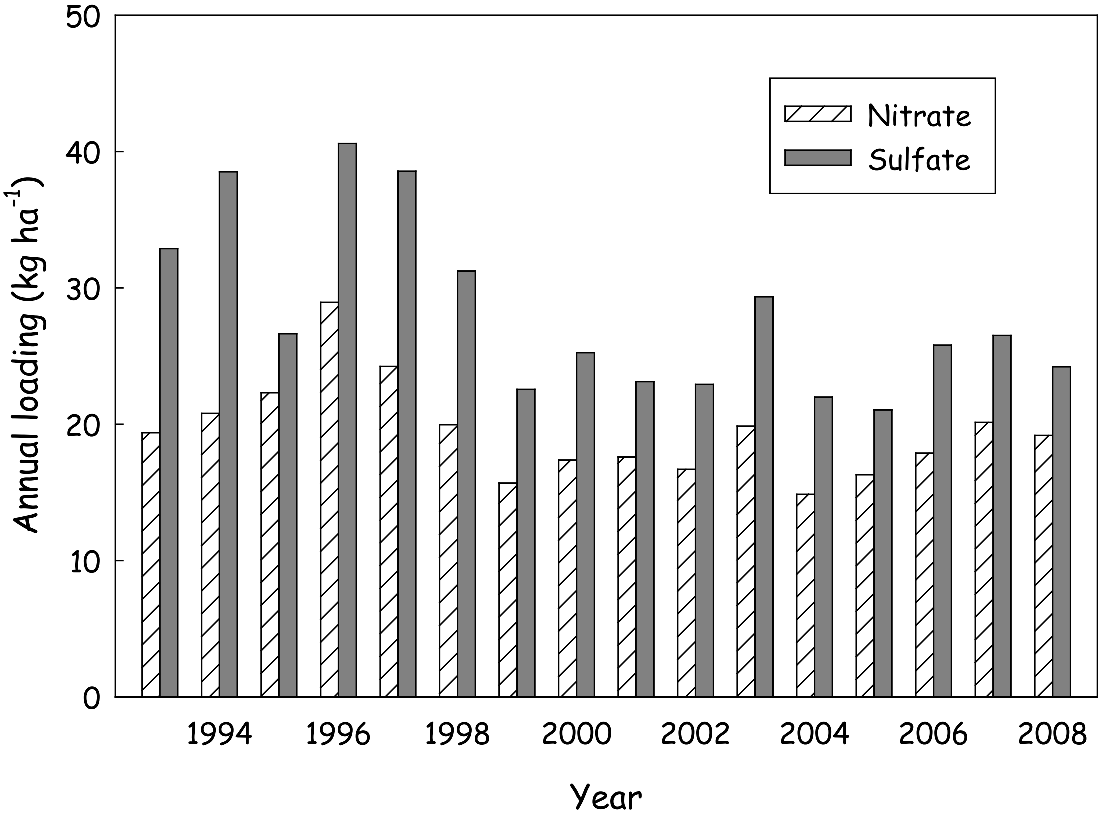

Figure 3-4. Bulk deposition for sulfate and nitrate at Bearden Knob.

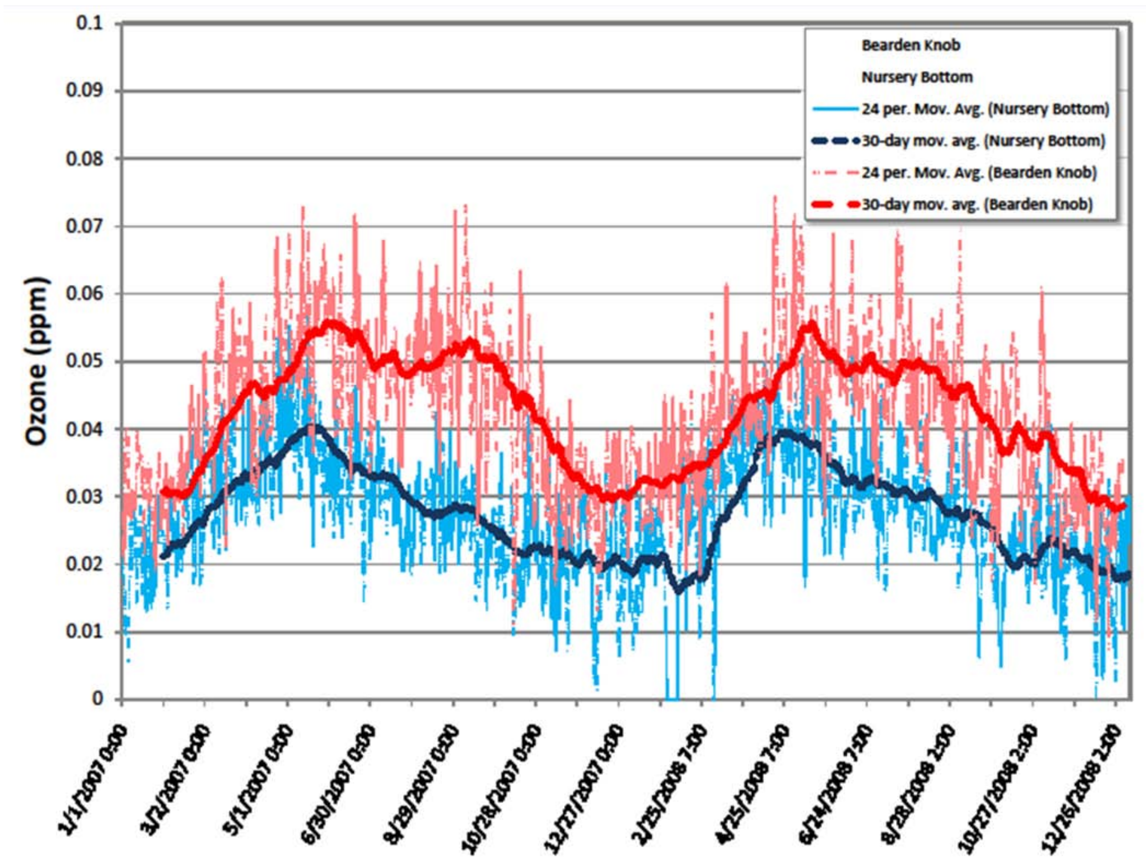

Figure 3-5. 2007 and 2008 hourly ozone data from Bearden Knob and the Nursery Bottom summarized with 24-hour and 30-day moving averages.

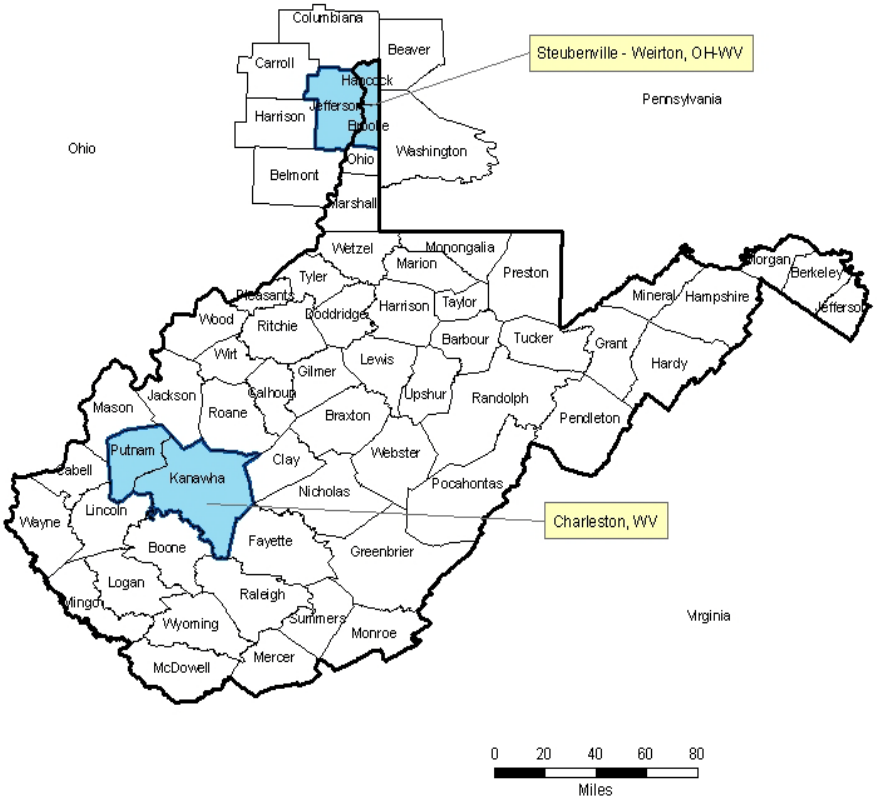

Figure 3-6. Map of West Virginia showing areas designated in nonattainment of the 2006 $PM_{2.5}$ standard.

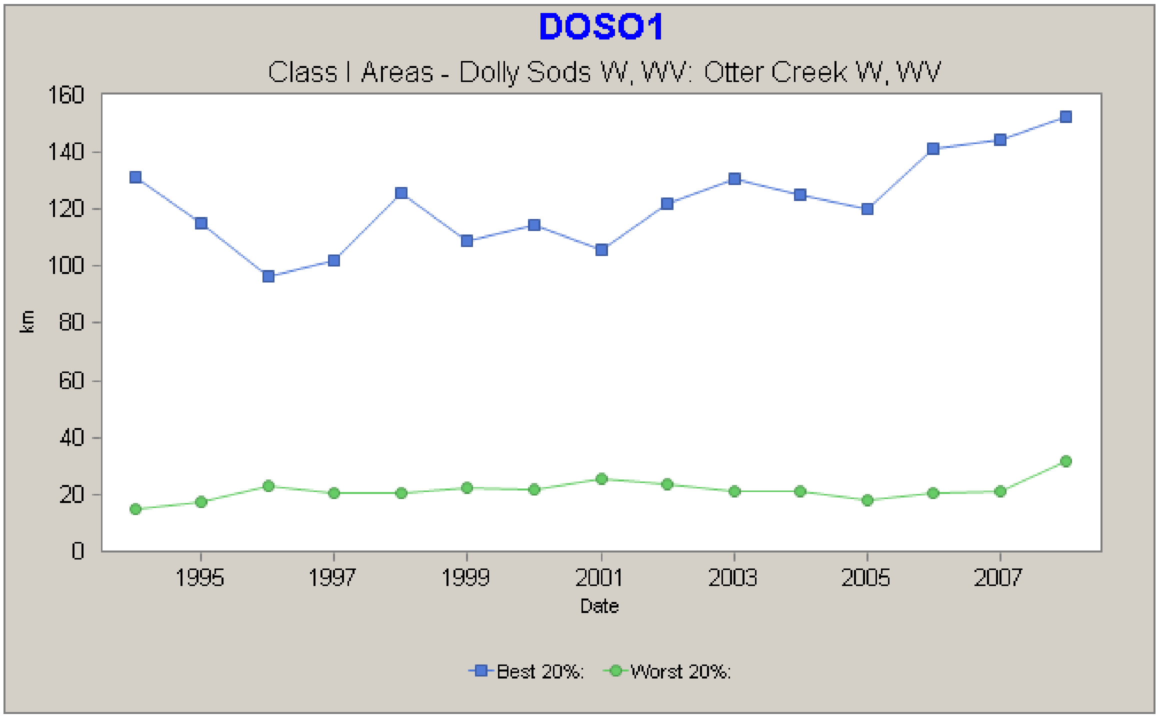

Figure 3-7. Visibility at the Bearden Knob IMPROVE monitoring site measured as Standard Visual Range (km). The top line represents the visibility on the best 20 percent days for visibility and the bottom line represents the 20 percent worst visibility days.

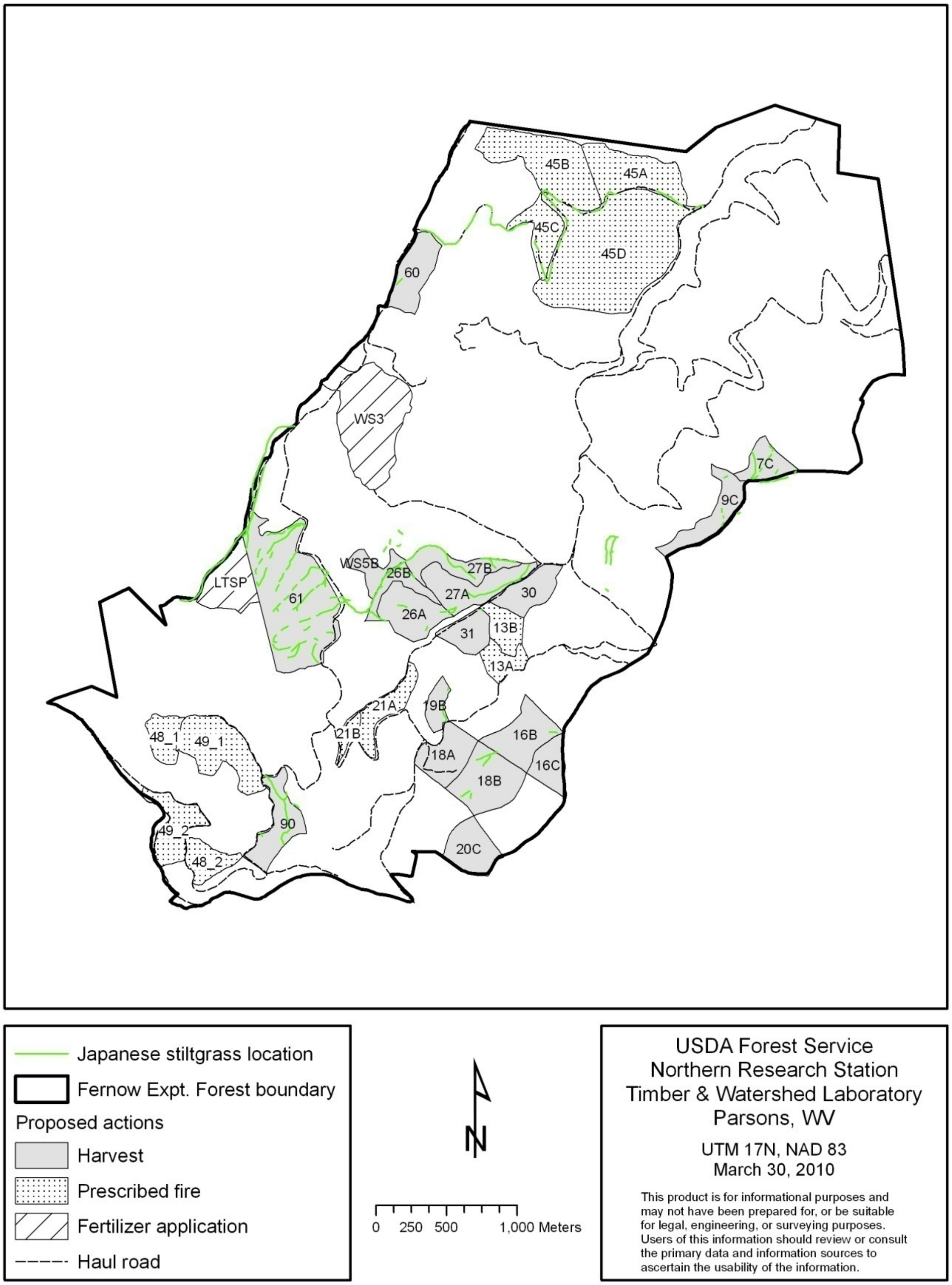

Figure 3-8. Japanese stiltgrass occurrence within the proposed action study areas of the Fernow Experimental Forest.

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

Subdrainage	Area	Ownership		Compartment			Treatment			
		Federal	Private	Name	Area	% Subdrainage	Type	Area	% Subdrainage	BA reduction
	(ac)	(%)	(%)		(ac)			(ac)		(%)
Side Hill	83.0	100.0	0.0	45	76.6	92.3	Prescribed fire, overstory mortality	76.6	92.3	10
				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, overstory mortality	224.4	56.7	10
				Other	171.1	43.3		--	--	
				Total	395.5	100.0		224.4	56.7	
Wilson Hollow	326.3	100.0	0.0	60	31.0	9.5	4% financial maturity	31.0	9.5	21
				Other	295.3	90.5		--	--	
				Total	326.3	100.0		31.0	9.5	
Camp Hollow	489.2	100.0	0.0	WS3	84.7	17.3	Fertilizer additions	84.7	17.3	0
				WS5B	11.8	2.4	Single-tree selection	11.8	2.4	34
				Other	392.7	80.3		--	--	
				Total	489.2	100.0		96.5	19.7	
Hickman Slide	294.5	100.0	0.0	7C	19.6	6.7	Single-tree selection	19.6	6.7	28
				Other	274.9	93.3		--	--	
				Total	294.5	100.0		19.6	6.7	
Bear Run	167.0	100.0	0.0	9C	31.9	19.1	Diameter-limit	31.9	19.1	43
				Other	135.1	80.9		--	--	
				Total	167.0	100.0		31.9	19.1	

Subdrainage	Area	Ownership		Compartment			Treatment			
		Federal	Private	Name	Area	% Subdrainage	Type	Area	% Subdrainage	BA reduction
	(ac)	(%)	(%)		(ac)			(ac)		(%)
Upper Elklick	736.1	100.0	0.0	13	31.3	4.3	Prescribed fire, overstory mortality	31.3	4.3	10
				16B	30.3	4.1	Single-tree selection	30.3	4.1	36
				16C	17.0	2.3	Single-tree selection	17.0	2.3	33
				18A	28.6	3.9	Patch clearcutting	4.0	0.5	26
				18B	41.6	5.7	Patch clearcutting	5.0	0.7	26
				19B	10.8	1.5	Single-tree selection	10.8	1.5	20
				20C	9.9	1.3	Diameter-limit	9.9	1.3	37
				21	30.9	4.2	Prescribed fire, overstory mortality	30.9	4.2	10
				26A	32.1	4.4	6% financial maturity	32.1	4.4	29
				26B	14.2	1.9	6% financial maturity	14.2	1.9	33
				27A	34.3	4.7	Diameter-limit	34.3	4.7	32
				27B	24.8	3.4	Single-tree selection	24.8	3.4	29
				30	23.0	3.1	Patch clearcutting	3.0	0.4	20
				31	18.8	2.6	3% financial maturity	18.8	2.6	17
				Other	388.5	52.8		--	--	
				Total	736.1	100.0		266.4	36.2	
Stonelick	617.8	87.9	12.1	61	118.4	19.2	3% financial maturity	118.4	19.2	18
				48	1.6	0.3	Prescribed fire	1.6	0.3	0
				49	8.8	1.4	Prescribed fire	5.0	0.8	0
				90	3.0	0.5	Group selection	0.8	0.1	34
				LTSP	16.0	2.6	Fertilizer, lime additions	12.0	1.9	0
				Other	470.0	76.1		--	--	
				Total	617.8	100.0		137.8	22.3	
Canoe	691.5	100.0	0.0	20C	17.8	2.6	Diameter-limit	17.8	2.6	37
				48	9.7	1.4	Prescribed fire	1.5	0.2	0
				90	5.0	0.7	Group selection	1.3	0.2	34
				Other	659.0	95.3		--	--	
				Total	691.5	100.0		20.6	3.0	
Sugarcamp	221.3	99.9	0.1	48	17.8	8.0	Prescribed fire	16.1	7.3	0
				49	65.8	29.7	Prescribed fire	33.0	14.9	0
				90	23.0	10.4	Group selection	5.8	2.6	34
				Other	114.7	51.8		--	--	
				Total	221.3	100.0		54.9	24.8	

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

Subdrainage and area (ac)	Compartment	Haul roads Length (mi)	Haul roads Area (ac)	Haul roads % Subdrainage	Skid roads Length (mi)	Skid roads Area (ac)	Skid roads % Subdrainage	Decks Area (ac)	Decks % Subdrainage	Total Area (ac)	Total % Subdrainage
Side Hill	45	0.00	0.00	0.00	2.34	3.69	4.44	0.00	0.00	3.69	4.44
83.0	Other	0.00	0.00	0.00	0.10	0.16	0.19	0.00	0.00	0.16	0.19
	Total	0.00	0.00	0.00	2.44	3.84	4.63	0.00	0.00	3.84	4.63
John B. Hollow	45	1.55	3.76	0.95	3.58	5.64	1.43	0.00	0.00	9.40	2.38
395.5	Other	0.96	2.33	0.59	1.43	2.25	0.57	0.00	0.00	4.58	1.16
	Total	2.51	6.08	1.54	5.01	7.89	2.00	0.00	0.00	13.98	3.53
Wilson Hollow	60	0.00	0.00	0.00	0.48	0.76	0.23	0.06	0.02	0.82	0.25
326.3	Other	2.27	5.50	1.69	2.28	3.59	1.10	0.00	0.00	9.10	2.79
	Total	2.27	5.50	1.69	2.76	4.35	1.33	0.06	0.02	9.91	3.04
Camp Hollow	WS3	0.14	0.34	0.07	2.20	3.47	0.71	0.00	0.00	3.81	0.78
489.2	WS5B	0.00	0.00	0.00	0.22	0.35	0.07	0.00	0.00	0.35	0.07
	Other	1.84	4.46	0.91	3.39	5.34	1.09	0.65	0.13	10.45	2.14
	Total	1.98	4.80	0.98	5.81	9.16	1.87	0.65	0.13	14.61	2.99
Hickman Slide	7C	0.00	0.00	0.00	0.50	0.79	0.27	0.00	0.00	0.79	0.27
294.5	Other	2.02	4.90	1.66	7.10	11.19	3.80	0.44	0.15	16.52	5.61
	Total	2.02	4.90	1.66	7.60	11.98	4.07	0.44	0.15	17.31	5.88
Bear Run	9C	0.00	0.00	0.00	0.76	1.20	0.72	0.00	0.00	1.20	0.72
167.0	Other	0.95	2.30	1.38	3.97	6.26	3.75	0.32	0.19	8.88	5.32
	Total	0.95	2.30	1.38	4.73	7.45	4.46	0.32	0.19	10.08	6.03

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	13	0.00	0.00	0.00	0.80	1.26	0.17	0.00	0.00	1.26	0.17
736.1	16B	0.00	0.00	0.00	0.69	1.09	0.15	0.00	0.00	1.09	0.15
	16C	0.00	0.00	0.00	0.48	0.76	0.10	0.00	0.00	0.76	0.10
	18A	0.41	0.99	0.14	0.33	0.52	0.07	0.00	0.00	1.51	0.21
	18B	0.00	0.00	0.00	1.14	1.80	0.24	0.13	0.02	1.93	0.26
	19B	0.00	0.00	0.00	0.36	0.57	0.08	0.00	0.00	0.57	0.08
	20C	0.00	0.00	0.00	0.31	0.49	0.07	0.00	0.00	0.49	0.07
	21	0.00	0.00	0.00	0.53	0.84	0.11	0.02	0.00	0.86	0.12
	26A	0.00	0.00	0.00	1.06	1.67	0.23	0.00	0.00	1.67	0.23
	26B	0.00	0.00	0.00	0.87	1.37	0.19	0.00	0.00	1.37	0.19
	27A	0.00	0.00	0.00	0.95	1.50	0.20	0.00	0.00	1.50	0.20
	27B	0.00	0.00	0.00	0.98	1.54	0.21	0.00	0.00	1.54	0.21
	30	0.00	0.00	0.00	0.44	0.69	0.09	0.33	0.04	1.02	0.14
	31	0.00	0.00	0.00	0.26	0.41	0.06	0.25	0.03	0.66	0.09
	Well	0.20	0.48	0.07	0.00	0.00	0.00	0.33	0.04	0.81	0.11
	Other	3.59	8.70	1.18	7.18	11.31	1.54	0.21	0.03	20.23	2.75
	Total	4.20	10.18	1.38	16.38	25.81	3.51	1.27	0.17	37.26	5.06
Stonelick	61	0.00	0.00	0.00	3.22	5.07	0.82	0.09	0.01	5.16	0.84
617.8	48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	49	0.00	0.00	0.00	0.14	0.22	0.04	0.07	0.01	0.29	0.05
	90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	LTSP	0.00	0.00	0.00	0.42	0.66	0.11	0.00	0.00	0.66	0.11
	Other	2.73	6.62	1.07	1.22	1.92	0.31	0.46	0.07	9.00	1.46
	Total	2.73	6.62	1.07	5.00	7.88	1.28	0.62	0.10	15.12	2.45

Subdrainage and area (ac)	Compartment	Haul roads Length (mi)	Haul roads Area (ac)	Haul roads % Subdrainage	Skid roads Length (mi)	Skid roads Area (ac)	Skid roads % Subdrainage	Decks Area (ac)	Decks % Subdrainage	Total Area (ac)	Total % Subdrainage
Canoe	20C	0.00	0.00	0.00	0.54	0.85	0.12	0.00	0.00	0.85	0.12
691.5	48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	90	0.00	0.00	0.00	0.06	0.09	0.01	0.00	0.00	0.09	0.01
	Other	2.01	4.87	0.70	0.94	1.48	0.21	0.00	0.00	6.35	0.92
	Total	2.01	4.87	0.70	1.54	2.43	0.35	0.00	0.00	7.30	1.06
Sugarcamp	48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
221.3	49	0.00	0.00	0.00	0.51	0.80	0.36	0.02	0.01	0.82	0.37
	90	0.00	0.00	0.00	0.54	0.85	0.38	0.00	0.00	0.85	0.38
	Other	1.37	3.32	1.50	0.03	0.05	0.02	0.07	0.03	3.44	1.55
	Total	1.37	3.32	1.50	1.08	1.70	0.77	0.09	0.04	5.11	2.31

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	97.0	0.80	35.2	2.09	58.1
	Other	0.04	3.0	1.47	64.8	1.51	41.9
	Total	1.33	100.0	2.27	100.0	3.60	100.0
Wilson Hollow	60	0.00	0.0	0.00	0.0	0.00	0.0
	Other	0.48	100.0	2.97	100.0	3.45	100.0
	Total	0.48	100.0	2.97	100.0	3.45	100.0
Camp Hollow	WS3	0.05	4.3	0.98	21.9	1.03	18.3
	WS5B	0.00	0.0	0.00	0.0	0.00	0.0
	Other	1.10	95.7	3.50	78.1	4.60	81.7
	Total	1.15	100.0	4.48	100.0	5.63	100.0
Hickman Slide	7C	0.00	0.0	0.00	0.0	0.00	0.0
	Other	0.87	100.0	1.39	100.0	2.26	100.0
	Total	0.87	100.0	1.39	100.0	2.26	100.0
Bear Run	9C	0.00	0.0	0.14	14.4	0.14	10.2
	Other	0.40	100.0	0.83	85.6	1.23	89.8
	Total	0.40	100.0	0.97	100.0	1.37	100.0
Upper Elklick	13	0.05	2.7	0.44	7.3	0.49	6.2
	16B	0.00	0.0	0.05	0.8	0.05	0.6
	16C	0.00	0.0	0.00	0.0	0.00	0.0
	18A	0.00	0.0	0.41	6.8	0.41	5.2
	18B	0.00	0.0	0.04	0.7	0.04	0.5
	19B	0.00	0.0	0.04	0.7	0.04	0.5
	20C	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
	26A	0.00	0.0	0.41	6.8	0.41	5.2
	26B	0.00	0.0	0.01	0.2	0.01	0.1
	27A	0.00	0.0	0.48	7.9	0.48	6.1
	27B	0.00	0.0	0.07	1.2	0.07	0.9
	30	0.31	16.7	0.02	0.3	0.33	4.2
	31	0.00	0.0	0.00	0.0	0.00	0.0
	Other	0.86	46.2	3.97	65.7	4.83	61.1
	Total	1.86	100.0	6.04	100.0	7.90	100.0
Stonelick	61	0.00	0.0	1.85	38.9	1.85	29.4
	48	0.00	0.0	0.00	0.0	0.00	0.0
	49	0.00	0.0	0.00	0.0	0.00	0.0
	90	0.00	0.0	0.00	0.0	0.00	0.0
	LTSP	0.00	0.0	0.23	4.8	0.23	3.7
	Other	1.53	100.0	2.68	56.3	4.21	66.9
	Total	1.53	100.0	4.76	100.0	6.29	100.0

Subdrainage	Compartment	Perennial		Nonperennial		Total	
		Length (mi)	% Subdrainage	Length (mi)	% Subdrainage	Length (mi)	% Subdrainage
Canoe	20C	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
	90	0.00	0.0	0.00	0.0	0.00	0.0
	Other	2.25	100.0	2.31	94.3	4.56	97.0
	Total	2.25	100.0	2.45	100.0	4.70	100.0
Sugarcamp	48	0.00	0.0	0.01	0.5	0.01	0.4
	49	0.17	26.2	0.22	10.4	0.39	14.1
	90	0.00	0.0	0.00	0.0	0.00	0.0
	Other	0.48	73.8	1.89	89.2	2.37	85.6
	Total	0.65	100.0	2.12	100.0	2.77	100.0

Table 3-4. Subdrainages of the Fernow Experimental Forest, geologic formations

Subdrainage	Compartment	Alluvium	Chemung	Hampshire	Pocono	Greenbrier	Mauch Chunk	Pottsville	Total
		---------- acres ----------							
Side Hill	45	0	0	76.6	0	0	0	0	76.6
	Other	0	0	6.4	0	0	0	0	6.4
	Total	0	0	83.0	0	0	0	0	83.0
John B. Hollow	45	0	0	224.4	0	0	0	0	224.4
	Other	0	1.4	169.7	0	0	0	0	171.1
	Total	0	1.4	394.1	0	0	0	0	395.5
Wilson Hollow	60	0	0.9	30.1	0	0	0	0	31.0
	Other	0	4.4	290.9	0	0	0	0	295.3
	Total	0	5.3	321.0	0	0	0	0	326.3
Camp Hollow	WS3	0	0	84.7	0	0	0	0	84.7
	WS5B	0	0	11.8	0	0	0	0	11.8
	Other	0	9.6	383.2	0	0	0	0	392.8
	Total	0	9.6	479.7	0	0	0	0	489.3
Hickman Slide	7C	0	0	0	0	0	0.3	19.3	19.6
	Other	0	0	47.9	40.2	33.4	75.1	78.3	274.9
	Total	0	0	47.9	40.2	33.4	75.4	97.6	294.5
Bear Run	9C	0	0	0	0	0.1	25.8	5.9	31.8
	Other	0	0	38.1	32.0	19.1	46.1	0	135.3
	Total	0	0	38.1	32.0	19.2	71.9	5.9	167.1

Subdrainage	Compartment	Alluvium	Chemung	Hampshire	Pocono	Greenbrier	Mauch Chunk	Pottsville	Total
		-----	-----	-----	----- acres -----	-----	-----	-----	-----
Upper Elklick	13	0	0	14.8	12.1	4.4	0	0	31.3
	16B	0	0	0	0	0	20.7	9.6	30.3
	16C	0	0	0	0	0	0	17.0	17.0
	18A	0	0	0	1.4	14.2	13.0	0	28.6
	18B	0	0	0	0	0	22.3	19.3	41.6
	19B	0	0	1.6	9.1	0.1	0	0	10.8
	20C	0	0	0	0	0	0.6	9.3	9.9
	21	0	0	30.9	0	0	0	0	30.9
	26A	0	0	32.1	0	0	0	0	32.1
	26B	0	0	14.2	0	0	0	0	14.2
	27A	0	0	34.3	0	0	0	0	34.3
	27B	0	0	24.8	0	0	0	0	24.8
	30	0	0	23.0	0	0	0	0	23.0
	31	0	0	18.8	0	0	0	0	18.8
	Other	0	0	144.7	69.7	57.8	60.1	56.2	388.5
	Total	0	0	339.2	92.3	76.5	116.7	111.4	736.1
Stonelick	61	0	11.9	106.5	0	0	0	0	118.4
	48	0	0	1.6	0	0	0	0	1.6
	49	0	0	8.8	0	0	0	0	8.8
	90	0	0	3.0	0	0	0	0	3.0
	LTSP	0	5.7	10.3	0	0	0	0	16.0
	Other	18.4	262.6	189.0	0	0	0	0	470.0
	Total	18.4	280.2	319.2	0	0	0	0	617.8
Canoe	20C	0	0	0	0	0	1.8	16.0	17.8
	48	0	0	9.7	0	0	0	0	9.7
	90	0	0	4.5	0.5	0	0	0	5.0
	Other	5.2	80.2	130.4	69.6	79.9	153.8	139.9	659.0
	Total	5.2	80.2	144.6	70.1	79.9	155.6	155.9	691.5
Sugarcamp	48	0	2.0	15.8	0	0	0	0	17.8
	49	0	27.6	38.2	0	0	0	0	65.8
	90	0	0	21.1	1.9	0	0	0	23.0
	Other	3.0	65.3	46.3	0.0	0	0	0	114.6
	Total	3.0	94.9	121.4	1.9	0	0	0	221.2

Table 3-5. Emissions estimated by the regional planning organization (VISTAS – Visibility Improvement State and Tribal Association of the Southeast)

County	2002 estimated emissions[1]						
	VOC	NO_X	CO	SO_2	PM_{10}	$PM_{2.5}$	NH_3
	tons						
Barbour	818	756	5,079	68	408	190	79
Grant	1,062	36,830	6,603	21,353	707	365	813
Pendleton	538	623	3,596	61	376	187	1,810
Preston	1,950	6,596	11,964	21,883	937	436	254
Randolph	2,081	2,622	11,394	187	432	277	137
Tucker	**654**	**589**	**3,349**	**124**	**497**	**408**	**29**
Garrett, MD	3,121	2,877	21,765	667	849	575	610

[1]VOC – volatile organic compounds, NO_X – nitrous oxides, CO – carbon monoxide, SO_2 – sulfur dioxide, PM_{10} – particulate matter < 10 microns in diameter, $PM_{2.5}$ – particulate matter < 2.5 microns in diameter, NH_3 – ammonia

Table 3-6. Comparison of emissions from proposed harvest activities with regional (Tucker and adjacent Counties) emissions

Average annual comparison	NO_X	VOC	PM_{10}
	tons yr^{-1}		
Total annual regional emissions	50,893	10,224	4,206
Total emissions from average annual timber harvest activities	0.39	0.45	0.02
	percent		
Harvest emissions as percent of total annual pollution load	0.0008	0.0044	0.0005

Table 3-7. Comparison of emissions from proposed prescribed burns to regional emissions

Comparison	NO_X	PM_{10}	$PM_{2.5}$
Total annual regional emissions (tons yr^{-1})	50,893	4,206	2,438
Total emissions from prescribed fires (tons)	4	50	43
Prescribed fire emissions as percent of total pollution load (percent)	0.008	1.2	1.8

Table 3-8. Current fragmentation of forest within five mile radius of Big Spring Cave

Landscape feature	100-foot edge width			325-foot edge width		
	(number)	(acres)	(percent)	(number)	(acres)	(percent)
patch	328	108.1	0.2	404	481.1	1.0
edge	132	2,473.5	4.9	32	5,839.7	11.6
perforation	119	337.4	0.7	80	1,871.6	3.7
small core (<250 ac)	236	1,037.5	2.1	64	775.6	1.5
medium core (250-500 ac)	3	1,194.0	2.4	2	682.8	1.4
large core (>500 ac)	19	39,866.4	79.3	20	35,364.7	70.4
total forested		45,016.9	89.6		45,015.6	89.6
total open		5,248.5	10.4		5,249.8	10.4
total area		50,265.4			50,265.4	

Table 3-9. Proposed project areas with archaeological sites present, eligibility status, and management recommendations

Area	Site	National Register eligibility	Recommended management action
7C	-	-	-
9C	-	-	-
13	-	-	-
16B	-	-	-
16C	-	-	-
18A	-	-	-
18B	-	-	-
18C	-	-	-
19B	-	-	-
20C	-	-	-
21	-	-	-
26A	-	-	-
27A	-	-	-
27B	-	-	-
30	-	-	-
31	-	-	-
45	-	-	-
48	01-333	Not eligible	No protection
49			
60	01-340	Not eligible	No protection
61	01-332	Not eligible	No protection
90	-	-	-
WS3	01-333	Not eligible	No protection
WS5B	01-340	Not eligible	No protection
LTSP			

Table 3-10. Costs and benefits used in the 2010 Fernow Experimental Forest economic analysis and their discounted present value based on a 4 percent discount rate (NRS and EXT denote Northern Research Station and unknown external partner, respectively)

Fiscal year	Description	Type	Value	Present value	Partner
2011	Timber sale	Benefit	$128,710	$119,000	NRS
2012	Timber sale	Benefit	$70,685	$62,839	NRS
2013	Timber sale	Benefit	$99,592	$85,131	NRS
2014	Timber sale	Benefit	$113,940	$93,650	NRS
2015	Timber sale	Benefit	$156,686	$123,831	NRS
2011	Log deck repair	Cost	$450	$432	NRS
2012	Log deck repair	Cost	$450	$416	NRS
2013	Log deck repair	Cost	$450	$401	NRS
2014	Log deck repair	Cost	$450	$385	NRS
2015	Log deck repair	Cost	$450	$370	NRS
2011	Fertilizer (LTSP)	Cost	$1,000	$962	NRS
2012	Fertilizer (LTSP)	Cost	$1,000	$925	NRS
2013	Fertilizer (LTSP)	Cost	$1,000	$889	NRS
2014	Fertilizer (LTSP)	Cost	$1,000	$855	NRS
2015	Fertilizer (LTSP)	Cost	$1,000	$822	NRS
2012	Rx fire (Oak-bats)	Cost	$24,255	$22,425	NRS
2013	Rx fire (Fire-gaps)	Cost	$1,294	$1,150	NRS
2013	Rx fire (Oak-shelterwood)	Cost	$2,891	$2,570	NRS
2011	Invasive species control	Cost	$200	$192	NRS
2012	Invasive species control	Cost	$200	$185	NRS
2013	Invasive species control	Cost	$200	$178	NRS
2014	Invasive species control	Cost	$200	$171	NRS
2015	Invasive species control	Cost	$200	$164	NRS
2011	WS 3 – acidification	Cost	$25,000	$24,038	EXT
2012	WS 3 – acidification	Cost	$25,000	$23,114	EXT
2013	WS 3 – acidification	Cost	$25,000	$22,225	EXT
2014	WS 3 – acidification	Cost	$25,000	$21,370	EXT
2015	WS 3 – acidification	Cost	$25,000	$20,548	EXT

List of Preparers

Mary Beth Adams, Research Soil Scientist, NRS
B.S.F. Forestry, Purdue University, 1980
M.S. Forestry, Purdue University, 1982
Ph.D. Soil Science and Forestry, North Carolina State University, 1986
21 years with the Forest Service

Pamela J. Edwards, Research Hydrologist, NRS
B.S. Forest Science, Penn State University, 1981
M.S. Forest Hydrology, Penn State University, 1983
Ph.D. Forest Soils, North Carolina State University, 1994
28 years with the Forest Service

Edward Huffman, Air Resources Management Specialist, Eastern Region
B.S. Forestry, Michigan Technological University, 1998
M.S. Watershed Science, Colorado State University, 2001
8 years with the Forest Service

Jane Rodrigue, Ecologist, NRS
B.S. Zoology, University of Georgia, 1988
M.S. Wildlife Biology, University of Georgia, 1994
3 years with Westvaco Corporation
2 years with Georgia Department of Wildlife Resources
9 years with the Forest Service

Thomas M. Schuler, Research Forester, NRS
B.S.F. Forest Management, Purdue University, 1979
M.S. Silviculture, Colorado State University, 1987
Ph.D. Forest Biology, Purdue University, 1998
23 years with the Forest Service

Melissa Thomas-Van Gundy, Research Forester, NRS
B.S. Pre-forestry, Davis and Elkins College, 1989
M.S. Resources Management, State University of New York, College of Environmental Science and Forestry, 1992
20 years with the Forest Service

Frederica Wood, Information Technology Specialist, NRS
B.S. Natural Resources, University of the South, 1981
M.F. Forestry, North Carolina State University, 1986
22 years with the Forest Service

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.

Airshed. A geographic area that, because of topography, meteorology, and/or climate, is frequently affected by the same air masses.

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 places 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** or **d.b.h.**). 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. In the diameter-limit treatment, all trees 17.0 inches dbh (diameter at breast height) 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). This type of harvest practice is commonly applied on non-industrial private forest lands in the Appalachians because it is easy to apply, and results in a significant immediate monetary gain.

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.

Financial rate of return management. Financial rate of return management is based on the silviculture-economic guidelines established by Trimble et al. (1974). These economic guidelines are in the form of rates of return for individual trees. Application of these marking guides is limited to saw timber-size trees (stems above 11.0 inches dbh.). Trees are designated for cutting or for leaving – with the intention of retaining a residual stand adequately stocked for attainment of specific objectives. Trees expected to exceed minimum acceptable rate of return – because of rapid growth or quality improvement – should be left to grow, while those expected to fall below the minimum acceptable rate are financially mature and should be harvested. Periods between cuts are based largely on growth rates.

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 clearcutting. The system of patch clearcutting was designed to replicate conditions needed for regeneration of shade-intolerant tree species, without creating large clearcuts. Each patch clearcut 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 a 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.

Sere. 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. 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. Defined in terms of total height of trees that consistently have been in a dominant position in well-stocked stands at specified age, usually 50 years. 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.

Stable air mass. An air mass that has little vertical mixing.

Stage. Stage is the measure of vertical distance between a fixed datum in a stream, such as a channel bottom, and the water surface.

Strip clearcutting. A regeneration method that uses narrow strips where all trees >1 inch dbh are removed. Each strip is 2 ½ chains (165 feet) wide. The amount of area cut at each cutting period is controlled by the size of the compartment area, cutting cycle, and length of rotation.

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.

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
RBC	Running buffalo clover
RWU	Research Work Unit
TES	Threatened, Endangered and Sensitive Species
WS	Watershed

Scientific and Common Names of Species

Scientific Name	Common Name
Arthropods:	
Adelges piceae	Balsam wooly adelgid
Cryptococcus fagisuga	Beech scale insect
Lymantria dispar	Gypsy moth
Other Invertebrates:	
Baylisascaris procyonis	Baylisascaris roundworm
Stygobromus emarginatus	Greenbrier cave isopod
Fish:	
Cottus bairdi	Mottled sculpin
Catostomus commersonii	White sucker
Onchorynchus mykiss	Rainbow trout
Salmo trutta	Brown trout
Salvelinus fontinalis	Brook trout
Amphibians:	
Aneides aenus	Green salamander
Cryptobranchus alleganiensis	Hellbender
Plethodon nettingi	Cheat mountain salamander
Reptiles:	
Crotalus horridus	Timber rattlesnake
Birds:	
Accipiter gentiles	Northern goshawk
Bonasa umbellus	Ruffed grouse
Bubo virginianus	Great horned owl
Contopus virens	Eastern wood pewee
Dendroica cerulea	Cerulean warbler
Dendroica pensylvanica	Chestnut-sided warbler
Dryocopus pileatus	Pileated woodpecker
Falco peregrinus anatum	Peregrine falcon
Haliaeetus leucocephalus	Bald eagle
Helmitheros verminvorus	Worm-eating warbler
Hylocichla mustelina	Wood thrush
Meleagris gallopavo	Wild turkey
Melospiza melodia	Song sparrow
Otus asio	Screech owl
Parus atricapillus	Black-capped chickadee
Passerina cyanea	Indigo bunting
Seiurus aurocapillus	Ovenbird

Scientific Name	Common Name
Spizella passerina	Chipping sparrow
Piranga olivacea	Scarlet tanager
Spizella pusilla	Field sparrow
Strix varia	Barred owl
Mammals:	
Canis lupus	Gray wolf
Corynorhinus townsendii virginianus	Virginia big-eared bat
Cryptotis parva	Least shrew
Felis concolor cougar	Eastern cougar
Felis domesticus	House cat
Felis rufus	Bobcat
Glaucomys sabrinus coloratus	Northern flying squirrel
Glaucomys sabrinus fuscus	Virginia northern flying squirrel
Glaucomys volans	Southern flying squirrel
Lasionycteris noctivagans	Silver-haired bats
Lasiurus anereus	Hoary bats
Lepus americanus	Snowshoe hare
Martes pennanti	Fisher
Mephitis mephitis	Striped skunk
Microtus chrotorrhinus carolinensis	Southern rock vole
Myotis leibii	Eastern small-footed myotis
Myotis septentrialis	Northern myotis
Myotis sodalis	Indiana bat
Neotoma magister	Allegheny woodrat
Odocoileus virginianus	White-tailed deer
Peromyscus polionotus	Oldfield mouse
Pipistrellis subflavus	Eastern pipestrelle
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

Scientific Name	Common Name
Ailanthus altissima	Tree-of-heaven
Amelanchier sanguinea	Serviceberry
Amphicarpaea bracteata	Hog peanut
Arabis serotina	Shale-barren rockcress
Betula alleghaniensis	Yellow birch
Betula lenta	Sweet birch
Bizzania spp.	Clubmoss
Carya cordiformis	Bitternut hickory
Carya glabra	Pignut hickory
Carya ovata	Shagbark hickory
Castanea dentata	American chestnut
Cornus canadensis	Bunchberry
Crataegus spp.	Hawthorn
Dryopteris goldiana	Shield fern
Eleagnus umbellata	Autumn olive
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
Lonicera spp.	Honeysuckle
Magnolia acuminata	Cucumbertree
Microstegium vimineum	Japanese stiltgrass
Ostrya virginiana	Eastern hophornbeam
Panicum spp.	Panicgrass
Picea abies	Norway spruce
Picea rubens	Red spruce
Pinus strobus	Eastern white pine
Pinus virginianus	Virginia pine
Polystichum acrostichoides	Christmas fern
Populus tremuloides	Aspen
Prunus pennsylvanica	Fire cherry
Prunus serotina	Black cherry
Psuedotsuga menzeisii	Douglas fir
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	Multi-flora rose
Rubus spp.	Blackberry

Scientific Name	Common Name
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 appalachiensis	Appalachian blue violet
Viola spp.	Violet
Vitis spp.	Wild grape

Literature Cited

Abrams, M.D., J.A. Downs. 1990. Successional replacement of old-growth white oak by mixed mesophytic hardwoods in southwestern Pennsylvania. Canadian Journal of Forest Research 20:1864-1870.

Abrams, M.D., G.J. Nowacki. 1992. Historical variation in oak recruitment, and post-logging accelerated succession in Pennsylvania. Bulletin of the Torrey Botanical Club 119:19-28.

Abrams, M.D., D.A. Orwig, T.E. DeMeo. 1995. Dendroecological analysis of successional dynamics for a presettlement-origin white pine-mixed oak forest in the southern Appalachians, USA. Journal of Ecology 83:133-143.

Adams, M.B. 1999. Acidic deposition and sustainable forest management in the central Appalachians. Forest Ecology and Management 122:17-28.

Adams, M.B. 2002. Prescribed fire effects on a nitrogen-saturated hardwood forest. In: United sciences: solutions for the global community, 2002 annual meetings. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America. (abstract)

Adams, M.B., T.R. Angradi. 1995. Decomposition and nutrient dynamics of hardwood leaf litter in the Fernow Whole-Watershed Acidification Experiment. Forest Ecology and Management 83:61-69.

Adams, M.B., J.A. Burger, A.B. Jenkins, L. Zelazny. 2000. Impact of harvesting and atmospheric pollution on nutrient depletion of eastern US hardwood forests. Forest Ecology and Management 138(2000):301-319.

Adams, M.B., J. Burger, L. Zelazny, J. Baumgras. 2004. Description of the Fork Mountain long-term soil productivity study: site characterization. Gen. Tech. Rep. NE-323. Newtown Square, PA: USDA Forest Service, Northeastern Research Station. 40 p.

Adams, M.B., D.R. DeWalle, J.L. Hom, eds. 2006. The Fernow Watershed Acidification Study. New York: Springer. 279 p.

Adams, M.B., P.J. Edwards, F. Wood, J.N. Kochenderfer. 1993. Artificial watershed acidification on the Fernow Experimental Forest, USA. Journal of Hydrology 150:505-519.

Adams, M.B., J.N. Kochenderfer, T.R. Angradi, P.J. Edwards. 1995. Nutrient budgets of two watersheds on the Fernow Experimental Forest. In: Gottschalk, K.W., S.L.C. Fosbroke, eds. Proceedings, 10th central hardwood forest conference. Gen. Tech. Rep. NE-197. Radnor, PA: USDA Forest Service, Northeastern Research Station:199-130.

Adams, M.B., J. Kochenderfer, P. Edwards. 2007. The Fernow watershed acidification study: ecosystem acidification, nitrogen saturation, and base cation leaching. Water, Air, and Soil Pollution: Focus 7:267-273.

Adams, M.B., J.N. Kochenderfer, F. Wood, T.R. Angradi, P. Edwards. 1994. Forty years of hydrometeorological data from the Fernow Experimental Forest, West Virginia. Gen. Tech. Rep. NE-184. Radnor, PA, USDA Forest Service, Northeastern Forest Experiment Station. 24 p.

Adams, M.B., T.M. Schuler, W.M. Ford, J.N. Kochenderfer. 2003. Large woody debris in a second-growth central Appalachian hardwood stand: volume, composition, and dynamics. In: Van Sambeek, J.W., J.O. Dawson, F. Ponder, Jr., E.F. Loewenstein, J.S. Fralish, eds. Proceedings, 13th central hardwood forest conference. Gen. Tech. Rep. NC-234. St. Paul, MN: USDA Forest Service, North Central Research Station:237-245.

Ahlgren, C.E. 1966. Small mammals and reforestation following prescribed burning. Journal of Forestry 64:614-618.

Albright, J.S. 1991. Storm hydrograph comparisons of subsurface pipe and stream channel discharge in a small forested watershed in northern California. M.S. thesis. Arcata, CA: Humboldt State University. 118 p.

Alila, Y., P.K. Kuraś, M. Schnorbus, R. Hudson. 2009. Forests and floods: a new paradigm sheds light on age-old controversies. Water Resources Research 45, W08416, doi:10.1029/2008WR007207. 24 p.

Ambuel, B., S.A. Temple. 1983. Area-dependent changes in bird communities and vegetation of southern Wisconsin forests. Ecology 64:159-171.

Angradi, T.R. 1996. Inter-habitat variation in benthic community structure, function, and organic matter storage in 3 Appalachian headwater streams. Journal of the North American Benthological Society 15(1):42-63.

Angradi, T.R. 1997. Hydrologic context and macroinvertebrate community response to floods in an Appalachian headwater stream. American Midland Naturalist 138:371-386.

Angradi, T.R. 1999. Fine sediment and macroinvertebrate assemblages in Appalachian streams: a field experiment with biomonitoring applications. Journal of the North American Benthological Society 18(1):49-66.

Angradi, T.R., R. Hood. 1998. An application of the plaster dissolution method for quantifying water velocity in the shallow hyporheic zone of an Appalachian stream system. Freshwater Biology 39:301-315.

Ash, A.N. 1988. Disappearance of salamanders from clearcut plots. Journal of the Elisha Mitchell Scientific Society 104:116-112.

Ash, A.N. 1995. Effects of clear-cutting on litter parameters in the southern Blue Ridge Mountains. Castanea 60:89-97.

Askins, R.A. 1993. Population trends in grassland, shrubland, and forest birds in eastern North America. Current Ornithology 7:1-34.

Atkeson, T.D., A.S. Johnson. 1979. Succession of small mammals on pine plantations in the Georgia Piedmont. American Midland Naturalist 101(2):385-392.

Aubertin, G.M., J.H. Patric. 1972. Quality water from clearcut forest land. The Northern Logger & Timber Processor 20(8):14-15, 22-23.

Auchmoody, L.R., H.C. Smith. 1977. Response of yellow-poplar and red oak to fertilization in West Virginia. Soil Science Society of America Journal 41:803-807.

Barrett, J.W. 1995. Regional Silviculture of the United States. New York: John Wiley and Sons.

Bartman, C.E. 1998. Migration of southern Appalachian salamanders from a shelterwood cut. M.S. thesis. Athens, GA: University of Georgia. 54 p.

Barton, D.R., W.D. Taylor, R.M. Biette. 1985. Dimensions of riparian buffer strips required to maintain trout habitat in southern Ontario streams. North American Journal of Fisheries Management 5:364-378.

Bates, N.S. 2000. Hydrological effects of forest harvesting on headwater watersheds in West Virginia. Senior thesis. Princeton, NJ: Princeton University. 122 p.

Bergelson, J., J.A. Newman, E.M. Floresroux. 1993. Rates of spread in spatially heterogeneous environments. Ecology 74(4):999-1011.

Bill, M.D. 2005. Channel morphology and substrate responses to high flows and road construction in forested mid-Appalachian watersheds. M.S. thesis. Forestry. Carbondale, IL: Southern Illinois University.

Bjornn, T.C., D.W. Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publication 19:83-138.

Blake, J.G., J.R. Karr. 1984. Species composition of bird communities and the conservation benefit of large versus small forests. Biological Conservation 30:173-187.

Bormann, F., G. Likens. 1979. Pattern And Processes in a Forested Ecosystem. New York: Springer-Verlag. 254 p.

Brashears, M.B., M.A. Fajvan, T.M. Schuler. 2004. An assessment of canopy stratification and tree species diversity following clearcutting in central Appalachian hardwoods. Forest Science 50(1):54-64.

Braun, E.L. 1950. Deciduous Forests of North America. New York: MacMillan Publishing Co. 596 p.

Brooks, A.B. 1911. Forestry and wood industries. In: West Virginia Geological and Economic Survey. Morgantown, WV: Acme Publishing Co.

Brose, P.H., K.W. Gottschalk, S.B. Horsley, P.D. Knopp, J.N. Kochenderfer, B.J. McGuinness, G.W. Miller, T.E. Ristau, S.H. Stoleson, S.L. Stout. 2008. Prescribing regeneration treatments for mixed-oak forests in the Mid-Atlantic region. Gen. Tech. Rep. NRS-33. Newtown Square, PA: USDA Forest Service, Northern Research Station. 100 p.

Brose, P., T. Schuler, D. Van Lear, J. Berst. 2001. Bringing fire back: the changing regimes of the Appalachian mixed-oak forests. Journal of Forestry 99(11):30-35.

Brose, P.H., D.H. Van Lear. 1998. Responses of hardwood advanced regeneration to seasonal prescribed fires in oak-dominated shelterwood stands. Canadian Journal of Forest Research 28:331-339.

Brown, G.W. 1962. Piping erosion in Colorado. Journal of Soil and Water Conservation 17:220-222.

Bryan, R.B. 1990. Knickpoint evolution in rillwash. In: Bryan, R.B., ed. Soil erosion: experiments and models. Catena supplement 17:111-132.

Buckelew, A.R., G.A. Hall. 1994. The West Virginia Breeding Bird Atlas. Pittsburgh, PA: University of Pittsburgh Press. 215 p.

Burton, T.A. 1997. Effects of basin-scale timber harvest on water yield and peak streamflow. Journal of the American Water Resources Association 33(6):1187-1196.

Burton, T.M., G.E. Likens. 1973. The effect of strip-cutting on stream temperatures in the Hubbard Brook Experimental Forest, New Hampshire. BioScience 23(7):433-435.

Campbell, T.A. 2003. Movement ecology of white tailed deer in the central Appalachians of West Virginia. Ph.D. dissertation. Athens, GA: University of Georgia. 162 p.

Campbell, T.A., B.R. Laseter, W.M. Ford, K.V. Miller. 2004. Movements of female white-tailed deer (*Odocoileus virginianus*) in relation to timber harvests in the central Appalachians. Forest Ecology and Management 199:371-378.

Castleberry, N.L. 2000a. Food habits of the Allegheny woodrat (*Neotoma magister*) in West Virginia and Virginia. M.S. thesis. Morgantown, WV: West Virginia University. 108 p.

Castleberry, S.B. 2000b. Habitat use and conservation genetics of the Allegheny woodrat (*Neotoma magister*) in managed and unmanaged forests of the central Appalachians. Ph.D. dissertation. Morgantown, WV: West Virginia University. 166 p.

Castleberry, S.B., P.B. Wood, W.M. Ford, N.L. Castleberry, M.T. Mengak. 2002. Summer microhabitat selection by foraging Allegheny woodrats (*Neotoma magister*) in a managed forest. American Midland Naturalist 147:93-101.

Cederholm, T.W., L.M. Reid. 1987. Impact of forest management on coho salmon (*Oncorhynchus kisutch*) populations of the Clearwater River, Washington: a project summary. In: Salo, E.O., T.W. Cundy, eds. Proceedings, Streamside management: forestry and fisheries interactions. Seattle, WA: University of Washington, Institute of Forest Resources:373-398.

Clark, F.B. 1993. An historical perspective of oak regeneration. In: Loftis, D., C.E. McGee, eds. Proceedings, Oak regeneration: serious problems, practical recommendations. Gen. Tech. Rep. SE-84. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station:3-13.

Confer, J.L., S.M. Pascoe. 2003. Avian communities on utility rights-of-ways and other managed shrublands in the northeastern United States. Forest Ecology and Management 185:193-205.

Conner, R.N., C.S. Adkisson. 1975. Effects of clearcutting on the diversity of breeding birds. Journal of Forestry 73:781-785.

Cordone, A.J., D.W. Kelly. 1961. The influences of inorganic sediment on the aquatic life of streams. California Fish and Game 47(2):189-228.

Costello, C.A., M. Yamasaki, P.J. Pekins, W.B Leak, C.D. Neefus. 2000. Songbird response to group selection harvests and clearcuts in a New Hampshire northern hardwood forest. Forest Ecology and Management 127:41-54.

Crawford, J.A., R.D. Semlitsch. 2008. Post-disturbance effects of even-aged timber harvest on stream salamanders in southern Appalachian forests. Animal Conservation 11(5):369-376.

Cromer, R.B., J.D. Lanham, H.H. Hanlin. 2002. Herpetofaunal response to gap and skidder-rut wetland creation in a southern bottomland hardwood forest. Forest Science 48(2):407-413.

Della-Bianca, L., F.M. Johnson. 1965. Effect of an intensive cleaning on deer-browse production in the southern Appalachians. Journal of Wildlife Management 29:729-733.

Dellinger, R.L., P.B. Wood, P.D. Keyser. 2003. Songbird abundance and nesting success on landscapes of differing harvesting intensities on an industrial forest. Abstracts of the 10th annual meeting of the Wildlife Society, Burlington, VT, number 104.

DeMeo, T., L. Tracy, L. Wright. 1995. Landtype associations of the Monongahela National Forest. 1:250,000; UTM map projection. USDA Forest Service, Monongahela National Forest.

DeMeo, T.E. 1999. Forest songbird abundance and viability at multiple scales on the Monongahela National Forest, West Virginia. Ph.D. dissertation. Morgantown, WV: West Virginia University. 159 p.

Dennis, B., P.L. Munholland, J.M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs 61:115-143.

DeWalle, D.R., P.J. Edwards, B.R. Swistock, R. Aravena, R.J. Drimmie. 1997. Seasonal isotope hydrology of three Appalachian forest catchments. Hydrological Processes 11:1895-1906.

DeWalle, D.R., J.N. Kochenderfer, M.B. Adams, G.W. Miller, F.S. Gilliam, F. Wood, S.S. Odenwald-Clemens, W.E. Sharpe. 2006. Chapter 5. vegetation and acidification. In: Adams, M.B., D.R. DeWalle, J.L. Hom, eds. The Fernow watershed acidification study. New York: Springer:137-188.

Dickinson, M.B., M.J. Lacki, D.R. Cox. 2009. Fire and the endangered Indiana bat. In: Proceedings of the 3rd fire in eastern oak forests conference. Gen. Tech. Rep. NRS-P-46. Newtown Square, PA: USDA Forest Service, Northern Research Station:51-75.

Dissmeyer, G.E. 1994. Evaluating the effectiveness of forestry best management practices in meeting water quality goals or standards. Misc. Publ. 1520. USDA Forest Service.

Dissmeyer, G.E., A. Stump. 1978. Predicted erosion rates for forest management activities in the Southeast. Unnumbered report. Atlanta, GA: USDA Forest Service, State & Private Forestry, Southeast Area. 27 p.

Dobony, C.A. 2000. Factors influencing ruffed grouse productivity and chick survival in West Virginia. M.S. thesis. Morgantown, WV: West Virginia University. 108 p.

Donovan, T.M., R.H. Lamberson, A. Kimber, F.R. Thompson, J. Faaborg. 1995. Modeling the effects of habitat fragmentation on source and sink demography of neotropical migrant birds. Conservation Biology 9(6):1396-1407.

Douglass, J.E., W.T. Swank. 1975. Effects of management practices on water quality and quantity, Coweeta Hydrologic Laboratory, Otto, NC. In: Proceedings, Municipal watershed management symposium. Gen. Tech. Rep. NE-13. Broomall, PA: USDA Forest Service, Northeastern Forest Experiment Station:1-13.

Duffy, D.C., A.J. Meier. 1992. Do Appalachian herbaceous understories ever recover from clearcutting? Conservation Biology 6(2):196-201.

Duguay, J.P., P.B. Wood, G.W. Miller. 2000. Effects of timber harvests on invertebrate biomass and avian nest success. Wildlife Society Bulletin 28(4):1-9.

Dunne, T., L.B. Leopold. 1978. Water in Environmental Planning. San Francisco, CA: W.H. Freeman and Co. 818 p.

Dury, G.H. 1969. Relation of morphology to runoff frequency. In: Chorley, R.J., ed. Water, earth, and man. London: Methuen:419-430.

Edgerton, B.R. 2008. Berry Energy pipeline construction, Elklick Run channel crossing. Unpublished report. Elkins, WV: USDA Forest Service, Monongahela National Forest.

Edwards, P.J. 2003. Forestry best management practices: where we’ve been, where we’re going. In: Proceedings, 2003 Penn State forest resources issues conference, forestry’s role in integrated water management. University Park, PA: Pennsylvania State University:26-33.

Edwards, P.J. 2008. Monitoring report for the Fernow gas well: surface erosion and in-stream turbidity results. Unpublished report. Parsons, WV: USDA Forest Service, Northern Research Station.

Edwards, P.J., G.E. Evans. 2004. Giving greater consideration to cross-drainage discharge from forest roads. In: Proceedings, Riparian ecosystems and buffers: multi-scale structure, function, and management, American Water Resources Association summer specialty conference. Herndon, VA: American Water Resources Association. 6 p. (CD-ROM)

Edwards, P.J., C.A. Troendle. In press. Water yield and hydrology. In: Audin, L.J., ed. (2008, October 6--last update). DRAFT Cumulative watershed effects of fuels management in the eastern United States. [Online]. Available: http://www.na.fs.fed.us/fire/cwe.shtm [2010 March 17].

Edwards, P.J., E.A. Watson. 2002. Converting a hardwood watershed to spruce: effects on channel morphology. In: American Water Resources Association 2002 annual water resources conference. Herndon, VA: American Water Resources Association:163. (abstract)

Edwards, P.J., F. Wood. 1994. Centroid lag time changes resulting from harvesting, herbiciding, and stand conversion. In: Marston, R.A., V.R. Hasfurther, eds. Proceedings, annual summer symposium of the American Water Resources Association, effects of human-induced changes on hydrological systems. Bethesda, MD: American Water Resources Association:727-734.

Edwards, P.J., D.L. Carnahan, Z. Henderson. 1999. Channel cross-section and substrate comparisons among four small watersheds with different land-disturbance histories. In: Olsen, D.S., J.P. Potyondy, eds. Proceedings, American Water Resources Association symposium specialty conference, wildland hydrology. Herndon, VA: American Water Resources Association:217-218. (abstract)

Edwards, P.J., C. Huber, F. Wood. 2004a. Ozone exposures and implications for vegetation in rural areas of the central Appalachian Mountains, USA. Environmental Monitoring and Assessment 98:157-174.

Edwards, P.J., J. Wang, J.T. Stedman. 2009. Recommendations for constructing forest stream crossings to control soil losses. In: Colosimo, M., ed. Proceedings, American Water Resources Association 2009 summer specialty conference, adaptive management of water resources II. Herndon, VA: American Water Resources Association. 6 p. (CD-ROM)

Edwards, P.J., K.W.J. Williard, J.N. Kochenderfer. 2004b. Sampling considerations for establishment of baseline loadings from forested watersheds for TDML applications. Environmental Monitoring and Assessment 98:201-223.

Edwards, P.J., F. Wood, J.N. Kochenderfer. 1991. Characterization of ozone during consecutive drought and wet years at a rural West Virginia site. Journal of the Air and Waste Management Association 41(11):1450-1453.

Edwards, P.J., F. Wood, J.N. Kochenderfer. 2002a. Baseflow and peakflow chemical responses to induced watershed acidification. Hydrological Processes 16:2287-2310.

Edwards, P.J., F. Wood, J.N. Kochenderfer, D.W. Coble, M.B. Adams. 2002b. Soil leachate responses during 10 years of induced whole-watershed acidification. Water, Air, and Soil Pollution 140:99-118.

Elder, K., L. Porth, and C.A. Troendle. 2006. The effect of timber harvest on the Fool Creek watershed after five decades. Eos Transactions of the American Geophysical Union 87(52), fall meet. suppl., abstract B21F-01.

Elliott, K.J., D.L. Loftis. 1993. Vegetation diversity after logging in the southern Appalachians. Conservation Biology 7:220-221.

Everest, F.H., R.D. Harr. 1982. Influence of forest and rangeland management on anadromous fish habitat in western North America: silvicultural treatments. Gen. Tech.

Rep. PNW-134. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 19 p.

Faaborg, J., M. Brittingham, T. Donovan, J. Blake. 1993. Habitat fragmentation in the temperate zone: a perspective for managers. In: Finch, D.M., P.W. Stangel, eds. Status and management of neotropical migratory birds. Gen. Tech. Rep. RM-229. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station:331-338.

Fansler, H.F. 1962. History of Tucker County West Virginia. Parsons, WV: McClain Printing Co. 737 p.

Faustini, J.M, P.R. Kaufmann, A.T. Herlihy. 2009. Downstream variation in bankfull width of wadeable streams across the conterminous United States. Geomorphology 108(2009):292-311.

Fei, S., K.C. Steiner. 2007. Evidence for increasing red maple abundance in the eastern United States. Forest Science 53(4):473-477.

Filipek, S.P. 1993. The impact of forest practices on warmwater and coldwater fisheries: similarities and differences. Fisheries Tech. Rep. FR-93-1. Little Rock, AR: Arkansas Game and Fish Commission.

Fisher, R.F., D. Binkley. 2000. Ecology and Management of Forest Soils. New York: John Wiley and Sons, Inc. 489 p.

Fletcher, J.E., K. Harris, H.B. Peterson, V.N. Chandler. 1954. Piping. Transactions of the American Geophysical Union 35(2):258-262.

Flory, S.L., K. Clay. 2009. Invasive plant removal method determines native plant community response. Journal of Applied Ecology 46:434-442.

Ford, W.M., J.L. Rodrigue. 2001. Soricid abundance in partial overstory removal harvests and riparian areas in an industrial forest landscape of the central Appalachians. Forest Ecology and Management 152:159-168.

Ford, W.M., B.R. Chapman, M.A. Menzel, R.H. Odom. 2000a. Stand-age and habitat influences on salamanders in Appalachian cove hardwood forests. Forest Ecology and Management 93:237-246.

Ford, W.M., C.A. Dobony, J.W. Edwards. 2002. Shrews in managed northern hardwood stands in the Allegheny Mountains of West Virginia. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Agencies 56:374-384.

Ford, W.M., A.S. Johnson, P.E. Hale, J.M. Wentworth. 1993. Availability and use of spring and summer woody browse by deer in cut and uncut forests of the southern Appalachians. Southern Journal of Applied Forestry 17:116-119.

Ford, W.M., J. Laerm, K.G. Barker. 1997. Soricid response to stand-age in cove hardwood communities in the southern Appalachians. Forest Ecology and Management 91:175-181.

Ford, W.M., D. Madarish, T.M. Schuler, S.B. Castleberry. 2003. Influence of white-tailed deer digestion on running buffalo clover (*Trifolium stoloniferum*: Fabaceae Muhl. ex A. Eaton) germination. American Midland Naturalist 142:425-428.

Ford, W.M., T.S. McCay, M.A. Menzel, W.D. Webster, C.H. Greenberg, J.F. Pagels, J.F. Merritt. 2006. Influence of elevation and forest type on community assemblage and species distribution of shrews in the central and southern Appalachian Mountains. In: Merritt, J.F., S. Churchfield, R. Hutterner, B.I. Sheftel, eds. Advances in the biology of shrews. Pittsburgh, PA: Carnegie Museum of Natural History:303-315.

Ford, W.M., M.A. Menzel, D.W. McGill, J. Laerm, T.S. McCay. 1999a. Effects of a community restoration fire on small mammals and herpetofauna in the southern Appalachians. Forest Ecology and Management 114:223-243.

Ford, W.M., M.A. Menzel, J.L. Rodrigue, J.M. Menzel, J.B. Johnson. 2005. Relating bat species presence to simple habitat measures in a Central Appalachian forest. Biological Conservation 126(4):528-539.

Ford, W.M., R.H. Odom, P.E. Hale, B.R Chapman. 2000b. Stand-age, stand characteristics, and landform effects on understory herbaceous communities in southern Appalachian cove-hardwoods. Biological Conservation 93:237-246.

Ford, W.M., S.L. Stephenson, J.M. Menzel, D.R. Black, J.W. Edwards. 2004. Habitat characteristics of the endangered Virginia northern flying squirrel (*Glaucomys sabrinus fuscus*) in the central Appalachian Mountains. American Midland Naturalist 152:430-438.

Ford, W.M., P.B. Wood, J.W. Edwards. 1999b. Mammalian and avian predator response to intensive forest management in the central Appalachians. Project proposal. USDA Forest Service, Northeastern Research Station. 3 p.

Forman, R.T.T., M. Gordon. 1986. Landscape Ecology. New York: John Wiley & Sons. 619 p.

Franklin, J.F., R.T.T. Forman. 1987. Creating landscape patterns by forest cutting: ecological consequences and principles. Landscape Ecology 1:5-18.

Freeman, R.E., E.H. Stanley, M.G. Turner. 2003. Analysis and conservation implications of landscape change in the Wisconsin River floodplain, USA. Ecological Applications 13(2):416-431.

Galone, D.G. 1989. Temporal trends in water quality, determined by time series and regression analysis from streams on undisturbed, cut and herbicide-treated watersheds in the Appalachian Mountains. M.S thesis. State College, PA: The Pennsylvania State University.

Gehring, J.L. 1997. Wildlife habitat quality in central Appalachian hardwood forests following three different timber harvest techniques. M.S. thesis. Morgantown, WV: West Virginia University. 113 p.

Giai, C., R.E.J. Boerner. 2007. Effects of ecological restoration on microbial activity, microbial functional diversity, and soil organic matter in mixed-oak forests of southern Ohio, USA. Applied Soil Ecology 35:281-290.

Gillespie, A.R., R. Rathfon, R.K. Myers. 1996. Rehabilitating a young northern red oak planting with tree shelters. Northern Journal of Applied Forestry 13:24-29.

Gilliam, F.S. 2007. The ecological significance of the herbaceous layer in temperate forest ecosystems. Bioscience 57:845-858.

Gilliam, F.S., M.B. Adams. 1996. Wetfall deposition and precipitation chemistry for a central Appalachian forest. Journal of the Air and Waste Management Association 46:978-984.

Gilliam, F.S., N.L. Turrill. 1993. Herbaceous layer cover and biomass in a young versus a mature stand of a central Appalachian hardwood forest. Bulletin of the Torrey Botanical Society 120(4):445-450.

Gilliam, F.S., M.B. Adams, B.M. Yurish. 1996. Ecosystem nutrient responses to chronic nitrogen inputs at Fernow Experimental Forest, West Virginia. Canadian Journal of Forest Research 26:196-205.

Gilliam, F.S., A.W. Hockenberry, M.B. Adams. 2006. Effects of atmospheric nitrogen deposition on the herbaceous layer of a central Appalachian forest. Journal of the Torrey Botanical Society 133(2):240-254.

Gilliam, F.S., N.L. Turrill, M.B. Adams. 1995. Herbaceous-layer and overstory species in clear-cut and mature Central Appalachian hardwood forests. Ecological Applications 5(4):947-955.

Gilliam, F.S., B.M. Yurish, M.B. Adams. 2001. Temporal and spatial variation of nitrogen transformations in nitrogen-saturated soils of a central Appalachian hardwood forest. Canadian Journal of Forest Research 31:1768-1785.

Godwin, M.L., F. Wood, M.B. Adams, M.C. Eye, comps. 1993. Annotated bibliography of research related to the Fernow Experimental Forest. Gen. Tech. Rep. NE-174. Radnor, PA: USDA Forest Service, Northeastern Forest Experiment Station. 131 p.

Gove, J.H., C.W. Martin, G.P. Datil, D.S. Solomon, J.W. Hornbeck. 1992. Plant species diversity in even-aged harvests at the Hubbard Brook Experimental Forest: 10-year results. Canadian Journal of Forest Research 22(11):1800-1806.

Greenberg, C.H., D.E. McLeod, D.L. Loftis. 1997. An old-growth definition for western and mixed mesophytic forests. Gen. Tech. Rep. SRS-16. Asheville, NC: USDA Forest Service, Southern Research Station. 16 p.

Groeschl, D.A., J.E. Johnson, D.W. Smith. 1990. Forest soil characteristics following wildfire in the Shenandoah National Park, Virginia. In: Nodvin, S.C., T.A. Waldrop, eds. Fire and environment: ecological and cultural perspectives. Gen. Tech. Rep. SE-69. USDA Forest Service, Southern Forest Experiment Station:129-137.

Hadley, G.L., K.R. Wilson. 2004a. Patterns of density and survival in small mammals in ski runs and adjacent forest patches. Journal of Wildlife Management 68:288-298.

Hadley, G.L., K.R. Wilson. 2004b. Patterns of small mammal density and survival following ski-run development. Journal of Mammalogy 85:97-104.

Hakala, J. 2000. Factors influencing brook trout (*Salvelinus fonfinalis*) abundance in forested headwater streams with emphasis on fine sediment. M.S. thesis. Morgantown, WV: West Virginia University. 166 p.

Hall, J.D., R.L. Lantz. 1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. In: Northcote, T.G., ed. Symposium on salmon and trout in streams. Vancouver, BC: University of British Columbia:355-375.

Hardt, R.A., W.T. Swank. 1997. A comparison of structural and compositional characteristics of southern Appalachian young second-growth, maturing second-growth, and old-growth stands. Natural Areas Journal 17:42-52.

Hardy, C.C., R.D. Ottmar, J.L. Peterson, J.E. Core, P. Seamon, eds. 2001. Smoke management guide for prescribed and wildland fire 2001 edition. PMS 420-2, NFES 1279. Boise, ID: National Wildfire Coordination Group. 226 p.

Harman, P.J. 1996. Running buffalo clover-conservation strategy. Unpublished document. Elkins, WV: West Virginia Division of Natural Resources, Natural Heritage Program. 27 p.

Harper, C.A., D.C. Guynn. 1999. Factors affecting salamander density and distribution within four forest types in the southern Appalachian Mountains. Forest Ecology and Management 114:245-252.

Harr, R.D., W.C. Harper, J.T. Krygier, F.S. Hsieh. 1975. Changes in storm hydrographs after road building and clear-cutting in the Oregon Coast Range. Water Resources Research 11(3):436-444.

Harr, R.D., F.M. McCorison. 1979. Initial effects of clearcut logging on size and timing of peak flows in a small watershed in western Oregon. Water Resources Research 15(1):90-94.

Harris, D.D. 1973. Hydrologic changes after clear-cut logging in a small Oregon coastal watershed. Journal of Research of the US Geological Survey 1:487-491.

Harris, L.D. 1984. The Fragmented Forest, Island Biogeography Theory and the Preservation of Biotic Diversity. Chicago, IL: University of Chicago Press. 211 p.

Hartman, K.J., M.K. Cox. 2001. Fish survey and trout habitat assessment for the Fernow Experimental Forest. Progress report to the USDA Forest Service, Northeastern Research Station. May 2001. 14 p.

Hartman, K.J., J.P. Hakala. 2006. Relationships between fine sediment and brook trout recruitment in forested headwater streams. Journal of Freshwater Ecology 21(2):215-230.

Healy, W.M. 1997. Thinning New England oak stands to enhance acorn production. Northern Journal of Applied Forestry 14(3):152-156.

Healy, W.M., R.T. Brooks. 1988. Small mammal abundance in northern hardwood stands in West Virginia. Journal of Wildlife Management 52:491-496.

Heede, B.H. 1971. Characteristics and processes of soil piping in gullies. Res. Pap. RM-68. Ft. Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 15 p.

Henneman, C., D.E. Andersen. 2008. Occupancy models of nesting-season habitat associations of red-shouldered hawks in Central Minnesota. Journal of Wildlife Management 73(8):1316-1324.

Henson, M.B. 1994. Estimating the bankfull event in small watersheds of the southern Appalachian mountains. M.S. thesis. Clemson, SC: Clemson University.

Hewlett, J.D. 1982. Forests and floods in the light of recent investigation. In: Canadian hydrology symposium: 82. Associate committee on hydrology. Ottawa, Ontario: National Research Council of Canada:543-559.

Hewlett, J.D., J.D. Helvey. 1970. Effects of forest clearfalling on the storm hydrograph. Water Resources Research 6(3):768-782.

Hewlett, J.D., R.A. Hibbert. 1967. Factors affecting the response of small watersheds to precipitation in humid areas. In: Sopper, W., H.W. Lull, eds. Proceedings, forest hydrology. Oxford: Pergamon Press:275-290.

Hornbeck, J.W. 1973. Storm flow from hardwood-forested and cleared watersheds in New Hampshire. Water Resources Research 9:346-354.

Hornbeck, J.W., J.N. Kochenderfer. 2001. A century of lessons about water resources in northeastern forests. In: A monumental event: proceedings, Society of American Foresters 2000 national convention. Bethesda, MD: Society of American Foresters:31-37.

Hornbeck, J.W., M.B. Adams, E.S. Corbett, E.S. Verry, J.A. Lynch. 1993. Long-term impacts of forest treatments on water yield; a summary for northeastern USA. Journal of Hydrology 150:323-344.

Huebner, C.D. 2006. Fire and invasive plant species in eastern oak communities: an assessment of current knowledge. In: Dickinson, M.B., ed. Fire in eastern oak forests: delivering science to land managers, proceedings of a conference. Gen. Tech. Rep. NRS-P-1. Newtown Square, PA: USDA Forest Service, Northern Research Station:218-232.

Hutchinson, T.F., R.P. Long, R.D. Ford, E.K. Sutherland. 2008. Fire history and the establishment of oaks and maples in second-growth forests. Canadian Journal of Forest Research 38(5):1184-1198.

Iverson, L.R., A.M. Prasad, B.J. Hale, E.K. Sutherland. 1999. Atlas of current and potential future distributions of common trees of the eastern United States. Gen. Tech. Rep. NE-265. Radnor, PA: USDA Forest Service, Northeastern Research Station. 245 p.

Jackson, W.A., L. Arbucci. 1989. Ozone symptoms were present on bioindicator plants at the Otter Creek Wilderness and Dolly Sods Wilderness, Monongahela National Forest, 1989. Unpublished report. Morgantown, WV: USDA Forest Service, Forest Pest Management.

Jacobson, R.B., J.P. McGeehin, E.D. Cron, C.E. Carr, J.M. Harper, A.D. Howard. 1993. Landslides triggered by the storm of November 3-5, 1985, Wills Mountain Anticline, West Virginia and Virginia. Bulletin 1981. Reston, VA: U.S. Geological Survey:c1-c33.

Jenkins, M.A., G.R. Parker. 1998. Composition and diversity of woody vegetation in silvicultural openings of southern Indiana forests. Forest Ecology and Management 109(1):57-74.

Jenkins, M.A., G.R. Parker. 1999. Composition and diversity of ground layer vegetation in silvicultural openings of southern Indiana forests. American Midland Naturalist 142(1):1-16.

Johnson, A.N. 2002. Determining the genetic distances between sub-populations of *Aneides aeneus* in the Westvaco Wildlife and Ecosystem Research Forest. M.S. thesis. Huntington, WV: Marshall University. 62 p.

Johnson, A.S., W.M. Ford, P.E Hale. 1993. The effects of clearcutting on herbaceous understories are still not fully known. Conservation Biology 7:433-435.

Johnson, A.S., P.E. Hale, W.M. Ford, J.M. Wentworth, J.R. French, O.F. Anderson, G.B. Pullen. 1995. White-tailed deer foraging in relation to successional stage, overstory type and management of southern Appalachian forests. American Midland Naturalist 133:18-35.

Johnson, E.A., J.L. Kovner. 1956. Effect on streamflow of cutting a forest understory. Forest Science 2:82-91.

Johnson, J.B., J.W. Edwards, W.M. Ford, J.E. Gates. 2009. Roost tree selection by northern myotis (*Myotis septentrionalis*) maternity colonies following prescribed fire in a central Appalachian Mountains hardwood forest. Forest Ecology and Management 258:233-242.

Johnson, P.S. 1984. Responses of planted northern red oak to three overstory treatments. Canadian Journal of Forest Research 14:536-542.

Johnson, P.S. 1992. Underplanting northern red oak in Missouri without herbicides. Gen. Tech. Rep. NC-152. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station. 4 p.

Jones, J.A., G.E. Grant. 1996. Peak flow responses to clear-cutting and roads in small and large basins, western Cascades, Oregon. Water Resources Research 43(4):959-974.

Jones, J.A.A. 1971. Soil piping and stream channel initiation. Water Resources Research 7(3): 602-610.

Jones, J.A.A. 1981. The nature of soil piping: a review of research. British Geomorphological Research Group Research Monograph Series No. 3. Norwich, England: Geo Books. 301 p.

Jones, J.A.A. 1987. The effects of soil piping on contributing areas and erosion patterns. Earth Surface Processes and Landforms 12:229-248.

Jules, E.S. 1998. Habitat fragmentation and demographic change for a common plant: trillium in old-growth forest. Ecology 79:748-762.

Kaller, M., K.J. Hartman. 2004. Evidence of a threshold level of fine sediment for altering benthic macroinvertebrate communities. Hydrobiologia 518:95-104.

Kirkland, G.L., H.W. Snoddy, T.L. Amsler. 1996. Impact of fire on small mammals and amphibians in a central Appalachian deciduous forest. American Midland Naturalist 135:253-260.

Klock, G.O., J.D. Helvey. 1976. Soil-water trends following wildfire on the Entiat Experimental Forest. Proceedings of the Tall Timbers Fire Ecology Conference 15:193-200.

Knapp, S.M. 1999. Effects of timber harvesting on terrestrial salamander abundance and behavior. M.S. thesis. Blacksburg, VA: Virginia Polytechnic Institute and State University. 122 pp.

Knapp, S.M., C.A. Haas, D.N. Harpole, R.L. Kirkpatrick**.** 2003. Initial effects of clearcutting and alternative silvicultural practices on terrestrial salamander abundance. Conservation Biology 17:752-762.

Kochenderfer, J.N. 1970. Erosion control on logging roads in the Appalachians. Res. Pap. NE-158. Upper Darby, PA: USDA Forest Service, Northeastern Forest Experiment Station. 28 p.

Kochenderfer, J.N., G.M. Aubertin. 1975. Effects of management practices on water quality and quantity: Fernow Experimental Forest, West Virginia. In: Municipal water management symposium proceedings. Gen. Tech. Rep. NE-13. Upper Darby, PA: USDA Forest Service, Northeastern Forest Experiment Station:14-24.

Kochenderfer, J.N., P.J. Edwards. 1991. Effectiveness of three streamside management practices in the Central Appalachian. In: Sixth biennial southern silvicultural research conference proceedings. Gen. Tech. Rep. SE-70. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station:688-700.

Kochenderfer, J.N., J.D. Helvey. 1987. Using gravel to reduce soil losses from minimum-standard forest roads. Journal of Soil and Water Conservation 42(1):46-50.

Kochenderfer, J.N., P.J. Edwards, J.D. Helvey. 1990. Land management and water yield in the Appalachians. In: Riggins, R.E., E.B. Jones, R. Singh, P.A. Rechard, eds. Proceedings, IR conference, watershed management, IR DIV/ACE, watershed planning and analysis in action symposium. New York: American Society of Civil Engineers:523-532.

Kochenderfer, J.N., P.J. Edwards, F. Wood. 1997. Hydrologic impacts of logging an Appalachian watershed using West Virginia's best management practices. Northern Journal of Applied Forestry 14:207-218.

Kochenderfer, J.N., J.D. Helvey, G.W. Wendel. 1987. Sediment yield as a function of land use in central Appalachian forests. In: Hay, R.L., F.W. Woods, H. DeSelm, eds. Proceedings, 6th central hardwood forest conference. Knoxville, TN: University of

Tennessee:497-502.

Koger, J.L., E.C. Burt, A.C. Trouse, Jr. 1985. Multiple pass effects of skidder tires on soil compaction. Transactions of the American Society of Agricultural Engineers 28(1):11-16.

Kubel, J.E., R.H. Yahner. 2008. Quality of anthropogenic habitats for golden-winged warblers in central Pennsylvania. The Wilson Journal of Ornithology 120(4):801-812.

Lantagne, D.O. 1995. Effects of tree shelters on planted red oaks after six growing seasons. In: Gottschalk, K.W., S.L.C. Fosbroke, eds. Proceedings,10th central hardwood forest conference. Gen. Tech. Rep. NE-197. Radnor, PA: USDA Forest Service, Northeastern Forest Experiment Station:215-221.

Lantagne, D.O., C.W. Ramm, D.I. Dickman. 1990. Tree shelters increase heights of planted oaks in a Michigan clearcut. Northern Journal of Applied Forestry 7:24-26.

Larabee, P.A. 1986. Late-quaternary vegetational and geomorphic history of the Allegheny Plateau at Big Run Bog, Tucker County, West Virginia. M.S. thesis. Knoxville, TN: University of Tennessee.

Laseter, B.R., T.A. Campbell, B.F. Miller, D.A. Osborn, K.V. Miller, W.M. Ford. 2004. Female white-tailed deer: are there really social groups in the central Appalachians? Southeast Deer Study Group Meeting 27:33.

Lawrey, J.D. 1993. Lichen biomonitoring program in the Dolly Sods and Otter Creek Wildernesses of the Monongahela National Forest: a resurvey of lichen floristics and elemental status. Final report to the Forest Supervisor, Monongahela National Forest, USDA Forest Service. 112 pp.

Lawrey, J.D., M.E. Hale, Jr. 1988. Lichens as indicators of atmospheric quality in the Dolly Sods and Otter Creek Wildernesses of the Monongahela National Forest, West Virginia. Final report submitted to the Forest Supervisor, Monongahela National Forest, USDA Forest Service.

Lefohn, A.S., P.J. Edwards, M.B. Adams. 1994. The characterization of ozone exposures in rural West Virginia and Virginia. Journal of the Air and Waste Management Association 44:1276-1283.

Leopold, L.B. 1994. A View of the River. Cambridge, MA: Harvard University Press. 298 p.

Litvaitis, J.A. 1993. Response of early successional vertebrates to historic changes in land use. Conservation Biology 7:866-873.

Loeb, S.C. 1993. The role of coarse woody debris in the ecology of southeastern mammals. In: McMinn, J.W., D.A. Crossley, eds. Biodiversity and coarse woody debris in southern forests. Gen. Tech. Rep. SE-94. Asheville, NC: USDA Forest Service, Southeastern Research Station:108-118.

Loftis, D.L. 1990. A shelterwood method for regenerating red oak in the southern Appalachians. Forest Science 36:917-929.

Lorimer, C.G. 1985. The role of fire in the perpetuation of oak forests. In: Johnson, J., ed. Proceedings of challenges in oak management and utilization. Misc. Publ. Madison, WI: University of Wisconsin:8-25.

Lorimer, C.G. 1989. The oak regeneration problem: new evidence on cause and possible solutions. University of Wisconsin, Forest Resource Analyses, Number 8.

Lorimer, C.G. 2001. Historical and ecological roles of disturbance in eastern North American forests: 9,000 years of change. Wildlife Society Bulletin 29(2):425-439.

Lu, Shiang-Yue. 1994. Forest harvesting effects on streamflow and flood frequency in the northern Lake States. Ph.D. dissertation. St. Paul, MN: University of Minnesota. 112 p.

Lyford, W.H. 1973. Forest soil micro-topography. In: Dindal, D.L., ed. Proceedings, first soil microcommunities conference. Oak Ridge, TN: US Atomic Energy Commission, Office of Information Services:47-58.

Lynch, J.A., W.E. Sopper, D.B. Partridge. 1972. Changes in streamflow following partial clearcutting on a forested watershed. In: Proceedings, watersheds in transition. American Water Resources Association Proceedings Series 14:313-320.

Madarish, D.M., T.M. Schuler. 2002. Effects of forest management practices on the federally endangered running buffalo clover (*Trifolium stoloniferum* Muhl. ex. A. Eaton). Natural Areas Journal 22(2):120-128.

Madarish, D.M., J.L. Rodrigue, M.B. Adams. 2002. Vascular flora and macroscopic fauna on the Fernow Experimental Forest. Gen. Tech. Rep. NE-291. Newtown Square, PA: USDA Forest Service, Northeastern Research Station. 37 p.

Marcum, C. 1994. Ecology and natural history of four Plethodontid species in the Fernow Experimental Forest, Tucker County, West Virginia. M.S. thesis. Huntington, WV: Marshall University. 254 p.

Marini, M.A, S.K. Robinson, E.J. Heske. 1995. Edge effects on nest predation in the Shawnee National Forest, southern Illinois. Biological Conservation 74:203-213.

Marsh, D.M. 2007. Edge effects of gated and ungated roads on terrestrial salamanders. Journal of Wildlife Management 71(2):389-394.

McCuen, R.H. 1998. Hydrologic Analysis and Design, Second Edition. Upper Saddle River, NJ: Prentice Hall, Inc. 814 p.

McEwan, R.W., T.F. Hutchinson, R.P. Long, D.R. Ford, C.B. McCarthy. 2007. Temporal and spatial patterns in fire occurrence during the establishment of mixed-oak forests in eastern North America. Journal of Vegetation Science 18(5):655-664.

McMinn, J.W. 1992. Diversity of woody species 10 years after four harvesting treatments in the oak-pine type. Canadian Journal of Forest Research 22:1179-1183.

McNab, W.H., P.E. Avers., comps. 1994. Ecological subregions of the United States: section descriptions. Admin. Publ. WO-WSA5. Washington, DC: USDA Forest Service. 267 p.

Meegan, S.K., S.A. Perry. 1996. Periphyton communities in headwater streams of different water chemistry in the central Appalachian mountains. Journal of Freshwater Ecology 11(3):247-255.

Meffe, G.K., Carroll, C.R., Pimm, S.L. 1994. Community-level conservation: species interactions, disturbance regimes, and invading species. In: Principles of conservation biology. Sunderland, MA: Sinauer Associates:209-236.

Megahan, W.F. 1972. Logging, erosion, sedimentation-are they dirty words? Journal of Forestry 70:403-407.

Meginnis, H.G. 1959. Increasing water yields by cutting forest vegetation. In: Symposium of Hannoversch-Munden. Publ. 48. Louvain, Belgium: International Association of Scientific Hydrology:59-68.

Menzel, J.M. 2003. An examination of the habitat requirements of the endangered Virginia northern flying squirrel (*Glaucomys sabrinus fuscus*) by assessing nesting sites, habitat use and the development of a habitat model. Ph.D. dissertation. Morgantown, WV: West Virginia University. 122 p.

Menzel, J.M., W.M. Ford, J.W. Edwards, M.A. Menzel. 2004. Nest tree use by the endangered Virginia northern flying squirrel in the central Appalachian Mountains. American Midland Naturalist 151:355-368.

Menzel, J.M., W.M. Ford, M.A. Menzel, T.C. Carter, J.E. Gardner, J.D. Garner, J.E. Hofmann. 2005. Summer home range and habitat use analysis of the endangered Indiana bat. Journal of Wildlife Management 69(1):430-436.

Menzel, M.A., S.F. Owen, W.M. Ford, J.W. Edwards, P.B. Wood, B.R. Chapman, K.V. Miller. 2002. Roost tree selection by northern long-eared bat (*Myotis septentrionalis*) maternity colonies in an industrial forest of the central Appalachian Mountains. Forest Ecology and Management 155:107-114.

Michael, E.D., B.L. Hahn, H.J. Hansen. 1982. Response of deer, hare, and grouse to whole-tree harvesting in central Appalachia. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Agencies 36:627-633.

Mikan, C.J., D.A Orwig, M.D. Abrams. 1994. Age structure and successional dynamics of a presettlement-origin chestnut oak forest in the Pennsylvania Piedmont. Bulletin of the Torrey Botanical Society 121(1):13-23.

Miller, G.W., P.B. Wood, J.V. Nichols. 1995. Two-aged silviculture – an innovative tool for enhancing species diversity and vertical structure in Appalachian hardwoods. In: Eskew, L.G., ed. Forest health through silviculture. Gen. Tech. Rep. RM-267. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station:175-182 .

Miller, J.H. 2003. Nonnative invasive plants of southern forests: a field guide for identification and control. Gen. Tech. Rep. SRS-62. Asheville, NC: USDA Forest Service, Southern Research Station. 93 p.

Miller, K.V., W.M. Ford, T.A. Campbell. 1999. Minimizing the impacts of herbivory in forest regeneration: a test of localized management. USDA NRI proposal. 25 p.

Mohering, D.M., C.X. Grano, J.R. Bassett. 1966. Properties of forested loess soils after repeated prescribed burns. Res. Note SO-40. New Orleans, LA: USDA Forest Service, Southern Forest Experiment Station. 4 p.

Mohnen, V.A. 1992. Atmospheric deposition and pollutant exposure of eastern U.S. forests. In: Eagar, C., M.B. Adams, eds. 1992. Ecology and decline of red spruce in the eastern United States. Ecological studies 96. New York: Springer-Verlag. 417 p.

Morris, D.R., V.C. Baligar, T.M. Schuler, Harmon, P.J. 2002. Nitrogen fixation and running buffalo clover habitat. Journal of Plant Nutrition 25:735-746.

Moseley, K. 2008. An assessment of Monongahela National Forest management indicator species. Ph.D. dissertation. Morgantown, WV: West Virginia University. 258 p.

Muller, R.N., Y. Liu. 1991. Coarse woody debris in an old-growth deciduous forest on the Cumberland Plateau, southeastern Kentucky. Canadian Journal of Forest Research 21:1567-1572.

NADP (NRSP-3). 2010. National Atmospheric Deposition Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820.

NAPAP. 2001. National Acid Precipitation Assessment Program biennial report to Congress: an integrated assessment. Silver Spring, MD: National Science and Technology Council.

Nowacki, G.J. 1995. Historical development, disturbance dynamics, and community ecology of oak-dominated forests of central Pennsylvania. Ph.D. dissertation. State College, PA: The Pennsylvania State University.

Nowacki, G.J., M.D. Abrams. 2008. The demise of fire and "mesophication" of forests in the eastern United States. Bioscience 58:123-138.

Odom, R.H., W.M. Ford, J.W. Edwards, C.W. Stihler, J.M. Menzel. 2000. Developing potential habitat models for the endangered Virginia northern flying squirrel (*Glaucomys sabrinus fuscus*) in the Allegheny Mountains of West Virginia. Biological Conservation 99:245-252.

Oliver, C.D., B.C. Larson. 1996. Forest Stand Dynamics. New York: John Wiley and Sons.

Osborn, R.G., K.F. Higgins, R.E. Usgaard, C.D. Dieter, R.D. Neiger. 2000. Bird mortality associated with wind turbines at the Buffalo Wind Resource Area, Minnesota. American Midland Naturalist 143:41-52.

Owen, S.F. 2000. Impacts of timber harvest in the central Appalachians hardwood region on bat foraging and roosting behavior. M.S. thesis. Athens, GA: University of Georgia. 52 p.

Owen, S.F. 2003. Ecology and management of raccoons within an intensively managed forest in the central Appalachians. Ph.D. dissertation. Morgantown, WV: West Virginia University. 93 p.

Owen, S.F., J.W. Edwards, W.M. Ford, J.M. Crum, P.B. Wood. 2004a. Raccoon roundworm in raccoons in central West Virginia. Northeastern Naturalist 11:137-142.

Owen, S.F., M.A. Menzel, J.W. Edwards, W.M. Ford, J.M. Menzel, B.R. Chapman, P.B. Wood, K.V. Miller. 2004b. Bat activity in harvested and intact forest stands in the Allegheny Mountains. Northern Journal of Applied Forestry 21:154-159.

Owen, S.F., M.A. Menzel, W.M. Ford, J.W. Edwards, B.R. Chapman, K.V. Miller, P.B. Wood. 2002. Roost tree selection by maternal colonies of northern long-eared myotis in an intensively managed forest. Gen. Tech. Rep. NE-292. USDA Forest Service, Northeastern Research Station. 6 p.

Parker, C.G. 1964. Piping, a geomorphic agent in landform development of the drylands. In: Land erosion, precipitations, hydrometry, soil moisture, proceedings of the General Assembly of Berkeley. Publ. No. 65. Louvain, Belgium: International Association of Scientific Hydrology: 103-113.

Parker, G.R., D.J. Leopold, J.K. Eichenberger. 1985. Tree dynamics in an old-growth, deciduous forest. Forest Ecology and Management 11:31-57.

Patric, J.H. 1976a. Soil erosion in the eastern forest. Journal of Forestry 74(10):671-677.

Patric, J.H. 1976b. Effects of wood products harvest on forest soil and water resources with emphasis on clearcutting in moist climates. In: The scientific base for silviculture and management decisions in the National Forest System: selected papers. Washington, DC: USDA Forest Service:39-51.

Patric, J.H. 1977. Soil erosion and its control in eastern woodlands. Northern Logger 25(11):4-5,22-23,31,51.

Patric, J.H. 1978. Harvesting effects on soil and water in the eastern hardwood forest. Southern Journal of Applied Forestry 2:66-73.

Patric, J.H., K.G. Reinhart. 1971. Hydrologic effects of deforesting two mountain watersheds in West Virginia. Water Resources Research 7:1182-1188.

Patric, J.H., D.W. Smith. 1975. Forest management and nutrient cycling in eastern hardwoods. Res. Pap. NE-324.Upper Darby, PA: USDA Forest Service, Northeastern Forest Experiment Station. 12 p.

Pauley, T.K. 1995a. Aquatic salamanders. In: Reardon, R.C., ed. Effects of diflubenzuron on non-target organisms in broadleaf forested watersheds in the Northeast. Report FHM-NC-05-95. Morgantown, WV: USDA Forest Service, Forest Health Management:14-22.

Pauley, T.K. 1995b. Terrestrial salamanders. In: Reardon, R.C., ed. Effects of diflubenzuron on non-target organisms in broadleaf forested watersheds in the Northeast. Report FHM-NC-05-95. Morgantown, WV: USDA Forest Service, Forest Health Management:42-52.

Pauley, T.K., A.M. Rodgers. 1998. Baseline survey for amphibians and reptiles on the Westvaco Wildlife and Ecosystem Research Forest. Final report submitted to the Westvaco Wildlife and Ecosystem Research Forest Steering Committee, Rupert, WV. 127 p.

Peterjohn, W.T., M.B. Adams, F.S. Gilliam. 1996. Symptoms of nitrogen saturation in two central Appalachian hardwood forest ecosystems. Biogeochemistry 35:507-522.

Plaugher, G.F. 1998. Seasonal habitat, foods, and movements of ruffed grouse in the central Appalachian Mountains of West Virginia. M.S. thesis. Morgantown, WV: West Virginia University. 159 pp.

Prasad, A.M., L.R. Iverson, S. Matthews, M. Peters. 2007-ongoing. A climate change atlas for 134 forest tree species of the eastern United States. [Online database]. Available at: http://www.nrs.fs.fed.us/atlas/tree [Accessed 2010 August 17].

Pritchett, W.L., R.F. Fisher. 1987. Properties and Management of Forest Soils. Second Edition. New York: John Wiley and Sons. 500 p.

Rauws, G., G. Govers. 1988. Hydraulic and soil mechanical aspects of rill generation on agricultural soils. European Journal of Soil Science 39:111-124.

Reinhart, K.G., A. Eschner. 1962. Effect on streamflow of four different forest practices in the Allegheny Mountains. Journal of Geophysical Research 67:2433-2445.

Reinhart, K.G., G.R. Trimble, Jr. 1962. Forest cutting and increased water yield. Journal of the American Water Works Association 54(12):1464-1472.

Reinhart, K.G., A. Eschner, G.R. Trimble, Jr. 1963. Effect on streamflow for four forest practices in the mountains of West Virginia. Res. Pap. NE-1. Upper Darby, PA: USDA Forest Service, Northeastern Forest Experiment Station. 79 p.

Rich, A.C., D.S. Dobkin, L.J. Niles. 1994. Defining forest fragmentation by corridor width: the influence of narrow forest-dividing corridors on forest-nesting birds in southern New Jersey. Conservation Biology 8:1109-1121.

Rieffenberger, J.C., J.C. Pack, W.K. Igo, C.W. Ryan. 2000. Influence of mast production on black bear harvests in West Virginia. Abstracts of the 56th Annual Northeast Fish and Wildlife Conference, Charleston, WV:8-9.

Robbins, C.S. 1988. Forest fragmentation and its effects on birds. In: Johnson, J.E., ed. Managing north central forests for non-timber values. Publ. 88-04. Bethesda, MD: Society of American Foresters:61-65.

Robinson, S.K., F.R. Thompson, T.M. Donovan, D.R. Whitehead, J. Faaborg. 1995. Regional forest fragmentation and the nesting success of migratory birds. Science 267:1987-1990.

Rodrigue, J.L., T.M. Schuler, M.A. Menzel. 2001. Observations of bat activity during prescribed burning in West Virginia. Bat Research News 42(2):48-49.

Römkens, M.J.M., S.N. Prasad, J.J.P. Gerits. 1997. Soil erosion modes of sealing soils: a phenomenological study. Soil Technology 11:31-41.

Rosenblatt, D.L, E.J. Heske, S.L. Nelson, D.M. Barber, M.A. Miller, B. MacAllister. 1999. Forest fragments in east-central Illinois: islands of habitat patches for mammals? American Midland Naturalist 141:115-123.

Rothacher, J.S. 1973. Does harvest in west slope Douglas-fir increase peak flow in small forest streams? Res. Pap. PNW-163. Portland, OR: USDA Forest Service, Pacific Northwest Forest Experiment Station. 13 p.

Rowan, E. 2004. Effects of spring prescribed fire on chipmunk home ranges and a woodland salamander community in a central Appalachian hardwood forest. M.S. thesis. Athens, GA: University of Georgia. 96 p.

Rubey, W.W. 1967. Gullies in the Great Plains formed by sinking of the ground. American Journal of Science 13:417-422.

Sauer, J.R., J.E. Hines, J. Fallon. 2008. The North American breeding bird survey, results and analysis 1966 - 2007. Version 5.15.2008. Laurel, MD: US Geological Survey, Patuxent Wildlife Research Center. [Online] Available at: http://www.mbr-pwrc.usgs.gov/bbs/bbs.html [Accessed 2010 March 18].

Schlesinger, R.C., I.L Sander, K.R Davidson. 1993. Oak regeneration potential increased by shelterwood treatments. Northern Journal of Applied Forestry 10:149-153.

Schuler, T.M. 2004. Fifty years of partial harvesting in a mixed mesophytic forest: composition and productivity. Canadian Journal of Forest Research 34:985-997.

Schuler, T.M., M.A. Fajvan. 1999. Understory tree characteristics and disturbance history of a central Appalachian forest prior to old-growth harvesting. Res. Pap. NE-710. Radnor, PA: USDA Forest Service, Northeastern Research Station. 12 p.

Schuler, T.M., A.R. Gillespie. 2000. Temporal patterns of woody species diversity in a central Appalachian forest from 1856 to 1997. Journal of the Torrey Botanical Society 127:149-161.

Schuler, T.M., W.R. McClain. 2003. Fire history of a Ridge and Valley oak forest. Res. Pap. NE-274. Newtown Square, PA: USDA Forest Service, Northeastern Research Station. 9 p.

Schuler, T.M., D.W. McGill. 2007. Long-term assessment of financial maturity, diameter-limit selection in the central Appalachians. Res. Pap. NRS-2 Newtown Square, PA: USDA Forest Service, Northern Research Station. 16 p.

Schuler, T.M., G.W. Miller. 1995. Shelterwood treatments fail to establish oak reproduction on mesic forest sites in West Virginia. In: Gottschalk, K.W., S.L.C. Fosbroke, eds. Proceedings,10th central hardwood forest conference. Gen. Tech. Rep.

NE-197. Radnor, PA: USDA Forest Service, Northeastern Forest Experiment Station: 375-388.

Schuler, T.M., G.W. Miller. 1996. Guidelines for using tree shelters to regenerate northern red oak. In: Brissette, J., ed. Proceedings, tree shelter conference. Gen. Tech. Rep. NE-221. Radnor, PA: USDA Forest Service, Northeastern Forest Experiment Station:37-45.

Semlitsch, R.D., B.D. Todd, S.M. Bloomquist, A.J.K. Calhoun, J.W. Gibbons, J.P. Gibbs, G.J. Graeter, E.B. Harper, D.J. Hocking, M.J. Hunter, Jr., D.A. Patrick, T.A.G. Rittenhouse, B.B. Rothermel. 2009. Effects of timber harvest on amphibian populations: understanding mechanisms from forest experiments. BioScience 59:853-862.

Settergren, C.D., R.M. Nugent, G.S. Henderson. 1980. Timber harvest and water yield in the Ozarks. In: Symposium on watershed management. New York: American Society of Civil Engineers. 2:661-668.

Shahlaee, A.K., W.L. Nutter, E.R. Burroughs, Jr., L.A. Morris. 1991. Runoff and sediment production from burned forest sites in the Georgia Piedmont. Water Resources Bulletin 27:485-493.

Shetron, S.G., J.A. Sturos, E. Padley, C. Trettin. 1988. Forest soil compaction: effect of multiple passes and loadings on wheel track surface soil bulk density. Northern Journal of Applied Forestry 5:120-123.

Shumway, D.L., M.D. Abrams, C.M. Ruffner. 2001. A 400-year history of fire and oak recruitment in an old-growth oak forest in western Maryland, U.S.A. Canadian Journal of Forest Research 29:166-171.

Smith, C.R., D.M. Pence, R.J. O'Conner. 1993. Status of neotropical birds in the Northeast: a preliminary assessment. In: Status and management of neotropical migratory birds. Gen. Tech. Rep. RM-229. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station:172-184.

Smith, D.W. 1993. Oak regeneration: the scope of the problem. In: Loftis, D.L., C.E McGee, eds. Oak regeneration: serious problems, practical recommendations (symposium proceedings). Gen. Tech. Rep. SE-84. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station: 40-52.

Smith, R.D.M. 2003. Raptor assemblage, abundance, nesting ecology, and habitat characteristics under intensive forest management in the central Appalachian Mountains. M.S. thesis. Morgantown, WV: West Virginia University. 106 p.

Stark, N.M. l977. Fire and nutrient cycling in a Douglas-fir/larch forest. Ecology 58:16-30.

Stedman, J.T. 2008. To-stream sediment delivery and associated particle size distributions in unmanaged and managed forested watersheds. M.S. thesis, Forestry. Carbondale, IL: Southern Illinois University.117 p.

Stihler, C.W. 1994. Radio telemetry studies of the endangered Virginia big-eared bat (*Plecotus townsendii virginianus*) at Cave Mountain Cave, Pendleton County, West Virginia. Final report to USDA Forest Service, Monongahela National Forest. 18 p.

Stihler, C.W. 1995. A radio telemetry study of female Virginia big-eared bats (*Corynorhinus townsendii virginianus*) at a maternity colony in Cave Mountain Cave, Pendleton County, West Virginia. Final report to USDA Forest Service, Monongahela National Forest. 11 p.

Stihler, C.W. 1996. A summer bat survey near Big Springs Cave on the Fernow Experimental Forest, Tucker County, West Virginia. Final report to USDA Forest Service, Northeastern Research Station. 18 p.

Stihler, C.W., J.L. Wallace, E.D. Michael, H. Pawelczyk. 1995. Range of *Glaucomys sabrinus fuscus*, a Federally endangered subspecies of the northern flying squirrel in West Virginia. Proceedings of the West Virginia Academy of Science 67:13-20.

Stuart, G.W., P.J. Edwards. 2006. Concepts about forests and water. Northern Journal of Applied Forestry 23(1):11-19.

Sullivan, T.P., J.O. Boateng. 1996. Comparison of small-mammal community responses to broadcast burning and herbicide application in cutover forest habitats. Canadian Journal of Forest Research 26:462-473.

Swank, W.T., L.W. Swift, Jr., J.E. Douglass. 1988. Streamflow changes associated with forest cutting, species conversions, and natural disturbances. In: Swank, W.T., D.A. Crossley, Jr., eds. Forest hydrology and ecology at Coweeta. Ecological studies, vol. 66. New York: Springer:297-312.

Swank, W.T., J.M. Vose, K.J. Elliott. 2001. Long-term hydrologic and water quality responses following commercial clearcutting of mixed hardwoods on a southern Appalachian catchment. Forest Ecology and Management 143:163-178.

Sweka, J.A., K.J. Hartman. 2001. Effects of turbidity on prey consumption and growth in brook trout and implications for bioenergetics modeling. Canadian Journal of Fisheries and Aquatic Sciences 58:386-393.

Sweka, J.A., K.J. Hartman. 2008. Contributions of terrestrial invertebrates to yearly brook trout prey consumption and growth. Transactions of the American Fisheries Society 137:224-235.

Swift, L.W. 1983. Duration of stream temperature increases following forest cutting in the southern Appalachian Mountains. In: Johnson, A.I., R.A. Clark, eds. Proceedings, international symposium on hydrometeorology. Middleburg, VA: American Water Resources Association:273-275.

Swift, L.W., Jr., K.J. Elliott, R.D. Ottmar, R.E. Vihnanek. 1993. Site preparation burning to improve southern Appalachian pine-hardwood stands: fire characteristics and soil erosion, moisture and temperature. Canadian Journal of Forest Research 23:2242-2254.

Swindel, B.F., J.E. Douglass. 1984. Describing and testing nonlinear treatment effects in paired watershed experiments. Forest Science 30(2):305-313.

Swindel, B.F., L.R. Grosenbaugh. 1988. Species diversity in young Douglas-fir plantations compared to old-growth. Forest Ecology and Management 23:227-231.

Sykes, D.J. 1971. Effects of fire and fire control on soil and water relations in northern forests. In: Slaughter , C.W., R.J. Barney, G.M. Hansen, eds. Fire in the northern environment. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station:37-44.

Tatum, V. 2003. Toxicity, transport, and fate of forest herbicides. Abstracts of the 10th Annual Wildlife Society Meeting, September 6-10, 2003, Burlington, VT.

Taylor, S.B., J.S. Kite. 1998. Surficial and bedrock geology of the Fernow Experimental Forest, Monongahela National Forest, Tucker County, West Virginia. Final Technical Report, Contract No. 23-023. Morgantown, WV: West Virginia University. 25 p.

Thomas, R.B., W.F. Megahan. 1998. Peak flow responses to clear-cutting and roads in small and large basins, western Cascades, Oregon: a second opinion. Water Resources Research 34(12):3393-3403.

Tiedemann, A.R., J.D. Helvey, T.D. Anderson. 1978. Stream chemistry and watershed nutrient economy following wildfire and fertilization in eastern Washington. Journal of Environmental Quality 7:580-588.

Torri, D., M. Sfalanga, G. Chisci. 1987. Threshold conditions for incipient rilling. In: Bryan, R.B., ed. Rill erosion: processes and significance. Catena supplement 8:97-107.

Trimble, G.R., Jr. 1977. A history of the Fernow Experimental Forest and the Parsons Timber and Watershed Laboratory. Gen. Tech. Rep. NE-28. Upper Darby, PA: USDA Forest Service, Northeastern Forest Experiment Station. 46 p.

Trimble, G.R., Jr., J.J. Mendel, R.A. Kennell. 1974. A procedure for selection marking in hardwoods combining silvicultural considerations with economic guidelines. Res. Pap. NE-292. Upper Darby, PA: USDA Forest Service, Northeastern Forest Experiment Station. 13 p.

Trimble, G.R., Jr., E.H. Tryon. 1969. Survival and growth of yellow-poplar seedlings depend on date of germination. Res. Note NE-101. Broomall, PA: USDA Forest Service, Northeastern Forest Experiment Station. 6 p.

Troendle, C.A. 1970. The flow interval method for analyzing timber harvesting effects on streamflow regimen. Water Resources Research 6:328-332.

Troendle, C.A., R.M. King. 1985. The effect of partial and clearcutting on streamflow at Deadhorse Creek, Colorado. Journal of Hydrology 90:145-157.

Troendle, C.A., L.H. MacDonald, C.H. Luce, I.J. Larsen. 2010. Fuels management and water yield. In: Elliot, W.J., I.S. Miller, L. Audin, eds. Cumulative watershed effects of fuels management in the western United States. Gen. Tech. Rep. RMRS-231. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station:126-148.

Trombulak, S.C., C.A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18-30.

Tuley, G. 1983. Shelters improve the growth of young trees in the forest. Quarterly Journal of Forestry 77:77-87.

U.S. Census Bureau. 2008. Tucker County, West Virginia QuickFacts. [Online] Available at: http://quickfacts.census.gov/qfd/states/54/54093.html [Accessed 2010 March 31].

United States Environmental Protection Agency. 1997. Emission standards reference guide for heavy-duty and nonroad engines. EPA420-F-97-014. Washington, DC: Office of Air and Radiation.

United States Environmental Protection Agency. 1999. Exhaust emission factors for nonroad engine modeling - spark ignition, Feb. 24, 1998, revised March 30, 1999. EPA420-R-979-009. Washington, DC: Assessment and Standards Division, Office of Transportation and Air Quality.

United States Environmental Protection Agency. 2002. Exhaust and crankcase emission factors for nonroad engine modeling - compression ignition, November 2002. EPA420-P-02-016. Washington, DC: Assessment and Standards Division, Office of Transportation and Air Quality.

United States Fish and Wildlife Service. 2007. Running buffalo clover (*Trifolium stoloniferum*) recovery plan: first revision. Fort Snelling, MN: USDI US Fish and Wildlife Service. 76 p.

United States Fish and Wildlife Service. 2009. White-nose syndrome bulletin for federal and state personnel. Cortland, NY: USDI US Fish and Wildlife Service, New York Field Office.

University of Connecticut, Center for Land Use Education and Research. 2009. Landscape fragmentation tools v2.0. [Online] Available at: http://clear.uconn.edu/tools/lft/lft2/index.htm [Accessed 2010 February 25].

Urban, V. 1988. Home range, habitat utilization, and activity of the endangered northern flying squirrel in West Virginia. M.S. thesis. Morgantown, WV: West Virginia University. 59 p.

USDA Forest Service. 1989. Position statement on national forest old-growth values. Memorandum to Regional Foresters, Station Directors, and WO staff, October 11, 1989. Washington, DC.

USDA Forest Service. 2006. Monongahela National Forest Final Environmental Impact Statement for Forest Plan Revision. Elkins, WV: USDA Forest Service, Region 9, Monongahela National Forest.

Van Lear, D.H., S.J Danielovich. 1988. Soil movement after broadcast burning in the southern Appalachians. Southern Journal of Applied Forestry 12:49-53.

Van Lear, D.H., P.R. Kapeluck. 1989. Fell and burn to regenerate mixed pine-hardwood stands: an overview of effects on the soil. In: Proceedings, pine-hardwood mixtures: a symposium on management and ecology of the type. Gen. Tech. Rep. SE-58. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station:83-90.

Van Lear, D.H., Waldrop, T.A. 1989. History, uses, and effects of fire in the Appalachians. Gen. Tech. Rep. SE-54. Asheville, NC: USDA Forest Service, Southeastern Forest Experiment Station. 20 p.

Verry, E.S. 1997. Hydrologic processes of natural, northern forested wetlands. In: Trettin, C.C. et al., eds. Northern forested wetlands, ecology and management. Boca Raton, FL: Lewis Publishers:163-188.

Verry, E.S. 2000. Water flow in soils and streams: sustaining hydrologic function. In: Verry, E.S., J.W. Hornbeck, C.A. Doloff, eds. Riparian management in forests of the continental eastern United States. Boca Raton, FL: Lewis Publishers:99-124.

Verry, E.S, J.R. Lewis, K.N. Brooks. 1983. Aspen clearcutting increases snowmelt and storm flow peaks in north central Minnesota. Water Resources Bulletin 19(1):59-67.

Vogt, P., K.H. Riitters, C. Estreguil, J. Kozak, T.G. Wade, J.D. Wickham. 2007. Mapping spatial patterns with morphological image processing. Landscape Ecology 22:171-177.

Vose, J.M., B.D. Clinton, W.T. Swank. 1993. Fire, drought, and forest management influences on pine/hardwood ecosystems in the southern Appalachians. In: Proceedings, 12th international conference on fire and forest meteorology. Bethesda, MD: Society of American Foresters:232-238.

Waldron, J.L. 2000. Ecology and sympatric relations of crevice salamanders in Randolph County, West Virginia. M.S. thesis. Huntington, WV: Marshall University. 107 p.

Weakland, C.A. 2000. Songbird response to diameter-limit and two-aged timber harvesting on an industrial forest in central West Virginia. Ph.D. dissertation. Morgantown, WV: West Virginia University. 161 p.

Weakland, C.A., P.B. Wood, W.M. Ford. 2002. Response of songbirds to diameter-limit cutting in the central Appalachians of West Virginia, USA. Forest Ecology and Management 155:115-129.

Weitzman, S. 1949. The Fernow Experimental Forest Parsons, West Virginia. Misc. Publ. Upper Darby, PA: USDA Forest Service, Northeastern Forest Experiment Station. 16 p.

Wendel, G.W., Smith, H.C. 1986. Effects of prescribed fire in a central Appalachian oak-hickory stand. Res. Pap. NE-594. Broomall, PA: USDA Forest Service, Northeastern Forest Experiment Station. 8 p.

Wentworth, J.M., A.S. Johnson, P.E. Hale, K.E. Kammermeyer. 1990. Seasonal use of clearcuts and food plots by white-tailed deer in the southern Appalachians. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 44:215-223.

Whitaker, D.M. 2003. Ruffed grouse (*Bonasa umbellus*) habitat ecology in the central and southern Appalachians. Ph.D. dissertation. Blacksburg, VA: Virginia Polytechnic Institute and State University. 205 p.

Wiemann, M.C., T.M. Schuler, J.E. Baumgras. 2004. Effects of uneven-aged and diameter-limit management on West Virginia tree and wood quality. Res. Pap. FPL-RP-621. Madison, WI: USDA Forest Service, Forest Products Laboratory. 16 p.

Williams, G.E., P.B. Wood. 2000. The utility of miniature video cameras for monitoring wood thrush nests in the Monongahela National Forest, West Virginia: results of pilot work in 1998. In: Abstracts of the 56th annual northeast fish and wildlife conference, Charleston, WV:42.

Williard, K.W.J., D.R. DeWalle, P.J. Sharpe, P.J. Edwards, M.B. Adams. 1999. Spatial variations in stream nitrate concentrations in a region exhibiting symptoms of nitrogen saturation. In: Sharpe, W.E., J.R. Drohan, eds. The effects of acidic deposition on aquatic ecosystems in Pennsylvania. Proceedings of the 1998 PA acidic deposition conference, vol. II. University Park, PA: Environmental Resources Research Institute:23-30.

Wunz, G.A., J.C. Pack. 1992. Eastern turkey in eastern oak-hickory and northern hardwood forests. In: Dickson, J.G., ed. The wild turkey: biology and management. Harrisburg, PA: Stackpole Books:232-264.

Yahner, R.H. 2003. Responses of bird communities to early successional habitat in a managed landscape. The Wilson Bulletin 115(3):292-298.

Yates, M.D., R.M. Muzika. 2006. Effect of forest structure and fragmentation on site occupancy of bat species in Missouri Ozark forests. Journal of Wildlife Management 70(5):1238-1248.

Yates, M.D., S.C. Loeb, D.C. Guynn. 1997. The effect of habitat patch size on small mammal populations. Proceedings of the Annual Conference of Southeastern Fish and Wildlife Agencies 51:501-510.

Zwieniecki, M.A., M. Newton. 1999. Influence of streamside cover and stream features on temperature trends in forested streams of western Oregon. Western Journal of Applied Forestry 14(2):106-113.

List of Agencies, Persons and Organizations to whom the EIS 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, Region 9, 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, Washington
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

State:

West Virginia Division of Forestry, Barbara Breshock
West Virginia Division of Natural Resources, Shawn Head

Organizations/Individuals:

West Virginia University, Joe McNeel
West Virginia Forestry Association, Dick Waybright
West Virginia Division, Society of American Foresters, Aaron Plaugher
MeadWestvaco Corporation, Roger Sherman
The Nature Conservancy, Thomas Minney
West Virginia Sierra Club, Jim Sconyers
West Virginia Highlands Conservancy
Marian Keegan
Jean Public
Don Gasper

Index

Acidic deposition	2-4, 3-56, 3-57, 3-76, 3-77, 3-109, 3-125
Air quality	2-9, 3-56 through 3-63, 3-131
Bankfull	3-8, 3-9, 3-53, 3-54, 3-55
Best management practices (BMPs)	1-4, 2-2, 2-8, 3-3, 3-7, 3-9, 3-10, 3-11, 3-14, 3-17, 3-52, 3-70, 3-71, 3-81, 3-113,3-127
Black bear	3-88, 3-94, 3-119, 3-120
Butternut	2-1, 3-107, 3-113
Caves	1-6, 2-2, 2-8, 3-79 through 3-82, 3-93, 3-95, 3-99
Clean Air Act	1-3, 3-56, 3-57
Clearcut	2-3, 3-6, 3-7, 3-9, 3-22, 3-27, 3-28, 3-39, 3-40, 3-43, 3-44, 3-45, 3-52, 3-67, 3-68, 3-71, 3-72, 3-73, 3-81, 3-89, 3-90, 3-100, 3-101, 3-102, 3-105, 3-106, 3-108, 3-109
Climate change	3-53, 3-54, 3-55, 3-76, 3-78, 3-85, 3-86, 3-94, 3-97, 3-102, 3-105, 3-115, 3-117
Comparison of alternatives	2-5 through 2-8
Cowbirds	3-91
Cumulative effects	3-14, 3-36 through 3-55, 3-62, 3-63, 3-74, 3-75, 3-76, 3-77, 3-80, 3-82, 3-85, 3-86, 3-94, 3-95, 3-96, 3-97, 3-98, 3-101, 3-102, 3-112, 3-115, 3-116, 3-119, 3-120, 3-122, 3-123, 3-124, 3-125, 3-128
Deer	2-5,3-88, 3-89, 3-90, 3-94, 3-101, 3-105, 3-108, 3-118, 3-119, 3-120
Diameter-limit harvest	2-3, 3-21, 3-22, 3-28, 3-33, 3-37, 3-42, 3-43, 3-44, 3-46, 3-72, 3-81, 3-89, 3-90, 3-100, 3-109
Ecological land type	1-1, 3-104
Economic	1-3, 2-4, 3-102, 3-124 through 3-125, 3-126
Fertilization	2-3, 2-5, 3-16, 3-57, 3-68, 3-73, 3-74, 3-80, 3-92, 3-95, 3-111, 3-127
Financial maturity treatment	2-3, 2-4, 3-18, 3-22, 3-29, 3-30, 3-31, 3-41, 3-42, 3-43, 3-45, 3-46, 3-48, 3-72, 3-109
Fish	3-84 through 3-86, 3-118, 3-119, 3-126
Fragmentation	3-84, 3-91, 3-96, 3-99 through 3-103, 4-21
Gas well	3-22, 3-26, 3-46, 3-53, 3-62, 3-75, 3-76, 3-77, 3-80, 3-85, 3-86, 3-89, 3-102, 3-115

Herbicide 1-4, 2-2, 2-3, 2-4, 2-5, 3-37, 3-40, 3-41, 3-46, 3-67, 3-80, 3-82, 3-92, 3-106, 3-111, 3-114, 3-115, 3-127
Heritage resources 2-2, 3-121 through 3-123, 3-130, 3-131
History 1-2, 3-107, 3-108, 3-122
Hunting 3-89, 3-90, 3-118, 3-119, 3-120, 3-125

Indiana bat 1-5, 2-7, 2-8, 3-79, 3-81, 3-89, 3-93, 3-99, 3-101, 3-111, 3-113, 3-127, 3-128, 3-131

Japanese stiltgrass 1-5, 2-5, 3-98, 3-114, 3-115, 3-116, 4-10

Long-term research 1-3, 1-4, 2-3, 3-102, 3-125, 3-127 through 3-128

Mitigation measures 1-4, 2-1, 2-7, 2-8, 3-10, 3-13, 3-14, 3-62, 3-70, 3-71, 3-75, 3-84, 3-85, 3-91, 3-110, 3-113, 3-115, 3-117, 3-130, 3-131
Monitoring 1-4, 2-1, 2-3, 2-7, 2-8, 2-9, 3-3, 3-4, 3-5, 3-21, 3-38, 3-39, 3-46, 3-56, 3-57, 3-59, 3-71, 3-73, 3-74, 3-75, 3-83, 3-93, 3-108, 3-112, 3-127, 3-128

Nitrogen 2-4, 3-56, 3-57, 3-60, 3-61, 3-62, 3-63, 3-68, 3-72, 3-73, 3-76, 3-77, 3-108, 3-111

Old growth 3-97 through 3-98, 3-105, 3-109

Pipeline (natural gas) 3- 47, 3-53, 3-75, 3-76, 3-77, 3-80, 3-85, 3-86, 3-102, 3-115
Prescribed burning / fire 2-3, 2-4, 2-6, 2-8, 3-5, 3-12, 3-13, 3-14, 3-15, 3-22, 3-23, 3-33 through 3-37, 3-46, 3-48, 3-50, 3-59 through 3-62, 3-66 through 3-77, 3-80, 3-81, 3-85, 3-86, 3-90, 3-92, 3-93, 3-94, 3-100, 3-102, 3-106, 3-108 through 3-111, 3-115, 3-119, 3-120, 3-124, 3-125, 3-127, 4-21
Proposed action 2-3 through 2-8
Purpose and need 1-4 through 1-5

Recreation 3-54, 3-75, 3-77, 3-95, 3-100, 3-116, 3-118 through 3-120, 3-125
Riparian 2-2, 2-6, 2-7, 3-1 through 3-55, 3-64, 3-65, 3-84, 3-114, 3-130, 3-131

Roads	1-3, 1-4, 2-2, 2-3, 2-5, 2-6, 2-8, 3-3 through 3-55, 3-60, 3-62, 3-63, 3-66, 3-67, 3-69, 3-70, 3-71, 3-73 through 3-78, 3-81, 3-84, 3-85, 3-86, 3-89, 3-93, 3-99, 3-100, 3-101, 3-108, 3-110, 3-113, 3-114, 3-115, 3-116, 3-118, 3-119, 3-120, 3-130, 3-133, 4-13 through 4-15
Running buffalo clover	1-5, 2-9, 3-80, 3-89, 3-93, 3-107, 3-108, 3-110, 3-112, 3-113, 3-116, 3-127, 3-128, 3-131
Scoping	1-1, 1-4, 1-5, 1-6, 2-1, 2-7, 3-126, A-1
Sediment	1-6, 2-2, 2-6, 2-8, 3-1 through 3-55, 3-66, 3-75, 3-77, 3-80, 3-81, 3-83 through 3-86, 3-114, 3-131
Shelterwood	2-4, 3-90, 3-92, 3-100, 3-106, 3-111
Smoke	3-59, 3-60, 3-61
Songbirds	3-88 through 3-92, 3-99, 3-100 3-101
Soils	1-2, 1-4, 2-2, 2-4, 2-5, 2-9, 3-1 through 3-55, 3-64 through 3-78, 3-80, 3-81, 3-85, 3-86, 3-87 3-92, 3-97, 3-104, 3-107, 3-109, 3-112, 3-113, 3-124, 3-127, 3-130, 3-131, 3-132
Threatened, endangered and sensitive species	1-4, 1-5, 1-6, 2-6, 2-7, 3-87, 3-89, 3-93, 3-94, 3-96, 3-112, 3-130, 3-133
Tree-of-heaven	1-5, 2-5, 3-98, 3-114, 3-116
Wildlife habitat	1-5, 2-1, 2-4, 2-7, 2-8, 3-14, 3-15, 3-46, 3-71, 3-72, 3-75, 3-81, 3-83 through 3-96, 3-99 through 3-102, 3-112, 3-119, 3-125, 3-131

Appendix A – Public Involvement

Summary of Scoping Comments

1) Comment: What is the purpose and need of including diameter-limit cutting in the research studies of silvicultural treatment?
   Response: Diameter limit cutting is the predominant form of harvesting on private land throughout the central Appalachians. Therefore we need to understand the effects of this harvesting practice over an extended period. By comparing diameter-limit cutting with true silvicultural treatments such as individual tree selection and clearcutting, we can compare and contrast the stand dynamics, diversity and productivity of the various treatments over the long-term.

2) Comment: Burning is bad for the air and can lead to health problems.
   Response: Prescribed fire is a legitimate management tool which must be evaluated in order to develop and improve the practice for a variety of goals. All possible precautions would be taken to minimize the effects of smoke from the proposed prescribed burns. We will obtain and use weather and smoke management forecasts. Burning will not be conducted during stagnant air conditions. All air pollution control regulations will be followed and the West Virginia Division of Forestry will use the burn permit only when favorable conditions for smoke management exist. Burning is not planned near any dwellings or populated areas. Mop-up will be aggressive adjacent to the FEF to avoid residual smoke from the fire and begin during the same burning period as the prescribed fire. Most of the burning will be conducted between 11:00 a.m. and 4:00 p.m. when smoke dispersion is likely to be most favorable. The planned estimates for smoke do not violate any state or Federal clean air regulations. This comment is further addressed in Section 3.2.

3) Comment: You should not use toxic chemicals such as pesticides and fertilizers that pollute the earth.
   Response: These chemicals would be used as experimental treatments, and applied according to existing federal and state guidelines. The amounts that would be used are sufficiently low that no toxic effects will be detected beyond the immediate treatment areas. This comment is addressed further in Section 3.1, 3.3, 3.9.

4) Comment: You need an updated citizen attitude poll (of activities other than logging).
   Response: This is an excellent suggestion for on-going research evaluating use of forest resources. However, this is beyond the scope of this analysis. Scientists involved in this form of research will be invited to consider conducting such research on the FEF.

5) Comment: I would advocate a strong research program be started on Elklick Run.
   Response: We have been monitoring water quality on Elklick Run for a number of years, and also have been participating in a long-term cooperative program monitoring trout population dynamics on a number of streams in the area, including Elklick Run. Some of these data are discussed in Section 3.5. There is also on-going

monitoring of sediment and channel characteristics at several locations along Elklick Run and those data were used in Section 3.1.

6) Comment: We support proposed fire research, and would like to know the specific history of fire regimes on the Fernow.
Response: We do not know the specific fire history of the Fernow Experimental Forest. However, research has shown that stand-wide disturbance intervals on the Fernow, such as those that might be caused by winter storm damage or more intense wild fires, occurred about every 30 years from 1728 to 1994. Historical documents from when the Fernow was established in 1934 refer to fire damaged areas of the Experimental Forest. Most likely the damage was caused by post-logging fires from the initial logging (circa 1905-1912). However, the Fernow was chosen as an Experimental Forest because it was representative of millions of acres throughout the central Appalachians. Since vegetative associations stabilized thousands of years ago, the region has experienced three different fire regimes. Periodic low-intensity fires characterized the first regime and it is believed that this period lasted until about the beginning of industrial logging activities. The second regime is associated with the logging practices of a century ago and is characterized by a brief period of high-intensity, often stand replacing, fire. The third regime begins about 1920 and extends to the present and is characterized by the absence of any fire use or fire as an ecological disturbance. During the first period of low-intensity fire, disturbance intervals from 10 to 15 years documented for eastern West Virginia, western Maryland, and southeastern Ohio are believed to be similar to the fire disturbance regime on parts of the Fernow. Of course, the cool and moist coves and riparian areas probably experienced fewer fires than the warmer and drier portions of the forest. The elevation gradient and variety of aspects and slope positions on the Fernow span much of the variability present throughout the central Appalachians, and fire histories on the Fernow likely vary according to the environmental characteristics of the site.

7) Comment: The proposal to control Japanese Stiltgrass on the Fernow should include a research component, to evaluate management activities have promoted invasions of the weed, and how management activities interact with site conditions.
Response: There is on-going long-term research on Japanese stiltgrass on the Fernow, which is evaluating site conditions and their role in the spread and survival of the plant. We are cooperating in this larger study, but at the moment do not anticipate initiating new research. We agree, however that there are many information gaps relative to invasive exotic plants.

Summary of Draft EIS Comments

This is a summary of the comments received as a result of the public comment period for the Draft EIS beginning April 9, 2010. The following organizations and individuals offered comments:

Don Gasper
U.S. Environmental Protection Agency, Region III
Jean Public
Barbara Breshock, West Virginia Division of Forestry
Monongahela National Forest

Many of the comments have been paraphrased. Following each comment is the Forest Service response. Copies of all comments are included in the project file. The project files also contain requests for additional information that have been supplied by the Forest Service and is not contained in this summary, as well as comments that do not require a response.

Don Gasper comments

1) Comment: What is the riparian protective strip width? Is it 100' on each side, is it 100' horizontally or upslope and shorter? Is your riparian standard the same as defined in the Monongahela National Forest plan?
   Response: Allowable streamside management and associated protections are described in Chapter 2. Riparian and streamside management for the FEF are not identical to that of the Monongahela National Forest. Applicable text from that chapter is presented:
   - 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 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.
   - Trees would not be cut from within the stream channel or off the stream banks. Logging equipment is restricted in this area except at designated stream crossing points.

2) Comment: I would like you to explain better "Sediment is source limited rather than energy limited", and why?
   Response: Most nonglacially-affected mountain streams with limited soil disturbances near the stream are considered sediment source-limited. This is because sediment exports (as suspended sediment or turbidity) typically reach their instantaneous maximum peak prior to peak streamflow during storm or snowmelt events. Even though streamflow, and thus stream energy, continues to increase for some additional amount of time, available sediment sources are limited, so that sediment levels in streamflow decline throughout the remaining the storm

hydrograph. Sediment source limited streams typically have clockwise hysteresis when sediment levels collected through the event are plotted against associated discharge. Energy limited systems are streams where sediment levels will continue throughout the event as long as stream discharge or energy continues to increase. In these situations, there are large amounts of available sediment in or near the stream, so sediment peaks at about the same time, or sometimes even after peakflow. Energy limited streams typically result in counterclockwise hysteresis. Sediment source-limited streams can transition to energy-limited, at least in the short term (usually months to a few years) if substantial near-stream disturbance occurs. Likewise an energy-limited stream can become a source-limited stream if the sources of available sediment eventually become depleted through natural recovery, reclamation, etc.

3) Comment: Page 3-04 "Fining" means filling?
Response: Fining means that the streambed is accumulating small particles and these are filling the spaces or interstices around larger particles. Channel embeddedness results when fining is substantial. There are physical effects from embeddedness, including reductions in channel roughness, and changes in channel form and hydraulics. Biological effects, such as loss of habitat diversity, reduction in spawning areas, and reduction in oxygen exchange between the bed and water column also can occur. This is clarified in the text.

4) Comment: At the end of page 3-10, the data you offer in sediment from roads, is not clear that you mean yearly values.
Response: These are the mean annual values calculated from 4 years of measurements, and is clarified in the text.

5) Comment: When you report fires seldom remove more than 50% of the forest floor – do you mean 50% of weight, depth, carbon, area?
Response: Generally, this is 50% of mass of the forest floor. Note that mass loss of the forest floor is a function of fire intensity, so it will vary spatially.

6) Comment: Are you not cutting any hickory or just not the shagbark?
Response: We would protect shagbark hickory because the exfoliating bark characteristics provide desirable day-roost characteristics for the Indiana bat. Bitternut hickory does not have similar exfoliating bark and is not a preferred day roost species for bats. References in the EIS about preserving hickory trees have been changed to express our desire to protect shagbark hickory, specifically.

7) Comment: Increased deposition at Bearden Knob – is it higher because of deposition from fog and other sources?
Response: Greater precipitation amounts at higher elevations have often been documented in mountains. From the Mountain Cloud Chemistry Program, we know that fog can contribute 2 to 4 times the precipitation of rainfall in the southern Appalachians (Mohnen 1992). While fog may contribute to the higher deposition at

Bearden Knob, we have not quantified the sources of inputs, but are measuring total amounts.

8) Comment: I would like to you quantify sediment sources even more, then ‘fix” problems (hanging culvert outfalls, black top road, etc.) and evaluate brook trout populations afterwards.
Response: This would be an interesting research problem, and this work is beyond the scope of this analysis. Research needs are addressed in other forums than EIS documentation.

9) Comment: I would like to see more brook trout work. Replace hatchery fish in Elklick with true native brook trout.
Response: We are continuing our participation in the Long-Term Trout Monitoring Study, conducted by Dr. Kyle Hartmann at WVU, in partnership with the Monongahela National Forest, West Virginia DNR, Northern Research Station. Replacing fish populations in Elklick is beyond the scope and purpose of this analysis.

10) Comment: The effects of air pollution and harvesting on long-term forest resources is important, and worthy of more study.
Response: We are continuing long-term research and monitoring of the effects of air pollution and harvesting on nutrient capitals. Our Long-Term Soil Productivity study has 2 study locations (one on the FEF) where we are working to address these questions over the long term. Research needs are addressed in other forums than EIS documentation.

11) Comment: Watershed liming might be worth studying.
Response: We have done some previous research on liming effects on soils on the Fernow. At the present we have no intention to conduct a whole watershed liming project, but agree that this would be worth studying. Research needs are addressed in other forums than EIS documentation, and are beyond the scope of this analysis.

12) Comment: Substrate quality is good; can you address sediment movement? What is the fate of mobile sediment?
Response: I assume this comment refers to sediment mobility within the channel rather than on the hillside, prior to entry into a water body. Sediment movement is discussed to some degree in relation to the individual subdrainages and receiving waters downstream. It is not possible to quantify sediment mobility precisely due to the lack of studies on this subject in the FEF and also because sediment sinks are transitory, with flushing events occurring erratically. From other studies in the US (both western and eastern), a substantial portion of mobile sediment is stored in channels for decades or longer, as documented in the literature review section of Chapter 3.1. Within-channel storage occurs within and behind roughness structures (e.g., large wood, debris jams, small to large size boulders), within pools, and in interstitial voids causing embeddedness.

In the moderate to long-term, storage and fate of sediment delivered to Elklick Run is a predominately controlled by the old Parsons Reservoir. Most mobile sediment upstream of the dam eventually becomes deposited behind the dam wall, and will remain there until manually removed, the reservoir effectively fills with sediment (residual sediment will remain, but new sediment will remain largely entrained in the water column), or the dam wall fails.

As described in the EIS, particularly the cumulative effects section, the lack of mobile sediment below the dam results in hungry water (or water with substantial ability to erode), which has created long sections of the bedrock substrate in the channel below the dam. The combination of continued hungry water and extensive lengths of bedrock streambed in Elklick Run means that much of the sediment entering Elklick Run below the dam has limited potential to be stored in Elklick and instead is carried downstream and delivered to the Black Fork River.

13) Comment: I think the 2 most effective monitoring tools you can develop is the fines and bottom composition and stream channel width.
Response: Various tools or techniques for monitoring fines and bottom composition and stream channel width (presumably you mean bankfull width) already exist. There are many techniques available for quantifying these metrics. To-date, EIS monitoring has involved measuring channel cross-sections, which include channel width measurements, and Wolman pebble counts and riffle stability measurements as ways to examine stream substrate. The results of some of this monitoring are presented in the Affected Environment section of Chapter 3.1.

14) Comment: What of subterranean piping and scour as the original source of sediment?
Response: Five factors are needed for substantive piping to occur: there must be a source of water; the permeability rate of some layer of soil must be less than the surface infiltration rate; an erodible subsurface soil layer must exist, water above the impermeable layer must have a hydraulic gradient; and an outlet for emergent flow to the surface must exist (Fletcher et al. 1954). Except for in soils with high levels of exchangeable sodium (e.g., dry climates) (Heede 1971), the erodible overlying soil layer is typically dependent on soils which have a high degree of expandable (2:1) clays, especially montmorillonite clays (Parker 1964). When water moves through the 2:1 clays as a result of the existing hydraulic gradient that is present, soil dispersion occurs, thereby allowing erosion and pipe formation (Jones 1987). Biotic factors, such as root decay and animal burrows are less important to true soil pipe formation than the physical factors (Jones 1971, 1981). Most pipe development due to land management has been documented in dry lands (Albright 1991), especially in overgrazed areas (Brown 1962) where reductions in vegetation have resulted in surface soil drying during warm periods and increased overland flow during wet periods (Parker 1964). By contrast, many land management activities in humid climates reduce connectivity of pipes, thereby reducing the number and length of connected pipes (Albright 1991). Where erosion from soil pipe formation is substantial, it becomes visibly evident by collapse or subsidence of the soil pipe, followed by gully development or the extension or initiation of surface channels (Jones 1971, 1981, 1987, Rubey 1967). In a rare study to quantify erosion from soil

pipes, Jones (1987) estimated up to 15% of a Welsh stream's annual sediment load came from soil pipes. We do not dispute that some portion of the annual sediment load to streams in the Fernow comes from soil pipes, but the soil conditions present on the Fernow are not particularly conducive or evidentiary of substantial soil pipe erosion. Montmorillonite and other 2:1 clays do not exist in the area, and the soils overall are not dominated by clays or restrictive clay layers. There also is no surface evidence of pipe subsidence or gully formation, which have been documented elsewhere in the world where piping is important (e.g., Jones 1987). There is some evidence of channel extension in some individual watersheds, but these extensions appear to have been the result of surface erosion (e.g., channel head cutting or erosion below culvert outlets, etc.) rather than subsurface erosion processes. Therefore, while some subsurface piping contributes to annual sediment loads exported from these watersheds, it is probably a small percentage of the total annual sediment budget.

15) Comment: I disagree with your conclusions that erosion will be minimal or non-existent.
Response: The analyses for the compartments and subdrainages were based on: analyses of current conditions and expected amounts of soil disturbance, proximity of those disturbances to water bodies and expected potential for sediment delivery, potential for increased runoff based on percentages of basal area to be removed within the watershed, and channel conditions (including numbers and types of stream crossings that would be used). Erosion and sediment delivery were projected for some compartments or watersheds, while for others the effects were expected to be negligible; conclusions were area-specific, based on local conditions and proposed treatments, and the information used to develop those conclusions are detailed for each in Chapter 3.1.

16) Comment: On page 3-15 you note "no channels within the sub-basin". You are wrong to ignore the underground piping drainage system.
Response: In the scientific literature, subsurface soil pipes are not considered channels. They are referred to as pipes to distinguish them from surface channels. By scientific convention, the term channel generally refers to surface features. We retain this convention in this EIS.

17) Comment: I'm not sure why you think oak regeneration is at risk. If we have a warming trend and more violent winds to accelerate treefall –creating gaps that cause them to be preserved (gaps) in the original forest.
Response: Many studies across the eastern and mid-western forests have documented the decline in oak species dominance and proposed that the reduction in fire in these forests is a cause (Nowacki and Abrams 2008, Lorimer 2001, Lorimer 1989, Lorimer 1985). Old-growth forests show little to no recruitment of oak into the canopy around the time of organized fire control or exclusion of fire (Abrams et al. 1995). While acorns still germinate and many small oak seedlings can be found in the understory, few oak saplings are found that can compete with shade-tolerant and fire-intolerant species. There is also a documented increase in red maple throughout the eastern hardwood forests (Fei and Steiner 2007). While global climate change may increase

suitability of sites for oaks in some areas (Prasad et al. 2007) there is uncertainty associated with those predictions in space and time. Our research into the role of fire and overstory removal on the competitiveness of oak regeneration is still needed to manage current oak forests in the near-term. Also, fire appears to benefit oak regeneration and place oak seedlings/saplings in a better position to capture gaps created by any mechanism. With management to increase the competitiveness of oaks regeneration, oak-dominated forests should be more resilient to future climate changes.

18) Comment: I mentioned before that the FEF was picked as a research station because it was then thought to be typical. It is however, much more favorable and trouble-free.
Response: Northern red oak site indices on the FEF range from the high 50s to the low 80s and this is typical and representative of the Allegheny Mountains of the Central Appalachians. The potential natural vegetation of the Fernow is strongly influenced by elevation and aspect and includes northern hardwoods, mixed mesophytic, and oak communities, representing a wide range of ecological conditions as described in Section 3.9. There are other ecological conditions present in the region not represented by the FEF such as the high elevation spruce forests and the more xeric Ridge and Valley section. To compensate for this omission, we work collaboratively with others on issues that are specific to those forest types.

It is our mission to address important forest management problems and to provide information to managers and to the public alike to solve these problems, but we do not agree that the FEF is more favorable and trouble-free. The Fernow was exploitively logged a century ago just like the rest of the region, has been impacted by invasive species such as gypsy moth and Japanese stilt grass, has been impacted by atmospheric deposition of pollutants, is on the cusp of being impacted by white nose syndrome, has been repeatedly harvested in some areas intentionally to better understand the impacts of multiple timber harvests, and recently was subjected to activities related to natural gas development. All of these activities are typical of the region. However, because we do practice good forest stewardship and perhaps because not all areas are experimentally manipulated, many visitors are impressed by the aesthetic characteristics of the area, perhaps suggesting that the Fernow is more trouble free than other areas. Further analysis is beyond the scope of this project.

19) Comment: The current trend of further disturbance and destabilization must stop. Don't you think you should be studying "recovery" now that the Chief's Office is re-emphasizing it?
Response: At the FEF, we are dedicated to continuing important long-term research studies to understand the effects over time, as well as initiating new studies when possible. Many of the studies described within the EIS are unique because of their longevity and the consistency of treatment. We are just beginning to understand the changes in ecosystem processes, above and below ground, from these long-term studies. To meet the Purpose and Need for this analysis, we must continue these long-term activities. We are interested in recovery of ecosystems, both changes over time in our reference areas, and from discrete disturbances. Indeed, we are studying

recovery from disturbance in a number of studies, and evaluating them over time. Also, research needs are addressed in other forums than EIS documentation.

20) Comment: You have often noted cumulative effects and generally claimed none. I would say they are great everywhere and greatly limit responsible logging – perhaps even experiments.
Response: It is our mission to better understand the cumulative effects of forest disturbances such as chronic nitrogen deposition, various forms of repeated timber harvesting, multiple prescribed fires, and the effects of climate change. We do not harvest timber to achieve one aspect of responsible multiple-use management; we harvest timber to better understand the impacts of this form of disturbance. Continuing with the Proposed Action will enable scientists to better gauge the cumulative impacts of a range of disturbances, both chronic and episodic, planned and unplanned, that commonly occur on both public and private lands, and develop mitigation strategies, if needed.

21) Comment: We should set a critical aquatic load at pH 4.2 without delay to protect our resources (from acidic deposition).
Response: Establishing critical loads is a policy and regulatory decision and not one that Forest Service scientists can make. We have provided results of our long-term acidic deposition research to many other scientists, to state and federal regulatory agencies, and to a variety of interested publics. Making policy recommendations is beyond the scope of this analysis.

Comments from EPA – Region III

22) Comment: Better explanation of Purpose and Need in chapter 1 – does not provide a clear statement of what is needed.
Response: Several sentences have been added to Chapter 1 to more clearly identify the needs associated with this analysis. Specifically, we need to conduct experimental manipulations in order to continue on-going long-term research studies, and we need to manage the Fernow for long-term research, which requires maintenance of roads and structures, control of nonnative invasive species, and other management activities. The proposed activities will address the needs.

23) Comment: In Chapter 2, additional information should be provided describing the span of these projects, how the data is used, and where it is presented, if there were conclusions to these studies, if there are ever modifications, and how that is determined. We suggest adaptive management techniques be considered.
Response: Data from the FEF are used in the preparation of peer reviewed scientific journal articles and other technical publications such as Station research papers. Data from the FEF are also presented and synthesized at scientific conferences, used in oral presentations at meetings for natural resource professionals and other professionals, and increasingly used in meta-analyses with data from other research locations around the world. A listing of some of our publications can be found at http://www.nrs.fs.fed.us/units/appalachian/pubs/?pageno=1. We also have additional

information about our research focus at http://www.nrs.fs.fed.us/units/appalachian/. In addition to formal outlets, we also present the results of our work during field tours of the FEF for a variety of groups. In many cases, the results are presented first hand by the scientists that did or are doing the research. We strive to maintain the integrity of the original study design by not altering it, but in some cases modifications are necessary. When we do make changes, we document such changes 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 controlling invasive species, maintaining the road and skid trail system, and restoration activities following unplanned disturbances such as natural gas development.

24) Comment: Chapter 3 – Other methods to define stream types, such as benthic macroinvertebrate populations, should be considered.
Response: There are many ways to define stream types. The convention of defining them in terms of nonperennial or perennial within this EIS is employed because the effects in Chapter 3.1 are described from the perspective of physical factors and conditions; however, distinguishing between nonperennial and perennial channels does not suggest that perennial channels are considered more important, hydrologically or otherwise, than nonperennial streams. Different descriptions of stream types involving biologic populations could be considered, but at this time are beyond the scope of this analysis.

25) Comment: It is unclear if the downstream extent of project-related impacts is monitored, and whether these studies are impacting macroinvertebrate and fish populations in the project vicinity and downstream.
Response: On the gauged watersheds, project-related impacts upon hydrology and water quality are directly and routinely monitored, and a significant database covering many years has been developed. Elklick Run is one of the streams that is part of a regional Long-Term Trout Monitoring Project. This study has monitored fish populations and macroinvertebrate abundance over the last 6 years and will continue into the future. This monitoring is stream specific. The headwater streams which are gauged are generally too small to support fish populations.

26) Comment: We recommend that the Forest Service work with the US Fish and Wildlife Service and other agencies regarding state and federal listed species. Coordination letters should be provided in the EIS.
Response: Informal consultation with the U.S. Fish and Wildlife Service (FWS) was initiated in October 2009. A Biological Assessment has been prepared by NRS-01 wildlife staff, based on best available scientific information and provided to the FWS. Formal consultation with the FWS was initiated on May 21, 2010, regarding impacts on Indiana bat and running buffalo clover. A Biological Opinion from the FWS has been delivered, concurring with our findings and providing an Incidental Take Statement for both running buffalo clover and Indiana bat. Biologists with the West

Virginia Division of Natural Resources received copies of the draft EIS, however no comments were received from this agency.

27) Comment: Details of stream monitoring should be provided as well as steps taken if the monitoring indicates there are issues that need to be addressed.
Response: Over the past 10 years, annual monitoring for physical parameters has focused primarily on channel cross section measurements and Wolman pebble counts in conjunction with riffle stability measurements. The cross section measurements have been made at "permanent" locations within several streams on the FEF, as well as "floating" locations that are coincident with treatments applied within the 5-year EIS cycle. Likewise Wolman pebble counts also have involved "permanent" and "floating" locations, though most have been performed in perennial streams. Riffle stability indices typically have been calculated only for middle and lower Elklick Run, as channel bar formation (which occurs only in the larger streams) is a requisite for the calculation. Similar monitoring for physically-based characteristics is expected for the next 5 years. We continue to monitor water quality on the gauged watersheds and at the mouth of Elklick, based on weekly samples. Data are evaluated on a recurring basis, and if unexpected problems occur, they are investigated as soon as they are discovered, and addressed. Also there are NRS-01 personnel on the FEF on a regular basis (almost daily), and they are aware of the need to watch the stream for signs of significant changes (turbidity, appearance of dead fish, etc.), so that problems that arise would be dealt with quickly.

Jean Public comments

28) Comment: Ban all logging.
Response: The Purpose and Need section of the EIS (Chapter 1) describes the need for the proposed logging activities. Any logging on the Fernow is done to meet the Purpose and Need, and is limited to research logging. Also, the "No-Action" alternative was considered in the analysis for this EIS. We have no control over logging on other lands and ownerships. Further development of this issue is outside the scope of this analysis.

29) Comment: Prescribed burning releases mercury, and … "pollutes the air with fine particulate matter which travels thousands of miles poisoning fellow americans, babies and senior citizens".
Response: While prescribed fire can release mercury to streams and other bodies of surface water, the low intensity of fire utilized in these studies, and the relatively low combustion of organic matter in the soil suggests the effects are likely to negligible. Also, as described in Chapter 3.2, the results of this analysis show that prescribed fire emissions, including fine particulates, from the FEF in any given year would be very small in comparison with total regional emissions.

30) Comment: Stop the toxic chemicals… These toxic chemicals have not been properly evaluated and are adding to the 300 toxic chemicals that americans carry around in their bodies.

Response: Herbicides would only be used for the control of invasive plants, primarily Japanese stiltgrass and Tree-of-heaven. Tree-of-heaven is not common on the FEF so a control program would consist of locating isolated stems and injecting them with a glyphosate-based product (see Section for 3.9 for more details). All herbicides would be applied under the supervision of a Certified Public Applicator as sanctioned by the State of West Virginia and the USDA Forest Service. All label instructions would be strictly followed, and only herbicides which have been evaluated by EPA would be used. Hand pulling of extensive areas of Japanese stiltgrass is impractical and ineffective because of the seedbank characteristics of the species. A tree-of-heaven stem cannot just be cut because it will sprout profusely after cutting. Limited and highly targeted use of herbicides is the only practical means of controlling these invasive species on the FEF

31) Comment: We want natural areas left natural.
Response: The FEF, like most of West Virginia, was heavily logged in the 1910's. The FEF was established in 1934 with silvicultural research, including timber harvest, beginning in 1948. In this context, it is hard to define what is meant by natural; there is no true old-growth forest on the FEF. There are areas on the forest that are designated as biological controls or reference watersheds where no timber harvest, road construction, or treatments such as prescribed fire is planned. These areas are discussed in the EIS and these areas serve as future old-growth forests and could be considered natural areas that will continue to be unmanaged.

Monongahela National Forest

32) Comment: The DEIS suggests that the gas pipeline construction activity was the source of Japanese stiltgrass in that area. We disagree, and suggest adding verbiage to describe the measures taken to prevent or reduce the potential for spread of nonnative invasive species.
Response: The text accurately states that Japanese stiltgrass has been observed in some locations along the pipeline. However, the sentence has been revised to make it more obvious that this is just one location where stiltgrass exists on the FEF. Additional verbiage relative to pipeline installation is beyond the scope of this analysis.