Chapter 3 – Affected Environment and Environmental Consequences

This chapter provides information about the existing environment of the FEF, and the potential consequences to that environment. It also represents the summary of scientific and analytic basis for the comparison of alternatives presented in chapter 2. Each resource potentially affected by the Proposed Action or Alternatives is described by its current condition and uses.

Following each resource description is a discussion of the potential effects (environmental consequences) to the resource associated with the implementation of each alternative. All significant or potentially significant effects, including direct, indirect and cumulative effects, are disclosed. Effects are quantified wherever possible, and qualitative discussions are also included. The means by which potential adverse effects would be reduced or mitigated are described.

Environmental consequences are the effects of implementing an alternative on the physical, biological, social and economic environment. The CEQ regulations implementing NEPA include a number of specific categories to use for the analysis of environmental consequences. Several are applicable to the analysis of the proposed project and alternatives and form the basis for much of the analysis that follows, and are explained briefly here.

Direct, Indirect and Cumulative Effects

Direct environmental effects are those occurring at the same time and place as the initial cause or action. Indirect effects are those that occur later in time or are spatially removed from the activity but would be significant in the foreseeable future. Cumulative effects result from the incremental effects of actions, when added to other past, present and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions. Cumulative effects can result from individually minor, but collectively significant actions taking place over a period of time.

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 occur (Fig. 3-1). In terms of the areas proposed for treatment in the alternatives, Upper Elklick subdrainage contains all of compartments/subcompartments 13, 17A, 19A, 21, and 26, and 18.7 acres of subcompartment 20A, 18.0 acres of subcompartment 20B, and 9.9 acres of subcompartment 20C. Camp Hollow subdrainage contains all of watersheds 3 and 5. John B. Hollow subdrainage contains 238.4 acres of compartment 45. Side Hill subdrainage contains 75.5 acres of compartment 45. Big Spring Run subdrainage contains all of subcompartments 8B, 8C, and 8D. Hickman Slide Run subdrainage contains all of subcompartments 5B and 7A and 7B. Stonelick subdrainage contains all

of compartment 61 and 8.8 acres of R1. Canoe Run subdrainage contains 6.5 acres of subcompartment 20A, 7.3 acres of subcompartment 20B, and 17.8 acres of subcompartment 20C. Sugarcamp Run subdrainage contains 65.8 acres of compartment R1. Fire Run subdrainage contains 2.5 acres of compartment R1. Side Hill subdrainage is a previously unnamed subdrainage that has been named for this EIS.

The Sugarcamp Run, Canoe Run, Stonelick Run, and Fire Run subdrainages are located in the larger Shaver's Fork watershed. All other subdrainages are in the Elklick Run watershed. Cumulative effects are described in terms of the Shaver's Fork and Elklick Run, and Black Fork watersheds.

Based on on-the-ground geologic mapping of the FEF, these 10 subdrainages contain 7 bedrock geologic formations (Figure 3-2): Chemung, Pocono, Mauch Chunk, Hampshire, Greenbrier, Allegheny, and Pottsville (Taylor and Kite 1998).

Soil series delineation was determined using county soil survey information (Losche and Beverage 1967). The major soil series mapped for the FEF are Belmont, Cateache, Shouns, Calvin, Dekalb, Ernest, Gilpin, and Meckesville. In general, Belmont, Cateache, Shouns, Ernest, and Meckesville have high erodibility, Dekalb has low erodibility, and Gilpin and Calvin soils have moderate erodibility. 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, Sugarcamp Run, and Fire 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 depending upon local water table conditions. Consequently, for purposes here, channel type definition was done based on visual channel condition combined with field experience. From this, perennial channel length for the Elklick Run watershed is estimated to be 10.25 miles, and nonperennial channel length is approximately 24.30 miles. Perennial channel length in the Shaver's Fork watershed subdrainages included in these analyses is approximately 4.43 miles. Nonperennial channel length in those subdrainages of the Shaver's Fork watershed is approximately 10.26 miles.

The majority of the known hydrologic information for the FEF comes from gauged watersheds located on Hampshire geology and primarily Calvin soils. It 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 conditions occur about 70-75 % of the time throughout Elklick. 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 occurs the remaining 25-30 % 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 % of the largest storms and 60 % of the largest stormflows 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. Research throughout the eastern United States has shown that forest operations do not affect flooding (Hornbeck et al. 1997; Lu 1994).

Stream water throughout the FEF is generally clear during baseflow periods. Turbidity increases during stormflows occur but vary greatly among sites. Some streams experience little turbidity increases during all but the most intense or largest storms. Others may experience turbidity increases during smaller less intense stormflow. Maximum measured stormflow turbidity level from the control watershed located on Hampshire geology on the Fernow was 15 ppm (Reinhart and Eschner 1962) compared to maximums of 25 and 210 ppm for watersheds that were harvested and employed BMPs, (though all of these figures probably are biased low because intensive stormflow sampling was not included in Reinhart and Eschner's work). Maximum turbidity levels found from intensive stormflow sampling regimes for other nearby (i.e., off of the FEF) similar nonharvested watersheds were in the range of 0-328 NTUs (unpublished data), and 0-720 NTUs for harvested watersheds (unpublished data). Stormflow turbidities have not been measured by local research staff for subdrainages within the highly erodible soils. However, visual observation of stream discharge during storm events from some of these more sensitive areas suggests flow more turbid than those less erodible soils for a given storm. Whether this effect is due to natural soil sensitivity or past land use or a combination of both is not known.

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 limited rather than energy limited. As such, sources of available sediment both from the hillside and within channel are exploited during the rising limb of a storm; 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 the past 5 years (monitoring done in conjunction with the 2000 EIS for the FEF). These measurements have shown that Elklick Run is an unstable, aggrading stream -- it is retaining more sediment than it is transporting, and pools and riffles are becoming less distinct. The substantial lengths of bedrock streambed in Elklick Run may aggravate problems associated with sediment accumulation, because sediment deposition is limited to and concentrated in nonbedrock reaches.

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

Effects

Harvesting and road construction can alter streamflow. Studies throughout the East confirm this finding. The most consistent finding across all of these types of studies 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. Streamflow increases become measurable when about 23-25 % of the basal area within a watershed is harvested (Reinhart and Trimble 1962; Hornbeck et al. 1993). However, most streamflow augmentation occurs during the growing season and during baseflow.

Bates (2000) provided the most thorough analysis to-date 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, Bates 2000). As has been reported in other locations in the United States (e.g., Lake States) (Verry et al. 1983), snowmelt sometimes occurred earlier and resulted in earlier peaks in clearcuts.

Hydrographic responses to periods of intense rainfall also changed after harvesting on a watershed that was clearcut to 1-inch dbh but employed 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).

Analysis of flow duration curves also suggests that clearcutting augments low flows for a longer period than water yields are increased (Bates 2000). The greatest change in flow durations occurred for the lowest flows. Low flow augmentation is beneficial to aquatic biota (Patric 1976b).

Changes to peakflows due to forest harvesting and related activities (e.g., road construction) are not universal. 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). 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, Hornbeck et al. 1993, and Edwards and Wood 1994). Watersheds on the FEF do not tend to show peakflow increases after harvesting, including clearcutting (Bates 2000). However, on basins larger than 5000 acres, 25 % cutting of the vegetation using partial cuts resulted in a 66 % increase in annual daily maximum discharge (Burton 1997).

Stream sedimentation risks increase as the levels of litter and soil disturbance and soil compaction increase. Sediment transport to streams above natural climate-driven levels is eliminated or largely controlled by compacting as little soil area as possible and by keeping those compacted areas as far from stream channels as possible. Sediment transport from hillsides to streams is almost entirely a surface phenomenon attained by sheet flow, interrill transport, or gully transport. These sediment transport processes occur predominantly due to soil disturbance. Consequently, by maintaining and protecting the high natural infiltration rates of forest soils (Patric 1977), the opportunity for precipitation to infiltrate the soil immediately or deposit any sediment it may be transporting before it reaches a channel is maximized.

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, since both can provide sediment sources that can reach 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 ungravelled road surface. Roads with limestone gravel had levels 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 this sediment actually reaches the stream.

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 3 forested watersheds. The reservoir is at the mouth of an intensively managed 1600-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 compared to 33 lb/acre from an undisturbed watershed, 166 lb/acre from a watershed which was partially harvested 10 years earlier, and 253 lb/acre on a watershed that had been a mountain farm 50 years earlier. They also reported that 87 and 96 % of the sediment was exported during stormflows, for the latter two watersheds.

Controlled burning, or prescribed fires, has little effect on erosion and sedimentation because the fires are not hot enough to burn all of the forest floor and humus material present. Swift et al. (1993) captured insignificant levels of mineral material in sediment traps following a burn. Approximately 30 % 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.

Channel morphology and stability are controlled by channel maintenance flows. Channel maintenance flows in gravel and cobble bottom streams are bankfull or near-bankfull flows (Dury 1969, Dunne and Leopold 1978). 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 morphology.

Bankfull stage occurs in the eastern United States about 2-3 days per year for perennial channels. Because bankfull is a concept developed for perennial channels, the level of flow needed for maintenance of nonperennial channels is not known. Likely the concept of bankfull (analogous to that for perennials) is applicable to intermittent channels since they have water tables above their streambed bottom for at least part of the year. Initial analyses of multiple pieces of data collected at the Fernow 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. However, some studies have shown changes in morphology due to forest harvesting. In Minnesota, clearcutting an aspen stand increased bankfull flow volume by 150 % even though 25- to 100-year flood flows did not change. This bankfull increase widened the bankfull width (Lu 1994). Also, data from the north central states 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). Head-cutting, which results in upslope channel extension, may be due to activities such as: down-cutting by downstream channels, straightening channels, 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 % of the basin area to protect against streamflow changes that could alter channel morphology (Harr et al. 1975; Verry 2000).

Although there are many components of channel morphology that are measured to determine stream stability, bankfull width is the most easily measured and most consistent diagnostic parameter 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).

Bankfull width was measured at transects demarcating 70 acre watersheds on 3 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 with no watershed BMPs, channel widening was attributed to the extensive and poorly planned skidroad 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 due 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 2 harvested watersheds were 1.7 and 1.3 times greater than the control watershed, indicating headcutting. Where no BMPs were employed, the channel network was extended up to almost the catchment ridge top.

Local channel geometry has been measured in the channel in watershed 2 (Camp Hollow Run subdrainage in FEF), Camp Hollow Run (upper, middle, and lower reaches), and Elklick Run (upper, middle, and lower reaches) for the past 3-5 years. The cross section measurements have been stable over this short period, except for one pool in middle Elklick Run in which the log jam that formed the plunge pool washed out during a high flow. As a result, the pool no longer is present and the channel in that segment has filled in and reverted to a riffle.

Vegetated riparian zones not only protect streams from sedimentation, but they 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).

Direct and Indirect Effects of Alternative B: Proposed Action

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

Silvicultural research projects are proposed for ten subdrainages. 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 (Chapter 4). Complete text descriptions of the proposed treatments are detailed in the "Compartment Details and Analysis" document, on file at the Timber and Watershed Laboratory.

Crown closures for riparian shading are greater than those stated in the 1986 Monongahela National Forest Plan (in effect at the time this document was prepared). At least 60 % crown closure would be retained along all nonperennial channels and 75 % crown closure would be retained along all perennial channels. Consequently, stream shading would be provided at an adequate level within each compartment in all alternatives, therefore stream shading and temperature are not discussed further in this document.

A study involving prescribed fire and herbicide treatments is included in the proposed actions for Alternatives B and C. 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 totaling 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 negatively affect stream sedimentation. 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. Controlling water and soil movement on skid roads after they are closed with water bars and dips, and on decks with liming and seeding similarly would help reduce in-stream sedimentation. Matching harvesting equipment and methods to the site conditions will 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 bufferstrips and maintaining trees on the streambank and in channels, 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 in size. There are no haul roads in the subdrainage, but the lower boundary of Side Hill subdrainage is Forest Road 701. There are 0.69 miles of skid roads in the subdrainage, which occupy 1.31 % of the subdrainage area. There are no perennial or nonperennial streams in the subdrainage, but since the ditch lines of Forest Road 701 contribute directly into perennial Elklick Run any runoff or sediment contributions from Side Hill drainage that reach the ditch line are delivered into that adjacent 0.53 miles of Elklick Run.

Compartment 45 occupies 75.5 acres, or 91 %, of Side Hill subdrainage. All of compartment 45 is upslope of Forest Road 701 and it is composed of Hampshire geology overlain by Calvin soil, which is moderately erodible. In Alternative B, 44.2 acres of compartment 45 in the Side Hill subdrainage would be subjected to prescribed fire and herbiciding of individual trees.

Prescribed burning in Side Hill subdrainage would not change soil moisture substantially because burning would be relatively light in intensity and would be done either prior to leaf out or after leaf fall when hardwood vegetation is not transpiring. Herbiciding in the 44.2 acres to be treated could reduce the transpiring overstory basal area by as much as 50-75 %. However, no stream channel exists in the section of compartment 45 in the Side Hill subdrainage, so in-channel erosion and channel extension by erosion would not increase. Furthermore, any excess soil moisture resulting from herbiciding (from reducing the available transpirational demands) would move as subsurface flow to the ditchline along Forest Road 701 and enter Elklick Run through a cross drain culvert, or would exist as even deeper soil moisture and enter Elklick Run directly or enter a deeper groundwater table. In either case, the increased water yield would not be sufficient to result in substantial streamflow increases in Elklick Run or changes to channel morphology in Elklick Run, as the area treated would be less than 1.8 % of the Lower Elklick subdrainage (the area contributing to Elklick Run below Camp Hollow Run).

There is no direct or close connection between any stream channel and the skid road or proposed fire breaks in compartment 45 in Side Hill subdrainage. However, reblading the current skid road and creating an additional 0.31 miles of skid road with a bulldozer will expose soil and create a potential for erosion. The 100-feet wide buffer between Elklick Run and the treated area will help to alleviate sediment delivery to Elklick Run. Forest Road 701 is located between Elklick Run and the treated area. Sediment inputs into Elklick Run from Forest Road 701 are considered to be much greater and more chronic than any inputs that would occur from firebreak construction in this portion of the compartment. Elklick Run suffers from high sediment loads and accumulations of fine sediment, as determined by Wolman pebble counts and riffle stability index values from monitoring in upper, middle, and lower Elklick Run during the past 5 years. Lower Elklick would be less susceptible to any additions of sediment from compartment 45 skid roads than upper reaches, because Lower Elklick has long lengths of bedrock channel bottom that tend not to accumulate and store much fine sediment.

Prescribed burning would burn the litter layer but would be done under conditions that would not result in a fire hot enough to destroy the humus layer. As a result, soil exposure would be extremely limited if it occurred at all, thereby limiting it to small discrete sources from which transport would be expected to be very short distances. The prescribed burn would not be expected to contribute a measurable amount of sediment to Elklick Run, and natural restoration of the litter layer within a year or less would assure that any erosion increases would be short-lived.

John B. Hollow Subdrainage

John B. Hollow subdrainage is 398.9 acres. It has 1.33 miles of perennial stream channel length and 2.28 miles of nonperennial channels. Within John B. Hollow subdrainage, there are 2.68 miles of haul roads, and a single skid road that is 0.27 miles long. 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.

Compartment 45 comprises approximately 60 % (238.4 acres) of John B. Hollow subdrainage. The treatment proposed for compartment 45 is a prescribed fire and overstory herbicide treatment. Slightly less than one-half of the area of compartment 45 (107.9 ac) would be subjected to prescribed fire and herbiciding of overstory trees. The treated area would cover about 27 % of John B. Hollow subdrainage, primarily in the lower two-thirds of the subdrainage. The prescribed burn would be light and the herbicide treatments would kill as much as 50-75 % of the overstory basal area.

The existing haul road and skid road sections in compartment 45 would be employed as fires breaks. An additional maximum of 2.04 miles of proposed skid roads would be constructed to be used as fire breaks in compartment 45. The total area in roads in John B. Hollow subdrainage would be 10.14 acres or 2.54 % of the subdrainage area.

Seventy 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 1.25 miles of nonperennial streams.

Although there would be a 100-feet or wider buffer between treatment areas and perennial reaches and a 50-feet or wider buffer between the treatment areas and nonperennial reaches, several of the proposed sections of fire breaks/skid roads would parallel the stream channels. Some also would run perpendicular to the contour.

The fire breaks could be the most problematic activity with respect to sediment availability and delivery in the proposed study. Construction of these fire breaks by blading with a bulldozer could create a source of disturbed soil that has the potential to contribute sediment to stream channels. However, water bars would be installed at least every 100 feet to help control runoff and erosion from the skid roads. The buffer strip also would help to filter out eroded sediment before it enters a stream channel. Soils in

the area are only moderately erodible, but because fire breaks would not be seeded or mulched, the presence of exposed soil would potentially provide a source of sediment for in-stream sedimentation until naturally re-vegetated and fully covered by a complete layer of litter and humus. More than one year of leaf fall will be required for this condition to become established. However, unlike actual skid roads, these fire breaks would not be used for vehicular travel after construction, which would leave them less compacted and provide conditions more conducive to natural re-vegetation, especially initially by herbaceous plants. Thus, sediment availability would be expected to decrease noticeably over several years.

The prescribed fire proposed for compartment 45 would be light, with the majority of burned material being the litter layer; the humus layer would stay intact. Consequently, soil exposure would be extremely limited, thereby limiting erosion from the burn to small discrete sources from which transport would be expected to be very short distances. The prescribed burn would not be expected to contribute a measurable amount of sediment to the stream in John B. Hollow, and natural restoration of the litter layer within a year or less would assure that any erosion increases are short-lived. Because an extremely small portion of the evapotranspiring surfaces would be killed, no substantial reductions in evapotranspiration or increases in soil moisture are expected that would change streamflow regimes and/or in channel erosion processes or budgets.

The total basal area of John B. Hollow subdrainage or compartment 45 is not known, but since the proposed treatment area occupies 27 % of the subdrainage if one makes the assumption that the basal area in the subdrainage is distributed evenly across the watershed, then killing 50-75 % of the compartment's basal area would translate to affecting about 13 to 20 % of the basal area in John B. Hollow. This value is less than the 25 % reduction in basal area that is required to induce a measurable increase in water yields. Consequently, the herbicide treatment would not affect hydrology or resulting erosional processes measurably.

The additive effects of herbiciding, fire, and fire break construction might have a combined effect of altering hydrology sufficiently to increase annual streamflow totals in John B. Hollow slightly, but measurably for only a short period of time – probably for 2-3 years maximum. The change would not be large enough to change in-channel erosion, since the total increase would be quite small and would be confined primarily, if not exclusively to the growing season.

Stonelick Run Subdrainage

Stonelick Run subdrainage is 620.1 acres in size. It holds 2.93 miles of haul roads that comprise 7.10 acres of area, all of which run along the ridge tops in the subdrainage. Nine decks totaling 0.85 acres are present along the haul road. There are 4.82 miles of skid road in Stonelick Run subdrainage, which is confined to the upland areas in the northeastern portion of the subdrainage. A total of 2.51 % of the subdrainage is occupied by haul roads, skid roads, and decks, and no new roads or decks are proposed.

Perennial stream length in Stonelick Run subdrainage is 1.53 miles, which occurs only on the main channel. All of the 4.88 miles of side channel tributaries are nonperennial and occur in the head of the subdrainage.

There are two compartments within Stonelick Run subdrainage proposed for treatment in Alternative B. In compartment R1 a prescribed fire with a shelterwood harvest is proposed. In compartment 61 a 3% financial maturity harvest is proposed. Both compartments are in the uplands on opposite slopes.

Compartment R1 occupies 8.8 acres of ridge top in Stonelick Run subdrainage, or 1.4 % of the area. Approximately 50 % of the basal area would be harvested from compartment R1.

There is a haul road the lies just downslope from the lower boundary of compartment R1 but it is outside the compartment. One deck is located in compartment R1 at the end of this haul road. Additionally, there is a 0.1-mile-long skid road running from the ridge top to this haul road in approximately the middle of the compartment.

No stream channels occur in compartment R1, and no tributaries come close to the compartment. Moderately-erodible Calvin soil overlays Hampshire geology.

Even though soil disturbance would exist from re-opening skid roads and decks, these features are high on the ridge top and are not close to stream channels. The affected soils also are not highly erodible. Thus, eroded soil would not be expected to reach downslope stream channels. Elevated sedimentation to streams along the haul road throughout Stonelick Run subdrainage would not be increased measurably from what already exists because the road is graveled and would be spot re-graveled as needed to control erosion from developing trouble spots. Streamflow changes attributed to harvesting in compartment R1 also would be insignificant because the disturbed areas are small and located high up in the subdrainage. The small amount of basal area removed from this ridge top compartment relative to that found in the entire subdrainage would not be sufficient to change streamflow regimes, so changes to within channel sediment budgets and channel morphology also would be insignificant.

Whereas burning would occur over about 1/2 of compartment R1, the prescribed fires would be relatively light and confined to the ridge top. Thus, the litter layer would be largely consumed but the humus layer would remain intact, protecting mineral soil. Consequently, increased erosion and sedimentation would be insignificant, as would associated changes in sediment budgets or sediment routing in the stream channel. Changes to transpiration also would be small, so burning would not change streamflow regimes. Thus, overall there would be little or no change to the water resources in Stonelick Run subdrainage due to activities in compartment R1.

Compartment 61 occupies 118.4 acres in Stonelick Run subdrainage, or 19.1 % of the area. It lies in the headwaters of the subdrainage, predominantly on flat ridge and knob

areas. The proposed 3% financial maturity harvest would remove approximately 20 % of the basal area within compartment 61.

There is a haul road upslope from and running along much of the boundary of compartment 61, but it does not enter the compartment. Five of the 9 decks in Stonelick Run subdrainage are on or near the ridge top in compartment 61, just adjacent to the haul road. The area in decks in compartment 61 is 0.56 acres. Skid roads in compartment 61 are fairly dense (3.3 miles, 5.20 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 5.76 acres, which is 0.93 % of the Stonelick Run subdrainage. No new roads or decks are proposed.

There are no perennial channels in compartment 61, but the 1.85 miles of nonperennial channels constitute approximately 38 % of the nonperennial channel length and 29 % of total channel length in Stonelick Run subdrainage. Approximately 20 % of the soils in compartment 61 are Dekalb, which have low erodibility. They lie primarily in the lower portions of the compartment. Upslope from the Dekalb soil is Calvin soil, which is moderately erodible.

The amount of timber proposed for harvesting would not be sufficient to change evapotranspiration sufficiently to induce an increase in streamflow on a subdrainage basis. Thus, neither total streamflow nor streamflow energy would be affected sufficiently by harvesting in compartment 61 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, 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 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. However, the presence of Dekalb soil with its low erodibility within these stream areas and around the point of road termination would help to reduce the potential for erosion. 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 are re-opened for use. If sediment would be transported to the stream channels, there probably would 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; however, increased turbidities would not be noticeable at the mouth of the Stonelick Run subdrainage.

Because skid roads exist near some channels in compartment 61, minor changes to stream channel morphology may already have occurred. However, because of the low soil erodibility throughout the lower portion of compartment 61 and throughout most of Stonelick Run subdrainage, head cutting in the upslope areas containing Calvin soils would be more likely than widening or incision in the more downslope areas where the less erodible Dekalb soils are found. Both erosion and deposition could occur from the proposed actions. However, the potential for substantial morphological changes to the channels in Stonelick Run subdrainage is low.

Sugarcamp Run Subdrainage

Sugarcamp Run subdrainage is 221.3 acres. It contains 1.41 miles of haul roads, 0.51 miles of skid roads, and 0.1 acres of decks. The total area in roads and decks is 4.32 acres. No new road or deck construction is proposed. There are 0.64 miles of perennial stream channel and 2.91 miles of nonperennial channel in the subdrainage.

Compartment R1 occurs in two parts of Sugarcamp Run subdrainage: a northern one on the ridge top and one in the middle portion of the drainage that extends from ridge top to ridge top. The combined acreage of the two parts of compartment R1 in Sugarcamp Run subdrainage is 65.8, which accounts for 29.7 % of the subdrainage. The proposed action for compartment R1 is prescribed burn coupled with a shelterwood harvest. Fifty percent of the basal area in compartment R1 is proposed for harvesting,

The northern portion of compartment R1 includes 0.44 miles of nonperennial channels and 0.38 miles (0.60 acres) of skid roads. Skid roads do not cross streams in the northern part of compartment R1, but one skid road ends at and essentially is connected to a nonperennial stream channel. A haul road runs along the compartment boundary at the ridge top and has a deck along it. The southern portion of compartment R1 includes approximately half (0.17 miles) the length of skid roads as the northern section of R1 and is bounded to the east and west by a haul road. The southern portion of R1 also contains 0.17 miles of perennial stream length and 0.19 miles of nonperennial channels.

The northern portion of compartment R1 occurs entirely on Calvin soils. Slightly more than half of the southern portion occurs on Calvin and the remaining soils are Gilpin. Both soils are moderately erodible.

Because the shelterwood harvesting would be spread over two areas of Sugarcamp Run subdrainage, and the harvesting would not remove enough basal area over the entire subdrainage to increase runoff measurably, no direct effects on streamflow would be expected. Because the roads in the northern portion of the compartment do not cross streams and they are on the ridge top and in moderately erodible soils, no channel changes or stream sedimentation are expected either from direct introduction of sediment or from indirect changes due to shorter times of concentration for runoff.

The skid road in the southern portion of compartment R1 would not be anticipated to increase sediment inputs to the perennial stream downslope, because the end of the skid road is located 0.05 miles from the channel and it exists on a gentle slope.

Similarly, the principal existing runoff and sedimentation problem area in the northern part of compartment R1 is the existing skid road that terminates near the nonperennial stream channel. Currently, waterbars and established vegetation help to limit the length of the skid road that contributes runoff and sediment. Re-commissioning this skid road could increase runoff and sedimentation if it is used the entire way to the channel. Consequently, in Alternative B, the skid road reblading and use would end at least 50 feet from the channel to provide a buffer between the road and stream. Hay bales or silt fences also would be installed if additional water and sediment control are needed. The moderate erodibility of soils coupled with these mitigation procedures would prevent increased sediment and runoff effects to occur within the northern portion of compartment R1 in Sugarcamp Run subdrainage.

Although burning would occur over about 1/2 of compartment R1, the prescribed fire would be relatively light. Thus, the litter layer would be largely consumed but the humus layer would remain intact, protecting mineral soil. Consequently, increased erosion and in-stream sedimentation would be small. Further, changes to transpiration would be very small, so the proposed fire would not change streamflow regimes.

Thus, overall there would be little or no change to the water resources in compartment R1 from the combined prescribed burn and shelterwood harvest.

Fire Run Subdrainage

Fire Run subdrainage is 55.2 acres in size. Within the subdrainage, there are 0.91 miles of haul roads which occupy 4 % of the subdrainage area. There are no skid roads or decks in the subdrainage. No additional road or deck construction is proposed for Fire Run subdrainage. No perennial streams exist in Fire Run subdrainage, though there are 0.22 miles of nonperennial stream reaches.

Compartment R1 occupies 2.5 acres of ridge top in the Fire Run subdrainage, or 4.5 % of the entire area. A prescribed fire and shelterwood harvesting are proposed for compartment R1. Fifty percent of the basal area in compartment R1 would be removed by the shelterwood cut and about 1/2 the compartment would be burned. None of the roads or stream channels in Fire Run subdrainage is in compartment R1, and no new roads or decks are proposed for either the compartment or subdrainage.

Shelterwood harvesting would have a negligible effect on transpiration within the subdrainage, because the percentage of area treated is much less than that needed to generate a hydrologic response in this region. Therefore, significant changes to soil moisture or streamflow would not occur. While burning would occur in all of compartment R1, the prescribed fires would be relatively light. The litter layer would be largely consumed but the humus layer would remain intact, protecting mineral soil.

Consequently, the effects of the proposed action would result in no direct or indirect changes to stream sedimentation, channel changes, or flow increases.

Hickman Slide Subdrainage

Hickman Slide subdrainage covers 294.5 acres of which 4.90 acres (2.02 miles) is a cut-and-fill haul road that is open to low density traffic year round and generally is completely graveled. Both dips and culverts are employed as cross drainage features. Another 11.80 acres (7.49 miles) of Hickman Slide subdrainage is occupied by skid roads that are closed and waterbarred when not in use. Log decks comprise another 0.44 acres in the subdrainage that are limed and seeded with grasses to reduce erosion and encourage infiltration of precipitation and overland flow after deck use is completed.

Hickman Slide subdrainage has a total of approximately 2.24 miles of stream channel within its boundaries. Approximately 0.85 miles is perennial stream and 1.39 miles is nonperennial stream. The perennial stream is crossed by the haul road in Hickman Slide subdrainage in 6 locations and nonperennial tributaries are crossed at about 10 locations by the haul road and skid roads. No new roads or landings are proposed in this subdrainage.

Harvesting is proposed in 3 subcompartments in Hickman Slide subdrainage: 5B, 7A, and 7B. Single-tree selection is proposed for subcompartment 5B, and patch cuts are proposed for both subcompartments 7A and 7B. Most of the basal area reduction for the subdrainage would be from compartment 5B, in which basal are would be reduced by 30 % over 56.4 acres. Similar % basal area removals would occur in compartments 7A (28 %) and 7B (27 %), but the acreages involved would be much smaller, 6 and 10 acres, respectively. In total, harvesting would be applied to approximately 25 % (72.4 acres) of Hickman Slide subdrainage.

Harvesting in subcompartments 7A and 7B would occur in the lower two-thirds of the southern half of the subdrainage. Harvesting in compartment 5B would be in the middle one-third of the northern half of the subdrainage. Harvesting, haul road use, skid road use, and decking in subcompartment 7A would sometimes be in close proximity to perennial stream reaches. Only haul road use would be in close proximity to perennial reaches in compartment 5B.

Approximately 1.79 miles of skid roads and 0.08 acres of decks would be reopened and disturbed for timber harvesting in subcompartment 5B. An additional 0.63 and 1.82 miles of skid roads would be reopened in subcompartments 7A and 7B, respectively, along with a combined total of 0.22 acres of reopened decks for the two subcompartments. The total area of re-disturbed skid roads and decks in Hickman Slide subdrainage would be less than 2.4 % of the total subdrainage acreage.

Subcompartment 5B has both Belmont and Cateache soils. Both of these soils are highly erodible but the subcompartment would cover slightly less than 20 % of the area in

Hickman Slide subdrainage. Subcompartment 7B is covered by Belmont and Cateache soils also, but patch cutting will take place on only a small portion of subcompartment 7B and involve only 3.4 % of the entire subdrainage area. Subcompartment 7A is located in the lower slope area of Hickman Slide subdrainage, and has Belmont soil in its upper one-third, Dekalb soil in its middle 10-15 %, and Calvin soil in the lower half of the subcompartment. Dekalb soil overlying Pottsville geology has a low erodibility potential and Calvin soil has a moderate erodibility potential.

Although harvesting would occur on 24.6 % of the total Hickman Slide subdrainage area, only approximately 30 % of the basal area on the treated acreage would be harvested. Therefore, streamflow changes would not be detectable. The thick Belmont and Cateache soils in subcompartment 5B, where most of the harvesting would occur, and subcompartment 7B would provide a reservoir for storing excess moisture so it would be released as streamflow slowly over time. Consequently, neither direct hydrologic changes nor indirect within-channel erosion or other channel morphological changes should occur from streamflow changes.

Direct entry of sediment into stream channels would be possible from skid road use, particularly in compartments 5B and 7A, where Belmont and Cateache soils occur. Generally built along the contour, the skid roads cross stream channels several times. Given the high erodibility of these soils, sediment likely would enter the channel at these crossings, particularly since harvesting would occur during the wetter months of the year when soil becomes most easily detached and transported. Direct additions of sediment in the areas of the subdrainage dominated by Dekalb and Calvin soils would be expected to be less than from the more upslope erodible soils. However, the decks located in subcompartment 7A are close to perennial streams, making them much more susceptible to sediment inputs to the stream and sediment transport once in the stream. Turbidity increases in stream water likely would be visible at some times during operations near skidder crossings and decks, particularly during storm events, even if harvesting and skidding operations were suspended during those periods. Sediment additions to the channel should end or decrease substantially when skidroad use is terminated because the skid roads would be waterbarred; however, some sediment resulting from skid road use could be stored in the stream channel for a long period of time, and would be flushed slowly from the subdrainage during high flow events.

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

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

Camp Hollow Subdrainage

Camp Hollow subdrainage is 487.6 acres in size. It includes 1.95 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 runs adjacent to perennial Camp Hollow Run and includes about 6 stream crossings of this stream and an additional stream crossing of an intermittent channel near the end of Camp Hollow Road. There are another 6.49 miles of skid roads in Camp Hollow subdrainage; these occur within watersheds 2, 3, and 5. There are 3 decks along Camp Hollow Road that are very near the perennial stream channel. There are another 2 decks in Camp Hollow subdrainage on the ridge top of watershed 5 on Fork Mountain Road. The total area in haul roads, skid roads, and decks in Camp Hollow subdrainage is 15.39 acres, or 3.16 % of the subdrainage area.

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

There are 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 acidification on watershed processes, and compartment A in watershed 5 would be harvested using single-tree selection.

Watershed 3 is 84.7 acres in area, which is 17.4 % of Camp Hollow subdrainage. The entire watershed area would receive fertilizer applications in Alternative B.

Watershed 3 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 is not a problem and that situation is not expected to change.

There are 2.22 miles of skid roads in watershed 3. These were constructed before 1973, and have mostly been unused by vehicles since 1972, so they have developed a protective vegetation and litter layer on them, and trees now grow within some of the skid roads.

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 be continued to be collected. Changes in hydrology also would not be expected because the treatment has not yet changed tree growth significantly (unpublished data) and is not expected to change it enough during the next 5 years to alter evapotranspiration. Therefore, channel morphology, in-channel sediment storage and routing, and sediment budgets would not change in response to ammonium sulfate applications.

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

Watershed 5A has 0.25 miles of haul roads that are confined to the ridge top. Two decks also are located along the haul road, and these encompass 0.16 acres of area. There are 2.32 miles of skid roads, constituting 3.66 acres.

There is 0.13 miles of perennial stream channel near the mouth of watershed 5A. An additional 0.97 miles of nonperennial channels is located throughout watershed 5A. The principal skid road in watershed 5A runs parallel to the main stream channel from the mouth of the watershed almost the entire way to the ridge top. In the lower portion of the watershed, that skid road is less than 125 feet from the 0.13 miles of perennial channel. In the upper two-thirds of the watershed, that skid road is about 150 feet, on average, from the nonperennial segment of the channel. Other shorter segments of skid road also are within tens of feet of the channel or immediately adjacent to it, and there are about 8 locations where the skid road crosses the nonperennial stream.

Most of the soils in watershed 5A are moderately erodible, but there are a few locations that contain soils with low erodibility.

Streamflow increases from watershed 5A would not be expected given that the basal area removal will be less than 25 % of the entire watershed 5 area. Further, the harvesting would be as single-tree selection spread across the area which would also act to temper runoff alterations. Thus, hydrologic changes would not be expected to change in-channel sediment routing and erosion processes.

No new road or deck construction is planned in watershed 5A. The acreage in roads and deck in watershed 5A also is not large enough to approach the level needed to observe changes in streamflow by roads (Verry 2000). Therefore, increases in stream runoff or channel morphology changes would not result from the roads in watershed 5A.

By contrast, skid road contributions of sediment to the stream channel likely would increase from renewed skid road use, as substantial lengths of the skid roads in watershed 5A are less than 100 feet away from the stream, including the perennial reach. The relatively large number of stream crossings by the skid road also would provide a relatively continuous source of sediment to the stream reaches when the road was in use. These sediment inputs would alter local sediment deposition in the stream and potentially affect erosion processes by affecting overall sediment budgets. Following harvesting, the skid roads would be water barred at least every 100 feet to help control erosion and sedimentation until the roads restabilize and litter layer and other vegetative cover become established. However, because the skid roads would not be seeded and mulched, erosion and sedimentation could continue for a longer period than if the bare soil was covered.

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

Canoe Run Subdrainage

Canoe Run subdrainage is 691.5 acres. There are 3.25 miles of haul road and 1.39 miles of skid road in the subdrainage. All roads constitute 10.07 acres or 1.46 % of the subdrainage area. There are no decks located in Canoe Run subdrainage. The haul road crosses nonperennial stream reaches 4 times in the subdrainage, but it does not cross the perennial channel. Skid roads do not cross any of the streams. All of the miles of skid roads are located in the head of the subdrainage, primarily along the ridge.

Canoe Run subdrainage includes 2.25 miles of perennial stream, which continues almost to the top of the watershed. There also are 2.45 miles of nonperennial stream channel. The nonperennial channel reaches are all tributaries of Canoe Run except for a very short

reach on the main channel that continues from the where the perennial channel ends to almost the subdrainage boundary.

Canoe Run subdrainage includes three different proposed treatments on adjacent compartments, a single-tree selection harvest (compartment 20A), a 4% financial maturity harvest (compartment 20B), and a diameter-limit harvest (compartment 20C). These compartments all are located on the ridge top of Canoe Run subdrainage. Compartment 20A is 6.5 acres in size, compartment 20B is 7.3 acres, and compartment 20C is 17.8 acres. The harvests would be spread across the entire acreage in each of the compartments. The basal area that would be removed from compartments 20A, 20B, and 20C would be 23%, 21%, and 35%, respectively.

There are no perennial or nonperennial streams present in compartments 20A, 20B, or 20C. There also are no haul roads or decks in any of the compartments, though there is a haul road just along the outer edge of compartment 20A. There are skid roads in all three of the compartments. The skid road length in compartment 20C is 0.57 miles, about 5-6 times the lengths in compartments 20A (0.10 miles) and 20B (0.14 miles).

The soils in compartment 20C primarily have low soil erodibilities, dominated by Dekalb and exposed rock outcrops. There is a small amount of Cateache soil in compartment 20C, which is highly erodible, but the skid roads in compartment 20C are all within the portion of the compartment that contains the low erodibility soils. The soils in compartments 20A and 20B are Cateache, Shouns, and Belmont, which are all highly erodible.

Sediment delivery to streams in Canoe Run subdrainage from skid roads in the treated compartments would not be expected to occur because there are no streams in any of the compartments, there are no channels close to the compartments, and skid road length in the highly erodible soils is very short.

Streamflow changes in the treated compartments also would not occur, as there are no streams within the compartments. Any small increases in soil moisture that might occur locally within the compartments from losses to the evapotranspirational demand would occur during the growing season, and would be easily retained and released slowly by the relatively thick Belmont, Cateache, and Shouns soils. Consequently, hydrologic changes in Canoe Run would not occur nor would hydrologically-driven changes, such as channel morphology and sediment budgets, occur.

There would be no significant direct or indirect effects to Canoe Run from the actions in compartments 20A, 20B, and 20C proposed in Alternative B.

Big Spring Run Subdrainage

Big Spring Run subdrainage is 200 acres. The subdrainage holds 1.49 miles of haul road, 1.99 miles of skid roads and a single 0.07 acres deck located along Forest Road 701, that makes up most of the haul road length in Big Spring subdrainage. The other haul road is

Turkey Run Road. About half of the length of Forest Road 701 and all of Turkey Run Road. is in the southern half of the subdrainage. The remaining half of Forest Road 701 is in the middle portion of the subdrainage and follows along the entire length of the main channel of Big Spring Run. Forest Road 701 crosses five nonperennial tributaries of Big Spring Run, three in the very headwaters, and two near their confluence with Big Spring Run.

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

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

Compartments 8B, 8C, and 8D, are located within Big Spring Run subdrainage, and a different harvesting treatment is proposed for each in Alternative B. Compartment 8B would have a diameter-limit harvest that would remove 50 % of the basal area. Compartment 8C would have a single-tree selection harvest that would remove 23 % of the basal area. Compartment 8D would have an intensive single-tree selection harvest that would remove 20 % of the basal area. Located in the northern portion of the subdrainage, the three compartments are adjacent to each other, and are each 5 acres in size and each comprise 2.5 % of the subdrainage area.

Stream length in the compartments is quite limited. There are no perennial streams in any of the compartments and there is only 0.05 miles, and 0.03 miles of nonperennial channel length, respectively, in compartments 8B and 8D. Less than 0.01 miles of nonperennial channel cuts across one corner of compartment 8C.

A skid road runs north-south through all three of the compartments near their western borders. One skid road goes through compartment 8D east-west and two go through compartment 8C east-west off of that skid road. The north-south skid road crosses the head of a nonperennial tributary to Big Spring Run in compartment 8B. This same skid road passes just upslope from the head of another nonperennial tributary in compartment 8D. Total skid road lengths in compartments 8B, 8C, and 8D, respectively, are 0.07 miles, 0.25 miles and 0.17 miles. No new road construction is planned, and there are no decks in any of these compartments.

Even though highly erodible Belmont soils occur across compartments 8B, 8C, and 8D, the small size of each of the compartments (5 acres) would help to temper increased erosion from skid roads. Relatively few trips would be made on the skid roads because the proposed basal area removal would range from only 20 % to 50 % in the three compartments. The lightest cuts would be in the two compartments with the most miles

of skid roads. Thus, skid road usage and erosion from skid roads would be low in the areas with the highest skid road densities. The limited stream length that exists within and close to the three compartments and the relatively gentle topography would help to control sediment delivery to stream channels in Big Spring Run subdrainage. Therefore, activities proposed in Alternative B would not contribute significantly to increased sediment loads to the stream channels or result in changes to in-channel sediment budgets or sediment routing.

Measurable changes to local hydrology and streamflow also would not occur from the proposed harvesting treatments. The percentage of basal area that would be removed is approaching or above that which would cause measurable streamflow increases if applied to an entire watershed. But since the compartments are only a portion of a watershed, streamflow increases would not occur from treating only these 15 acres. Small local increases in soil moisture could occur, but these would be experienced during the growing season when soil moisture deficits are greatest and would be retained easily by the thick Belmont soils present in all three compartments.

Compartments 8B, 8C, and 8D comprise only 7.5 % of the total area of Big Spring Run subdrainage and they are located in the uppermost headwater areas of two nonperennial tributaries of Big Spring Run. Since local changes to in-stream sediment and hydrology would not be measurable, there would be no significant direct or indirect effects to water resources in Big Spring Run subdrainage.

Upper Elklick Run Subdrainage

Upper Elklick Run subdrainage is 735.8 acres in area. It includes all of the headwaters of Elklick Run, which is the principle perennial stream in the Fernow Experimental Forest.

There is a high density of roads in Upper Elklick Run subdrainage. Total haul road length is 4.00 miles, which is almost entirely Forest Road 701. There are 16.71 miles of skid road. Approximately 36 acres of roads exist in Upper Elklick Run subdrainage. Thirteen decks cover an additional 0.95 acres. Roads and decks comprise 5.03 % of the area of Upper Elklick Run subdrainage.

Upper Elklick Run subdrainage has 1.87 miles of perennial stream channel, which is almost the entire portion of the main channel of Elklick Run that lies within the subdrainage and a portion of a tributary to the main channel. There also are 6.06 miles of nonperennial channel length which includes all the other tributaries and a very short reach in the head of the main channel.

Forest Road 701 parallels Elklick Run's main channel for most of the entire stream length in Upper Elklick Run subdrainage. For almost all of this length, Elklick Run is within 50 feet or less of Forest Service Road 701. All of the nonperennial tributaries on the right side of Elklick Run also are crossed in the headwaters or about half way up the tributaries by Forest Road 701 as it loops back toward the reservoir. As a result, Elklick Run and its tributaries have many stream crossings within the Upper Elklick Run subdrainage.

Upper Elklick Run subdrainage includes 9 compartments proposed for treatment in Alternative B. Compartments 13 and 21 would be subjected to prescribed fire and herbiciding of the overstory, compartments 17A and 19A would have patch clearcuts, compartment 26 (A and B) would have 6% financial maturity harvests, compartment 20A would have single-tree selection harvesting, compartment 20B would have a 4% financial maturity harvest, and compartment 20C would have a diameter-limit harvest.

Compartment 13 is 31.3 acres and is located near the mouth of Upper Elklick Run subdrainage. The compartment contains 0.84 miles of skid roads. A 0.44-miles nonperennial tributary of Elklick Run flows down the approximate longitudinal middle of compartment 13 for the entire length of the compartment. A burn/herbicide unit would lay on each side of this stream with a least a 50-feet wide buffer between the stream channel and the adjacent treatment units. The two proposed treatment units cover a total of 17.2 acres, or slightly more than one-half of compartment 13's acreage.

A skid road also runs beside the stream channel in the middle of compartment 13, which would serve as a fire break. A portion of a skid road in the upslope area of compartment 13 would also serve as a fire break, but an additional 0.24 miles of skid road would be extended to provide a complete fire break around the unit; also, 0.32 miles of skid road would be extended in the upslope area of the other half of the compartment to serve as a fire break. The total length of the fire break construction in compartment 13 would be 0.56 miles.

All of the constructed fire breaks would be in the upslope areas and would be away from stream channels in the compartments except where they approach the confluence of the compartment's tributary and Elklick Run. The fire break on the left side of the tributary (western half of compartment 13) would come within approximately 70 feet of the tributary. The fire break on the eastern half of compartment 13 would join an existing skid road that runs parallel to Elklick Run. The terminus would be approximately 130 feet from Elklick Run. The proposed prescribed fire would be light and primarily consume only the litter layer. 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 roads would be water barred at least every 100 feet to help control drainage and erosion from them. Most of the constructed skid road length would be in the uplands away from stream channels, which also would help control sediment delivery. Further, because the fire break would not be used for vehicular traffic after construction, compaction and overland flow would be minimal, as would soil disturbance since logs would not be moved over the surface.

However, the construction of fire breaks could increase sediment delivery in the tributary/Elklick Run confluence area where the constructed skid roads would terminate in both units of compartment 13. Fire breaks would not be mulched or seeded, which

would mean the potential for elevated erosion would exist until litter and vegetative cover would become established on the roads. Effective cover likely would require more than a single leaf fall season to become established, but cover would probably be established in less than 5 years.

Increases in local soil moisture could be expected from killing 50 to 75 % of the basal area in the compartment. In turn, streamflow increases also could occur in the tributary that is present in the middle of the compartment. These increases would be primarily measurable during the growing season low flow periods. However, because the treatment area is only a small acreage, streamflow increases would be small and short-lived, even if 75 % of the overstory basal area is killed. The small magnitude of and timing of the streamflow changes would not be large enough to change in-channel sediment budgets and sediment routing/storage in the tributary in compartment 13. Changes in sediment budgets, in-channel erosional processes, or stream hydrology from treating compartment 13 would not occur in Elklick Run because the contributions of sediment and streamflow would be masked in this much larger perennial stream system.

Compartment 21, which also would be treated with prescribed fire and overstory herbiciding in Alternative B, is located in the headwaters of Upper Elklick Run. The compartment essentially would have three treated units due to the position of perennial and nonperennial stream channels and the required buffer strips between the treatments and the stream channels. The compartment contains 0.55 mi of skid roads, 0.65 mi of perennial stream channel, and 0.1 mi of nonperennial stream channel.

Elklick Run and Forest Road 701 bound one side of all three units in compartment 21. Forest Road 701 also bounds two other sides of the most western unit, and the upslope side of the middle unit. A perennial stream separates the western and middle units and also has a skid road running adjacent to and within <50 ft of this stream channel. The eastern and middle units are divided by a nonperennial channel. Each of these features would act as a fire break for the proposed prescribed burn. The upslope boundary on the largest of the three units would be a 0.20-mi long skid road that would be constructed for this treatment.

The existing skid roads and proposed fire breaks would be water barred at least every 100 feett to help control drainage and erosion from them. All of the constructed fire break length would be in the uplands away from stream channels, which would help control sediment delivery. Because the fire breaks would not be used for vehicular traffic after construction, compaction and overland flow would be minimal, as would soil disturbance since logs would not be moved over the surface. Fire breaks would not be mulched or seeded, which would mean the potential for elevated erosion would exist until litter and vegetative cover would become established on the roads. Effective cover likely would require more than a single leaf fall season to become established, but cover would probably be established in less than 5 years. A potentially problematic skid road already exists and parallels the perennial stream channel separating the middle and western units. However, it will not be rebladed or used for vehicular traffic. Consequently, erosion and

sediment delivery to streams would not increase significantly from either existing or proposed skid roads in compartment 21 from the treatments proposed in Alternative B.

The proposed prescribed fire would be light and primarily only consume the litter layer. 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.

Increases in local soil moisture could be expected from killing 50 to 75 % of the basal area in the compartment. But because the total acreage that would be affected across the 3 units in compartment 21 is only 9.2 acres and a substantial portion of the compartment would occur as buffers, any increases in soil moisture would be retained within the buffer soils and would not be translated to measurable increases in streamflow in any of the tributaries or in Elklick Run. The small changes in soil moisture and lack of changes to streamflow would mean no change to the sediment budgets and sediment routing/storage in the streams in compartment 21 or within Elklick Run. Therefore, the proposed prescribed fire and herbiciding treatments would have no direct or indirect effects on moisture or sediment regimes within Upper Elklick Run subdrainage.

Compartment 26 occupies 46.2 acres, or 6.2 % of the Upper Elklick Run subdrainage. In the proposed action alternative, a 6 % financial maturity harvest is proposed, in which 31% of the basal area in the compartment would be removed.

There are no haul roads or decks in compartment 26, but there are 1.77 miles of skid roads, constituting 2.79 acres. While largely located on the contour, there are several stream crossings by skid roads. No decks currently exist in the compartment.

There are no perennial stream channels in compartment 26, but there is 0.42 miles of nonperennial channel.

Except for a small portion of Dekalb soil along the northeastern boundary, the rest of compartment 26 is Calvin soil, which is moderately erodible.

Whereas the basal area proposed for removal is at the level at which growing season soil moisture could be altered locally within compartment 26, on a watershed basis the basal area removed would be a much lower percentage. Consequently, insufficient basal area would be removed within the subdrainage to affect transpiration and soil moisture sufficiently to alter streamflow in Elklick Run in a significant or measurable way. Locally, soil moisture could increase slightly due to the harvesting, and a small increase in low flow discharges could occur in the nonperennial tributary within compartment 26. However, because this is a nonperennial stream, it is likely the excess soil moisture would be demonstrated as hyperheic zone flow rather than surface flow. Therefore, no significant direct and indirect changes in water resources would result from changes in flow or energy.

Channel changes already may have occurred within compartment 26 due to the presence of skid roads and skid road crossings. The skid roads parallel the channel very closely (< 50 feet) along several reaches and cross the stream four times. Additions of sediment to the stream channel from the skid road system may change the sediment balance of the stream channel. In turn, changes to within-channel erosion, deposition, and morphology could occur. Visible turbidity changes particularly during storm events could occur.

There may be measurable direct or indirect effects to sediment relationships in the stream within compartment 26. However, it is unlikely that these will be measurable in Elklick Run due to the elevated levels that already exist and continue to occur due to the presence of Forest Road 701.

Compartment 17A occupies 31.4 acres, or 4.3 %, of the Upper Elklick Run subdrainage. In Alternative B, 4 acres of the compartment would have ten 0.4-acre patch cuttings, which would remove 16 % of the basal area in compartment 17A.

There are no haul roads in compartment 17 but Forest Road 701 runs along both the upper and lower boundaries of compartment 17A. There are two principal skid roads in compartment 17A that total 0.82 miles or 1.29 acres. There are decks along the haul roads and these comprise 0.18 acres of area.

Compartment 17A has 0.06 miles of perennial Elklick Run, which also runs along the lower slope boundary of the compartment. There is 0.77 miles of nonperennial channels.

Soils within compartment 17A are primarily Calvin, with only a small area in Meckesville soil in the upslope area of the compartment.

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

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

stream is predominantly influenced by much larger sediment inputs from Forest Road 701.

Compartment 19A occupies 22.4 acres, or 3.0 %, of the Upper Elklick Run subdrainage. In Alternative B, 3.2 acres of the compartment would have eight 0.4-acre patch cuttings, which would remove approximately 16 % of the basal area in compartment 19A.

There are no haul roads in compartment 19A but Forest Road 701 runs along both the upper and lower boundaries of compartment 19A. There are two principal skid roads in compartment 19A that total 0.94 miles or 1.48 acres. There are decks along the haul roads and these comprise 0.12 acres of area.

Compartment 19A has 0.03 miles of perennial Elklick Run along the lower slope boundary of the compartment. There is 0.55 miles of nonperennial channels.

Soils in compartment 19A are primarily Calvin with a very small area in Meckesville soil in the most upper headwaters of the compartment.

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

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

Compartment 20 in Upper Elklick Run subdrainage has three subcompartments 20A, 20B, and 20C. Subcompartment 20A is 18.7 acres, subcompartment 20B is 18.0 acres, and subcompartment 20C is 9.9 acres. The proposed harvest treatments are single-tree selection, 4 % financial maturity harvest, and diameter-limit harvest for compartments 20A, 20B, and 20C, respectively. The harvests would be spread across the entire acreage in each of the compartments. The basal area that would be removed from compartments 20A, 20B, and 20C would be 23 %, 21 %, and 35 %, respectively.

There are no perennial or nonperennial streams in compartments 20A, 20B, or 20C. There also are no haul roads, though there is a haul road outside subcompartment 20A that runs along its entire length. There is one deck (0.15 acres) at the bottom of subcompartment 20A along that haul road. There are skid roads in all three of the compartments. The skid road length in compartment 20C is 0.33 miles, about half the lengths in compartments 20A (0.70 miles) and 20B (0.62 miles).

The soils in compartment 20C primarily have low soil erodibilities, dominated by Dekalb and exposed rock outcrops. There is a small amount of Cateache soil in compartment 20C, which is highly erodible. The soils in compartments 20A and 20B are Cateache, Shouns, Belmont, and Meckesville which are all highly erodible.

Although erosion could occur in compartment 20 from skid road use, sediment delivery to streams in Upper Elklick Run subdrainage would not be expected to occur because there are no streams in any of the subcompartments, there are no channels close to the compartments, and concentrated flow is retarded due to the high permeability of the soils and underlying limestone geology.

Streamflow changes in the treated compartments also would not occur, as there are no streams within the compartments. Any small increases in soil moisture that might occur locally within the compartments from losses to evapotranspirational demands would occur during the growing season, and would be easily retained and released slowly by the relatively thick Belmont, Cateache, Shouns, and Meckesville soils. Consequently, hydrologic changes in Upper Elklick Run subdrainage would not occur nor would hydrologically-driven changes, such as channel morphology and sediment budgets.

There would be no significant direct or indirect effects to Upper Elklick Run subdrainage from the actions proposed for compartments 20A, 20B, and 20C in Alternative B.

The total area that would be treated in Alternative B in Upper Elklick Run subdrainage would be 6.3 % of the subdrainage. The combined influences of all the proposed activities in compartments and subcompartments in Upper Elklick Run subdrainage would not significantly affect either streamflow, energy, or sediment budgets in Elklick Run because the area affected is small, few of the treatments would affect sediment locally, and none would affect streamflow. The effects to sediment in local tributaries would not result in measurable changes to sedimentation in Upper Elklick Run because the stream is primarily influenced by large, chronic inputs of sediment from Forest Road 701 which would continue to be present and used, regardless of whether Alternative B was implemented or not.

Cumulative Effects of Alternative B: Proposed Action

Cumulative effects of past, present, and reasonably foreseeable actions on both federal and private lands are discussed. Land disturbances having the greatest potential for cumulative flow and sediment-related effects to streams include timber harvesting, road construction, and road use.

Cumulative effects are described by subdrainage and in terms of the larger Elklick Run watershed, Black Fork watershed, and Shaver's Fork drainage. Because the subdrainages contain compartments and watersheds that have received treatments in the past, these other areas are considered for cumulative effects in each subdrainage.

Side Hill Subdrainage

Compartment 45 has not received treatments in the past and no other compartments have been treated in the past in Side Hill subdrainage. Consequently, the cumulative effects in Side Hill subdrainage are the same as the direct and indirect effects given previously for this subdrainage.

John B. Hollow Subdrainage

Compartment 45 has not received treatments in the past and no other compartments have been treated in the past in John B. Hollow subdrainage. Consequently, the cumulative effects in John B. Hollow subdrainage are the same as the direct and indirect effects given previously for this subdrainage.

Upper Elklick Run Subdrainage

Upper Elklick Run subdrainage includes a large number of compartments and subcompartments that have had some type of treatment(s) during the past.

The 27.1 acres of compartment 14 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 preharvest conditions in the ~50 years of regrowth that has occurred, so there would be no cumulative effects in Upper Elklick Run subdrainage from compartments 14 or 25.

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 in size, 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. Local soil moisture would have increased and streamflow also may have increased due to the losses of evapotranspirational surfaces. However, since these areas comprise less than 3 % of the Upper Elklick Run subdrainage, streamflow and soil moisture increases at the subdrainage level would not have occurred, and any local changes would have disappeared during the subsequent 15 years as the vegetation in the compartments regrew. Consequently, compartments 34 and 35 do not contribute to cumulative effects today.

Compartment 31 received financial maturity harvests in 1960, 1972, 1982, and 1993. In each harvest $\leq$29 % of the basal area across the 18.8 acres compartment was removed.

The most recent harvest in 1993 removed only 16 % of the basal area. The combination of the time since harvest and the low percentage of basal area removed each time would mean that the effects at the subdrainage level to soil moisture or streamflow would not have occurred, resulting in no current cumulative effects in Upper Elklick Run subdrainage from compartment 31.

Compartment 16 is divided into 3 subcompartments. Subcompartment 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 regrowth. In 1990, approximately 80 % of the basal area across 24.1 acres was harvested from subcompartment 16A. This harvest likely would have increased local soil moisture and possibly local streamflow. However, since harvesting effects in this region generally disappear in 10-15 years, streamflow and soil moisture would now be returned to pre-harvest levels. Furthermore, the effects would not be observable at the subdrainage level since subcompartment 16A comprises only 3.3 % of Upper Elklick Run subdrainage.

Subcompartments 16B and 16C have received single-tree selection harvests in 1951, 1961, 1971, 1982 (16B only), 1991, and 2002 (16B) or 2003 (16C). Harvest effects on soil moisture and streamflow prior to 1991 would no longer be present because they occurred longer than 15 years ago; however, it is doubtful that they had an effect even locally because only small areas were harvested and the harvests were spread across the compartments rather than concentrated in small groups. The 2002/2003 harvests removed 33-35 % of the basal area in the compartments. This reduction in evapotranspiration may have increased soil moisture and streamflow locally but on a subdrainage basis it would not have been measurable because compartments 16B and 16C comprise only 7 % of the acreage of Upper Elklick Run subdrainage. Sediment accumulations were noted in the stream channels in compartment 16 just before these most recent harvests. These were attributed to erodible soils, skid road use, and skid road crossings. Use of these skid roads during 2002 and 2003 was predicted to increase sediment delivery to the stream channels. If so, at least some of the added sediment probably still is stored in the channel and affecting sediment budgets, at least to a small extent. Therefore, the skid road use in compartment 16 during the 2002/2003 harvests could contribute to cumulative sediment effects in the Upper Elklick Run subdrainage.

Compartment 27 is divided into two subcompartments, 27A (34.3 acres) which received diameter-limit harvests in 1951, 1969, 1984, and 1999, and subcompartment 27B (24.8 acres) which received single-tree selection harvests in 1951, 1970, 1991, and 2004. The areas, respectively, comprise 4.7 and 3.4 % of Upper Elklick Run subdrainage. Any local soil moisture or streamflow effects that might have occurred from harvests prior to the 1999 in subcompartment 27A and prior to 2004 in subcompartment 27B would not be observable any longer due to the time which has past since the harvest and the regrowth of the forest vegetation. The 1999 diameter limit harvest in subcompartment 27A removed 32 % of the basal area, which would have put it above the level at which moisture could have increased in the locally affected area. In the past 5 years, most of the increases in available moisture would have disappeared as the remaining trees exploited the available growing space. However, moisture increases would not have been

observable on a subdrainage basis because subcompartment 27A is only 4.7 % of Upper Elklick Run subdrainage. Thirty-two % of the basal area in subcompartment 27B also was removed in the 2004 harvesting. Moisture increases would have resulted locally within the compartment, but they would not have been observable on a subdrainage basis because subcompartment 27B is only 3.4 % of Upper Elklick Run subdrainage.

Compartment 30 (23 acres) has been subjected to 0.4-ac patch clearcuts every 10 years since 1964. In each treatment year, 13 to 20 % of the compartment's basal area has been harvested. None of these harvests removed enough trees over a wide 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 effects in the Upper Elklick Run subdrainage.

In compartment 17, 0.4-ac patch clearcuts have been applied to subcompartment 17A (31.4 acres) every 10 years since 1957, and to subcompartment 17B (11.3 acres) in 1951, 1971, 1987, and 2003. Local increases in soil moisture and streamflow would have been rare from any of these treatments due to the small number of trees removed in each patch, and only the most recent harvests (1997 17A, 2003 17B) would have any possibility of still expressing increases today. However, since only 16 % of the basal area was removed from subcompartment 17A in 1997, no soil moisture or streamflow increases would have occurred. In 2003, 28 % of the basal area was removed from subcompartment 17B. This would have been just above the 25 % basal area reduction needed to see a local increase in soil moisture, some of which still could exist since the harvest was less than 2 years ago. However, the subcompartment is only 1.5 % of the subdrainage area, so increased soil moisture or streamflow would not be measurable on a subdrainage basis. Consequently, past activities in compartment 17 do not contribute to cumulative effects beyond those described for direct and indirect effects for the proposed patch clearcuts in compartment 17A.

Patch clearcuts in compartment 18 (115.6 acres) were done in all three of its subcompartments on 10 or 15 year intervals over approximately the last 50 years. Any potential harvest effects from the 1994 and prior patch clearcuts in subcompartments 18A and 18B would no longer exist. Likewise any from the 1989 patch cut in subcompartment 18C would no longer exist. The more recent harvests in 2004 in all three subcompartments removed 28, 26 and 26 % of the basal area in 18A, 18B, and 18C, respectively. These levels are just above the 25 % basal area reduction needed to show an increase in streamflow on a watershed basis. Locally within the compartment it is likely that soil moisture increased but local streamflow probably did not because there is little stream length in the compartment and most of it is located near the bottom of the compartment. Since the harvests were spread across the lower, middle, and upper portions of the compartment, increased local soil moisture probably would not have been sufficient to increase streamflow. Further, on a subdrainage basis not enough trees would have been harvested over a large enough area to induce soil moisture or streamflow increases. Consequently, past harvesting in compartment 18 would not contribute to cumulative effects in Upper Elklick Run subdrainage.

Compartment 26 (46.2 acres) has had 6% financial maturity harvests in 1951, 1971, 1982, and 1992. Approximately one-third of the basal area in the compartment was removed in the 1992 harvest, which would have been enough to increase soil moisture locally but not to increase streamflow on a subdrainage basis since only about 6 % of Upper Elklick Run subdrainage was harvested. Consequently, there are no additional cumulative effects to Upper Elklick Run subdrainage from compartment 26 above those described for the direct and indirect effects.

In compartment 19, patch clearcuts were performed in subcompartment 19A (22.4 acres) approximately every 10 years since 1958. In subcompartment 19B (10.8 acres), single-tree selection harvests occurred in 1958, 1967, 1981, and 1996. In the last two patch cutting cycles insufficient basal area (~20%) was removed to increase soil moisture or streamflow. Prior harvests occurred too long ago to have any residual effects. In the single tree harvests, only the 1996 harvest occurred recently enough to elevate moisture within the compartment, but only 20 % basal area was cut, so again, no increases in soil moisture or streamflow would have occurred. Thus, there are no cumulative effects to Upper Elklick Run subdrainage from compartment 19 above those described for direct and indirect effects.

Compartments 13 and 21 had farm woodlot harvests on them approximately every 10 years for the last 40-50 years. The most recent harvest in compartment 13 was in 2003, and it is the only one that occurred recently enough to still have the potential to show effects. At that time only 19 % of the basal area in the 31.3 acres compartment was harvested, so changes to soil moisture would not have occurred. The most recent cut in compartment 21 was in the early 1990s (the exact year is unknown), but removed only 11 % of the basal area from the 30.9 acres compartment. Thus, no effects to moisture regimes would have occurred from that small removal of timber. 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 has had single-tree selection in subcompartment 20A in 1952, 1968, 1973, 1977, 1987, and 1997. Subcompartment 20B has had 4% financial maturity harvests in 1952, 1968, 1977, 1987, and 1998, and subcompartment 20C has had diameter-limit cuts in 1952, 1970, and 1990. The most recent diameter-limit harvest was too long ago to continue to show effects to moisture regimes. The 1997 single-tree selection removed 25 % of the basal area in the compartment, which was just at the level at which soil moisture could increase measurably within the compartment. However, the area harvested was only 18.7 acres, or 2.5 % of the subdrainage, so it did not affect the hydrology of the subdrainage. The amount of basal area removed from subcompartment 20B in 1998 was not enough to increase soil moisture locally or within the subdrainage. Consequently, there are no cumulative effects to Upper Elklick Run subdrainage from compartment 20 above those described for direct and indirect effects.

Within Upper Elklick Run subdrainage, there are 36.98 acres of roads, skid roads, and decks, which constitute 5.03 % of the subdrainage area. This figure includes the portion

of Forest Road 701 that lies within the subdrainage, but is well below the 15 % 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 Forest Road 701, because this road runs along the channel for almost the entire channel length. There are 2.66 miles of Forest Road 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.

Hickman Slide Subdrainage

Compartments 5 and 7 have had 2 % financial maturity, patch cut, or single-tree selection treatments every 10 or 15 years, depending on subcompartment, since 1956. Together the two compartments effectively occupy all of the acreage within Hickman Slide subdrainage. Compartment 7 is composed of an additional Subcompartment not discussed earlier, 7C that is not proposed for treatment in this EIS, but was subject to single-tree selection in 2003. Effects from single-tree harvesting 28 % of the basal area from subcompartment 7C in 2003 would not have increased streamflow measurably due to the small size of the harvest area (19.6 acres), its position in the uppermost headwaters of the compartment, only single-tree selection was used (rather than a concentration of harvested trees in a patch or group), and the lack of a stream in the subcompartment. For those same reasons and because of the low erodibility of the Dekalb soil in this area, sedimentation and channel morphology changes due to streamflow or changing sediment budgets would not have occurred in subcompartment 7C during the 2003 harvesting. Subcompartment 5A, the other subcompartment in compartment 5 not discussed earlier, had 15 % of its basal area harvested with a 2 % financial maturity treatment in 1971 and has not been harvested again. Consequently, the cumulative effects in Hickman Slide subdrainage are the same as the direct and indirect effects for Alternative B described previously.

Within Hickman Slide subdrainage, there are 17.14 acres of roads, skid roads, and decks, which constitutes 5.82 % of the subdrainage area. This figure includes the portion of Forest Road 701 that lies within the subdrainage. This figure is well below the 15 % figure given for ditched roads to avoid changes to channel morphology (Verry 2000).

Camp Hollow Subdrainage

Camp Hollow subdrainage includes several gauged watersheds. Two of these watersheds are reference, or control, watersheds (watersheds 4 and 10) that have been untreated for at least 85 years. Therefore, these watersheds do not contribute to cumulative effects in the subdrainage.

The subdrainage also includes watershed 2, which received diameter limit harvests in one or both of its two subcompartments in 1958, 1972, 1978, and 1988, and 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. Most of these increases occurred during the dormant season. However, the presence of streamflow increases probably is not due to any of the past harvests on watershed 2 (either watershed 2A or B). Instead the increases probably are 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 (P.J. Edwards, 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 year suggests that increased streamflows on watershed 2 were not attributable to harvesting or associated activities. Consequently, indirect changes associated with increased flows, such as within-stream erosion would not have occurred.

However, almost 15 % 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 head cutting, that might occur from concentrating effects of runoff and sediment delivery likely already have occurred. Additional significant morphology changes would not be expected. 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 of both sides of the channel. To-stream sediment delivery was observed from the skid road for a short period after the 2003 harvesting before the skid road was water barred. These sediment inputs would have altered local sediment deposition and erosion in the nonperennial channel in watershed 2, but the delivery was short term. Therefore, past activities in watershed 2 probably changed sediment budgets within the local nonperennial stream. Some of this sediment could have been transported downstream into Camp Hollow Run, but the presence of the weir pond at the mouth of watershed 2 makes it likely that much of the excess sediment would have settled out into the pond rather than moving further downstream. However, sediment may have reached Camp Hollow Run via the log landing used for decking logs. The deck is adjacent to Camp Hollow Run, so sediment contributions from it probably occurred during each use.

Past harvesting in Camp Hollow subdrainage also included single-tree harvesting in watershed 5A and 5B subcompartments every 10 years from 1958 to 1998, and also in 1993. 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. As with the proposed harvesting in Alternative B, past 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 involved.

Because of the probable increases to in-stream sedimentation that occurred from past harvesting in watersheds 2 and 5, these watersheds contribute to the cumulative effects in Camp Hollow subdrainage.

Past harvesting also occurred in watershed 3. In 1958-59, a single-tree selection treatment was applied. Selected trees $\geq$5 inches diameter were harvested. Increased streamflow was observed in 1960. In 1970, the watershed was clearcut, except for a bufferstrip around the stream channel. In 1972, the bufferstrip also was clearcut and all 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 activities in watershed 3 do not contribute to cumulative effects in Camp Hollow subdrainage.

Skid roads, haul roads, and log landings constitute only 3.16 % of the Camp Hollow subdrainage area. This figure is well below the 15 % figure given for ditched roads (Verry 2000) that can result in hydrologic and channel morphology alterations. Forest Road 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 Forest Road 712, so washouts and large sediment pulses into the channel during large flows are not common problems, but in general, in-stream sedimentation in Camp Hollow Run subdrainage are predominately due to Forest Road 712.

Big Spring Run Subdrainage

Big Spring Run subdrainage includes compartments 32, 33, and 8. Both compartments 32 and 33 had seed tree harvests in the early 1960s and then were thinned in 1981. These compartments are 21.7 and 12.8 acres in size, respectively, and all of the basal area was removed from each compartment during the second seed tree cuts in 1963 and 1964. During the thinning approximately half of the basal area was removed from the compartments. Local soil moisture would have increased and streamflow also may have increased due to the losses of evapotranspirational surfaces. However, since these areas comprise only 16 % of the Big Spring Run subdrainage, streamflow and soil moisture increases at the subdrainage level would not have occurred, and any local changes would have disappeared during the subsequent 20+ years, as the vegetation in the compartments regrew. Consequently, compartments 32 and 33 do not contribute to cumulative effects today.

In addition to 8B, 8C, and 8D proposed for treatment in Alternative B, compartment 8 also includes two other subcompartments, 8A and 8E. Subcompartment 8E is a reference compartment that has had no treatments or disturbances in it, so it would not contribute to cumulative effects. Subcompartment 8A was clearcut in 1949. The effects to streamflow and soil moisture at that time would have been confined to the compartment, as it was only 5 acres in size. At the subdrainage level, changes to streamflow and soil moisture would not have been measurable since compartment 8A is only 2.5 % of the area in Big

Spring Run subdrainage. Any local effects no longer would be measurable as the stand has regrown and the transpiration demand have been been restored to pre-harvest levels. Consequently, there are no cumulative effects from subcompartment 8A.

Harvesting on subcompartments 8B, 8C, and 8D has occurred regularly and repeatedly in the past. Diameter-limit harvests have been performed on subcompartment 8B in 1949, 1968, and 1988. Although 50-60 % of the basal area was removed from the compartment during each harvest, the area treated was only 5 ac or 2.5 % of the subdrainage acreage so the effects would have been local at best and not measurable on a subdrainage basis. Because the last harvest on subcompartment 8B was in 1988, even local effects no longer would be present. Consequently, there are no cumulative effects from subcompartment 8B.

Single-tree selection was performed in subcompartment 8C in 1950, 1959, 1968, 1979, 1988, and 1999. Intensive single-tree selection was performed in subcompartment 8D in 1949, 1958, 1964, 1968, 1979, 1988, and 1999. In subcompartment 8C, $\leq$23 % of the basal area was harvested in each of the years, except the 1949 harvest. Consequently, local increases to soil moisture would not have been measurable. It is unlikely that even at 23 % basal area removal that soil moisture increases would have been measurable since the harvest was single-tree rather than small group or patch cuts. If small increases occurred, they all would no longer be measurable locally and they never would have been measurable on the subdrainage level.

Similarly, the intensive single-tree selection harvests in subcompartment 8D were $\leq$23 % of the basal area spread out over 5 acres, except the 1949 harvest which removed 42 % of the basal area. No increases in soil moisture would have been observed on the subdrainage level.

Skid roads, haul roads, and log landings constitute only 3.41 % of the 200 acre Big Spring Run subdrainage. This figure is well below the 15 % figure given for ditched roads (Verry 2000) that should be maintained to avoid streamflow changes that in turn can change channel morphology.

Consequently, past harvesting in compartment 8 does not contribute to cumulative effects, and the cumulative effects for Big Spring Run subdrainage are the same as the direct and indirect effects described earlier.

Stonelick Run Subdrainage

About half of compartment R1 was treated with prescribed fire in spring 2002 and 2003. The prescribed fires were relatively light and the humus layer remained mostly intact, protecting mineral soil. Consequently, the past burning did not contribute to cumulative effects.

Compartment 61 was harvested using a 3 % financial maturity harvest in 1974, 1984 and 1994. Compartment 71 received vertical strip clearcuts in 1977 (4 acres) and 1987 (4 acres). A new study was installed in compartment 71 in 1995; 75 % of a 16-acres area was clearcut in 1-acre blocks in 1996. Localized soil moisture increases may have occurred, but they would no longer be measurable and they never would have been measurable on the subdrainage level. A 3-acres group selection cut was applied to Compartment 90 in 1991. This represents about 34 % of the basal area. None of these activities would have removed sufficient basal area to have affected streamflow significantly then or to have a continued effect now at the subdrainage level. Consequently, there are no cumulative effects related to streamflow changes in the Stonelick Run subdrainage attributable to harvesting.

There are 15.55 acres of roads and decks in Stonelick Run subdrainage. This constitutes 2.51 % of the subdrainage. This figure is well below the 15 % 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.

Canoe Run Subdrainage

In addition to compartment 20, Canoe Run subdrainage contains compartment 43 and 90. Compartment 43 had seed tree and thinning treatments in 1960, 1963, and 1980. The treated area was 9.9 acres or 1.4 % of the subdrainage. Compartment 90 had a single 5.5-acres group selection cut in 1991 which removed 34 % of the compartment's basal area. Any increases in streamflow that might have occurred in Canoe Run from those harvests would have returned to pre-harvest levels by now. The Monongahela National Forest logged areas near Big Springs Gap, Turkey Run, and Condon Run in 1972. One or more subcompartments of compartment 20 received harvests in 1952, 1968, 1970, 1973, 1977, 1987, 1997, and 1998. None of these activities removed sufficient basal area on a subdrainage basis to have affected streamflow significantly then or to have a continued effect now. Consequently, there are no cumulative effects related to streamflow changes in the Canoe Run subdrainage attributable to harvesting.

There are 10.07 acres of Canoe Run subdrainage in roads and decks. This comprises 1.46 % of the acreage in Canoe Run subdrainage. This figure is well below the 15 % 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

About half of compartment R1 was treated with prescribed fire in spring 2002 and 2003. The prescribed fires were relatively light and the humus layer remained mostly intact, protecting mineral soil. Consequently, the past burning did not contribute to cumulative effects.

Approximately 21.7 acres of compartment 90 occurs in this subdrainage. Thirty-four % of the basal area was harvested by group selection in the compartment in 1991. Three-quarters of that basal area was harvested within the Sugarcamp Run subdrainage (calculated based upon area). This harvesting did not remove sufficient basal area to have affected streamflow significantly. Consequently, there would be no cumulative effects related to streamflow changes in the Sugarcamp Run subdrainage attributable to harvesting in Alternative B.

There are 4.32 acres in roads and decks in Sugarcamp Run subdrainage. This comprises 1.95 % of the acreage in Sugarcamp Run subdrainage. This figure is well below the 15 % 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.

Fire Run Subdrainage

About half of compartment R1 was treated with prescribed fire in spring 2002 and 2003. The prescribed fires were relatively light and the humus layer remained mostly intact, protecting mineral soil. Consequently, the past burning did not contribute to cumulative effects. No other compartments have been treated in the past in Fire Run subdrainage. Consequently, the cumulative effects in Fire Run subdrainage are the same as the direct and indirect effects given previously for this subdrainage.

Cumulative Effects on Elklick Run watershed of Alternative B

Elklick Run watershed at the confluence with the Black Fork River contains 3578 acres of Forest Service land and 136 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 during the last 5 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. The skid roads were not mulched or seeded following use and they remain bare. Because the harvest on the private land was fairly heavy, no additional harvests or skid road use by the land owner is expected in the foreseeable future.

No treatments are proposed in Alternative B for Lower Elklick Run subdrainage, but because it is within the Elklick Run watershed (it is the Forest Service portion of the Elklick Run watershed adjacent to the private land) attributes and past activities are described here in terms of their contributions to cumulative effects in the Elklick Run watershed.

Lower Elklick Run subdrainage contains a reference watershed (watershed 13) that has not been treated or disturbed in at least the last 85 years, so this watershed would not contribute to cumulative effects.

Several watersheds have had relatively intensive treatments, but these occurred several decades ago and their effects on soil moisture, streamflow, and stream water chemistry no longer exist. Watershed 1 was clearcut without BMPs in 1958, and increases in streamflow and turbidity/suspended sediment disappeared several decades ago (Hornbeck et al. 1993). Therefore, past activities in watershed 1 do not contribute to cumulative effects in Elklick Run watershed.

Watersheds 6 and 7 were clearcut in halves in the 1960s and herbicided for a number of years to maintain the watersheds barren of vegetation. Streamflow increases were significant, but returned to pretreatment levels by the mid to late 1980s (Hornbeck et al. 1993). Thus, effects from treatment of watersheds 6 and 7 in the 1960s are no longer measurable and would not contribute to cumulative effects in the Elklick Run watershed.

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 done in compartment 72, and contour strip clearcuts also were done in 5.2-acre strips in compartment 73 in 1978, 1988, and 1998. None of these clearcuts removed enough basal area within the 40-60 acre compartments to increase soil moisture or streamflow locally, or within the Lower Elklick subdrainage. Consequently, they would not contribute to cumulative effects in the Elklick Run watershed.

Compartment 80 (13.1 acres) underwent a deferment harvest in 1981, at which time 81 % of the compartment's basal area was harvested. As this cut approached a clearcut in terms of basal area removed, a local increase in soil moisture would have been observed, and streamflow might have increased immediately around the harvested area, but the effects to streamflow would not have been substantial since only 13.1 acres were treated. Today, effects to moisture and streamflow would no longer exist since more than 20 years has passed and forest regrowth occurred. On a subdrainage basis, streamflow increases would not have been measurable since compartment 80 is only 1 % of the Lower Elklick Run subdrainage. Consequently, past activities in compartment 80 would not contribute to cumulative effects in the Elklick Run watershed today.

Compartments 36, 37, and 38 had seed tree harvests in 1962 and 1964 followed later by thinnings in 1987 (compartments 36 and 37) and 1991 (compartment 38). These each removed enough trees to increase soil moisture locally, but since only a maximum of about 10 acres were treated in each compartment increases to streamflow probably would not have been measurable. Effects at the subdrainage level would not have be measurable since compartments 36, 37,and 38 together comprise less than 3 % of Lower Elklick Run subdrainage. Furthermore, even local effects would no longer be present given the length of time since the last treatment in each compartment, so past activities in compartments 36, 37, and 38 would not contribute to cumulative effects in the Elklick Run watershed.

Compartment 60 is the most recently treated compartment in Lower Elklick Run subdrainage. It received a 4% financial maturity harvest in 1972, 1981, 1991, and 2004. Enough basal area was removed only in the earliest two cuts to observe moisture increases locally. More recent wood removals, including the one in 2004, did not remove enough basal area to change moisture regimes. Consequently, historic and recent past activities on compartment 60 would not contribute to cumulative effects in the Elklick Run watershed.

Alternative B would be applied to only 448.6 acres, or 12.1 %, of the Elklick Run watershed area. These activities would have measurable effects only at the local or subdrainage level, as described for the individual subdrainages. Haul roads, skid roads, and decks comprise 3 % of the area in the Elklick Run watershed, which is well below the 15% required to affect runoff and channel morphology. Consequently, actions in proposed in Alternative B would have negligible cumulative effects at the 3714-acre Elklick Run watershed scale.

Cumulative Effects on Shaver's Fork of Alternative B: Proposed Action

Shavers Fork watershed drains approximately 124,350 acres at the confluence with Stonelick Run and neighboring subdrainages. Future activities in the Shaver's Fork watershed include the proposed construction of a limited access divided highway. An Environmental Impact Statement has been prepared for that project, and a new EIS is being prepared for a newly chosen route through part of the Shaver's Fork watershed. This is beyond the scope of this EIS. Sediment inputs and other sediment-related changes discussed in the Direct and Indirect Effects section for Alternative B would have negligible cumulative effects at the Shaver's Fork watershed scale.

Direct and Indirect Effects of Aleternative A: No-Action Alternative

Alternative A is the no-action alternative. In this alternative, no trees would be harvested and no new haul roads, skid roads, or log landings would be constructed. However, current open roads would remain open, and their use would remain high. 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 Fernow for recreation, access to Otter Creek Wilderness, also would continue. Normal road maintenance activities would continue, as would washouts of undersized culverts on Forest Road 701. Continued long-term aggradation of sediment within Elklick Run would be expected since Forest Road 701 runs very near Elklick Run for almost all of Elklick Run's length. Long-term aggradation of Forest Road 712 also would be expected since it closely parallels Camp Hollow Run. However, the effect on Camp Hollow Run probably would be less than aggradation of Elklick, simply because Forest Road 712 has no history of culvert washouts and it is gated, with traffic levels less than on Forest Road 701.

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 in the absence of repeated skid road use. The presence or absence of recovery would be largely dependent upon the rate and success of vegetation (especially trees) reestablishment on skid roads, and the degree of culvert washout on the skid roads at stream crossings. In the absence of skid road use, maintenance of the culverts would likely be rare or nonexistent. Consequently, the opportunity for culvert clogging and washout exists, and increases substantially over time. In these cases, stream recovery would require a very long time, and in fact may not occur simply due to long-term problems that develop due to the lack of maintenance.

Due to the generally smaller area in roads and decks in Stonelick Run, Canoe Run, Sugarcamp Run, and Fire 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.

Cumulative Effects of Alternative A: No-Action Alternative

Because there are no new Forest Service ground disturbing activities and no timber harvesting in this alternative, no additional adverse effects on water quality and riparian resources would exist. Stream habitat in Elklick Run would improve to some degree in the long term as treatment-derived sediment from all the cumulative treatments over time is flushed from Elklick Run. However, Forest Road 701 would still exist and be open to public use. Because Forest Road 701 is the primary chronic source of sediment to Elklick Run, large sediment inputs would still continue in Alternative A. Additionally, with no use, skid roads and perhaps some haul roads might not receive the maintenance they would under the other alternatives. 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.

No noticeable improvement in the Shaver's Fork River is expected because the contributing area and corresponding sediment loads of Stonelick Run, Canoe Run, Sugarcamp Run, and Fire Run subdrainages would be extremely small relative to the rest of the contributing upstream areas of the Shaver's Fork River.

Direct and Indirect Effects of Alternative C: Management Action

Alternative C includes the actions proposed in Alternative B and control of exotic plant species by spot herbiciding. The reduction in evapotranspiration from killing exotic species with herbicides would not be measurable due to the small number of plants and size of the plant surfaces affected. Application also would not involve the construction of additional roads or trails, nor would it involve techniques that would increase erosion. Consequently, there would be no additional direct and indirect effects to any of the subdrainages in Alternative C above those already described for Alternative B.

Cumulative Effects on Elklick Run Watershed of Alternative C: Management Action

Alternative C would have no additional changes to hydrology or sediment relationships above those described in Alternative B, so cumulative effects to Elklick Run watershed under Alternative C would be the same as those given for Alternative B.

Cumulative Effects on Black Fork Watershed of Alternative C: Management Action

Alternative C would have no additional changes to hydrology or sediment relationships above those described in Alternative B, so cumulative effects to Black Fork watershed under Alternative C would be the same as those given for Alternative B.

Cumulative Effects on Shaver's Fork Watershed of Alternative C: Management Action

Alternative C would have no additional changes to hydrology or sediment relationships above those described in Alternative B, so cumulative effects to Shaver's Fork watershed under Alternative C would be the same as those given for Alternative B.

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 of 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 not uncommon, particularly during the summer. These inversions are usually short-lived, however. Local emission sources include residential wood burning, burning of slash and land-clearing on private land, a local charcoal manufacturing plant, vehicular traffic, 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 (PM10), sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), and lead. The primary purpose of these standards is to protect human health, and the secondary purpose is to protect human welfare. An area that is found to be in violation of a NAAQS is called a non-attainment area. Pollution sources contributing to non-attainment areas are subject to tighter restrictions. There are no non-attainment areas in Tucker County, or any of the immediately surrounding counties (U.S. EPA Air Quality web page: http://www.epa.gov/airs/nonattn.html). The Clean Air Act also has provisions for the "Prevention of Significant Deterioration" and the prevention of visibility impairment in federally mandated Class 1 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 Fernow boundary, on the Fernow itself, and at locations more distant: Clover Run (8 miles northwest of the Fernow) and Bearden Knob (approximately 13 miles east of the Fernow). 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 (Table 3-4). Most of the pollutants that are deposited in Tucker County come from the west, usually the Ohio River Valley industrial complex.

The Timber and Watershed Laboratory participates in the National Atmospheric Deposition Program (NADP), a nation-wide 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. Deposition in bulk precipitation is approximately 10- 14 lb N/ac/yr and 12-15 lb S/ac/yr (11-15 kg N/ha/yr and 13-16 kg S/ha/yr; Adams et al. 1994; Helvey and Kunkle 1986). 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 Fernow 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 (~90 years old) of mixed hardwoods (Gilliam et al. 1995,Peterjohn et al. 1996). These symptoms include: high relative rates of net nitrification, elevated export of nitrate and of base cations such as calcium and magnesium, little seasonal variability in stream-water nitrate concentrations and low retention of organic nitrogen relative to other forested sites. These conclusions are in contrast to earlier research suggesting productivity of these forests is limited by nitrogen (Auchmoody and Smith 1977).

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 (J.N. Kochenderfer, unpublished data). 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. (Lawry 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 the present time. However, comparison of mean sulfur concentrations in *Flavoparmelia caperata* specimens collected in Otter Creek show a statistically significant increase between 1988 and 1993 (Lawry 1993).

Recently, deposition has been changing in Tucker County. Sulfate deposition at the Nursery Bottom has declined by almost 33% since 1989 (NAPAP 2001), and this change is attributed to the 1990 Clean Air Act Amendments. Nitrogen deposition trends are not as clear, but appear to be increasing. Deposition of basic elements (Ca, Mg) has decreased since the late 1970's 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 3-3 shows these trends.

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 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 by the vegetation differs, with lower exposures at the lower elevations of the FEF. Ozone levels sufficient to cause foliar injury of sensitive plant species have been recorded (Edwards et al. 1991; Lefohn et al. 1994), and some ozone symptoms have been recorded in Otter Creek (Jackson and Arbucci 1989) but widespread injury has not been observed. Response of vegetation to ozone in these areas from 1988 through 1999 was determined using the combination of W126 values (sigmoidally weighted exposure index), the number of hours that average concentrations were greater than or equal to 0.10 ppm (N100), and the presence of moderate or more extreme droughts. These values generally suggested minimal ozone effects, or effects to only highly sensitive tree species, with the exception of 1988. Values at Parsons in 1988 indicate that moderately sensitive and/or resistant tree species could have experience 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 would have been common, so moderate and severe ozone damage would have been unlikely. 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. 2004).

Visibility

Visibility is strongly affected by light scattering and absorption by fine particular 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 concentrations at the Bearden Knob site were found to be among the highest in the eastern U.S., but sulfate deposition is decreasing (NAPAP 1998). 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. Results show that visibility in general in eastern West Virginia is approximately the same as in most of the eastern U.S. (IMPROVE network; http://aqd.nps.gov/ard/impr). Trend plots from the IMPROVE monitoring site at Bearden Knob show that for the 20% worst visibility days, the extinction values are decreasing and visibility is improving (Figure 3-4). However, the 20% best visibility days (Figure 3-5) are not showing similar improvements (http://vista.cira.colostate.edu/views/).

Effects

Smoke from prescribed burning has the potential to cause significant effects on air quality within and surrounding the FEF, including the Class I wilderness area of Otter Creek. Prescribed fires can produce enough fine particulate matter to be a public health and/or welfare concern. Fine particulates in smoke can travel downwind and impact air quality in local communities, 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. Prescribed burning may also produce emissions of hydrocarbons, some of which may pose health problems to personnel in close proximity to the fire. However, Dost (1986) concluded that exposures are generally too low to represent a significant health risk. If properly managed, most negative effects of prescribed fire smoke can be minimized or eliminated.

Vehicular use associated with logging and transporting logs would produce some air pollutants, mainly nitrogen oxides, carbon monoxide and particulate matter (dust). Dust is produced primarily during periods when unpaved roads are dry. The effects are generally not detectable and insignificant beyond the immediate vicinity of the vehicles.

Direct and Indirect Effects of the Action Alternatives (Alternatives B and C)

Under both alternatives, a total of 2,729,301 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 (EPA 1997-2002) and basic operations assumptions for a “typical” logging operation in mountainous areas. Nitrogen Oxides (NOx), hydrocarbons (VOCs), and particulate matter (PM) were determined to be the most significant emissions emitted from harvesting equipment, 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 1999 base case emissions inventory (Stella and Jackson, emissions tool), and include total emissions from counties within 50 km of the FEF. Emissions from timber harvest activities were viewed as a percent of the total regional pollution load on an annual basis. The results of this comparison are in table 3-6., and demonstrate that the effects of felling, skidding and yarding on air quality would be insignificant in comparison with total regional emissions.

Under both alternatives, a total of approximately 204.8 acres would be burned over a five-year period. It is expected that burning would be completed over a period of several days on each of the two sites, so total emissions produced from prescribed burning activities will not all be emitted in one day. The prescribed fire would be a slow-moving

(1-5 ft/min) 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 as determined from the *Behave* Fire Simulator, Fuel Model 9. The burn plan and prescribed fires would be conducted according to state regulations administered by the West Virginia Division of Forestry. The most recent smoke management guidelines would be followed (Smoke Management Guide for Prescribed and Wildland Fire, National Wildfire Coordination Group, Dec 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 airsheds can be mitigated by burning under prescribed conditions that avoid putting smoke in those areas.

During burning it is estimated that a total of 31.23 tons of particulate matter ($PM_{2.5}$ + PM_{10}) and 3.89 tons of nitrogen oxides would be released to the atmosphere (FOFEM 5.1 model run results). The total PM and NOx emissions estimates were compared to regional emissions (in tons per year) from all source sectors. Regional emissions estimates come from the VISTAS 1999 base case emissions inventory (Stella and Jackson, emissions tool), and include total emissions from counties within 50 km of the FEF. Total emissions from prescribed fires were calculated as a percent of the annual regional pollution load (Table 3-7).Prescribed fire emissions represent less than 0.05% of the emissions for the region on an annual basis. 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 over a five-year period. Thus, prescribed fire emissions from the FEF in any given year will be much 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 insignificant in comparison with total regional emissions.

Nitrogen losses were estimated at 300-500 kg/ha (455 lbs/ac) from a hot understory fire in North Carolina (Vose et al. 1993). Emissions would be less from a cooler fire, as we propose, with lower fuel loadings (estimated at 26 tons/ac for FEF, compared to 60-90 tons/ac in North Carolina). NOx emissions are estimated at 30 lbs/ac (R.Ottmar, Pacific Northwest Research Station, personal communication), or less than 0.2% of the emissions in the county. Losses of N from the forest floor would be estimated as part of the proposed research to determine the significance of N losses.

Cumulative Effects of the Action Alternatives (Alternatives B and C)

The FEF is located within an area of the Monongahela National Forest of 26,056 acres that would not be burned or logged 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 two prescribed burns would not contribute significantly to local pollution levels, nor contribute to a NAAQS violation in Tucker County or the surrounding area. Deposition of sulfate is expected to continue to decrease, and deposition of N is expected to increase 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 the Action Alternatives (Alternatives A and C)

Proposed mitigations would have no effect on air resources.

Direct and Indirect Effects of the No-Action Alternative

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 the No Action Alternative (Alternative B)

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. Deposition of sulfate is expected to continue to decrease, and deposition of N is expected to increase over the long run. Because of the small acreage involved and the short duration of the prescribed burning, the incremental impact on the air resource would be insignificant.

3.3 Soil Resources

Affected Environment

Soils within the Fernow Experimental Forest belong to the following soil series: Alluvial; Belmont; Brinkerton; Calvin; Cateache; Cookport; Dekalb; Ernest, Gilpin, Meckesville, and Monongahela. The drainages where the series are found are identified in the individual soil series descriptions below.

ALLUVIAL LAND: (Hickman, Bear Run, Upper Elklick, Camp Hollow, Wilson Hollow) Alluvial land is 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. Frequent flooding and variations in drainage make this land type better suited to grasses and legumes for hay, forests, or grazing than to cultivated crops. Depth to bedrock is variable. Erosion is a major management concern. These soils are the major component soils of riparian zones.

BELMONT SERIES: (Bear Run, Tippy Toe, Upper Elklick) The Belmont series consists of deep, well drained soils formed in material weathered from limestone with some interbedding of shale, siltstone, and sandstone. They formed on uplands and depth to bedrock ranges from 40 to 60 inches. 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 in unlimed areas is strongly acid through slightly acid in the surface layer and upper subsoil. It is moderately acid through mildly alkaline in the substratum.

BRINKERTON SERIES: (Hickman, Canoe Run) The Brinkerton series are deep, nearly level to moderately sloping, somewhat poorly drained or poorly drained, grayish-brown soils that occur on plateaus. These soils are saturated with water in spring and in fall because the firm layer in the subsoil is very slowly permeable. They occur in minor amounts on the FEF.

CALVIN SERIES: (Sugarcamp Drainage, Hickman, Bear Run, Stonelick, Canoe Run, Tippy Toe, Upper Elk Lick, Camp Hollow, Wilson Hollow) The Calvin series consists of moderately deep, well drained soils formed in material weathered from interbedded shale, siltstone, and sandstone. They formed on uplands and 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. The reaction in unlimed areas is very strongly acid or strongly acid. The root zone of some plants is restricted at a depth of 20 to 40 inches.

CATEACHE SERIES: (Hickman, Tippy Toe, Upper Elklick, Bear Run) The Cateache series consists of moderately deep, well-drained soils with moderate permeability. 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: (Canoe Run, Hickman, Tippy Toe, Upper Elklick) 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. This soil is well suited to timber and to wildlife habitats. It is found in minor amounts on the FEF.

DEKALB SERIES: (Hickman, Stonelick, Wilson Hollow) The Dekalb series 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. The reaction in unlimed soils is extremely acid through strongly acid. The root zone of some plants is restricted at a depth of 20 to 40 inches. This soil has a moderate potential productivity for trees.

ERNEST SERIES: (Canoe 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. Can also be found at the heads of drainages. Depth to bedrock is 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. This soil has high potential productivity for trees. It is found in minor amounts on the FEF in or near riparian areas.

GILPIN SERIES: (Stonelick, Sugarcamp, Canoe Run, Fire 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 minor. The soils normally occur on ridges too steep for road construction.

MECKESVILLE SERIES: (Upper Elklick) 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. The reaction in unlimed areas is strongly acid or very strongly acid throughout. A seasonal high water table about 2 1/2 to 3 1/2 feet below the surface restricts the root zone of some types of plants. This soil type is found in minor amounts in the FEF.

MONONGAHELA SERIES: (Canoe Run, Sugarcamp, Fire Run) In the Monongahela series are deep, moderately well drained soils that developed in material weathered from sandstone and shale. These soils are on terraces along the major streams, mainly on high terraces along the Cheat River. This soil is found in minor amounts in the FEF.

Effects

Potential effects on soils from research activities and connected actions consist of: 1) disturbance and exposure of soil; 2) increased 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 (wind-throw 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 possible increasing infiltration and water holding capacity. Generally, prescribed fires seldom remove more than 50% of the forest floor (Pritchett and Fisher 1987). A spring prescribed burn conducted on the Fernow (Stonelick sub basin) in spring of 2002 resulted in a decreased average depth of forest floor from 5.6 to 2.5 cm, 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 and Edwards (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 skidroads in the more heavily cut portions of the untreated area. Exposed bare soil on both road types had decreased to 23.5% 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 skidroads 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% 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. 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% 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% 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 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 N/ac compared to 97 lbs N/ac in a sawtimber harvest (Adams 1999). However, repeated light cuts can remove as much biomass and nutrients over the course of a rotation as one commercial clearcut (Patric and Smith 1975).

Controlled burning affects nutrient leaching, soil temperature, and changes in soil fertility. Large amounts of nitrogen (N), the nutrient most commonly limiting to forests, may be released via volitization 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 Ca, Mg, and 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 WS3. Adding nitrogen and sulfur to a watershed 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 is absorbed reasonably strongly by clay and organic matter within the soil (Edwards et al. 2002). 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. 2002), but no significant change in the base cation status of the soils on WS3 has been detected by repeated sampling (Adams et al. in press). Also, the hypothesis of base cation depletion is one of the hypotheses being tested by the proposed research.

Direct and Indirect Effects of Alternative A: No-Action Alternative

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 road construction and no vehicular use of existing skidroads.

Soil movement

Under this alternative, no new road construction would occur, and existing skidroads would not be re-opened and used. Soil erosion would continue from system roads (mainly FR701) 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 continue to increase. Deposition of sulfate (SO_4) is decreasing (NAPAP 2001). Some of the stands on the Fernow may already be N-saturated as a result of ambient deposition (Peterjohn et al.

1996). Thus although effects of ambient deposition (approximately 14 lb N/ac/yr or 15 kg N/ha/yr) 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 natural factors, such as acidic deposition and elevated ambient N deposition. Detectable short-term changes in soil fertility are not likely. 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 Alternative

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 are 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 skidroads, past research activities have had relatively minor and short-term effects on the soil resource because of the dispersed nature of the most of the activities. Additional effects from the No-Action alternative are likely to be negligible.

Aggradation in Elklick Run is attributed primarily to the presence of Forest Service Road 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 purposes. 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 1345 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.

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.

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 and with log landings. Therefore only the area in skidroads and decks was used in this calculation because disturbance of mineral soil rarely occurs except under repeated passes. Based on this assumption, a maximum of 6.5 % of the treatment area or 45.45 acres would experience soil disturbance. This corresponds to less than 1% of the total FEF area.

The majority of the 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. For the proposed new study, soil would be disturbed as a result of the creation of 3.1 miles of firebreak. The potential effects on soil movement are discussed in section 3.1 and should be minimal due to the use of buffer strips.

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% 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% 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 and logging decks, or about 6.5% 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 decrease plant growth and can 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. Although the new fire breaks on John B. Hollow could result in some compaction, only one pass with the bulldozer would be required. Without repeated passes, compaction should be minimal and temporary. Therefore only about 6.5% of the area to be treated would likely be affected by compaction, or less than 1% 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 13% of the area. Dekalb soils are characterized by low erodibility, and occupy about 22% of the FEF. Gilpin and Calvin series, which have moderate erodibility, make up 56% 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; one new deck would be built, and one abandoned for this alternative. Because skid roads and decks are closed and mitigated, and BMPs followed during logging, erosion would be minimized due to the use of buffer strips.

Approximately 260 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 drainage of the Fernow 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 anecdotal insights from foresters and soil scientists working in burned areas suggest that hydrophobicity probably does not

play an important role in post fire erosion. Vegetative buffer strips will be used along the streams for the study "Prescribed burning and variable intensity overstory mortality for enhanced wildlife habitat structure and long-term oak restoration", further ameliorating or preventing soil movement resulting from prescribed burning.

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 (Table 3-8). 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 23.2 acres, or less than 0.1% 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% following fires have been reported (Klock and Helvey 1976). Thus, while we may see changes in soil moisture as a result of the proposed new research, "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 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, 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 proposed new 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. The study design will include monitoring to evaluate the effects on soil moisture and temperature to address this possibility.

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, 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 and strip 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 germinations 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 would result in a decrease of 15-30% of the total Ca pool, assuming no weathering inputs. There is no whole-tree harvesting proposed on the Fernow, 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, 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 260 acres would be burned during the period of the analyses (5.5 % of the FEF), so changes are not likely to be detectable. Rapid revegetation after the spring burn would take advantage of increases in available nutrients, so that leaching would be minimized. Monitoring of soil solution chemistry will continue in order to evaluate the significance of potential leaching losses.

Study 4300-FS-NE-4301-63, "The Effect of artificial acidification on vegetative growth and nutrient status" was designed to evaluate the effects of watershed acidification on soil and vegetation processes, including nutrient cycling. Since January 1989, ammonium sulfate fertilizer has been applied three times per year, for an annual rate of 35.5 kg N/ha and 40.6 kg S/ha. Numerous papers (Adams et al. 1993, Adams et al. 1995, Edwards et al. 2002, Edwards et al. 2002) have been published by Fernow scientists and show that nutrient cycling 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 nitrate. Repeated sampling of the soil on WS3 has not shown a significant decrease in mineral soil exchangeable Ca and Mg, (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 nitrate and sulfate. Experimental design calls for continued monitoring to evaluate the extent of this process, and documentation of other changes in soil chemistry.

Soil Fertility

Fertility is 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 surge 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 ground water 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% or more of a project area. Skidroads and decks cover less than 8% of the total treatment area and little more than 1% 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).

Study 4300-FS-NE-4301-63, "The Effect of artificial acidification on vegetative growth and nutrient status" was designed to evaluate the effects of watershed acidification on soil and vegetation processes. Although numerous papers (Adams et al. 1993, Adams et al. 1995, Edwards et al. 2002, Edwards et al. 2003) have been published by Fernow scientists which show that nutrient cycling has been affected by the fertilization treatment, repeated sampling of the soil on WS3 has not documented a significant decrease in mineral soil exchangeable Ca and Mg (M.B. Adams, unpublished data). 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). 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 study 4300-FS-NE4301-63, direct and indirect effects of the Proposed Alternative on soil resources of the FEF would not be significant. As the objective of study 4300-FS-NE-4301-63 is evaluate the effects of ecosystem acidification on ecosystem processes, the study design will allow us to evaluate the significance of the hypothesized effects on the treatment watershed.

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 are 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 skidroads, past research activities have had relatively minor and short-term effects on the soil resource because of the dispersed nature of the 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 8 % 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 1345 acres of private land within this area. Timber harvesting in general on private land has caused more disturbance to the soil mainly due to (historically) a much lower 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 acidification treatment outside of WS3, except possibly in the stream. Monitoring of downstream resources has shown no significant effects on stream chemistry approximately 975 feet downstream of the mouth of WS3.

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

Direct and Indirect Effects of Alternative C: Management Action

This alternative is very similar to the Proposed Alternative, but under this alternative herbicides would be used to control the spread of invasive exotic plant species on the

FEF. Control is targeted toward Japanese stiltgrass on 2.5 acres. In addition, individual plants such as Tree-of-Heaven and autumn olive would be eliminated by stem injection of hericides.

Soil disturbance

The effects on soil disturbance would be similar to those described in Alternative B. The treatment of exotic invasive plant species with herbicides does not affect the amount of ground disturbance.

Soil compaction

The effects are similar to those described in Alternative B. The treatment of exotic invasive plant species with herbicides does not affect the amount of soil compaction.

Soil movement

The effects are similar to those described in Alternative B. The treatment of exotic invasive plant species with herbicides does not affect the amount of soil movement.

Soil moisture

The effects would be similar to those described in Alternative B, and were discussed previously. The treatment of exotic invasive plant species with herbicides does not affect soil moisture, except perhaps on a very local scale as the plants are removed from transpiring. It is expected that any such effect would be ephemeral, and not detectable.

Soil temperature

The effects would be similar to those described in Alternative B, and were discussed previously. The treatment of exotic invasive plant species with herbicides does not affect soil temperature under a closed canopy.

Nutrient cycling

The effects would be similar to those described in Alternative B, and were discussed previously. The treatment of exotic invasive plant species with herbicides on a very limited area does not affect nutrient cycling.

Soil Fertility

The effects would be similar to those described in Alternative B, and were discussed previously. The treatment of exotic invasive plant species with herbicides does not affect soil fertility.

Cumulative Effects of Alternative C: Management Action

Alternative C proposes control of invasive exotic species, which should have little or not impact on soil resources, either directly or indirectly. Other cumulative effects are identical to those described in the Proposed Action and have been described previously.

3.4. Geology and Minerals

Affected Environment

Seven bedrock geologic formations underlie the FEF. They are the Chemung Formation, Hampshire Formation, Pocono Formation, Greenbrier Group, Mauch Chunk Group, Pottsville Group, and Allegheny Formation (Taylor and Kite 1998). The Chemung and Hampshire formations occur west of Elklick Run and the Hampshire, Pocono, Greenbrier, Mauch Chunk, Pottsville, and Allegheny formations occur east of Elklick Run (Fig. 3-2). Compartment and subdrainage geology are summarized in Table 3-4.

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. Blowing Springs Cave (also known as Big Springs Cave because of its location near Big Springs Gap), located within the Greenbrier Group at the head of Big Springs Run, is the only sizeable cave on the FEF. Blowing Springs 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 Blowing Springs 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).

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 occurs 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 rockvole, 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 Governement acquired the land that is now the FEF, the mineral rights were reserved by the seller. There has been no mineral activity in the area, except past seismic exploration several decades ago. The two most important mineral resources that 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 classified as "inferred." A classification of inferred indicates that the area represents a continuation of geologic conditions similar to an area with measured natural gas reserves (Langley, 1989).

Direct, Indirect and Cumulative Effects of the Action Alternatives (Alternatives B and C)

The potential effects of the Action Alternatives would include changes in groundwater flow or introduction of sediment to caves from logging, or prescribed burning. Potential effects of the Action Alternatives also could include changes to groundwater quality in karst systems from run-off of herbicides, or the fertilization treatments from the Studies 4300-FS-NE-4301-59 and –63.

Compartments or areas WS3, WS5A, 21, 26, 61, R1 and R2

The proposed actions within these compartments would not affect caves or cave ecosystems because subsurface hydrologic conditions 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 ground water 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 WS3 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.

Compartments or areas 5B, 7, 8, 13, 19 and 20

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 2300 and 2800 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 Springs Cave. The amount of timber proposed for harvesting in other compartments is not sufficient to significantly change the flow of ground water 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 is 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 Action Alternatives.

There would be no direct, indirect, or cumulative effects of the Action Alternatives 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 3014 acres of the FEF or about 65 % of the area. This subwatershed contains numerous other smaller perennial and non-perennial streams namely: Slip Hollow, John B Hollow, Wilson Hollow, Camp Hollow, Big Spring Run, Bear Run, Hickman Slide Hollow, 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 calcaerous 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 Run, 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 quantified water quality for macroinvertebrates (Table 3-9, Angradi 1996, 1997, 1999, Angradi and Hood 1998, Meegan and Perry 1996). Macroinvertebrates are biological indicators of water quality and can be used to assess the effects of local and relatively short term environmental variations.

Effects

Potential adverse impacts on fisheries 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 water quality (unpublished data, Monongahela National Forest files). 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%, trout fry emergence is reduced to 40% (USDA Forest Service 1977, Everest and Harr 1982). Cederholm and Reid (1987) reported decreases in salmonid fry survival up to 3.4% for each 1% 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% can effectively eliminate a trout fishery (Everest and Harr 1982) as well as many macroinvertebrates species (Kaller and Hartman 2004). More recently, Hakala (2000) found that when fine sediment < 0.063 mm exceeded 1% in spawning gravels, the resulting year class strength of brook trout was reduced to 20% of that in unimpacted streams. Although the size fraction and percentage of sediment composition at which severe reproductive impairment of brook trout and alteration of macroinvertebrate communities varies across studies, it is clear that increased sedimentation is a threat to aquatic communities. 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%) that it was smaller particles, particularly < 0.063 mm that negatively affected recruitment. Based on this research, he suggested that the 5-7% 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 process can be found in Section 3.1, “Water and Riparian Resources”.

Effects Without Mitigation: If the action alternatives were implemented without the use of mitigation measures, including Forest Plan Standards and Guidelines, there would be increased stream sedimentation, reduction in water quality, and loss of aquatic habitats for fish and macroinvertebrates species. These would be caused by 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: If appropriate mitigation measures are implemented for the Action Alternatives (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.

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.

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

The Proposed Action would not yield any direct adverse effects to perennial or intermittent streams within the project area. 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 construction/reconstruction, landings, system road reconstruction and maintenance all increase the risk of sediment delivery to streams. Sediment from these small ephemeral channels can adversely affect trout fisheries downstream and far from the source of input. Continued 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 reduce sediment inputs to Elklick Run.

Direct, Indirect, and Cumulative Effects of Alternative C: Management Action

The direct and indirect effects of Alternative C on aquatic resources would be the same as those described for the Alternative B. Mitigation activities would reduce sediment inputs to Elklick Run.

3.6 Wildlife Resources

Classification of vegetation into forest cover types, size classes, sere, 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, and past or historic landuse 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 non-forested) and seres within those types. Moving from generalist to specialist, additional elements are factored in and include physical variables such as elevation, karst formations, emergent rock, springs, seeps, and standing water. Biological variables considered include: 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 1900's 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 1930's 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 has consisted of 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 frequent 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. 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 (Atkenson 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, Yahuner 2003). Neotropical migrant songbirds have been declining in numbers throughout recent years. Therefore, it is important to understand that forests can be readily manipulated to meet disturbance-dependence 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 2000, Ford et al. 2002, Ford et al. 2004), bats (Stihler 1994, Stihler 1995, Stihler 1996, Stihler 1997, Menzel et al. 2000, Owen 2000, Menzel et al. 2002, Owen et al. 2002, Owen et al. 2004), 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. 2004), black bear (Reiffenberger et al. 2000) and white-tailed deer (Miller et al. 1999, Campbell 2003, Laseter et al. 2004).

Nonforested Lands

Approximately 53 acres of nonforested openings (slightly more than 1% of the FEF) exist as logging decks, weir sites, skid roads and parking areas. Some wildlife species prefer disturbed or open areas such as fields, meadows, or areas with dense grassy and shrubby

growth. These species include the indigo bunting, chipping sparrow, field sparrow, and song sparrow (Buckelew and Hall 1994). Game species such as ruffed grouse, wild turkey, and white-tailed deer readily utilize open areas and nonforested lands (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 2004) and bats (Menzel et al. 2005). Roads can increase disturbance of some wildlife species, however, roads also provide access to hunters that are important in controlling white-tailed deer populations.

There are 27.2 miles of graveled haul road on the 4,615 acre FEF. Road densities on federal lands on the surrounding 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, Cheat Mountain salamander, Indiana bat, Virginia big-eared bat, and Virginia northern flying squirrel.

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 of early successional habitat which could possible 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 directly 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 the amount of annually disturbed, early successional habitat resulting from timber harvest ceases. 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 would continue to lessen with the no action alternative.

Direct and Indirect Effects of Alternative B: Proposed Action

Forested Lands

Under this alternative, regeneration harvests (patch clearcutting) are proposed on 20.8 acres (0.44% of the FEF) in Study No. 2. Light thinnings, including single-tree selection and diameter-limit harvests, are proposed for 362 acres (7.7% of the FEF) in Study No. 2, Study No. 8 and Study No. 62. Extensive thinnings, including shelterwood and heavy diameter-limit harvests, are proposed for 104.3 acres (2.2% of the FEF) in Study No. 8 and Study No. 62. Prescribed burning is proposed on 466 acres (9.9% of the FEF) in Study No. 12 and "Prescribed burning and variable intensity overstory mortality for enhanced wildlife habitat structure and long-term oak restoration." Herbiciding of select overstory trees is proposed to occur on perhaps 376.1 acres (6.9% of the FEF) in "Prescribed burning and variable intensity overstory mortality for enhanced wildlife habitat structure and long-term oak restoration."

These harvests would result in a minor, short-term reduction in overstory mast production for wildlife. However, residual overstory oak and hickory trees in Study No. 12 and "Prescribed burning and variable intensity overstory mortality for enhanced wildlife

habitat structure and long-term oak restoration" would be retained to provide a seed source for regeneration, and to provide an immediate food source for wildlife. Thinning, 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 reductions of short-term mast could indirectly impact bears, squirrels, white-tailed deer and Allegheny woodrat (Castleberry 2000b), however, the area affected is small relative to available mature forests and would be an insignificant impact. Increased light to the forest floor following all harvests would stimulate woody browse production and other forage used by wildlife. Moreover, increases in soft mast production important to wildlife from *Rubus* spp., *Vaccinium* spp., and *Smilax* spp. would be realized (Johnson et al. 1995) from regeneration cuttings. Regeneration cutting would provide important cover for Appalachian cottontails, snowshoe hare, and bear. Minor negative impacts to wildlife may occur. Salamander populations tend to decline following regeneration harvests in the Appalachians (Pauley and Rodgers 1998, Knapp 1999, Knapp et al. 2003), although impacts following shelterwood harvests with residual overstory trees that provide site shading may not be distinguishable from uncut stands (Bartman 1998). Biological viability of salamander species richness or abundance is not threatened, local extirpation does not occur (Ford et al. 2000) 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). It is possible that wildlife species occupying cut trees at the time of harvest could be temporarily impacted. Indirect and direct effects of all harvest types include temporary disruption of winter denning activity, disorientation, or death of some individuals of some species. Skidding felled timber adds additional noise and may disturb wildlife for a short time.

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 unfragmented to those with approximately 40% core area, and from research on the wholly forested but intensively managed MeadWestvaco Ecosystem Research Forest, found that few cowbirds were detected 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 (83.9% core area with edges buffered at 100 feett and 69.1% core area with edges buffered at 325 feet.), far above threshold levels where cowbird parasitism and mammalian predation would affect songbird nesting success.

As regenerated stands grow through the seedling and sprout stage, habitat is provided for a wide variety of generalist and specialist wildlife species (Atkenson and Johnson 1979). Forage and woody cover areas are essential in order to maintain viable populations of ruffed grouse (Plaugher 1998) and Appalachian cottontails in the central Appalachian region. Generally, these brushy areas are used by a variety of small mammals (Healy and Brooks 1988) and are utilized by Allegheny woodrats for foraging habitat (Castleberry 2000b). The greatest number of bird species occurs in regenerating stands in the central Appalachians (Weakland 2000). The lack of a closed overstory canopy stimulates vigorous herbaceous and shrub layer development in the first few years following

harvests (Della-Bianca and Johnson 1965, Ford et al. 1993). With an open understory, suitable hunting and feeding areas would be created in the short-term for raptors (Smith 2003). Within regeneration harvests, high exposed perches for raptors and scavengers would remain after logging. 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 bat, squirrel, raccoons, owls, woodpecker, and black-capped chickadee and titmouse nest site availability. Conversely, in the affected environment, black locust, abundant in regeneration areas, quickly becomes overtopped by other overstory tree species and develops into snags readily used as bat roosts (Menzel et al. 2000, Owen et al. 2002). 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 Riffenberger, West Virginia Division of Natural Resources, personal communication). Where practical, mitigation measures would be implemented to leave cull trees and snags for wildlife. 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. 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. 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).

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 2000). Overstory mortality treatments proposed in “Prescribed burning and variable overstory mortality for enhanced wildlife habitat structure and long-term oak restoration” would be created through herbicides and/or girdling; therefore, trees would remain as standing snags. These snags would be beneficial to many wildlife species including bats, birds and squirrels. Additionally, these mortality treatments will be species specific leaving mast-producing oak species in the overstory.

Prescribed burning impacts to wildlife from the 2 proposed burning studies likely would be transitory or unnoticeable to most small mammal, salamander, and reptile species (Ford et al. 1999a, Fish 2004). 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).

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 roads (Trombulak and Frissell 2000). 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, Cheat Mountain salamander, Indiana bat, Virginia big-eared bat, and Virginia northern flying squirrel. Only running buffalo clover, Indiana bat, and Virginia big-eared bat have been located during field surveys. See section 3.9 for discussion on running buffalo clover.

For the Indiana bat, a finding of “may affect, is likely to adversely affect” was delivered. Felling trees during October and April could possibly impact individuals of the population, although the probability of such an event is extremely low. Monitoring of bat activity during these times will help us determine the activity/hibernation patterns and dates for these bats in the central Appalachians. Under the Proposed Action, potential Indiana bat roost trees could be lost through tree removal via harvesting, herbicide and prescribed burning. Herbicide applications should benefit Indiana bats by creating available snags for day roosts. 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. 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 Fernow Experimental Forest, including the southern water shrew, southern rock vole, 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 all three of these species. Other sensitive species including the Greenbriar cave amphipod and the small-footed myotis had a finding of "no impacts" for the Proposed Action. For details see the Biological Assessment.

Cumulative Effects of Alternative B: Proposed Action

Overall impacts to wildlife from the proposed action would be small. Habitat changes from the proposed action would provide habitat for generalist species, special generalist species, general specialist species, and specialist species as opposed to only generalist species and forested 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 habitats and seres 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.

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 minor cumulative effects on wildlife populations of this Alternative.

Direct and Indirect Effects of Alternative C: Management Action

The direct and indirect effects of this alternative are the same as those of Alternative B. Although approximately 2.5 acres will be treated to control Japanese stiltgrass and the occasional Tree-of-heaven or autumn olive would be treated with herbicide, there should be little or no direct effect on wildlife from these management actions.

Cumulative Effects of Alternative C: Management Action

The cumulative effects of this alternative are the same as Alternative B. The additional management of exotic species through herbicide treatment should have little or no cumulative effect on wildlife on the FEF.