Greenwood Vegetation Management

Soil & Water Report

Prepared by:

Dr. Claudia Cotton
Soil Scientist
&
Jon Walker
Hydrologist

for:
Stearns Ranger District
Daniel Boone National Forest

Updated May 18, 2017

United States Department of Agriculture
Forest Service
The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the bases of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, or all or part of an individual's income is derived from any public assistance program, or protected genetic information in employment or in any program or activity conducted or funded by the Department. (Not all prohibited bases would apply to all programs and/or employment activities.)
Contents

Introduction ................................................................................................................................. 1
Resource Indicators and Measures .......................................................................................... 1
Methodology ............................................................................................................................ 1
Spatial and Temporal Context for Effects Analysis ................................................................. 2
Affected Environment ............................................................................................................. 2
Existing Condition ................................................................................................................... 2
Environmental Consequences ............................................................................................... 7
Alternative 1 – No Action ....................................................................................................... 7
Alternative 2 – Proposed Action ............................................................................................. 8
Alternative 3 – No Herbicide Alternative .............................................................................. 16
Regulatory Framework ........................................................................................................... 17
  Compliance with Land and Resource Management Plan, Federal, State, and Local Law .... 17
  Executive Orders ................................................................................................................... 17
References Cited ....................................................................................................................... 18

Tables

Table 1. Resource indicators and measures for assessing effects for the Greenwood Vegetation
  Management Project, Stearns Ranger District, Daniel Boone National Forest .......................... 1
Table 2. Aquatic biota monitoring within the analysis area of the Greenwood Vegetation
  Management Project, Stearns Ranger District, Daniel Boone National Forest ......................... 2
Table 3. Properties of the individual soil series listed in the soil mapping units derived from the
  Soil Survey (Soil Survey, 2015) for the Greenwood Vegetation Management Project, Stearns
  Ranger District, Daniel Boone National Forest. ...................................................................... 5
Table 4. Properties of the six soil pits dug to bedrock and characterized by horizon in and around
  the Greenwood Vegetation Management Project, Stearns Ranger District, Daniel Boone
  National Forest. ....................................................................................................................... 7
Table 5. Estimates of stream sedimentation generated by the ACE model for the Greenwood
  Vegetation Management Project, Stearns Ranger District, Daniel Boone National Forest..... 9
Table 6. Activities that cause soil exposure compared to the total acres of activity in the
  Greenwood Vegetation Management Project, Stearns Ranger District, Daniel Boone
  National Forest. ..................................................................................................................... 10

Figures

Figure 1. Watershed map with proposed activities described in the Greenwood Vegetation
  Management Project, Stearns Ranger District, Daniel Boone National Forest ........................ 1
Figure 2. Location of six soil pits dug to bedrock and characterized by horizon in and around the
  Greenwood Vegetation Management Project, Stearns Ranger District, Daniel Boone National
  Forest. ...................................................................................................................................... 6
Introduction

This report describes the results of a soil and water resource assessment for the proposed Greenwood Vegetation Management Project. The project is part of the Daniel Boone National Forest’s (DBNF) efforts to improve forest health, restore/maintain fire-mediated ecosystems, and increase wildlife habitat. To accomplish this task the DBNF plans to manage vegetation and prescribe burn in six watersheds on the Stearns Ranger District.

The purpose of this assessment is to determine what effects the proposed Greenwood Vegetation Management project would have on soil and water resources. The impacts to water productivity and soil productivity would be addressed.

Resource Indicators and Measures

Table 1. Resource indicators and measures for assessing effects for the Greenwood Vegetation Management Project, Stearns Ranger District, Daniel Boone National Forest.

<table>
<thead>
<tr>
<th>Resource Element</th>
<th>Resource Indicator</th>
<th>Measure (Quantify if possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Quality</td>
<td>Stream Sedimentation</td>
<td>Tons of sediment per year and percent sediment increase over current conditions</td>
</tr>
<tr>
<td>Water Quality</td>
<td>Water productivity changes</td>
<td>Discussion of changes in water productivity from herbicides</td>
</tr>
<tr>
<td>Soil Productivity</td>
<td>Change in erosion potential</td>
<td>Acres of mineral soil exposure from various activities</td>
</tr>
<tr>
<td>Soil Productivity</td>
<td>Change in soil compaction</td>
<td>Acres of mineral soil exposure from various activities</td>
</tr>
<tr>
<td>Soil Productivity</td>
<td>Change to the O horizon</td>
<td>Acres of soil exposure from various activities; discussion of mastication effects on nutrient availability</td>
</tr>
<tr>
<td>Soil Productivity</td>
<td>Change in soil microbial and decomposer community</td>
<td>Discussion of herbicide mobility and persistence, the soil microbial and decomposer community, and plant-soil feedback from herbicide use</td>
</tr>
</tbody>
</table>

Methodology

Water Quality

For this project, stream sedimentation and impacts from nutrients would be addressed and used to evaluate the difference between alternatives. Soil erosion is the detachment and transport of individual soil particles by wind, water, and gravity. Erosion not only reduces soil productivity, but also contributes to stream sedimentation, which potentially lowers the quality of aquatic ecosystems. This, in turn, adversely affects various consumptive and non-consumptive uses. Sediment is the state’s second leading cause of stream impairment, according to Kentucky’s Clean Water Act 305b Report to Congress (2010).

A brief account of the process, baseline conditions, current conditions, future conditions, and the effects of each alternative follows. A full set of results can be found in the project record for this environmental assessment.

Upland erosion and stream sediment values were determined with the DBNF Aquatic Cumulative Effects (ACE) Model (Walker, 2007). The model uses the Water Erosion Prediction Project (WEPP) Model developed by Elliott (2000). It was also based on
erosion research by Dissmeyer and Stump (1978) and sediment delivery research by Roehl (1962). The results are expressed in tons per year and the percentage above current conditions would be discussed. Changes from baseline conditions were also considered and can be found in the project file. Baseline conditions are calculated by removing all sedimentation that is attributed to present human influences in the analyzed watersheds. The results are compared to values that were estimated in the DBNF Forest Plan Final Environmental Impact Statement (2004). The accuracy of the WEPP model (Elliott, 2000) is plus or minus 50 percent of the true value; therefore, the results should only be used for a comparison between alternatives.

Changes in water quality from herbicide use and potential for nutrient movement from prescribed fire would be discussed. Best available science would be the basis for this discussion.

**Soil Productivity**

The following soil productivity effects may arise from specific project actions:

1. Changes in mineral soil exposure (change in erosion and compaction potential, and in the amount O horizon): the construction and use of skid trails, roads, landings, and mechanical burn lines; the use of prescribed fire and herbicide; mastication.
2. Changes in herbicide mobility and nutrient availability: herbicide use, mastication

Constructed burn lines that were analyzed include: mechanically-constructed burn lines, roads that need clearing, and trails.

Erosion and compaction potential, and decreases in the O horizon were determined by 1.) Analyzing the soil mapping units and interpretations found in Web Soil Survey (Soil Survey Staff, 2015) and other local data, and 2.) Quantifying the number of acres of exposed mineral soil on these mapping units. Changes to the soil microbial and decomposer community from herbicide use and mastication were qualitatively discussed based on the best available science due to a lack of site-specific data.

Three soil pits have been excavated within the project boundary and three within three miles of the project boundary. They were analyzed by horizon for physical and chemical characteristics. This data was used for effects analyses in addition to the sources previously mentioned.

**Spatial and Temporal Context for Effects Analysis**

**Water Quality**

The spatial bounds for the water effects analysis include six 6th level watersheds (Figure 1). These watersheds vary in size from 11,060 to 20,114 acres and are between 22 to 95 percent National Forest System lands. These watersheds were used for analysis since they are the furthest downstream extent where impacts could be detected.
Research and local experience have shown that effects of similar actions are identifiable for up to 3 years (Miller et al., 1985). The timeframe of the erosion model is bound by activities that occur three years prior to and three years following the implementation of this proposed project. This captures the effects of other management activities that may still affect the project area. This would express the maximum possible effect that could occur. Past activities that have a lasting effect (such as roads and changes in land use) are captured by modeling the sediment increase from an undisturbed condition.

**Soil Productivity**

The spatial bounds for the soil effects analysis are the boundaries for the silvicultural and prescribed burning treatments (Figure 1). The temporal bounds are three years (Miller et al., 1985).
Figure 1. Watershed map with proposed activities described in the Greenwood Vegetation Management Project, Stearns Ranger District, Daniel Boone National Forest.
Affected Environment

Existing Condition

Water Quality
A majority of the project area is divided into two different landforms or Landtype Associations (LTAs): the Southern Cliff to the southeast and the Southern Knobstone Escarpment to the northwest. The Southern Knobstone Escarpment LTA, is characterized by narrow winding ridges capped in Pennsylvanian-age rocks with valleys and sideslopes on Mississippian-age rocks. The ridges are frequently demarcated from side slopes by low to high cliffs and often have knob-like appearances. The larger valleys are dominated by karst and sinking streams. This is especially true in the Sloan and Cave Creek valleys. The Southern Cliffs LTA to the southeast is the heart of the Southwestern Escarpment with more dissection and extensive, prominent cliff development. The ridges are moderately broad and winding and are capped by Pennsylvanian-age rocks. Valleys are narrow with little floodplain development. The widest valleys occur close to the Cumberland River. These landforms are typical in the Beaver Creek area.

Streamflow varies in a pattern similar to the seasonal variation in rainfall, and varies from stream to stream based on drainage basin size and other physical characteristics. The average annual streamflow is approximately 1.2 to 2.1 cubic feet per second per square mile. Most peak flows occur during the winter and spring months. About 65 percent of the annual peaks occur during the period January through March. Low-flow frequency is often expressed as the lowest average flow for a given number of consecutive days for a given recurrence interval. In this part of the State, the 7-day, 10-year recurrence interval flow approaches 0 cubic feet per second for smaller streams such as Helton Branch.

The most serious water quality problems in the project area are related to historic channel changes, stream sedimentation, urban development along the Highway 27 corridor, and acid mine drainage from coal mining. The only listed impaired stream near the project area is Cane Creek which was mined in the 1950’s. A Kentucky Division of Water report (Ormsbee & Tufail, 2006) states that the abandoned mining has resulted in depressed stream pH values.

In an effort to characterize stream quality and aquatic habitat, biological monitoring has been conducted over the last 25 years (Table 2). In general the macroinvertebrate (aquatic insects) and the fish indices show that the streams are in “Fair” to “Good” condition.

<table>
<thead>
<tr>
<th>Stream</th>
<th>Site Number</th>
<th>Collection Dates</th>
<th>Macroinvertebrate Index (MBI)</th>
<th>Fish Index (KIBI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Little Hurricane</td>
<td>DBF02006701</td>
<td>1993</td>
<td>No data</td>
<td>Good</td>
</tr>
<tr>
<td>Fish Trap</td>
<td>DBF02006702</td>
<td>1996</td>
<td>No data</td>
<td>Good</td>
</tr>
<tr>
<td>Fish Trap</td>
<td>DBF02006703</td>
<td>1996</td>
<td>No data</td>
<td>Fair</td>
</tr>
<tr>
<td>Cave Creek</td>
<td>DBF02006708</td>
<td>1994</td>
<td>No data</td>
<td>Good</td>
</tr>
<tr>
<td>Cave Creek</td>
<td>DBF02006709</td>
<td>1994, 2010</td>
<td>No data</td>
<td>Fair</td>
</tr>
<tr>
<td>Beaver Creek</td>
<td>DBF02006711</td>
<td>2005</td>
<td>Good</td>
<td>No data</td>
</tr>
</tbody>
</table>
Soil & Hydrology Specialist Report Greenwood Vegetation Management

<table>
<thead>
<tr>
<th>Stream</th>
<th>Site Number</th>
<th>Collection Dates</th>
<th>Macroinvertebrate Index (MBI)</th>
<th>Fish Index (KIBI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaver Creek</td>
<td>DOW02006032</td>
<td>2000, 2005</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>Middle Fork</td>
<td>DBF02006712</td>
<td>2005</td>
<td>Fair</td>
<td>No Data</td>
</tr>
<tr>
<td>Mill Creek</td>
<td>DBF02006717</td>
<td>2007, 2010</td>
<td>Excellent</td>
<td>Fair</td>
</tr>
</tbody>
</table>

**Soil Productivity**
Across the dissected landscape of the analysis area, soils can be tremendously different in a very short distance. Therefore, it is important to keep in mind the great variance of soil conditions that surround the “average” conditions described herein. The four resource indicators would be described as well as specific soil mapping units found in the analysis area.

Broadly speaking, most of the soils found in the analysis area are strongly leached, highly weathered, old, acid, and have definite horizon development and low native fertility (ultisols). A smaller portion of the soils, particularly those on steep, exposed upper and side slopes, are recently formed with no horizon development (entisols) or are very mildly weathered with some horizon development (inceptisols). The entisols and inceptisols often have high sand content.

**Erosion Potential and Compaction.** Erosion is defined as a process where soil and rock-particles detach from the land and transport over an area by wind, water, gravity, ice, and chemical action. Forested soil erosion is affected by rainfall erosivity (amount and intensity), soil erodibility (infiltration capacity and structural stability), topography (slope percent and length), and vegetative cover (Brady and Weil, 2002). Rock fragment content also influences soil erosion.

Erosion potential of a soil increases with:

- *Increasing rainfall amount and intensity:* Rain is the primary erosive force acting on the soil. The longer and harder it rains, the higher the potential for the soil to become detached and flow downhill.
- *Decreasing soil infiltration capacity and structural stability:* Soil infiltration capacity and structural stability can be negatively affected by compaction. Areas that have been disturbed by human activities, such as mining, often have very compacted soils.
- *Increasing slope percent and length:* As a slope gets steeper and longer, the potential of soil detachment increases as does the opportunity for concentration of the runoff water.
- *Decreasing vegetation cover on the slope:* Vegetation reduces erosion in several ways: it reduces the amount of water flowing over the surface by intercepting it on the foliage, stems, and surface organic matter; it inhibits channel formation, which reduces the rate and slope of soil movement; and soils with small particles can be held together by roots and fungal strands (Oliver & Larson, 1996).

Compaction is an increase in soil strength and a decrease in macropore space. It inhibits rooting, soil aeration, and water infiltration, and decreases soil productivity. Both erosion and compaction are often the result of improperly maintained forest roads. Road construction and road use are the primary sources of non-point source pollution on forested lands, contributing up to 90 percent of the total sediment from forestry operations (EPA, 2016).
O Horizon. A defining characteristic of forest soil is the presence of a litter layer, or O horizon. Across the hardwood-dominated forests of the analysis area, the O horizon may range from 1 to 3 inches in depth. This layer serves several important functions: 1.) it protects the soil from exposure to erosive forces, 2.) it serves as a nutrient source of several important macronutrients, including nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur 2.) it is the source of nutrients for soil organisms which in turn drive most of the transformations and nutrient cycling in the soil, 3.) it alleviates compaction, 4.) it increases infiltration in heavy soils and decreases infiltration in sandy soils, and 5.) it insulates the mineral soil from extremes of temperature and moisture. It is a crucial element of long-term productivity and nutrient cycling within a stand. The retention of the O horizon is essential for the maintenance of soil productivity.

Soil Organisms and Plant-Soil Feedback. Another important aspect of the forest soils across the analysis area is their relationship with the plant community that grows on them. An area of soil should be thought of as an entire environment that includes a community of microbes and other soil organisms that serve to break down and transform the soil into available nutrients for plant growth. Nutrient availability is highly influenced by microbial activity and other chemical parameters, particularly pH. Many nutrients taken up by plant roots are first cycled through a soil organism before becoming available to the plant. In fact, natural biological processes in the soil are responsible for about 60% of the available nitrogen and 50% of the available phosphorus in the soil (Follett, 1995). Additional vital functions of soil organisms include:

- The formation of soil humus
- Improvement of soil physical properties
- Release of plant nutrients from insoluble inorganic soil minerals
- Fixation of nitrogen
- Improved plant nutrition through mycorrhizal relationships
- Antagonistic action against plant pathogens

Soil organisms and the chemical environment of the soil directly affect the type, density, and diversity of the plants that can grow on it. When a plant loses its leaves and/or dies, it would decompose and affect the soil by adding organic matter, which can stimulate microbial activity, change the soil nutrient availability, change the soil water availability, affect the soil pH, and change the soil structure, among other things. The cycle between plants and soil is known as a plant-soil feedback (van der Puttin et al., 2013).

As young forests mature across the analysis area, the native condition of the plant-soil feedback is negative. A positive plant-soil feedback would favor only one species, whereas a negative plant-soil feedback encourages diversity of species. A diverse plant community tends to encourage a soil environment that includes beneficial and harmful organisms, and those plant species that can adapt to the environment would survive and reproduce. On native forest communities in the analysis area, plant and soil diversity is comparatively high.

Soil Mapping Units and Properties. There are thirty soil mapping units mapped within the spatial bounds of the soils analysis area (Soil Survey Staff, 2015). Most of these soils are well-drained silt loams, sandy loams, or loams in texture. Maximum depths may reach up to 80
inches to bedrock. Many of the mapping units are complexes, which contain two or more components.

The majority of the acreage within the analysis area, or 86%, falls within seven mapping units:

1. Rigley-Alticrest complex, 20 to 80 percent slopes, very rocky; 2,531 acres
2. Wernock-Sequoia complex, 12 to 25 percent slopes; 2,390 acres
3. Shelocta-Lily complex, 20 to 35 percent slopes, rocky; 1,786 acres
4. Jefferson stony loam, 30 to 65 percent slopes; 1,241 acres
5. Sequoia-Wernock complex, 6 to 12 percent slopes, 860 acres
6. Shelocta-Sequoia complex, 20 to 35 percent slopes, rocky; 860 acres
7. Shelocta-Jefferson complex, 30 to 50 percent slopes; 790 acres

Table 3. Properties of the individual soil series listed in the soil mapping units derived from the Soil Survey (Soil Survey, 2015) for the Greenwood Vegetation Management Project, Stearns Ranger District, Daniel Boone National Forest.

<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Typical Pedon</th>
<th>Depth (in.)</th>
<th>Drainage</th>
<th>Permeability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigley</td>
<td>Fine sandy loam, on an E-facing steep side slope in second growth woods</td>
<td>55</td>
<td>Well</td>
<td>Moderately rapid</td>
</tr>
<tr>
<td>Alticrest</td>
<td>Sandy loam, forest</td>
<td>32</td>
<td>Well</td>
<td>Well to somewhat excessively</td>
</tr>
<tr>
<td>Wernock</td>
<td>Silt loam, forested</td>
<td>47</td>
<td>well</td>
<td>moderate</td>
</tr>
<tr>
<td>Sequoia</td>
<td>Silt loam, cultivated</td>
<td>70</td>
<td>Well</td>
<td>Moderately slow</td>
</tr>
<tr>
<td>Lily</td>
<td>Loam, smooth convex 4% slopes in field</td>
<td>30</td>
<td>Well</td>
<td>Moderately rapid</td>
</tr>
<tr>
<td>Jefferson</td>
<td>Gravelly silt loam, convex 20% slope on lower part of steep mtn side in woods</td>
<td>80</td>
<td>Well</td>
<td>Moderately rapid</td>
</tr>
<tr>
<td>Shelocta</td>
<td>silt loam, on a 25% concave slope in pasture</td>
<td>60</td>
<td>Well</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

All of the individual soil series listed above are commonly found across the DBNF, with Shelocta silt loam being the most common forest-wide. All of the seven mapping units are rated as having severe erosion potential on more than 50% of the mapping unit. The amount of extensive cliffline within the analysis area influences this interpretation. That being said, there is a caveat to using Soil Survey information for forestry purposes.

While GIS and soil survey information is valuable, it has distinct limitations recognized by forest soil scientists and forest land managers (Binkley and Fisher, 2000). The soil survey was created to map productive soils for agricultural use. Since forested soils are often too rocky and steep for this purpose, they were mapped at a coarser scale and the series were often grouped together into complexes that include multiple soil series and characteristics. Soil map units in NRCS soil surveys are typically delineated at a mapping scale of 1:20,000 (3.18 inches/mile) or 1:24,000 (2.64 inches/mile). This scale of mapping is larger than the area typically covered by stands, the common unit of management on the Daniel Boone National Forest. For this reason, soil mapping unit slopes can have a wider range than stands. Thus, it is necessary to judge risks to
soil stability and productivity based on site-specific topography rather than on inclusion in a broad slope class or soil map unit.

Multiple field visits to the analysis area for this project has yielded additional on-the-ground information that modifies the severe erosion potential interpretation. Rather than solely depend on the interpretation of the soil mapping units listed above, our field observations and prior work with soil pits in the area indicate that the soils in the analysis area vary in their erosion potential.

Observations made during multiple field visits to the stands show that the soils in the analysis area are on ridge tops with slope gradients often less than 15%, and on side slopes with slope gradients often less than 30%. Additional soil and site data from six soil pits dug (Figure 2) by the DBNF Soil Scientist in the summer of 2015 may be seen in Table 4, which mimic the field observations. It may be argued that this data is more accurate than what is found in the generalized soil survey maps. Soil survey data may be useful but it needs to be modified and augmented by site-specific sampling.

Figure 2. Location of six soil pits dug to bedrock and characterized by horizon in and around the Green Vegetation Management Project, Stearns Ranger District, Daniel Boone National Forest.
Table 4. Properties of the six soil pits dug to bedrock and characterized by horizon in and around the Greenwood Vegetation Management Project, Stearns Ranger District, Daniel Boone National Forest.

<table>
<thead>
<tr>
<th>Pit #</th>
<th>Soil Series</th>
<th>Lab Texture</th>
<th>Surface Fragments (%)</th>
<th>Total Depth (in)</th>
<th>Observed Slope (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Gilpin</td>
<td>Sandy loam</td>
<td>2</td>
<td>39</td>
<td>5</td>
</tr>
<tr>
<td>1</td>
<td>Rayne</td>
<td>Loam</td>
<td>2</td>
<td>52</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>Gilpin</td>
<td>Loam</td>
<td>1</td>
<td>48</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Wernock</td>
<td>Silt loam</td>
<td>0</td>
<td>50</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Wernock</td>
<td>Silt loam</td>
<td>1</td>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Gilpin</td>
<td>Silt loam</td>
<td>5</td>
<td>49</td>
<td>12</td>
</tr>
</tbody>
</table>

Environmental Consequences

**Alternative 1 – No Action**

**Project Design Features**
Project design features may be found under effects analysis specific to particular actions.

**Direct and Indirect Effects**
The No Action Alternative would not change the existing stream sedimentation in any of the 6th level watersheds (Table 5). It should be noted that the largest single contributor to stream sedimentation is “Past and Present” land use. Most of this can be attributed to the road system, urbanization, and past mining of private coal. In some of these watersheds, there are several proposed road and trail improvement projects that would reduce stream sedimentation. Since there is no prescribed burning with this alternative, there would not be a change in water quality from nutrient runoff, or changes from herbicide use. However the risk of wildfire and the effects to soil and water increase if fuel loads are not reduced. When a wildfire burns too hot from high fuel loading, it can completely consume the litter layer, which protects the mineral soil among other functions. If vegetation is consumed from a wildfire, then exposed mineral soil would have a higher potential for erosion, since it would be more exposed to rainfall and erosive forces. If excessive erosion occurs, it can lead to stream sedimentation, which is detrimental to water quality.

There would be no impact to three of the soil productivity indicators (erosion, compaction, and O horizon) as a result of implementing the No Action Alternative. Road maintenance may take longer to occur without this project, so erosion potential could increase over time if road maintenance was deferred due to budget or resource constraints.

There could be a potential change to the soil microbial and decomposer community in the form of a changed plant-soil feedback from persistent NNIPS on the landscape. NNIPS are known to change soil biotic and abiotic conditions, which could change the surrounding plant community over time to favor NNIPS versus native species.

**Cumulative Effects**
Since there are no direct or indirect effects to the existing condition from this alternative, there would be no cumulative effects to the water resource. Under current conditions, the stream sedimentation levels vary from average to above average as estimated by the DBNF Forest Plan.
Soil & Hydrology Specialist Report Greenwood Vegetation Management

(Feis pp. 3-20 & 3-21). As mentioned previously, this condition is a result of human activities on private lands within many of these watersheds.

Regarding soils, there could be a potential change to the soil microbial and decomposer community from persistent non-treated NNIPS as described above. No treatment in the prescribed areas would be in addition to the rest of the project area, which would not be treated; however, NNIPS would still be treated under the Forestwide NNIP treatment project helping to offset this effect.

**Alternative 2 – Proposed Action**

**Direct and Indirect Effects**

*Water Quality*

Stream sedimentation and nutrient changes from prescribed fire would be used to evaluate the difference between alternatives. Impacts to water quality from herbicide would be discussed in the “Soils” section.

*Stream Sedimentation* - Changes in stream sedimentation in the 6th level watersheds that contain treatment units from this alternative are shown in Table 5. The Proposed Action would produce between 26 and 539 tons/year of stream sedimentation in these watersheds. This represents a less than a 6 percent increase over current conditions. This increase in stream sedimentation can be attributed mainly to skid trails, landings, and temporary haul roads within the commercial harvest areas. Mechanically constructed fire lines may also be contributing to the sedimentation. This sedimentation would be greatest immediately after ground disturbing activities and would return to pre-disturbance levels in 3 years. The implementation of buffer strips and Best Management Practices (BMPs) as detailed in the Forest Plan would reduce the probability of sediment actually being delivered to the stream channels.

There are several reasons why it is unlikely that changes in stream sedimentation of this magnitude would influence water productivity in these drainages. As previously stated, for modeling purposes, the proposed actions were constrained to a single year to display the maximum possible effects that could occur. It is much more likely that activities would occur over a several year period which would reduce the total amount of sediment in the stream at any given point in time. For example, due to logistics there would most likely be a couple of vegetation management contracts in Beaver Creek that would happen several years apart. Stream sedimentation would also be spread through time and space. Temporally, sediment would only reach the stream during rain events and there are approximately 25 of these events per year. In addition the proposed activities are spread throughout any watershed and as a result the sediment reaching the main channels are staggered through space. Due to all of these reasons it would be very difficult to measure or detect the change in sedimentation at any given point in the receiving streams. With surface water not being affected it is also unlikely that the connected groundwater resources would be affected. The closest karst sinkhole feature is over half a mile from the nearest activity and most units are miles from a karst feature.
Table 5. Estimates of stream sedimentation generated by the ACE model for the Greenwood Vegetation Management Project, Stearns Ranger District, Daniel Boone National Forest.

<table>
<thead>
<tr>
<th>Watershed Number</th>
<th>Watershed Name</th>
<th>Proposed Project (t/yr)</th>
<th>Percent Increase over Present Conditions</th>
<th>Cumulative Percent Increase (Proposed &amp; Future) over Present Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>No Action</td>
<td>Proposed Actions</td>
<td>No Action</td>
</tr>
<tr>
<td>051301011406</td>
<td>Cumberland River</td>
<td>0</td>
<td>45</td>
<td>0</td>
</tr>
<tr>
<td>051301030201</td>
<td>Beaver Creek</td>
<td>0</td>
<td>539</td>
<td>0</td>
</tr>
<tr>
<td>051301030202</td>
<td>Wildcat Frontal</td>
<td>0</td>
<td>148</td>
<td>0</td>
</tr>
<tr>
<td>051301030203</td>
<td>Lick Branch Frontal</td>
<td>0</td>
<td>224</td>
<td>0</td>
</tr>
<tr>
<td>051301030204</td>
<td>Hollow Frontal</td>
<td>0</td>
<td>118</td>
<td>0</td>
</tr>
<tr>
<td>051301040704</td>
<td>South Fork Cumberland River</td>
<td>0</td>
<td>26</td>
<td>0</td>
</tr>
</tbody>
</table>

Prescribed Fire and Nutrient Movement - There are numerous studies, locally and in the southeastern U.S., that have investigated water nutrient changes associated with fire. In the late 1990s, two studies reported on the monitored effects of larger prescribed burns on the Daniel Boone National Forest. Walker and Chalfant (1996) examined the impacts to soils and riparian areas and found that prescribed burns only burned the most recent layer of leaf litter and often extinguished when backed into the riparian areas. The second study (personal communication with Bishop, 2007) examined changes to aquatic insects and water productivity parameters (e.g., temperature, pH, DO, and various other nutrients). No change in pre- and post-burning water productivity was recorded.

In the southeastern U.S. the best available science has reported few effects on water productivity from nutrient runoff associated with prescribed burning (Douglas & Van Lear, 1983; Vose et al., 1999). Other studies have concluded little or no impact to biological or drinking water resources from nutrient movement associated with fire (Vose et al., 2005; Neary & Currier, 1982). These water productivity responses are much lower in the eastern U.S. versus the western U.S. due to less extreme topography, lower fire severity, and rapid vegetation recovery (Elliott and Vose, 2006). This is supported by a recent paper where Kolka (2012) concluded that “In general, prescribed fire or other fuels management approaches appear to have little impact on water productivity in Eastern North America.”

The impact of the prescribed burns in this project should be similar to the previously mentioned studies. Therefore, any water quality changes from burning should be small in magnitude and short-term in duration.

Soil Productivity
Changes in erosion potential, compaction, and the O horizon from exposed mineral soil – Activities that could cause change to the native erosion potential, compaction, and O horizon of
the soils in the project area include the construction and use of roads, landings, machine-constructed fire line, and skid trails; the use of prescribed fire and herbicide; and mastication.

The temporary and reconstructed roads would expose soil until the installation of the gravel cover. To put it into perspective, out of 141 miles of roads to be used for implementation, 5.72 miles of temporary and reconstructed road, or 4% of the total road system to be used, is a small proportion of newly disturbed ground. If 4% of the total road system is to be constructed, then soil exposure would be limited, which would minimize the potential for erosion, compaction, and O horizon removal.

Landings and machine-constructed fire line could increase the erosion potential and decrease the O horizon through vegetation removal, and increase the compaction though heavy equipment operation during construction and use. The DBNF Forest Plan contains a vegetation standard requiring no more than 10% of a harvest area to be in landings, skid roads, or exposed soil (USDA FS, 2004). An additional objective in the same plan charges the forest to maintain the productive potential of the soil on at least 85% of each project area following land management activities (USDA FS, 2004).

While the construction and use of landings and machine-constructed fire lines do temporarily reduce the productivity of the soil, the amount of exposed soil relative to the entire analysis area must be kept in context (Table 6). Although the existing skid trails in the harvested units would be used, and even with the uncertainty of the location of new skid trails, the soil exposing activities proposed in Alternative 2 may still be accomplished within acceptable limits of the effects. In both cases of landings and machine-constructed fire line, the amount of disturbed soil relative to the total acres of activity fall within the Forest Plan (Table 6).

Table 6. Activities that cause soil exposure compared to the total acres of activity in the Greenwood Vegetation Management Project, Stearns Ranger District, Daniel Boone National Forest.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Amount</th>
<th>Acres of Disturbed Soil¹</th>
<th>Total Acres of Activity</th>
<th>Acres of Disturbed Soil /Total Acres of Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Landings</td>
<td>139 landings</td>
<td>208.5</td>
<td>2,900 Harvest</td>
<td>7.2%</td>
</tr>
<tr>
<td>Machine fire line</td>
<td>37.5 miles</td>
<td>22.7</td>
<td>10,809 Rx Burn</td>
<td>0.2%</td>
</tr>
</tbody>
</table>

¹ Assuming 1 landing = 1.5 ac and machine constructed fire line width of 5 feet.

Furthermore, if Alternative 2 is implemented, then the following design criteria would offset any potential effects from construction of skid trails, roads, landings, and mechanical burn lines:

- No more than 1/3 of the total machine constructed prescribed fire line would be constructed in any one year, nor would it be constructed on slopes exceeding 35%

- Implementation of Kentucky BMPs and Forest Plan Standards (USDA FS, 2004; DB-VEG-27)

- Do not construct prescribed firelines with heavy, mechanized equipment, e.g., trackhoes and dozers in riparian areas (USDA FS, 2004; 1E-FIRE-1))
• Any temporary roads, log landings, skid trails, and firelines would be replanted (seeded) with a mixture of native and annual grasses

Controlled fire could potentially affect the soil productivity by consuming too much of the O horizon and exposing mineral soil. When burning a steep slope, there would be the possibility that the fire could get too hot and burn off the protective O horizon. If mineral soil is exposed on a steep slope, then erosion potential increases.

The DBNF has historically used controlled fires to achieve different objectives, such as species reduction, species enhancement, and fuels reduction. These controlled burns are carefully planned and monitored to create low temperatures and flame heights so that soil and water resources are protected. The following design criteria would offset the potential for soil effects caused by prescribed fire:

• Do not conduct a prescribed burn in an area where more than half of the soils are severely erodible with an average of less than one-half inch of litter and duff

• Soil exposed by projects would be revegetated with either annual cereal grasses (wheat, rye, oats, or barley alone or in mixture) for temporary cover, or with a combination of annual cereal grasses for temporary cover, and native species when seeding directly for permanent vegetation.

An increase in soil exposure and decrease in the O horizon should not occur with the use of herbicides because in most cases, herbicides would be directly applied to the target plants using spot treatment. If spot treatment of herbicide is employed, then large patches of total vegetation removal that would result in exposed mineral soil would be unlikely. If mineral soil is not exposed, then erosion potential and sediment delivery should remain unchanged. If large patches of vegetation are eradicated through the use of herbicide, then the remaining plant residue should arrest any soil movement. Furthermore, if an area is especially bare following herbicide treatment, the following design criteria would offset soil and water effects:

• Soil exposed by projects would be revegetated with either annual cereal grasses (wheat, rye, oats, or barley alone or in mixture) for temporary cover, or with a combination of annual cereal grasses for temporary cover, and native species when seeding directly for permanent vegetation.

Mastication is the mechanical chipping or shredding of woody vegetation. It creates a layer of fresh wood chips that covers the existing O horizon and/or mineral soil. Mastication would reduce mineral soil exposure, which would decrease erosion potential, compaction potential, and increase the thickness of the O horizon. Mulch, when applied to water bars with seed, has proved to be the most effective treatment for arresting erosion on skid trails (Cristan et al., 2016). Mastication, in this light, would create a short-term beneficial effect on soil productivity through the reduction of erosion and compaction potential.

Changes to soil microbial and decomposer community and water quality from herbicide use - Herbicide use could potentially affect soil productivity and water quality in the project area depending on herbicide persistence and mobility. Changes to the soil microbial/decomposer community and the environmental fate of the chemical used would be influenced by the
persistence and mobility of the chemical in soil. Each herbicide proposed would be discussed in this light.

**Glyphosate.** Several studies have addressed the environmental fate of glyphosate in soil and water and concluded that the effects are minimal. Glyphosate has a tendency to adsorb strongly to soils and is moderately persistent with a 3 to 130 day half-life (USDA, 1984). Mobility, and hence leachability, of a compound in soil depends on its sorption characteristics, i.e. strong sorption to soil solids results almost in immobilization, while a weakly adsorbed compound can be readily leached. Compared with other pesticides, glyphosate possesses unique sorption characteristics in soil. Almost all other pesticides are moderately to weakly adsorbed in soils, mainly by soil organic matter. In contrast, glyphosate, which is a small molecule with three polar functional groups (carboxyl, amino and phosphonate groups), is strongly adsorbed by soil minerals (Borggard and Gimsing, 2008). Schuette (1998) also found that glyphosate would not move readily through soil and leach into non-target areas. Degradation of glyphosate in soils is mainly a biological process accomplished by different microorganisms, but bacteria were found to be the most common agent of degradation (Borggard and Gimsing, 2008). A study on the effects of glyphosate on microbial biomass (Stratton G. and Stewart K., 1992) found glyphosate generally had no statistically significant effect on the numbers of bacteria or fungi in forest soil and overlying forest litter.

Since glyphosate has a tendency to adsorb strongly to soils it is unlikely that it would leach into waterways. Feng, et al. (1990) concluded that even under worst case conditions of direct overspray, chemical concentrations would be insufficient to result in a significant toxic impact on aquatic organisms. Borggard and Gimsing (2008) found that the risk of ground and surface water pollution by glyphosate was limited. If the herbicide does reach a waterway the U.S. Environmental Protection Agency (EPA) tests using water from natural sources found the half-life ranged from 35 to 63 days (U.S. EPA, 1998, in Schuette, 1998). The half-life of a chemical compound indicates how long it takes for 50% of the compound to degrade. It is available to affect aquatics during this time frame, although the quantities would most likely be low enough that they would be hard to detect.

**Triclopyr (amine formulation).** Studies have addressed the environmental fate of triclopyr in soil and water (USFS, 1996; Ganapathy, 1997). Both showed that triclopyr binds to organic matter in the soil and is held near the surface where it degrades more easily than in the lower horizons of the soil. Adsorption of triclopyr is generally characterized as “not strong.” Microorganisms degrade triclopyr readily. It degrades more rapidly under warm, moist conditions which favor microbial activity. Persistence varies widely, depending on soil type and climate. Under most conditions triclopyr breaks down relatively quickly and has a half-life in soil of 1.1 to 90 days (NPIC, 2002). Triclopyr did not affect the growth of soil microorganisms up to 500 parts per million (USFS, 1984). Given the application methods it is unlikely that the 500 ppm level would be reached under normal circumstances.

Long-term forest and pasture studies found very little indication the triclopyr would leach substantially either horizontally or vertically in loamy soils (Durkin, 2011b). This reduces the likelihood that the herbicide would leach into streams, lakes, or groundwater. If it does reach water, triclopyr breaks down relatively quickly and has a half-life 1 to 10 days in
water (NPIC, 2002). Ganapathy (1997) concluded that “with the use of buffer zones around streams and ephemeral drainage routes, forestry applications of triclopyr could be made without harm to nearby streams”. The USFS (1996) stated that “triclopyr contamination of groundwater has not been reported.”

If glyphosate and triclopyr are used in the project area, then effects to soil and water quality would be controlled through the following design criteria:

- No herbicide shall be applied within 30 horizontal feet of lakes, wetlands, perennial or intermittent springs (seeps) and streams. However, herbicides approved for aquatic use may be used when such treatment is prescribed to control invasive species. (USDA FS, 2004; DB-VEG-19)

- Necessary buffer zone areas must be designated before making herbicide treatments so applicators can easily recognize and avoid the buffer area. (USDA FS, 2004; DB-VEG-20)

- Herbicide mixing, loading, or cleaning areas in the field are not to be located within 200 feet of private land, open water or wells, or other sensitive areas. (USDA FS, 2004; DB-VEG-21)

- Soil exposed by projects would be revegetated with either annual cereal grasses (wheat, rye, oats, or barley alone or in mixture) for temporary cover, or with a combination of annual cereal grasses for temporary cover, and native species when seeding directly for permanent vegetation.

- Herbicide shall not be used within 6 hours of predicted rainfall.

In addition to herbicide, soil microbes and decomposers could be affected by vegetation removal. Soil microbial activity increases with increased water and warmth. When a forest canopy is opened, both the soil moisture and temperature increase from the increased exposure and insolation, which provide a short-term beneficial effect to the underground biotic community. Soil microbial activity increases with increased temperature and moisture (Fisher and Binkley, 2000). This in turn increases soil nutrient availability until vegetation recolonizes the site.

There could be a potential change to the soil microbial and decomposer community in the form of a changed plant-soil feedback from controlling NNIPS on the landscape. NNIPS are known to change soil biotic and abiotic conditions, which could change the surrounding plant community over time to favor NNIPS versus native species. By treating the NNIPS with herbicide, this effect should be minimized.

Changes to the O horizon from mastication - If Alternative 2 is implemented, then mastication would occur, which would introduce a large source of carbon to the soil surface in the form of wood chips. No conclusive studies have been conducted in the analysis area that examines the effects of this action.
Research indicates that the application of woody mulch can change soil nitrogen (N) availability for plant uptake (Homyak et al., 2008; Rhodes et al., 2012; Battaglia et al., 2009). Other effects include an increase in soil moisture and a decrease in soil temperature, which could potentially affect decomposition of organic matter and N mineralization. N is the most limiting nutrient to forest growth (Fisher and Binkley, 2000), and is biochemically used for amino acids, proteins, enzymes, nucleic acids, and the production of chlorophyll. The bulk of soil N is organic, which must be mineralized into inorganic N by soil organisms to become available for plant uptake. Homyak et al. (2008) reported a rapid accumulation of N in the wood chips, which decreased the inorganic soil N that may be available for plant growth or leach out in runoff. When overstory vegetation is removed from a forest, water and nutrient availability in the soil often increase due to the decrease in vegetation demand. This sudden increase in water and nutrients often results in a flush of herbaceous early successional vegetation. If not taken up by this flush, then the increase in water may carry off excess nutrients, including N, if not managed through BMPs. The application of woody mulch has shown a beneficial effect on this phenomenon since it “traps” N.

Other studies have shown a net effect of higher soil N availability 3-5 years post-treatment with wood chip applications in conifer forests because the decreased demand of overstory trees balanced out the increased demand of the herbaceous early successional vegetation in addition to the N immobilized in the wood chips (Rhodes et al., 2012; Downs et al., 1996). Battaglia et al. (2009) found few short-term negative effects on plant communities and soil processes in western conifer ecosystems; however, results varied by ecosystem and could not be generalized. The same study found that a depth of mulch thicker than 7.5 cm negatively affected herbaceous plant cover and soil N availability in some ecosystems.

Another effect to contemplate is burned mineral soil from wood chip consumption as part of prescribed fire. The addition of wood chips would increase fuel loading, decrease ladder fuels, and increase the chance of burned mineral soil. Burned mineral soil often results in decreased nutrient availability, increased erosion potential, and death of soil organisms. Prescribed fires are carefully planned and monitored to create low temperatures and flame heights so that soil and water resources are protected (see erosion design criteria). Thickness of the wood chips and soil cover would vary across the harvested unit, which should create a mosaic of burn severities with limited mineral soil exposure.

It is apparent that soil response varies with the addition of wood chips via mastication. The intensity of these potential effects to soil organisms and soil productivity should be limited and occur within acceptable limits with the following design criteria:

- Unevenly scatter the mastication residue across the unit and do not pile it up in thick layers.

A final thing to consider is context: only 184 acres out of 12,133 acres would be masticated. This is 1.5% of the total area that may experience soil disturbance via mastication throughout the project. It is also assuming that all masticated acres would be disturbed in the same year, which is not the case. Relatively speaking, this is a very small area of soil disturbance.
Cumulative Effects

Soil Productivity
Additional activities within the analysis area include timber harvest on private lands, illegal off-road vehicle use, and herbicide use. There is one known completed timber harvest on private land in the headwaters of Cave Creek, off of FR 5224. It was completed in the past year and was visited in December 2015 by the DBNF Forest Soil Scientist, Forest Hydrologist, and District Fire Management Officer. BMPs were implemented and sediment appeared to be stable. In the area of Bauer Road, there is evidence of illegal off-road vehicle use on the ridgetop. Elsewhere in the analysis area the DBNF is working to close off illegal off-road trails. There may be herbicide spraying on private land to control vegetation along roads and power lines. However, since this alternative’s direct or indirect changes from herbicide runoff are very limited, the additional cumulative effects would be small in magnitude.

NNIPS treatments under this alternative would be in addition to NNIPS treatments under the Forestwide NNIP treatment project. There would be a cumulative decrease in changes to soil conditions associated with NNIPS treatment such as changes to soil chemistry and the microbial community that make it more conducive to further colonization of NNIP species.

This narrative also applies to the discussion of water quality cumulative effects, listed below.

Water Quality
The sediment increases in these watersheds are due to past activities. More specifically, the largest increases in stream sedimentation are from existing “Past and Present” landuse changes that have occurred over the last 200 years. A majority of these changes have been the conversion of land from forest to either roads, low density urban, or pasture use.

In the affected watersheds the cumulative percent stream sediment increases over current conditions are estimated to be between 1.0 and 6.1 percent (Table 3). These changes are often offset by other restoration projects in the watersheds (i.e., road and OHV trail closures). Based on these increases there is no measurable change to the Watershed Condition Rank or the Species Sediment Load index listed in the Forest Plan (USDA Forest Service, 2004, FEIS, page 3-20) from this alternative.

Future sources of stream sedimentation might include minor stream sediment increases from pre-commercial thinning, maintaining wildlife openings, pond development, research projects, and timber cutting on Forest Service and private lands. Several of these projects where used when running the cumulative effects model but others are still too speculative to make accurate sediment predictions and are subject to future independent decisions, such as the Pine Creek Integrated Resources Management Strategy.

Soil and water analyses of actions within Alternative 2 indicate that they may be implemented within defined limits of the effects. If there are no direct or indirect effects from the actions described in Alternative 2, then the additional cumulative actions described should not change the affected environment.
Alternative 3 – No Herbicide Alternative

Direct and Indirect Effects

*Water Quality*

The direct and indirect stream sedimentation effects for this alternative from the vegetation management, prescribed fire and wildlife work would be the same as the Proposed Action (Alternative 2). The effects from herbicide use would be eliminated. This indirectly reduces the already limited risks of ground and surface water pollution.

*Soil Productivity*

Direct and indirect soil effects for Alternative 3 would be consistent with those described in Alternative 2, with the exception of changes to the soil microbial and decomposer community and plant-soil feedback.

If NNIP species are not eradicated with herbicide as a consequence of implementing Alternative 3, then NNIP species would persist longer on the landscape. Recent studies have suggested that NNIP species can change the soil chemistry and microbial community to make it more conducive to further colonization of NNIP species (Callaway et al., 2004; Reinhart and Callaway, 2004; Agrawal et al., 2005; Engelkes et al., 2008; Maron et al., 2014). In other words, it would induce a positive plant-soil feedback (see discussion in Affected Environment). For example, in hardwood-dominated forests outside of Knoxville, TN, soil pH and microbial activity were statistically significantly higher in plots that contained *Lonicera maackii* and *Ligustrum sinense* (amur honeysuckle and Chinese privet, respectively; both highly invasive) versus that found in control plots (Kuebbing et al., 2013). Soil pH is the “master variable” that controls the availability of soil nutrients for plant uptake. Native soils on the DBNF are often acid, or have a pH less than 7. Where amur honeysuckle and Chinese privet exist on the forest, the soil pH may be higher and unsuitable for native vegetation. Soils with higher pH values often have different plant species than what occur in soils with lower pH values.

The soils in the project area have a native acidic condition (pH<5), a diverse microbial and decomposer community, and negative plant-soil feedback that support a diverse hardwood community. If NNIP species persist in the project area as a result of slower eradication, then over time they could cause a change in soil pH and other soil characteristics native to the landscape. In time, these soil changes could affect native forest community composition and diversity in the project area.

Cumulative Effects

*Water Quality*

The cumulative stream sedimentation effects of this alternative would be the same as the Proposed Action (Alternative B).

The cumulative effects of herbicide use on water productivity would be less than the other alternatives. This is due to the elimination of herbicide use on Forest Service lands. The private activity would remain the same but this alternative would reduce the additional direct and indirect risks of the herbicide affecting the soil or water.

*Soil Productivity*
If Alternative 3 is implemented, cumulative effects to the soil would be consistent with those described for Alternative 2, with the exception of herbicide.

Regulatory Framework

**Compliance with Land and Resource Management Plan, Federal, State, and Local Law**

Based on the analysis, the Greenwood Vegetation Management project is consistent the DBNF Forest Plan. This work also complies with Kentucky water productivity regulations (401 KAR) and the Clean Water Act.

**Municipal Watersheds**

There are no current municipal watersheds located within the project area. The cities Burnside and Somerset withdraw water from the Cumberland River but they are over six miles downstream. Impacts from this project would not be detectible at these intakes.

**Executive Orders**

**Wetlands (Executive Order 11990)**

Other than an occasional farm pond and riparian areas near the tail waters of Lake Cumberland, there are very few wetlands in the project area. With Forest Plan Riparian Prescription Area standards and low intensity backing fires near the shoreline, these anthropogenic wetlands would be unaffected and the intent of Executive Order 11990 would be met.

**Floodplains (Executive Order 11988)**

Numerous floodplains exist throughout the project area, but these areas should not have adverse effects from the project since they are protected by Forest Plan Riparian Prescription Area standards. They are also not likely to burn due to backing fires and increased soil moisture. (Walker and Chalfant, 1996). The intent of Executive Order 11988 would be met.
References Cited


Kentucky Integrated Report to Congress on the Condition of Water Resources in Kentucky. 2010. Pg. 74


