Watershed, Riparian and Aquatic Resources

INTRODUCTION

The Monongahela National Forest is home to a wide range of aquatic ecosystems that support a diversity of aquatic organisms and provide a range of services from municipal water supplies to recreation. Protecting the streams, rivers, lakes and springs of the Forest is an important element of the revision process, and a key to protecting water quality and riparian and aquatic communities.

The Monongahela National Forest (MNF) contains the headwaters of five major river systems: the Monongahela, Potomac, Greenbrier, Elk, and Gauley Rivers. Twelve river segments on the MNF are considered eligible for potential inclusion in the National Wild and Scenic Rivers System. There are more than 600 miles of coldwater streams and 350 miles of warm water streams across the Forest. Although the State of West Virginia manages many stream segments as put-and-take trout fisheries with seasonal trout stocking, some estimates indicate that 90 percent of West Virginia's native brook trout streams occur on the MNF.

The recreational fishing opportunities that brook trout and other game fish on the Forest provide have an economic impact of nearly $38 million (American Sportfishing Association 2006). In addition to the recreational opportunities the streams on the Forest provide, much of the water draining National Forest System lands is used for domestic and agricultural purposes by communities both within and downstream of the proclamation boundary. Protecting the headwater streams on the Forest is important for protecting water supplies for many West Virginians.

An important principle in aquatic ecosystem management is the link between aquatic habitat conditions and watershed conditions. Streams are the end result of a number of watershed processes that integrate the flow of water, energy and nutrients, which in turn are products of the watershed's geology, soil, vegetation, precipitation patterns, and other factors. The variability of these processes, both in time and space, creates a diverse and dynamic environment. Aquatic communities depend upon the physical, chemical and biological components of the aquatic ecosystems they inhabit and the watershed characteristics that create those conditions. Because of the relationship between aquatic environments and watershed conditions, the following analysis will be based upon watershed characteristics and the potential for land management activities to affect those characteristics.

Need for Change

In May 2002, a Notice of Intent (NOI) was published in the Federal Register initiating the Forest Plan revision process for the MNF. The NOI identified watershed health as a management emphasis in need of change. More specifically, the NOI stated,

- "Establish management area goals, and standards and guidelines, to improve watershed health in terms of ecological sustainability, including: ecological functions, riparian area

management, erosion and sedimentation control, flood and flood damage control, and restoration of aquatic ecosystems."

- "Establish standards and guidelines to mitigate any adverse impacts on watersheds from acid deposition."

These issues were derived from comments received from Forest personnel and the public during the scoping process. Citizens wanted to see a continued emphasis on improving water quality and addressing erosion and sediment on the Forest so as to promote healthy aquatic habitats. Some individuals, organizations, and agencies also wanted to see the Forest address acid deposition, and the effect it is potentially having on Forest resources. In the 1986 Forest Plan, acid deposition was an issue considered but not brought forward due to its scope and the general feeling that the Forest Service did not have the ability to prevent acid deposition. This position has changed and is discussed in greater detail in the *Soil Resource* section.

There are a number of variables and watershed conditions that influence the health of aquatic ecosystems in the analysis area. Land management activities can affect the natural characteristics of aquatic ecosystems and alter their aquatic resource potential. Today, due to historic logging activities and contemporary pressures such as timber harvesting, roads and acid deposition, most of the streams on the MNF are under stress and their productivity is reduced. Factors contributing to the impairment include elevated levels of fine sediment, acid deposition, impacts to riparian vegetation, and passage barriers that reduce habitat availability and isolate populations.

A wide range of activities permitted under the Forest Land and Resource Management Plan can contribute to these impairments. The land management activities that are the greatest concern to watershed, riparian, and aquatic resources are timber harvesting and roads. At a Forest-wide analysis scale, soil and watershed disturbances associated with timber harvesting and road management account for the largest acreage of soil and vegetation disturbance. Unlike other programs that remain relatively constant through the alternatives, the area of potential timber harvest varies between alternatives and can be used to evaluate differences between alternatives. Disturbances related to recreation sites, grazing allotments, mineral development, watershed restoration and other programs occur but tend to be localized and are difficult to assess at the landscape scale. Likewise, the benefits incurred from watershed, riparian, and aquatic habitat improvements are also localized and better addressed at the site-specific project planning scale. Therefore, the emphasis of this analysis will be on the potential effects of timber and road management activities on watershed and aquatic conditions, while the direct, indirect and cumulative effects of other management programs will be addressed in more detail during project planning and evaluation.

Issues and Indicators

Issue Statement

Forest timber management strategies may affect watershed, riparian and aquatic resources.

Background to the Issue

Timber harvest and connected actions have the potential to affect a number of watershed processes. The removal of timber, the type of logging method used and the associated transportation system all have the potential to affect watershed, riparian and aquatic conditions to varying degrees. The potential risk of these activities is dependent upon the scope of the action, the existing site conditions and the effectiveness of the mitigation measures used. Because the amount and distribution of timber harvest varies by alternative, it can be used to show the relative differences in the potential impacts related to:

1) Soil erosion and sedimentation effects on aquatic ecosystems,
2) Soil nutrient and base cation depletion and soil acidification related to acid deposition,
3) Water quality and quantity, and
4) Channel and floodplain modifications.

Indicators

The following indicators will be used to reflect the differences between alternatives and the potential risk to watershed, riparian and aquatic resources.

- Acres of Management Prescriptions that allow commercial timber harvest by alternative

This indicator sets the location for potential timber management activities. Alternatives differ by their allocation of management prescriptions across the Forest watersheds, and to what degree, they may be affected. The fifth level watershed layer was overlaid with management prescriptions that have lands considered suitable for timber production to identify the potential treatment areas. This overlay identified the range of watersheds that are potentially affected by timber management activities and, in turn, the species of concern that are potentially affected in those watersheds. Not all of the acres within the management prescriptions are available for harvesting. Resource protection measures, such as riparian buffers or West Virginia Northern Flying Squirrel habitat, reduce the overall acres that are available for harvest.

- Acres, volume, and methods of potential timber harvest by alternative

A key management objective for vegetation is to have better distribution of forest age classes through time. Timber harvesting is the primary management tool proposed to achieve the desired age class distribution. Using the Spectrum model, different management strategies, which form the basis of the Forest Plan alternatives, are run for a 150-year period to achieve the vegetative management objectives. Modeled outputs that potentially affect watershed and aquatic processes include the total acres treated, the volume of timber harvested, and the type of harvest method used. Possible effects include reducing the recruitment potential of large woody debris (LWD), affecting stream flows, reducing stream shading, and contributing to nutrient and base cation depletion on acid sensitive geologies. It is assumed that the more acres treated, the greater the risk to watershed, riparian and aquatic conditions.

The type of logging method used also has implications for potential impacts to watershed and aquatic conditions. The Spectrum model differentiates between acres treated using helicopter

logging and acres using conventional, ground-based logging systems. The potential for soil disturbance in conventional units is much greater than helicopter units. The assumption is the greater the level of ground disturbance, the greater the potential for impacts associated with erosion, sedimentation, soil nutrient loss, and modified runoff patterns. Conventional logging may also require more roads than helicopter logging in order to access remote units. Potential road-related impacts include ground disturbance, sedimentation, modified runoff patterns, channel and floodplain modifications, and aquatic passage barriers. The numbers generated by the Spectrum model are used as a relative comparison of alternatives, and are not intended to represent actual acres of projected activities.

Scope of the Analysis

The scope of the analysis is the potential direct, indirect and cumulative effects of management activities on NFS lands. The primary focus will be management prescriptions that allow timber harvesting activities. These are the management prescriptions with the greatest potential to affect watershed, riparian and aquatic conditions. Potential direct and indirect effects will be discussed for activities on NFS lands and the fifth level watersheds in which they occur. The potential cumulative effects area consists of the fifth level watersheds within the proclamation boundary, including activities on state and private lands. The analysis in this report was conducted on 31 of the 44 watersheds (fifth-level hydrologic units) that contain lands managed by the MNF. Nine of the 44 watersheds were omitted from the analysis because NFS lands comprise less than 0.85 percent of the watershed area. Four of the remaining 35 watersheds were combined with adjacent watersheds of similar form and function to address watershed size and to simplify the analysis process.

CURRENT CONDITIONS

Existing Conditions on the MNF

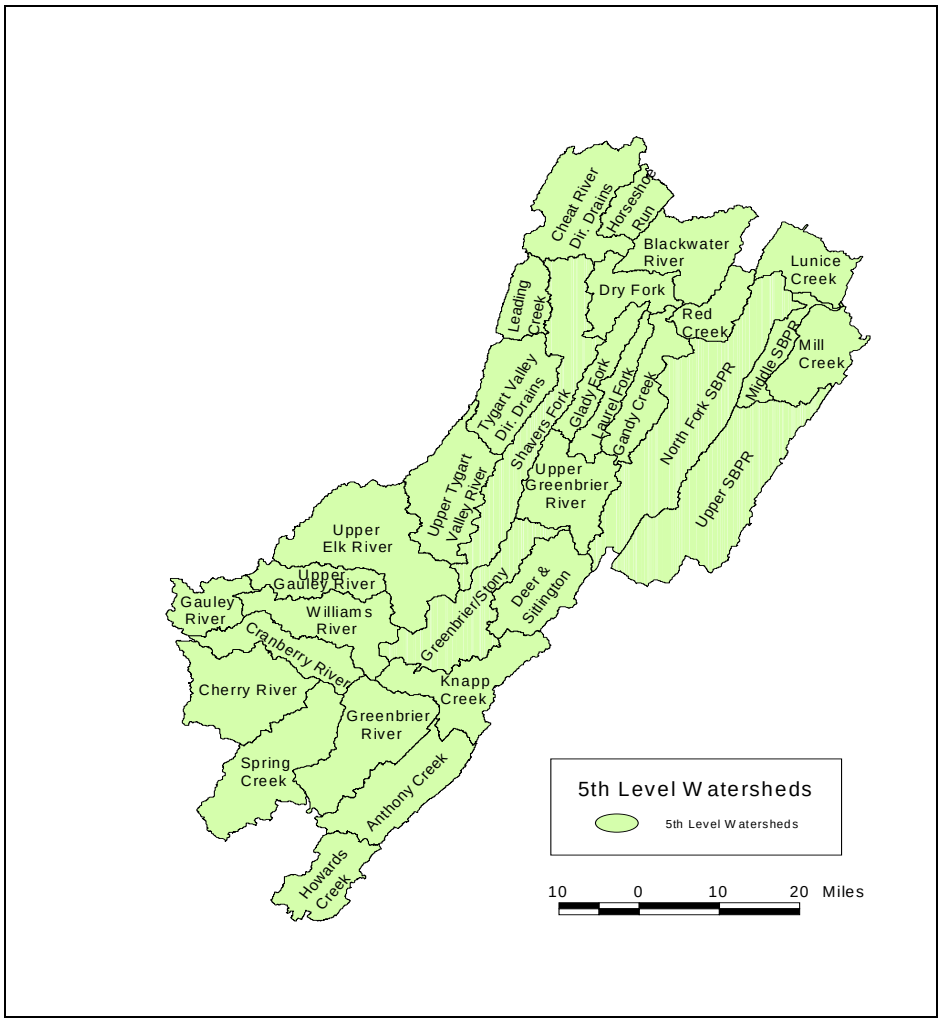
Watershed Characteristics

The MNF is located in the east-central portion of West Virginia among the Ridge and Valley and Allegheny Mountains Geographic Regions. The MNF lies within 44 fifth-level watersheds (Figure 1) nested within 6 different fourth-level sub basins, including the Cheat River, Elk River, Gauley River, Greenbrier River, Tygart River, and South Branch Potomac River. The fifth-level watersheds average 130 square miles (83,000 acres) with a range of 52 to 317 square miles (33,000-203,000 acres). The watersheds fall within two major hydrologic regions, with five watersheds draining through the Potomac River to the Atlantic, and 39 draining through the Ohio and Mississippi Rivers to the Gulf of Mexico.

National Forest ownership is important in Forest watershed-based planning because it determines the degree of influence the MNF will have in any particular watershed. The Forest can have the greatest influence on those watersheds with a high percentage of NFS land. NFS ownership within the 31 fifth-level watersheds ranges from 1.3 to 97.3 percent. There are 18 watersheds with more than 25 percent NFS ownership and 12 of these have more than 40 percent NFS

ownership. The Forest could have a considerable influence on the condition of these 18 watersheds through our management actions and collaboration with others. Seven watersheds have 15 to 25 percent NFS ownership. In these watersheds the Forest could have an important influence through collaboration with other agencies and citizen groups, particularly in key subwatersheds with substantial NFS ownership. In the three watersheds with 5 to 15 percent NFS ownership, the MNF would affect conditions through collaboration with other agencies that take the lead role in assessment and management. Three watersheds have less than 5 percent NFS ownership. Within these watersheds, the ability of the MNF to affect or influence conditions is generally limited to sixth- or seventh-level subwatersheds with substantial NFS ownership.

Figure WA-1. 5th Level Watersheds Overlapping the Monongahela National Forest



Watersheds can be characterized by their natural features such as soils, geology, and topography, and by management-related features such as road densities, road crossings, or ownership

patterns. A few key characteristics related to watershed and aquatic health issues are included in Appendix E. An important element of watershed condition is the highly erosive soils found throughout the analysis area. An average of 79 percent of the NFS lands within the fifth-level watersheds is classified as highly erosive due to soil types and topography. The most highly erosive parent geology, Mauch Chunk, is found in 16 of the watersheds in amounts ranging from 2 to 59 percent of NFS lands. Thirty of the thirty-one watersheds have varying degrees of acid sensitive geology. Leading Creek is the only watershed that does not have some acid sensitive geology on NFS lands. This is due in part to the relatively small piece of the watershed that is within the proclamation boundary and part of the Forest.

Water Quality

Water chemistry of streams and rivers is the by-product of dynamic nutrient pathways and chemical processes occurring within the contributing watershed environment—atmospheric, terrestrial, and biological. The significance of water chemistry is perhaps no more apparent than in aquatic ecosystems composed of diverse geology, particularly when these systems are exposed to acid deposition. Watersheds across the MNF are composed of a wide range of surface geologies that have variable capacities for neutralizing acid inputs.

Healthy, reproducing trout populations and their associated communities have various habitat requirements. Water quality in rivers and streams is an important consideration when establishing management priorities on the Forest to provide for the maintenance of healthy aquatic ecosystems. Water chemistry is one component of water quality and represents a fundamental building block for aquatic communities. For example, harmful effects to certain aquatic organisms begin to occur as pH values in streams fall below 6.0; detrimental effects occur to most aquatic organisms as pH falls below 5.0. Also, values less than 50 for acid neutralizing capacity (ANC) indicate a stream system is acid sensitive, values less than 25 suggest a system likely experiences episodic acidification during storms, and negative ANC values indicate a system is already acidic (http://www.dep.state.wv.us).

In 2001, the MNF initiated an effort to establish Forest-wide monitoring of water chemistry properties in streams across the Forest. Sample sites were strategically located to allow monitoring efforts to increase the level of understanding of the relationships between water chemistry and various local environmental factors, including the geologic composition of contributing watershed areas, rates of acid deposition, and supported aquatic communities. Results of water chemistry monitoring from fall low flow and spring high flow sampling across the Forest demonstrated a high degree of variability between sample locations and sample periods, as expected. For example, measures of pH ranged from 3.88 to 8.2 (mean = 6.8) during fall 2001 samples (low flow conditions) and from 3.73 to 8.55 (mean = 6.4) during spring 2002 samples (high flow conditions). Measures of ANC ranged from -166 to 2,868 (mean = 407) during fall 2001 samples and from -195 to 1,599 (mean = 135) during spring 2002 samples.

Variation in measures of pH and ANC between sample locations was largely explained by the variable capacity of a watershed's geology to neutralize acid inputs. Variation in measures of pH and ANC between sample periods at a given site was largely explained by the different stream discharge conditions. Except where acid mine drainage is an issue, water samples collected at

low flow conditions during the late summer to early fall period typically exhibit higher pH and ANC values due to the greater influence of groundwater on stream flows as compared to spring high flow conditions when direct inputs from melting snow and precipitation (i.e., acid rain) have greater influence.

State water quality monitoring programs are also documenting cases of stream acidification in West Virginia. In an attempt to mitigate impacts of stream acidification on native trout streams and the recreational fishing opportunities they provide, the State has developed and refined a program to treat acid impaired streams with limestone sand. Limestone sand is currently being applied to acid-impaired streams on the Forest and across the State to help neutralize acidity. Forest monitoring results show water chemistry downstream from treatment areas exhibit notable increases in ANC, pH, and Ca when compared to untreated water upstream. Although this action helps to mitigate many symptoms of stream acidification within the effective stream treatment zone, it does not affect the underlying cause of the condition to address risks to aquatic and terrestrial ecological processes and functions that extend beyond the treatment zones (McClurg, et al. 2004).

Section 303(d) of the Clean Water Act requires each state to periodically submit to the Environmental Protection Agency (EPA) for approval a list of impaired waters that do not meet state water quality standards. The West Virginia Department of Environmental Protection last submitted an updated list to EPA in November 2004 (WVDEP 2005). EPA approved the list of impaired waters in December 2004. Table WA–1 displays the total number of impaired stream miles within the Forest Proclamation Boundary.

Table WA-1. Stream Miles within the Forest Boundary on the 2004 303(d) List

Impairment	Within Proclamation Boundary	On NFS Lands
Aluminum (dissolved)	326 miles	122 miles
Benthic Macro-invertebrates	62 miles	27 miles
Fecal Coliforms	39 miles	1 mile
Mercury	159 miles	28 miles
pH	172 miles	126 miles

In all, an estimated 630 miles of stream within the proclamation boundary are on the current 303(d) list and 250 miles are on NFS lands. The miles shown in Table WA-1 total more than 630 and 250 respectively because stream miles may be counted more than once if they do not meet water quality standards for more than one criterion. The impaired streams occur in twenty-one watersheds within the Forest proclamation boundary. On NFS lands, impairments due to dissolved aluminum, mercury and pH are likely closely related to the effects of acid deposition, and to a much lesser extent acid mine drainage. The effects associated with typical forest management activities would generally be nonpoint sources of pollution, but can contribute to the benthic macro-invertebrate impairment. In the case of nonpoint sources of pollution, best management practices (BMPs), riparian buffers, and watershed and fish habitat improvement projects are used to help protect and restore desired conditions.

It should be noted that not all streams on the Forest have been sampled. If a stream does not show up on the 303(d) list, it may be because it either fully meets the water quality standards for its designated uses, or it may be because it has not been sampled. We do not assume that streams not on the list are currently meeting water quality standards. The West Virginia Department of Environmental Protection (WVDEP) website identifies those streams that are in compliance, called Category 1, and those that have insufficient data to determine compliance, called Category 3 (www.dep.state.wv.us). This website also includes the scheduling for developing Total Maximum Daily Load (TMDLs) to address streams listed as impaired.

Aquatic and Riparian Habitat

There are an estimated 600 miles of coldwater streams, 350 miles of warm water streams, and 216 acres of impoundments on the Forest. The coldwater streams on NFS land include 384 miles of native/wild trout streams, 186 miles of stocked trout stream, and 30 miles of trout stream which have not been differentiated as native/wild or stocked (USDA Forest Service 1990).

Aquatic and riparian habitats within the MNF proclamation boundary are still heavily influenced by historic impacts associated with agricultural developments and logging. Simplified channel conditions and elevated levels of fine sediment are a legacy of past land use activities and contemporary disturbances. Extensive clearcutting and burning during the late 1800s and early 1900s removed trees adjacent to stream channels that were the source of LWD. These activities that occurred prior to the area becoming a national forest have resulted in the existing low levels of LWD in stream channels, and stream environments that generally lack adequate pool habitat and hiding cover. Today, the riparian forests are maturing and natural recruitment of LWD is expected to increase as trees die and fall into the stream channels. This in turn will begin to restore the function of LWD within the watershed and improve the health of the aquatic environment. Protecting riparian buffer strips along stream channels is important for retaining the source of future LWD recruitment. Opportunities also exist to actively add wood to stream channels to facilitate recovery.

Large woody debris is important for a number of functions in perennial, intermittent and ephemeral channels. In perennial streams LWD increases habitat complexity by scouring pools, trapping spawning gravels, provides hiding cover, and helping to dissipate stream energy. In intermittent and ephemeral channels LWD helps to trap and store sediment in the watershed, provides structure for channel stability, and helps retain moisture (Duncan et al. 1987, Hicks et al. 1991, Flebbe and Dolloff 1995).

Stream surveys on NFS lands from 1996-1998 reveal the effect of LWD absence. The most common channel type of the stream reaches inventoried was “plane bed”. Plane bed reaches are generally featureless, with limited habitat complexity. Of the 670 stream reaches that were inventoried, 293 (44%) were classified as plane bed (data on file at the MNF Supervisors Office). The remaining reach types were cascades (15%), bedrock (12%), beaver (8%), pool-riffle (8%), step pool mix (7%), and pool-riffle mix (5%). The amount of plane bed reaches should decrease as riparian forests continue to mature and LWD increases. Through time this will improve pool development and result in more step pool and pool-riffle reaches.

Past and present land management activities have resulted in streams with levels of fine sediment that may impair aquatic productivity. Fine sediment can adversely affect aquatic communities by reducing habitat quantity, habitat quality, water quality, and food supplies (Waters 1995). Sediment sampling has been conducted on the MNF to assess the potential impacts of fine sediment (less than 4 millimeters in size) on trout productivity. Potential spawning gravels are sampled and decreased trout productivity can occur when levels of fine sediment exceed 20-25 percent of the sample. Of the 222 spawning gravel samples collected on NFS lands from 1994-1999, 142 (64%) exceeded 20 percent fine sediment (data on file at the MNF Supervisors Office).

There are no natural lakes on the Forest, but there are four major impoundments: Summit Lake (43 ac.), Lake Buffalo (22 ac.), Sherwood Lake (43 ac.) and Spruce Knob Lake (25 ac.). These impoundments were built in the early 1970s primarily to provide recreational opportunities. Other than routine maintenance and safety inspections, there is minimal operation of the dams. No water is diverted or utilized from the reservoirs, and essentially what flows into the reservoir flows out. Downstream flows are not controlled unless the pools are drawn down to work on the dam, or, in the case of Summit Lake, to supplement water supplies for Richwood during dry years. Management of the dams is carried out under the authority and limitations of various laws and regulations (see Forest Service Manual – FSM 7500).

Given the steep and rolling topography of the Forest, wetland development is relatively limited. Less than 1% (approximately 5,000 ac.) of NFS lands are identified on the National Wetlands Inventory. Approximately 15,000 acres are identified within the proclamation boundary. Wetlands can range in size from small seeps to large open water wetlands. Many of the larger identified wetlands on the Forest are protected as Botanical Areas and/or National Natural Landmarks. Protection has also been provided to wetlands through management direction in the 2006 Forest Plan (see SW30, SW31, SW51, SW57, VE32, RA18, MG32, MG33, LS04, and RF06 in Chapter II).

Aquatic Biota/MIS/Species Viability

The National Forest Management Act (NFMA) requires that aquatic habitat "be managed to maintain viable populations of existing native and desired non-native vertebrate species in the analysis area" (36 CFR 219.19). Viable populations are considered to be those populations that have the numbers and distribution of reproductive individuals to ensure their continued existence in the analysis area.

The MNF straddles the divide between the Mississippi River basin and the Atlantic slope, and forms the headwaters of several major river systems. The location of the Forest, in the central Appalachians, has influenced stream characteristics and the evolutionary pathways of aquatic communities. The result is fairly high aquatic diversity on the Forest, with species that may be unique to either side of the divide and species that are common on both sides.

Overall, the streams and rivers on the Forest support 87 species of fish as well as numerous species of invertebrates including insects, mollusks, and crayfish. Fish species are

predominantly native, non-game species. Appendix E displays a list of fish species that have been reported in the fifth-level watersheds that drain the Forest.

Species abundance and diversity in the analysis area today has been shaped, in part, by past land use activities. As the analysis area was settled and floodplains and riparian areas were utilized for agriculture, home sites and transportation systems, changes to aquatic ecosystems began to occur. Declines in fish populations were noted in the Potomac and Cheat River systems as early as the mid-1800s (Kinney 1958).

Large-scale modifications to streams, riparian areas and watershed conditions began in the late 1800s with logging, railroading, roads, and fires resulting in significant soil losses and loss of riparian vegetation. Within the area that is now the MNF, we can speculate that as timber harvest activities intensified, stream conditions became less favorable for native species that prefer cold, clean water and more favorable for species that are tolerant of warmer water temperatures and increased sediment loads. The disturbance probably resulted in an expansion in the range of cool and warm water communities within the proclamation boundary, while coldwater communities retreated into the higher, headwater streams. Moring et al. (1994), for example, observed a similar shift in species composition due to timber harvesting along a brook trout stream in a northeastern spruce-fir community in Maine. A reduction in streamside canopy and shading resulted in the disappearance of brook trout from the affected area and an increase in non-game species such as common shiner, northern redbelly dace, and white sucker. It is likely that fish communities in the analysis area today are, in part, a relic of the impacts that occurred with the historic logging. Even though forests and riparian areas are recovering, the recovery of aquatic conditions and fish communities is lagging. This is consistent with a study in North Carolina where researchers found that one of the best predictors of current aquatic diversity of the study streams was land use patterns in the 1950s (Harding et al. 1998). This legacy continues to influence the pattern of diversity in the analysis area, and it is unclear what implications it has on aquatic species viability as systems continue to recover and transition on a landscape scale, while localized and cumulative impacts continue to occur.

Aquatic Species Viability

There are a number of variables that influence the distribution and viability of aquatic species on the Forest. Habitat quality, habitat quantity, accessibility, water quality, and biological factors such as the presence of non-native species can all affect the range and abundance of aquatic species. The variables that are addressed here are those that are specific to Forest management activities. The primary concerns associated with land management activities are 1) increased sedimentation from ground-disturbing activities, 2) elevated stream temperatures due to reduced riparian vegetation and stream shading, 3) decreased habitat conditions and channel stability due to reduced recruitment of large woody debris, modified flow conditions, or modified channel and floodplain morphology, and 4) fragmentation of habitat and isolation of populations due to passage barriers associated with road crossings. In addition to these land management factors, much of the MNF is underlain by geologies that are sensitive to acid deposition, and streams within watersheds with poorly buffered geologic types are susceptible to acidic conditions. Acidification is happening independent of Forest land management activities, but the concern is

that the removal of nutrients and base cations from areas with acid sensitive geology could potentially contribute to cumulative impacts.

The process to determine aquatic species viability is to link the aquatic species on the Forest to the watersheds they inhabit, and then determine the potential for changes in aquatic habitat conditions related to land management activities, and the vulnerability of the species to the potential changes. More specific information regarding the species of concern and the methodology used to determine their viability can be found in the *Aquatic Species Viability Report, Monongahela National Forest, 2005*.

First, a comprehensive list of aquatic species with potential viability concerns was compiled for the MNF. Data from the West Virginia Division of Natural Resources, the Heritage Database, *Fishes of West Virginia* (Stauffer et al. 1995), and other sources were used to identify aquatic species within the Forest boundary and the fifth-level watersheds they inhabit. Species were considered to have viability concerns if:

- They are on the Regional Forester's Sensitive Species (RFSS) list,
- They have a global (G Rank), national (N Rank) or state (S Rank) status of 1-3,
- The species has a limited distribution within the analysis area and is considered locally rare.

No federally listed aquatic species occur within the MNF proclamation boundary, but 10 aquatic species are currently on the Regional Forester's Sensitive Species (RFSS) list, 7 fish, 2 mollusks and 1 amphibian. In addition to the species identified on the RFSS list, there are aquatic species of concern with G, N, or S rankings of 1, 2 or 3, that have been collected within the proclamation boundary, including 14 fish and 2 crustaceans (see Appendix E).

For the purposes of this analysis, locally rare species are considered to be those species that are reported in less than five fifth-level watersheds in the analysis area. Fish are the only faunal group that has this designation because of the extensive sampling data and distribution information that was available. Species in other faunal groups are listed based on their presence on the RFSS list or their G, N, or S rank.

The data used to generate the comprehensive species list came from a variety of sources and sampling efforts throughout the proclamation boundary. Given the differences in sampling techniques, sampling efficiency, and sampling locations, the comprehensive list basically represents species that have been reported in the analysis area and when they were reported. Without rigorous and routine sampling information, the data cannot be aggregated to accurately assess species abundance or population trends. As a result, rather than a numerical analysis, the determination of population viability is a general assessment of the vulnerability of the species to potential disturbances associated with Forest Plan management strategies.

Literature was reviewed to identify the vulnerability of each species to the variables that might change due to potential land management activities. Detailed information on habitat requirements was often lacking, so assumptions were made based on the species life history. The following assumptions were used to evaluate species vulnerability:

- Sedimentation: Benthic organisms, or life stages, are susceptible to sedimentation and the filling of interstitial spaces that affect habitat and food supplies.

- Water temperature: Coldwater species are more sensitive to changes in stream temperature than cool or warm water species.

- Habitat complexity: Species that prefer pool habitat are more sensitive to loss of channel structure and habitat complexity than riffle and run dwelling species. LWD plays a greater role in forming habitat in smaller headwater streams than in larger main stem systems, so species occupying headwater streams are more sensitive to losses of LWD.

- Passage barriers: Road crossings on small streams are more likely to create passage barriers and reduce the habitat available to headwater species than crossings on larger main stem rivers. Road crossings pose a greater problem to species that migrate or move than those with limited home ranges.

- Acid deposition: At times, the literature referred specifically to a species' sensitivity to acidic conditions. These species have been identified as being acid sensitive, when in actuality all species are susceptible to low pH levels. We also assumed that species in headwater streams are generally more susceptible to acidic conditions than species inhabiting main stem rivers with broad drainage areas.

Overall, the potential of the Forest to influence population viability, either positively or negatively, is generally greater in headwater streams than the larger main stem rivers. Headwaters streams are usually in closer proximity to Forest management activities, and the relative influence of management on NFS lands typically decreases as the drainage area increases downstream.

It is also assumed that the potential influence of Forest management activities on species that are tolerant of a wide range of conditions is probably negligible. In these cases, some other variable, such as a biologic control, may limit populations. Table WA–2 displays the species of concern and the potential effects related to land management activities to which they are vulnerable. These effects include sedimentation, water temperature, habitat complexity, passage and acid deposition.

Once the vulnerabilities for the species were identified, the next step was to determine the likelihood that management activities on NFS lands could affect the vulnerabilities. Given the direction for riparian buffers along perennial, intermittent and ephemeral channels in the 1986 and 2006 Forest Plans, the likelihood that management activities would affect stream shading or large woody debris recruitment is low. Species vulnerable to changes in water temperature and habitat complexity are not likely to be affected through the alternatives. Localized effects may occur, but at a programmatic scale, these should be relatively minor and can be minimized or mitigated at the project level.

Table WA-2. Aquatic Species of Concern and Factors that Potentially Effect Population Viability

Species	State S Rank	Species Vulnerability Factor				
		Sediment	Temp.	Habitat Complexity	Passage	Acid Dep.
FISH						
American eel (Anguilla rostrata)	S2					
Appalachia darter (Percina gymnocephala)*	S3	X		X		
Banded sculpin (Cottus carolinae)	S2	X				
Bigmouth chub (Nocomis platyrhynchus)	S3S4	X				
Bluebreast darter (Etheostoma camurm)	S3	X				X
Bluehead chub (Nocomis leptocephalus)	S3					
Candy darter (Etheostoma osburni)*	S2	X				
Cheat minnow (Rhinichthys bowersi)*	S1S2			X		X
Common shiner (Luxilus cornutus)	S3					
Creek chubsucker (Erimyzon oblongus)	S3	X			X	
Kanawha minnow (Phenacobuus teretulus)*	S1	X				X
Longhead darter (Percina macrocephala)	S2	X		X	X	
Mountain redbelly dace (Phoxinus oreas)	S3			X	X	
New River shiner (Notropis scabriceps)*	S2		X			X
Pearl dace (Margariscus margarita)*	S3S4		X	X	X	
Popeye shiner (Notropis ariommus)	S2	X				
Potomac scuplin (Cottus girardi)	S3	X				
Redside dace (Clinostomus elongatus)*	S1S2	X	X		X	X
Tesselated darter (Etheostoma olmstedi)	S2	X				
Tonguetied minnow (Exoglossum laurae)	S3	X				X
Torrent sucker (Thoburnia rhothoeca)	S3	X			X	
Black redhorse (Moxostoma dusquensnei)	S4	X	X	X	X	
Brindled madtom (Noturus miurus)	S4	X		X	X	
Logperch (Percina caprodes)	S5	X		X		
Longear sunfish (Lepomis megalotis)	S5	X		X		
Pumpkinseed sunfish (Lepomis gibbosus)	S5	X		X		
Rosefin shiner (Lythrurus ardens)		X				X
Spottail shiner (Notropis hudsonius)	S4			X		
Spotted bass (Micropterus punctulatus)	S5			X		
Yellow bullhead (Ameiurus natalis)	S5					
AMPHIBIAN						
Eastern Hellbender (Cryptobranchus alleganiensis)*	S2	X	X			X
INVERTEBRATE						
A Crayfish (Cambarus monongalensis)	S3			X		
New River Crayfish (Cambarus chasmodactylus)	S3	X				
MOLLUSK						
Elktoe (Alasmidonta marginata)*	S2	X		X		X
Green Floater (Lasmigona subviridis)*	S2	X		X		

*Regional Forester's Sensitive Species

Opportunities also exist to restore impaired conditions to increase riparian vegetation, stream shading, and channel structure over existing conditions. Although the potential effects to stream

temperatures and habitat complexity are low on NFS lands, population viability within the analysis area could still be affected by potential impacts from activities on state and private lands.

The likelihood that management activities on NFS lands could affect sedimentation, passage, and potentially contribute to stream acidification is largely associated with the potential effects of timber management and the transportation system on the Forest. At a programmatic scale, timber management and roads have the potential to affect watershed, riparian and aquatic conditions across the Forest, which in turn can potentially affect population viability.

Population viability outcomes were determined for each species of concern for each watershed in which they occur (Appendix E). The viability outcomes were primarily determined by the frequency of occurrences within the WVDNR and Heritage Database sampling records, and the potential for land management activities to affect conditions on which the species depend. The potential effect takes into consideration the existing watershed conditions, ownership patterns, and management direction for NFS lands within the watersheds. The following are the possible viability outcomes:

Outcome A. The species is generally common and the potential effects from land management activities are low due to management prescriptions, watershed characteristics or species tolerance.

Outcome B. Species is generally common within the watershed and management activities can potentially affect one or more of the species vulnerabilities. NFS lands represent more than 50 percent of the watershed area within the proclamation boundary increasing our potential influence on population viability.

Outcome C. Species is generally common within the watershed and forest management activities can potentially affect one or more of the species vulnerabilities. NFS lands represent less than 50 percent of the watershed area within the proclamation boundary reducing our potential influence on population viability.

Outcome D. Species occurrence is rare within the watershed and stochastic events (accidents, weather events, etc.) may place persistence of the species within the watershed at risk. Potential effects related to forest management activities are low due to management prescriptions, watershed characteristics, or species tolerance.

Outcome E. Species occurrence is rare within the watershed and stochastic events (accidents, weather events, etc.) may place persistence of the species within the watershed at risk. Management activities can potentially affect one or more of the species vulnerabilities. NFS lands represent more than 50 percent of the watershed area within the proclamation boundary, increasing our potential influence on population viability.

Outcome F. Species occurrence is rare within the watershed and stochastic events (accidents, weather events, etc.) may place persistence of the species within the watershed at risk. Management activities can potentially affect one or more of the species vulnerabilities. NFS

lands represent less than 50 percent of the watershed area within the proclamation boundary, reducing our potential influence on population viability.

It should be noted that the term "watershed" used in the context of the viability outcomes, refers to the portion of the fifth level watershed within the proclamation boundary, including NFS, state and private lands. This represents the area for potential direct, indirect and cumulative effects that might influence species viability within the planning area.

An assumption inherent in the determination of population viability outcomes is that a viable population currently exists. Often, this could not be confirmed using the available information. If a species was reported within a watershed, the assumption was other individuals exist and habitat conditions occur within that watershed to support a viable population. A species was considered to be "generally common" if it had been reported in the watershed more than five times and had been observed in the watershed within the past 10 years. In some cases, Stauffer et al. (1995) reported species within watersheds but there was no record of them in the WVDNR or Heritage databases. Or, species had been collected within the watershed, but the last reported collection was more than 10 years ago. In these cases, the species occurrence is considered rare within the watershed.

Management Indicator Species (MIS)

Aquatic MIS are used as bio-indicators to assess the effects of Forest management activities on the health of aquatic ecosystems. The concept of MIS suggests that the status and trend of one or more key species provide insights as to the integrity of the larger ecological system to which it belongs. MIS serve an umbrella function in terms of encompassing habitats needed for many other species, playing a key role in maintaining community structure or processes, being sensitive to the changes likely to occur in the area, or otherwise serving as an indicator of ecological sustainability. The 1986 Forest Plan identifies wild trout as the sole MIS for fisheries resources. Wild trout are defined as naturally reproducing trout populations and could include native and introduced brook trout (*Salvelinus fontinalis*), introduced rainbow trout (*Oncorhynchus mykiss*), and introduced brown trout (*Salmo trutta*). The selection of wild trout as the Aquatic MIS is based upon their sensitivity to potential habitat changes associated with land management activities, their broad distribution across the Forest, and their location within headwater streams that are often in relatively close proximity to management activities and set the stage for aquatic habitat conditions downstream. If land management activities affect wild trout populations, then chances are the communities downstream may also be affected.

During the plan revision process, the MIS for aquatic resources has been re-defined from wild trout to native brook trout. It is felt that the native brook trout are a better reflection of the natural processes and community structure of healthy aquatic ecosystems on the Forest, and there is a growing emphasis on the protection and recovery of native brook trout populations throughout their range. Rainbow and brown trout are non-native species, and it is unclear if their ecological relationships with other members of the aquatic community are similar to brook trout.

Habitat characteristics of native brook trout, and non-native browns and rainbows are relatively similar, although brown trout are more tolerant of temperature and sediment, and rainbow trout

are more tolerant of higher water velocities. Optimum habitats for native brook trout are streams with clean, cold, well-oxygenated water. They prefer water temperatures around 57-61 F and do poorly when water temperatures exceed 68 F for extended periods (NatureServe 2005). Brook trout are fall spawners and excavate redds in clean gravel beds. Brook trout feed primarily on aquatic and terrestrial insects, but will eat a wide range of organisms. Brook trout also prefer a mix of habitat types (pools, riffles, runs) and hiding cover (Raleigh 1982).

The MNF supports several hundred miles of coldwater streams suitable for wild trout. In 1974, the Forest tabulated a list of streams that occur within the proclamation boundary. Stream miles were calculated separately for coldwater streams with wild trout populations, coldwater streams with stocked trout, streams supporting warm water fisheries, and streams with sterile water quality. In addition, stream miles were classified according to their location on NFS lands or privately owned lands within the proclamation boundary. For the purpose of this analysis, the 1974 stream list provided the basis for the distribution of wild trout populations near the time of the signing of the 1986 Forest Plan.

In 2001, the West Virginia Department of Environmental Protection (WVDEP) published a presumptive list of Tier 2.5 streams in accordance to the anti-degradation policy of the Clean Water Act. Under the anti-degradation rule, Tier 2.5 streams are those streams that support naturally reproducing trout populations, are identified as reference streams, or have a high biological rating that indicates high water quality. Approximately 614 miles were designated as Tier 2.5 on NFS lands, 460 miles for trout, 94 miles as high quality, 41 miles as reference streams, and the rest were a mix of reference and high quality, or unidentified (WVDEP web site). This information, along with other fish population data available to the Forest, was considered during the evaluation of the current distribution of wild trout across the Forest.

A comparison of the information available on the distribution of wild trout populations across the MNF between 1974 to present indicates population trends are largely stable, with noted exceptions attributed to acid deposition. This information suggests that Forest Plan goals, objectives, standards, and guidelines support the protection and enhancement of aquatic habitat conditions and contributes to the maintenance of viable wild trout populations.

However, there is reason to believe that acid deposition is contributing to a shrinking distribution of wild trout populations in stream systems across the Forest. Using GIS data to overlay Tier 2.5 streams on acid sensitive geology, we found that an estimated 135 miles of Tier 2.5 streams on NFS lands are located on geologic types considered highly sensitive to acid deposition. Most streams that may have lost or are in the process of losing wild trout populations occur in watersheds with a geologic composition that characteristically provides poor acid neutralizing capacity. This finding is substantiated by reports of stream acidification in areas across the mid-Atlantic Highlands that include streams of the MNF (US EPA 2000). Conditions that contribute to stream acidification and their effects on wild trout populations are largely beyond the jurisdiction of the Forest Service to influence. However, the West Virginia Division of Natural Resources has developed a program to add limestone fines to poorly buffered stream systems to help neutralize the effects of acid deposition on stream pH. Through this effort, some streams are continuing to support wild fish populations despite their inherent susceptibility to acid deposition.

Although the distribution of wild trout populations appears to be relatively stable across the Forest where water chemistry allows, it is likely that wild trout productivity is impaired throughout this distribution. Wild trout populations have been affected by a wide variety of influences. Some influences are associated with stochastic events, such as periodic floods and droughts, which occur unpredictably in nature. Deterministic factors associated with in-stream habitat conditions are other elements that have impaired wild trout populations. These include but are not limited to water chemistry (*e.g.* pH), habitat composition and quality (*e.g.* pool and riffle development), structural complexity (*e.g.* large woody debris density), channel stability (*e.g.* vertical and lateral stability), sediment composition (*e.g.* percent fine sediment), habitat connectivity (*e.g.* migration barriers), and stream temperatures (*e.g.* shade). Fishing pressure (or more specifically, harvest mortality) can also influence trout populations.

A recent analysis of native brook trout populations discusses how they have diminished throughout their range in the eastern United States (Hudy et al. 2005). Of the subwatersheds (6th level HUC) that were studied in their historic range, native brook trout were extirpated from 21 percent. In the subwatersheds where self-sustaining native brook trout populations are present, habitat is considered "greatly reduced" (i.e., lost over 50 percent of the habitat supporting self-sustaining populations) in 45 percent of the subwatersheds. Consistent with conditions on the MNF, many of the extirpations and reductions are attributed to logging and agricultural activities that occurred around the turn of the last century and contemporary impacts are continuing to cause losses in native brook trout habitat and populations today.

Current management of NFS lands has the greatest potential to influence wild trout populations by directly altering in-stream habitat conditions, by affecting natural watershed processes that indirectly influence in-stream habitat conditions, and by changing access to wild trout streams. A relatively stable distribution of wild trout populations across the Forest suggests habitat requirements are being satisfied where water chemistry allows. However, as acid deposition continues to affect more streams, wild trout populations will likely continue to lose some degree of resiliency to other agents of disturbance. Therefore, it is important that land management on NFS lands strive to protect and restore natural processes and functions that contribute to recovery trends for stream resources if wild trout populations are to remain viable at the Forest level while productivity is to improve at the stream level.

ENVIRONMENTAL CONSEQUENCES

Resource Protection Methods

Resource protection methods come in the form of laws, regulations, policies, FSM and FSH direction, Forest Plan direction, and Forest Plan implementation procedures. An integral part of protecting watershed and aquatic conditions is the protection of soil resources. See the *Soil Resource* section for more detailed information.

Laws, Regulations, and Policies

The direction found in the Forest Plan is framed by the laws, policies and direction found in other national and regional plans. The primary laws that relate to aquatic resource management include:

- The Organic Administration Act of 1897.
- The Multiple-Use Sustained-Yield Act of 1960
- The National Forest Management Act of 1976 (NFMA)
- The Clean Water Act of 1972
- Forest and Rangeland Renewable Resource Planning Act (RPA) of 1974

The policies developed by the Forest Service that relate to soil and water resources are primarily contained within federal regulations (36 CFR 219.23) that were written to guide implementation of the National Forest Management Act (NFMA). Policies directing the protection of fish habitat (36 CFR 219.19) also influence soil and water activities due to the impacts associated with sedimentation and runoff. Direction on protecting aquatic resources can also be found within Forest Service Manuals and Handbooks.

The National Forests were first established under the Organic Administration Act of 1897, in part "…to improve and protect the forests within the boundaries or for the purposes of securing favorable conditions of water flows…"

The Multiple Use Sustained Yield Act of 1960 says that the national forests are to be used for outdoor recreation, range, timber, watershed, and wildlife and fish purposes. It requires "...harmonious and coordinated management of the various resources...and not necessarily the combination of uses that will give the greatest dollar return of the greatest unit output.

The NFMA directs National Forests to "…insure that timber will be harvested from National Forest System lands only where protection is provided for streams, stream-banks, shorelines, lakes, wetlands, and other bodies of water from detrimental changes in water temperatures, blockages of water courses, and deposits of sediment, where harvests are likely to seriously and adversely affect water conditions or fish habitat (16 U.S.C. 1604 (E))." The Act further emphasizes the need for multiple use and sustained yield of the products and services obtained from the Forest, including coordination to maintain watersheds, wildlife and fish, timber, wilderness, and other considerations.

The objective of the Clean Water Act is "…to restore and maintain the chemical, physical and biological integrity of the nation's waters" (33 USCA 1251(a)). It directs the States to set Water Quality Standards and Best Management Practices with the EPA's guidance. The Act's anti-degradation policy calls for federal agencies to "…protect and maintain water quality which exceeds the levels necessary to support fisheries and recreation."

The Forest and Rangeland Renewable Resources Planning Act (1974) requires an assessment of the present and potential productivity of the land. Regulations specify guidelines for land management plans to achieve the goals of the program that "…insure that timber will be

harvested from National Forest System lands only where …soil, slope or other watershed conditions will not be irreversibly damaged."

The Forest Service Manual (FSM) directs the agency to "Manage riparian areas under the principles of multiple-use and sustained-yield, while emphasizing protection and improvement of soil, water, and vegetation, particularly because of their effects upon aquatic and wildlife resources. Give preferential consideration to riparian-dependent resources when conflicts among land use activities occur" (FSM 2526.03).

In addition to providing direction for protecting fish habitat, there is also direction to protect fish populations. NFMA, the 1983 USDA Departmental Regulation 9500-4, FSM 2622 and FSM 2670 all include language for maintaining viable populations of native and desired non-native fish species. Direction for the identification and protection of management indicator species (MIS) are contained in the NFMA implementing regulations (36 CFR 219.19) and FSM 2620.

Because the Forest Service partners with other agencies, additional laws, policies, and direction are used to accomplish partnership goals and objectives. Opportunities are specially important in watersheds where NFS lands are a small percentage of the overall land base.

Forest Plan Direction

The 1986 Forest Plan direction for the management and protection of watershed, riparian, and aquatic resources occurs through Forest-wide general direction and standard/guidelines. Direction is also found within Management Prescriptions and Appendices R and S. During the revision process, Forest-wide direction has been expanded to include additional goals, and a new description of desired conditions. Objectives, standards, and guidelines have also been rewritten in some instances to provide more concise and clearer direction, and better integration between resources. Some 1986 Plan direction has been removed, including items that were process-oriented, or that were repeating existing law or policy.

The principal task of the watershed and aquatics programs that are guided by the Forest Plan is to protect, maintain, and enhance watershed and aquatic conditions. Program activities include conducting inventories, monitoring the effects of management activities, identifying proper mitigation measures, and implementing restoration projects.

In general, standards and guidelines are established to protect water quality and aquatic ecosystems on the Forest. The standards and guidelines are designed to:

- Prevent or reduce sedimentation related to management activities,
- Protect riparian areas and streamside vegetation,
- Protect water quality and quantity,
- Maintain or improve habitat for native brook trout and species of concern, and
- Restore or rehabilitate watershed and aquatic conditions to support their designated uses.

Forest Plan Implementation

The intent of the Forest Plan, as revised, is to provide overall direction for the protection and recovery of watershed and aquatic conditions at a programmatic level. As such, the direction is typically general in nature to allow for flexibility in meeting site-specific conditions. The direction found within the 2006 Forest Plan is implemented through more site-specific planning efforts such as watershed assessments, project-level planning, NEPA analysis, and inventory and monitoring. These smaller-scale evaluations allow for a more complete description of existing and desired conditions, resource objectives, restoration opportunities, and potential effects associated with land management activities than what is possible at the Forest Plan or landscape scale.

Watershed Assessment – Assessments at the watershed scale can be used to identify effects associated with past management, general watershed characteristics, sensitive areas, potential factors limiting the aquatic biota, and opportunities to protect and restore watershed, riparian and aquatic conditions.

Inventory – Inventories are conducted to collect data on aquatic habitat conditions, water quality, fish population data, and watershed conditions. This information is important to establish watershed and aquatic program priorities and direction, as well as for support to other land management activities.

NEPA Analysis – Proposed management activities and mitigation measures are analyzed for potential effects to the watershed, riparian, and aquatic resources by alternative. Effects are disclosed to the public for review and comment. Site-specific design features and mitigation are carried forward into the decision document and applicable contract clauses, permits, or operating plans for the proposed project or activities. Based on field data collected, site-specific mitigation can be designed. This may include the simple application of Forest-wide direction, or it may include additional measures to protect or restore the watershed, riparian, and aquatic resources such as alteration of proposed activities or methods, avoidance of high- risk areas, buffer extensions, road improvements, siltation fences, sediment traps, leaving additional nutrient sources on site, liming, or fertilizing.

Monitoring and Evaluation – Monitoring can occur at the Forest-wide or project level to confirm that specific mitigation is occurring and that it has the desired effects. If monitoring data shows that mitigation measures are not being implemented properly or having the desired results, then adjustments can be designed into future planning efforts.

Effects Common to All Alternatives

There are a variety of management activities and public uses that can affect watershed and aquatic conditions, and the relative amount of these activities may, in some cases, vary by alternative. However, they are likely to be present to some extent in all alternatives. Activities that are implemented can potentially affect watershed and aquatic conditions either positively or negatively. Standards and guidelines are designed to minimize or mitigate the potential negative

effects, but even with their application, unavoidable effects may occur as a result of project implementation.

The common mechanisms for activities affecting watershed, riparian and aquatic conditions are generally: 1) vegetation impacts, especially in riparian area, 2) ground disturbance that increases erosion and the potential for sedimentation, and 3) direct and indirect modifications of stream channels or floodplains. The potential for management activities to affect these mechanisms is largely dependent on the scope and location of the action, which is best described at a site-specific level. Nevertheless, at the programmatic scale, there are some common effects that can be anticipated with implementing the Forest Plan.

General Effects from Vegetation Management

Trees influence a variety of watershed and aquatic ecosystem functions, including stream flow, nutrient cycling, organic input, water quality, channel stability and habitat complexity. Trees in riparian areas are especially important for the role they play in protecting and maintaining aquatic ecosystems. Stream shading from riparian areas helps maintain coldwater temperatures important for native brook trout and coldwater communities. Leaves and branches from riparian areas are important sources of food and organic inputs in headwater streams. Riparian forests are the primary source of LWD, which provides channel structure important for channel stability, habitat complexity and the retention of sediment, moisture and organic matter. The root masses of riparian trees also help maintain bank stability.

Land management activities that reduce vegetation and are located within close proximity to stream channels have the potential to affect riparian vegetation and aquatic ecosystems. Timber harvesting, roads, grazing allotments, wildlife openings, power line corridors, dispersed recreation, and developed recreation sites are a few of the activities that can affect riparian areas.

Forest-wide directions within the 1986 and 2006 Forest Plans are intended to maintain or enhance riparian vegetation and the role it plays in aquatic ecosystem health. The plans differ in language, but both allow for adjustments to riparian protection according to site-specific conditions. The 2006 Plan includes a standard for buffer strip widths that restrict programmed timber harvest in order to protect riparian and aquatic conditions. The language in the 1986 Plan is more permissive, but does not preclude buffer strips with no harvest. Recent projects designed under the 1986 Plan typically had buffer strip widths similar to those prescribed in the 2006 Plan to protect stream channels and provide sources of LWD.

Direction for Water and Riparian Resources can be found in the 1986 Plan under FSM 2500, Water and Soil, pages 79-82b. A number of standards and guidelines address stream channel and riparian resource protection in the 2006 Plan. Two good examples are Forest-wide Standards SW34 and SW37 shown below.

<table>
<tr><td>Standard</td><td>SW34</td><td>No programmed harvest shall occur within the channel buffers identified in the table in SW37. Tree removal from the buffers may only take place if needed to meet aquatic or riparian resource management needs, or to;
a) Provide habitat improvements for aquatic or riparian species, or threatened, endangered, sensitive, and locally rare species;
b) Provide for public or worker safety;
c) Construct or renovate an approved facility;
d) Construct temporary road, skid road, or utility corridor crossings;
e) Conduct aquatic or riparian-related research, or
f) Allow for cable yarding.</td></tr>
<tr><td>Standard</td><td>SW37</td><td>During project-level planning and implementation, determine channel buffers for streams that would potentially be affected by proposed activities. The following table represents default buffer widths to be applied to both sides of the channel.
<table>
<tr><th>Stream Classification</th><th>Buffer Width</th></tr>
<tr><td>Perennial</td><td>100 feet</td></tr>
<tr><td>Large Intermittent (>50-acre drainage area)</td><td>100 feet</td></tr>
<tr><td>Small Intermittent (<50-acre drainage area)</td><td>50 feet</td></tr>
<tr><td>Ephemeral</td><td>25 feet</td></tr>
</table>
Buffer widths may be adjusted based on interdisciplinary review and site-specific field investigation. The buffers shall, at a minimum, encompass the riparian area defined on the basis of soils, vegetation and hydrology and the ecological functions and values associated with the riparian area.</td></tr>
</table>

Application of this direction, as well as other related standards and guidelines, should protect streamside vegetation and reduce the potential for direct and indirect effects on stream shading, LWD recruitment, organic inputs, and bank stability, which are important for protecting habitat conditions for native brook trout and aquatic species of concern.

Trees also play a role in the hydrologic function and nutrient cycling within watersheds. Runoff from forested watersheds is influenced by a number of factors such as precipitation patterns, vegetative cover, soil characteristics, elevation, and topography. Management activities that alter soil or vegetative characteristics can potentially affect the hydrologic response of the watershed if the size and intensity of the activity is great enough.

Studies of the effects of timber harvesting on stream flows in small, headwater drainages have shown that, as hardwood forests are harvested, evapotranspiration is reduced and stream flows can increase (Lull and Reinhart 1967, Hornbeck et al. 1997, Kochenderfer et al. 1997). This effect is most pronounced during the growing season and the increase is relatively short lived (Hewlett and Helvey 1970, Douglass and Swank 1972, Swank et al. 2001). Within a year, as the harvested sites revegetate, the influence on stream flows is greatly reduced and the hydrologic response of the site generally returns to pre-harvest conditions in 5-10 years (Hornbeck et al. 1997, Swank et al. 2001).

Increased stream flows due to timber harvesting primarily occur during the summer and fall when flows are typically at their lowest (Hornbeck 1973, Hornbeck et al. 1997, Swank et al. 2001). Studies show that timber harvesting can affect storm flows and peak flows, mainly during the growing season, and to a lesser extent during the dormant season (Hewlett and Helvey

1970, Swank et al. 2001). In watersheds that receive snow during the dormant season, peak flows can even be reduced because of changes in the distribution and melting of snow packs due to timber harvesting (Hornbeck 1973, Hornbeck et al. 1997). In a 74-acre watershed that was clearcut on the Fernow Experimental Forest, peak flows increased an average of 21 percent during the growing season and decreased 4 percent in the dormant season (Reinhart et al. 1963).

The amount of stream flow increase is largely dependent upon the type of harvest (e.g. clearcutting, partial cutting, or thinning) and the size of the area harvested (Reinhart et al. 1963, Douglass and Swank 1972, Arthur et al. 1998, Swank et al. 2001). Approximately 20-30 percent of the watershed basal area needs to be removed before an increase in flows due to harvesting can be detected (Hornbeck et al. 1997, Hornbeck and Kochenderfer 2000). Although increases in storm flows and peak flows have been measured on small, headwater channels where the entire catchment has been harvested, the effect on downstream channels is quickly diminished due to the limited treatment area relative to the increasing drainage size. In order to influence large-scale floods, large-scale harvesting would have to occur throughout a watershed (Hornbeck and Kochenderfer 2000). Researchers have generally concluded that contemporary timber harvesting in forests of the eastern United States is not on a scale that would affect flooding downstream (Douglass and Swank 1972, Hornbeck 1973, Hornbeck et al 1997). Potential effects on smaller, headwater drainage areas are best determined at the project scale.

The role of trees in nutrient cycling is a growing concern in watersheds with geologies that have poor acid-buffering capacity and are sensitive to acid deposition. Soil nutrient loss and base cation depletion due to acid deposition can impact water quality in the streams draining these watersheds (see the *Soil Resource* section for a more detailed description). A number of streams have already experienced a decrease in pH levels and no longer support aquatic life without the help of mitigation measures like the application of limestone sand. The concern is that additional soil disturbance and removal of timber can contribute to the loss of soil nutrients and base cations, and exacerbate the effects of acid deposition. Our understanding of the impacts of acid deposition on watersheds and aquatic ecosystems is increasing, but how land management activities relate to this issue is currently unclear.

Forest-wide direction within the 1986 Forest Plan to address potential soil nutrient loss and base cation depletion due to acid deposition is lacking. The 2006 Forest Plan includes standards and guidelines to address soil productivity and its potential influence on aquatic ecosystems. SW08 and SW13, below, are good examples. The *Soil Resource* section has more information on how Forest Plan strategies were designed to adequately address this issue.

Standard	SW08	Management actions that have the potential to contribute to soil nutrient depletion shall be evaluated for the potential effects of depletion in relation to on-site acid deposition conditions.
Guideline	SW13	Consider liming soils with a surface pH of less than 5.5 on seeding projects, except where there is an objective to maintain acidic ecosystems.

General Effects from Ground Disturbance

The primary concern is the potential to affect watershed and aquatic conditions due to ground-disturbing activities that cause erosion and reduce water quality and fish habitat. The extent of the effect is largely based on the magnitude of the ground disturbance, soil characteristics, topography, proximity to a stream channel, effectiveness of the mitigation measures, and the existing conditions of the receiving channel. Elevated sediment levels can adversely affect spawning and rearing habitat, and macro-invertebrate populations that are important food sources for fish.

Natural watershed conditions on the MNF add to the potential for sedimentation impacts on aquatic ecosystems. Approximately 80 percent of the MNF is classified as having highly erosive soils due, in part, to the steep topography, areas of Mauch Chunk geology, and high amounts of precipitation. These conditions, coupled with past and present activities both on and off-Forest, have resulted in roughly two thirds of the streams on the MNF having fine sediment (less than 4mm in size) at or above levels that begin to impair trout productivity.

There are a number of programs and projects that can result in ground disturbance such as timber harvesting, roads, trails, dispersed and developed recreation sites, mining, watershed improvement projects, fish and wildlife projects, and range allotments. The greatest source of sediment due to forest management activities is generally associated with roads (Duncan et al. 1987, Waters 1995). Closing unneeded roads and improving the drainage on existing roads can help reduce sediment inputs (Swift Jr. 1984, Trieu 1999).

Forest-wide direction within the 1986 and 2006 Forest Plans are intended to minimize soil disturbance, control erosion and provide filter strips to trap sediment. The plans differ in language for developing filter strip widths, but both allow for adjustments based on site specific conditions. Direction for Water and Riparian Resources can be found in the 1986 Plan under FSM 2500, Water and Soil, pages 79-82b, and Appendix R. In the 2006 Plan, a number of standards and guidelines address potential ground disturbance and erosion control. SW40, SW51, and SW62 provide good examples of direction to minimize the area of disturbed soils and avoid ground disturbance within close proximity of stream channels.

Standard	SW40	Skid trails and landings shall not be constructed within 100 feet of perennial, intermittent, and ephemeral channels except at crossings or when location outside the 100-foot zone pose a greater risk to aquatic or riparian resources. The 100-foot filter strip may be modified based on site-specific conditions such as soil type, slope, and stability.
Guideline	SW51	Ground disturbance should be avoided within seeps, vernal pools, bogs, fens, and other wetlands during project implementation. These areas should be managed to protect wet soils and rare plants and provide wildlife watering sources using the following protection: a) No new system roads or skid roads should be located within these areas except at essential crossings. Such crossings should be designed to minimize disturbance to the extent practical. b) Logs should not be skidded through these areas. Keep slash and logs out of them. c) Where available, maintain a canopy of 60-100 percent crown closure within and adjacent to these areas unless a more open canopy is needed for TEP species or RFSS management. d) Mast trees or shrubs may be planted in seeps if mast plants are currently lacking.
Guideline	SW62	Stream crossing construction on temporary and permanent roads should be completed as soon as practical, with mitigation as needed to minimize the potential for sedimentation.

Application of this direction, as well as other related direction, would reduce the potential for sedimentation by retaining filter strips, protecting sensitive areas, and rehabilitating disturbed sites. Filter strips have different management objectives than buffer strips so the widths of filter and buffer strips may vary. In our context, buffer strips primarily refer to riparian forests and standing vegetation, and are designed to provide stream shading, LWD recruitment and bank stability. Filter strips are an area of undisturbed ground between management activities and stream channels so sediment can settle out in the groundcover before reaching the channel network. Sediment movement can also be reduced by quickly revegetating and stabilizing disturbed soils.

General Effects from Modification of Channels and Floodplains

Streams and floodplains are in a dynamic equilibrium with the watersheds that surround them. The natural variability of stream flow, sediment movement, and inputs from riparian vegetation help to shape the aquatic ecosystem characteristics and stability. Alteration of any one of these elements can influence the others and cause a trend toward instability. Modifications to stream flows can occur through road-related impacts or potentially through extensive vegetation removal. Increased flows can result in increased bank erosion or channel down-cutting, which alters the channel morphology and habitat characteristics. Increased sediment deposition, due to ground disturbance or modified runoff patterns, can reduce the carrying capacity of the channel and also result in bank erosion and lateral movement of the channel. Loss of riparian vegetation can reduce bank stability, channel stability, and habitat complexity.

Modifications can also occur through physical features that constrict stream channels or floodplains. Stream crossings, such as culverts, are often narrower than the natural channel width, which can result in higher water velocities and localized erosion. Road beds that encroach upon floodplains can constrict channels, resulting in altered flow conditions and increased stream instability. The channel constrictions created by culverts can also create passage barriers for aquatic organisms.

Language in the 1986 Forest Plan did not speak specifically to channel and floodplain modifications, so standards and guidelines have been added in the 2006 Plan to protect channel and floodplain conditions. SW35, SW36, SW46, and SW60 are good examples.

Standard	SW35	Where new roads and skid roads cross stream channels, channel and bank stability shall be maintained.
Standard	SW36	When stream crossing structures are removed, stream channels shall be restored to their near-natural morphology (width, depth, and gradient associations for streambeds, bands, floodplains, and terraces). Disturbed soil shall be stabilized.
Standard	SW46	New structures (culverts, bridges, etc.) shall be designed to accommodate storm flows expected to occur while the structures are in place. Use scientifically accepted methods for calculating expected storm flows.
Guideline	SW60	Crossings should be designed so stream flow does not pond above the structure during normal flows to reduce sediment deposition and safely pass high flows.

Application of this direction, as well as other related direction, would greatly reduce the potential for stream channel of floodplain modification from management activities.

General Effects from Specific Forest Programs or Activities

There are a variety of resource management programs and activities that can contribute to vegetation impacts, ground disturbance, and modification of channels and floodplains. Many of these programs are relatively minor at the landscape scale, or they would not vary much between alternatives. All can result in localized effects and have the potential to contribute to cumulative effects within a watershed when combined with other land management activities occurring both on and off Forest. Forest-wide direction is designed to minimize and mitigate the potential effects on watershed and aquatic conditions, but some effects are unavoidable and there is an inherent risk when projects are implemented.

Timber Management – Timber management can affect a number of watershed processes and aquatic ecosystem functions by the removal of timber and potential for ground disturbance. The potential effects depend upon the quantity of timber removed, the logging methods employed, and the site-specific conditions.

The removal of timber can potentially affect hydrologic cycles, nutrient cycles, LWD recruitment, stream shading, organic inputs, and channel and bank stability. Timber management is one program that has the potential to alter vegetation on a scale that could potentially modify stream flows in small, headwater areas. The effects are likely to be localized, but could contribute to cumulative impacts downstream if channel erosion occurs. If nutrient and base cation loss occurs from harvesting in watersheds with acid sensitive geologies, the potential loss could contribute cumulatively to the impacts occurring from acid deposition. The potential effects on LWD recruitment, stream shading, organic inputs, and bank stability are addressed through Forest-wide direction for the management of riparian and streamside vegetation.

Timber harvesting also results in areas of ground disturbance, the extent of which depends on the logging method used. The logging method that is the greatest concern for watershed, riparian and aquatic resources is conventional logging using ground-based equipment. The potential for soil disturbance in conventional units is mainly associated with skid roads and landings. In general, the level of soil disturbance is about 10 percent of the harvest area (Kochenderfer et al. 1997). The level of soil disturbance in helicopter units is lower and primarily associated with landings, including servicing and re-fueling sites.

Forest-wide direction for filter strips, water and erosion control structures, and revegetation of disturbed soils are intended to minimize the area of disturbance and reduce the potential movement of sediment into channel networks. Revegetation of exposed soils can be fairly rapid following logging activities, but sediment that enters a channel network when soils are disturbed can remain in the system for years, even decades (NCASI 1999).

Landings are used in both conventional and helicopter harvest systems. Helicopter landings are generally around 2 acres in size and landings in conventional logging units are approximately ½

acre in size. The erosion potential of landing sites will be reduced if they are treated by seeding, mulching, and fertilizing. However, soil compaction can be a problem with lasting long-term effects and ripping may be necessary. Landings are often revegetated and used as wildlife openings.

Alternatives developed during the revision process incorporate different timber management strategies that can be used to analyze potential impacts between alternatives. The area that can be potentially harvested, the potential acres treated, the logging methods used, and the potential volume harvested can be used to compare alternatives and the potential effects to watershed, riparian, and aquatic resources.

Roads and Trails – Roads, and to a lesser extent trails, can contribute to the general effects described above by removing vegetation, increasing erosion and sedimentation, and modifying stream channels and floodplains. The extent of effects depends on the topography, location, level of use, level of maintenance, soils, geology, hydrology, and the nature of surrounding vegetation. Of particular concern are roads that cross, or are in close proximity to, stream channels. An estimated 216 miles of roads on NFS lands are within 100 feet of stream channels identified on 1:24,000 scale maps. The mileage is higher when unmapped channels, including ephemeral channels, are considered. Roads within 100 feet of channels are often hydrologically connected to the channel, and the trees removed to construct them reduce riparian vegetation and the recruitment potential of LWD.

Roads can modify the hydrologic response of an area by intercepting and converting ground water to surface flows, by increasing the drainage density of a watershed where ditch lines flow into functioning channels, and by reducing water infiltration rates through compaction of road surfaces. The level of modification depends on a number of variables such as soil type, slope and location of the road, frequency of road drainage structures, road surface material, and density of roads in a watershed.

Road construction creates ground disturbance that can deliver sediment to stream channels. Cut slopes, fill slopes, road surfaces, and drainage outfalls expose soils, modify runoff patterns and create new sources of surface erosion. Factors influencing road-related surface erosion include soil type, slope position, drainage frequency, road surface material, level of use, and the age of the road. The potential for erosion and sedimentation increases as the road slope increases. This occurs because water moves at higher velocities and increased volumes as slope increases. Drainage structure, function, and spacing are important in minimizing the amount of surface flow, which directly affects surface erosion. Road reconstruction and maintenance can result in sediment effects in the short term, but can correct a number of road related problems in the long term by increasing cross drainages, replacing problem culverts, maintaining culverts, and providing road surfacing such as gravel to reduce erosion potential.

Road crossings can influence stream channels by delivering sediment and other pollutants to the drainage network, by constricting channel widths and floodplain functions, by modifying the movement of water, wood, organic and inorganic sediments, and by modifying the movement and passage of aquatic organisms. Variables that effect the level of influence road crossings have on stream channels and their biota include the type of crossing, width of the crossing

relative to channel width, stability of the channel above and below the crossing, level of road use, and frequency of drainage structures on the road.

The influence of culverts on the movement of aquatic organisms is becoming an increasingly important issue related to the connectivity of stream segments and populations. The improper sizing and installation of culverts can result in passage barriers for organisms moving upstream and down. This in turn has the potential to isolate populations and habitat upstream of barrier culverts, and reduce the genetic mixing between populations. Should an upstream population fail, for example, during a period of drought, then downstream populations would be unable re-colonize the habitat during more favorable conditions. In some cases, though, the presence of a barrier can be favorable if it protects populations that are at risk from non-native species moving upstream.

Problems typically arise from culverts that are undersized and create water velocities that are impassable, culverts set too high so fish and other organisms are unable to enter from downstream, or culverts that are difficult to pass through because of their length, flow conditions and/or substrate. The Forest has not completed an inventory of road crossings, so the number of existing passage problems is undetermined. Direction in the 2006 Plan (WF21) would provide passage when new roads are constructed or reconstructed; unless a passage barrier is needed to meet aquatic resource management objectives (e.g., restrict the movement of non-native or undesirable species). There is also direction (SW32) to assess existing or proposed road stream crossings during watershed or project analyses for passage of aquatic organisms, and to prioritize crossings to address concerns.

Road and trail decommissioning includes a variety of management actions ranging from simple closures to complete obliteration. Obliteration can often ameliorate the long-term effects of a road or trail as the soil stabilizes, hydrologic function returns, compaction decreases, vegetation matures in former road or trail locations and aquatic passage is restored. Short-term or temporary effects often occur as the decommissioning work is implemented.

Roads are often associated with timber management activities and an assumption in this analysis is that alternatives with more potential harvesting activity would have more roads and road use than alternatives with less activity. It is also assumed that alternatives that have a greater level of conventional harvest would require more roads to access remote units than helicopter logging.

Mineral and Energy Exploration, Development, and Reclamation – Past and present activities associated with mineral and energy development have affected a number of watersheds and streams across the Forest. These developments include old strip mines, deep mines, settling ponds, well sites, pipeline corridors, and access roads. The effects on watershed and aquatic resources vary depending largely on the scale and location of development and mineral ownership. These effects include acid mine discharge, modified drainage patterns, reduced riparian vegetation, and increased erosion and sedimentation.

The level of mineral exploration and development is largely driven by market forces and regulated by existing mining law, so there should be little difference between alternatives and the potential effects to watershed, riparian and aquatic resources. The uncertainty of future

development does not allow for a meaningful predictive analysis between alternatives. See the Mineral Resources section in this chapter for more detailed information.

Facilities and Structures – These include a broad array of physical developments and structures, such as administrative facilities, utility developments, communications sites, dams and diversions authorized under special use authorizations, and mining facilities. Usually, there are both short-term and long-term effects from structures, site clearing, and soil disturbance. These effects vary depending on the scale and nature of the development, as well as the setting. Road construction for installation and/or maintenance purposes can contribute to the impacts from the facility. In general, once an area is committed to a facility or structure, there is a permanent commitment of resources. On a Forest-wide scale, facilities and structures comprise an extremely small amount of the land base, and are therefore not expected to have substantial direct, indirect, or cumulative effects on watershed, riparian, or aquatic resources.

Recreation – Developed and dispersed recreation activities can affect watershed and aquatic conditions in a variety of ways. Trails and campsites are often located in close proximity to stream channels and riparian areas, and the concentrated use can result in a loss of vegetation and increased soil disturbance. There are no foreseeable future plans to develop any large-scale recreation facilities or make any changes in the types of recreation allowed on the Forest. Therefore, there are no measurable differences in recreation-related activities that can be analyzed by alternative.

Range Management - Livestock grazing and range improvements may result in impacts to riparian vegetation and ground disturbance in areas where grazing is concentrated. Effects to the soil resource from grazing depend largely on the intensity and timing of forage utilization. Normally, allotment management plans require permittees to move their livestock so that they do not concentrate in sensitive areas, like meadows and riparian areas. Although there could be effects from seasonal trampling and heavy utilization of the soil, the potential for change to the soil resource is relatively slight, especially as livestock grazing only occurs on less than 1 percent of the entire Forest and the animal units per acre are strictly regulated. Mitigation may include developing feeding pads, water cisterns for drinking with an associated hardened pad, and fencing of riparian areas and sensitive wet soils with associated meadow habitat. All of these mitigations act to lessen soil compaction, soil disturbance, erosion and sediment production, and changes in riparian conditions. There is currently no expectation to change the size or amounts of the range allotments under the 1986 or 2006 Forest Plan direction under any alternative. Therefore, there are no measurable differences to watershed, riparian and aquatic resources that can be compared by alternative.

Watershed Improvements – There is a broad range of opportunities to restore watershed conditions across the Forest, such as protecting and restoring riparian areas, road obliteration projects, bank stabilization projects, and other efforts to revegetate and stabilize exposed soils. In the course of implementing these projects ground disturbance and to a lesser extent vegetation impacts will occur. The intent is to minimize the short-term effects to correct long-term problems. Generally, most improvements are relatively small and localized, and have a minor effect on soil loss, sedimentation, and vegetation. These structures have the beneficial effect of

reducing erosion and sedimentation over the long term. Additional mitigation such as seeding and mulching can ameliorate the short-term effects from sediment until soils are stabilized.

Opportunities for watershed restoration are typically identified during watershed assessments, project planning and inventory and monitoring activities. These efforts are not likely to change between alternatives, although watershed restoration opportunities within Management Prescription 5.1 may be limited if these recommended Wilderness areas are eventually designated as Wilderness by Congress.

Fish and Wildlife Habitat Improvements – Fish and wildlife habitat improvement projects include activities such as the creation and maintenance of wildlife openings and their access roads, development of watering holes, savannahs, and instream habitat structures, and delivery of limestone sand. Implementation of these projects can result in vegetation impacts and ground disturbance in varying degrees depending on the scope of the project and site conditions. At a landscape scale, habitat improvement projects treat a minor part of the analysis area and the potential benefits and impacts are best analyzed at a localized scale. The habitat improvement programs are unlikely to change much by alternative, although opportunities within MP 5.1 might be limited if these recommended Wilderness areas are eventually designated as Wilderness by Congress.

Wildfire Suppression – Fire suppression activities can produce both direct and indirect effects to watershed, riparian, and aquatic conditions. Some firefighting activities, such as mechanical fire line and safety zone construction, can result in direct long-term effects from vegetation clearing and soil disturbance. In the case of fire line construction, effects are usually magnified by the linear nature of the pattern of disturbance and the crossing of stream channels. This linear nature of the soil disturbance can result in routing sediment directly into a stream. This effect can be mitigated by hand constructing waterbars and small dips to disperse flow onto side slopes. These areas can also be rehabilitated after suppression with mulching and seeding to stabilize disturbed soils.

There have been less than 10 wildfires a year on the MNF in the past 20 years, the majority of which were human-caused. Alternatives that have the potential to increase or reduce road access could affect the susceptibility of areas to human-caused fires, but the frequency of wildfires and their impact on the landscape are unlikely to change by alternative.

Prescribed Fire – Prescribed fire is generally used to reduce ladder fuels and restore or maintain desired vegetative conditions. In these circumstances, fire intensity, severity, and scale are generally lower and smaller than wildfire events. Control and containment features such as fire lines can result in ground disturbance, but the level of prescribed fire activity is relatively minor and the potential effects are negligible. This activity may vary by alternative; but due to the nature of prescribed fire on this Forest (see *Vegetation Management* section), it does not produce large-scale watershed, riparian, or aquatic disturbances. If prescribed burn plans are followed and low-intensity burns typically occur as planned, then the effects would be minimal and temporary.

Special Uses – Special use authorizations vary greatly, from operating concessions to erecting and maintaining large facilities like transmission lines. Some of these activities have the potential for vegetative impacts and soil disturbance. Transmission lines that cross stream channels or special use fields within floodplains can have direct effects on riparian vegetation. The general activities associated with special uses that would affect soils—such as facility and road construction, timber removal, or recreation events—are addressed above. Individual authorizations are for localized areas, and the number, type, and location are unpredictable. Proposals would be analyzed on a case-by-case basis at the project level and would not likely vary by alternative for this analysis.

Direct and Indirect Effects by Alternative

General direct and indirect effects associated with timber management and roads were discussed in the previous section, and the mechanisms for the effects remain the same through all alternatives. What changes between alternatives is the location where timber management could potentially occur, the magnitude of the program, both in acres treated and volume harvested, and the types of harvest methods used, helicopter or conventional.

Suitable Acres by Watershed

The location of the potential harvest activity is defined as the suitable lands within management prescriptions that allow harvest activities. Management prescriptions are areas of land that have a common management emphasis and are described in greater detail in Chapter 2. Management prescriptions that permit a greater level of management activity, such as roads and timber harvesting, are considered to have a greater potential to disturb watershed, riparian and aquatic conditions than those that limit management actions and emphasize wilderness or remote backcountry. The management prescriptions that allow timber management activities in Alternative 1 are MP 2.0, 3.0, 4.0 and 6.1. In Alternatives 2, 2M, 3 and 4, timber management is allowed in MP 3.0, 4.1 and 6.1.

Not all of the acres located within the management prescriptions are available for timber harvest. A number of acres have been removed from the suited timber base due to suitability issues, or to protect other resources such as riparian areas or threatened or endangered species. The remaining acres within the management prescriptions are considered to be the suitable area for timber management.

Using GIS, the suitable lands for each alternative were clipped to fifth-level watersheds to identify what watersheds are potentially affected and to calculate the acres of suitable lands within each watershed. The assumption is the more of a watershed that is available for harvesting; the greater the potential there is for watershed, riparian and aquatic effects to occur. Of particular concern are watersheds that have Mauch Chunk geology or acid sensitive geology. The potential effects to watershed and aquatic conditions are also indicators for potential effects to the aquatic management indicator species (native brook trout) and species of concern that inhabit those watersheds. Table WA-3 displays the acres considered suitable for timber management within each fifth-level watershed by alternative.

Table WA-3. Suitable Timber Management Acres by Watershed by Alternative

Watershed	HUC	Total Acres	Acres Within Forest Boundry	Acres of NFS Land	Acres Suitable For Timber Mgt.				
					Alt. 1	Alt. 2	Alt. 2M	Alt. 3	Alt. 4
South Branch	02070001010	184,100	27,300	9,500	3,855	821	821	821	821
North Fork	02070001020	202,800	136,600	72,300	25,531	22,335	21,966	20,621	22,335
South Branch 1	02070001030	33,500	29,900	17,900	5,564	0	0	0	0
Lunice Creek	02070001040	57,000	800	800	501	660	660	660	660
Mill Creek	02070001050	66,800	7,800	1,500	933	0	0	0	0
U. Tygart Valley	05020001010	96,700	60,800	16,600	9,326	3,741	3,741	3,741	3,741
Tygart Valley Direct Drains	05020001020	78,600	29,800	11,000	6,331	3,589	3,589	3,589	3,589
Leading Creek	05020001030	38,600	1,300	1,000	648	852	852	852	852
Shavers Fork	05020004010	137,200	137,200	97,200	21,577	4,183	4,183	4,105	4,278
Red Creek	05020004020	39,200	38,000	26,600	623	57	30	0	5
Gandy Creek	05020004030	61,100	61,100	18,200	2,315	1,575	1,575	1,333	1,575
Laurel Fork	05020004040	38,600	38,600	22,500	2,912	3,889	3,747	3,747	3,889
Glady Fork	05020004050	40,600	40,600	27,400	13,356	11,646	11,646	11,646	11,646
Blackwater River	05020004060	89,300	45,400	14,200	1,593	1,045	1,045	715	1,100
Dry Fork	05020004070	51,100	51,100	36,700	3,664	0	0	0	0
Horseshoe Run	05020004080	35,300	35,300	13,900	7,236	9,521	9,521	9,521	9,521
Cheat River Direct Drains	05020004090	106,800	51,400	20,200	12,640	16,616	16,616	16,616	16,616
Upper Greenbrier	05050003010	85,100	85,100	69,300	31,837	37,114	37,114	36,890	40,271
Deer Creek	05050003020	74,400	74,400	30,500	17,404	23,331	23,331	22,662	23,331
Greenbrier River 1	05050003040	100,200	87,600	28,000	9,260	16,196	16,196	6,415	16,196
Knapp Creek	05050003060	86,100	78,400	44,500	28,129	33,840	33,840	11,879	35,018
Spring Creek	05050003080	119,000	23,100	7,200	2,392	0	0	0	0
Greenbrier River	05050003090	109,300	72,400	35,500	17,308	19,846	19,846	16,488	23,647
Anthony Creek	05050003100	95,000	94,900	72,400	30,477	42,460	42,460	14,968	49,092
Howards Creek	05050003110	58,400	8,300	7,300	92	120	120	120	352
U. Gauley River	05050005010	44,600	44,100	5,900	3,253	3,832	3,832	3,832	3,832
Williams River	05050005020	82,600	82,600	73,200	18,120	17,239	17,239	17,239	17,559
Gauley River	05050005040	41,700	20,900	12,000	7,966	10,498	10,498	10,498	10,498
Cranberry River	05050005050	62,100	62,100	60,400	16,681	17,842	17,842	9,916	17,842
Cherry River	05050005060	106,000	103,600	28,400	11,996	15,244	15,244	12,329	15,244
Upper Elk River	05050007010	154,200	70,500	33,000	16,950	9,924	9,553	9,885	10,950

Overall, Alternative 3 has the fewest acres of suitable timber management acres and would potentially affect the fewest number of watersheds (26) of all the alternatives. Alternatives 2, 2M and 4 potentially affect the same number of watersheds (27), but they differ by the total number of suitable acres: Alternative 2 (330,300 ac.), Alternative 2M (329,400 ac.) and Alternative 4 (346,700 ac.). Alternative 1 has the potential to affect all 31 of the fifth-level watersheds in the analysis and has 332,200 acres of suitable area.

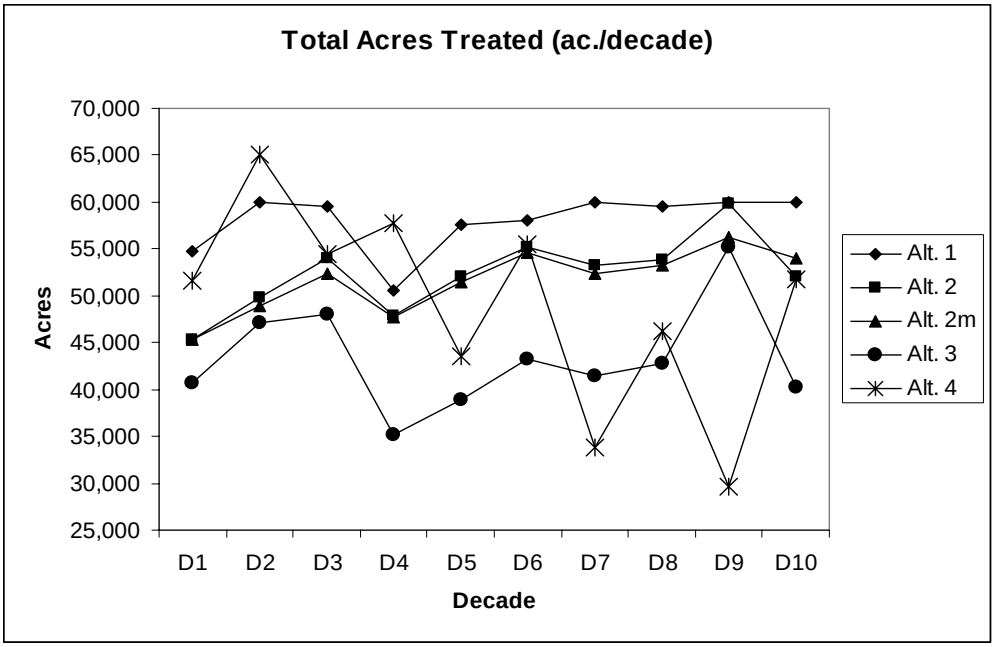
Differences between alternatives also occur as the amount of suitable acres within watersheds changes between alternatives. It is assumed that the alternative that has the lowest level of suitable acres within a given watershed has the least potential impact on the watershed. Alternative 3 has the lowest, or tied for lowest, potential impact in 19 of the 31 watersheds. Alternative 1 is next with 11 watersheds, and Alternative 2M, Alternative 2 and Alternative 4

follow in order, as they have the lowest level in 10, 9 and 8 watersheds respectively. The location of potential impacts is one issue that differentiates between alternatives; another is the potential impacts associated with the level of projected harvest activity.

Potential Harvest Activity (acres)

A major objective of vegetation management on the Forest is to create a better distribution of forest age classes and timber harvesting is the primary tool to achieve the objective. Various timber management strategies were run through the Spectrum model based on the allocation of management prescriptions by alternative. Spectrum was run over a 100-150-year period to model the effects of the different strategies. One output of the model is an estimate of the total acres to be harvested per decade. Figure WA-2 displays the long term trends in potential harvest activities by alternative. These numbers are used for the relative comparison of alternatives, but are not intended to represent actual acres of implemented activities.

Figure WA-2. Total Acres Potentially Treated by Alternative per Decade
(From Spectrum modeling)



Assuming a 10-year forest planning cycle during the projected life of the plan, Alternative 3 has the lowest estimated harvest activity in the first decade (40,764 ac.), followed by Alternatives 2 (45,297 ac.), 2M (45,338 ac.), 4 (51,573 ac.), and 1 (54,821 ac.). In subsequent decades, the potential level of activity shifts between alternatives. Alternative 3 maintains the lowest or second lowest level of potential treatment through all decades, while Alternative 1 remains the highest or second highest level through all decades. Alternative 4 has the broadest range with the high level of 65,000 acres in Decade 2 and the low level of 29,600 acres in Decade 9.

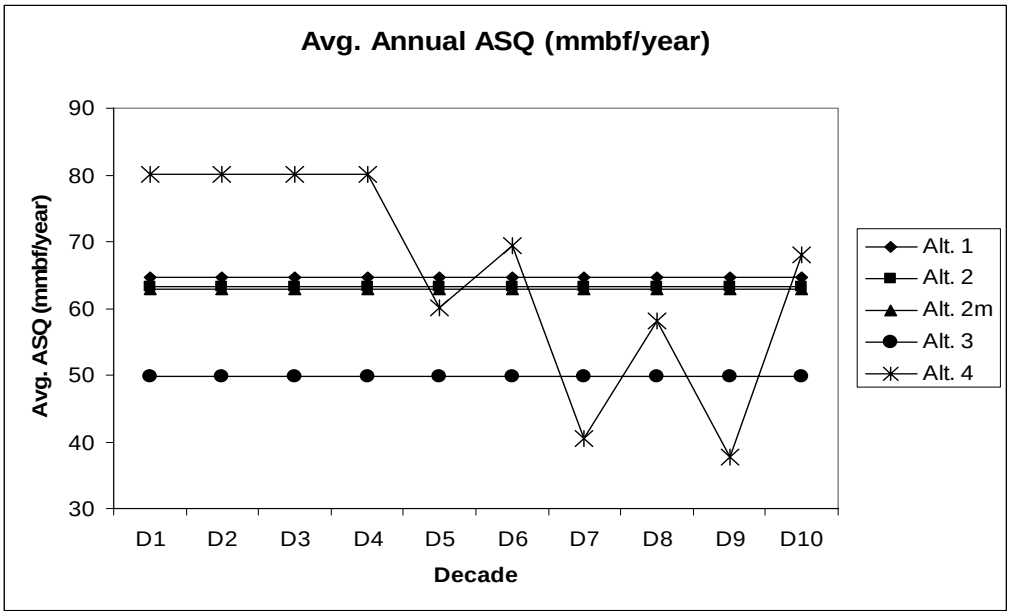
The estimates generated by Spectrum should be considered the maximum potential harvest activity that could occur. The average annual harvest activity in Decade 1 ranges from approximately 4,100 to 5,200 acres per year. In contrast, from 1986 to the present, an average of 3,400 acres has been harvested annually.

The potential effects on watershed and aquatic conditions will depend on how the harvest activity is distributed in the suitable areas, the volume of timber harvested, and the logging methods used. Generally speaking, alternatives that affect fewer acres have a lower risk of impacting watershed, riparian and aquatic conditions. An assumption in this analysis is that alternatives with more harvest activity would have more roads and road use than alternatives with less activity. However, harvest activity could also result in more road reconstruction that could correct or reduce existing impacts to watershed and aquatic resources.

Potential Harvest Activity (Volume)

Another output Spectrum generates is the allowable sale quantity (ASQ) which is a measure of the potential volume of timber harvested and reported as million board feet per year (mmbf/year). The removal of timber can remove nutrients and base cations in acid sensitive areas and potentially contribute to impacts on water chemistry and stream productivity associated with acid deposition. Timber harvest can also potentially increase run-off in small, headwater areas and affect channel stability. The assumption is that in alternatives where more timber is harvested there is a higher potential risk for watershed and aquatic resources to be negatively affected by harvest activities. Figure WA-3 displays the average annual ASQ for each decade.

Figure WA-3. Average Annual Allowable Sale Quantity (ASQ) by Alternative by Decade
(From Spectrum modeling)



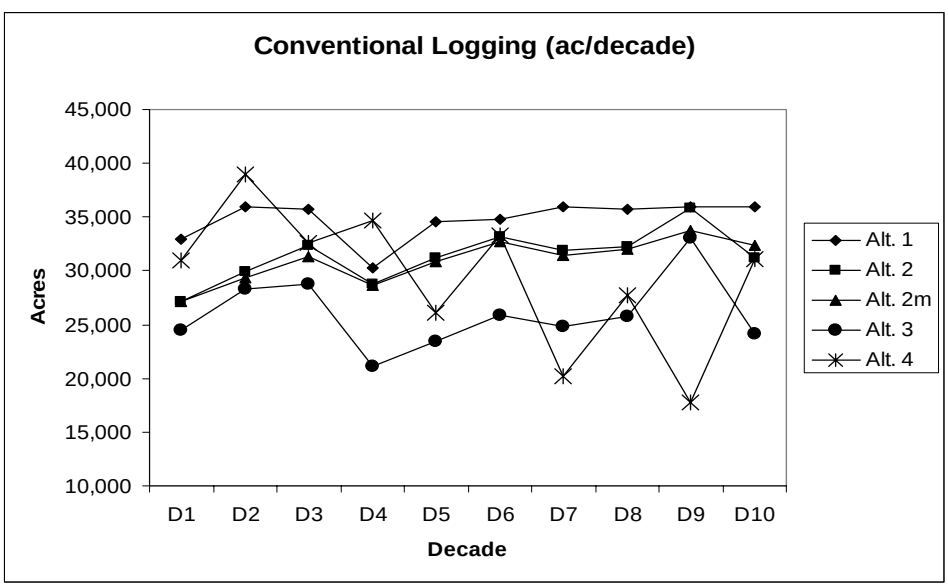
Similar to the other issues, Alternative 3 has the lowest ASQ in the first decade and most of the subsequent decades. The ASQ for Alternative 3 remains at 50 mmbf through all decades. For the life of the plan, Alternative 4 has the highest ASQ at 80 mmbf and it remains at that level for the first four decades before dropping off. For the remaining decades it is highly variable, but does represent the lowest level ASQ at 38 mmbf in Decade 9. Alternatives 2, 2M, and 1 remain constant through the decades at 63, 63, and 65 mmbf, respectively. Although volumes for Alternatives 2 and 2M round to the same number, Alternative 2 is actually about 300,000 mmbf/year higher.

The potential effects of the timber harvest are largely dependent on site-specific conditions that will be determined at the project level. The preference for maximum protection of watershed and aquatic conditions is to minimize the potential risk of harvesting in sensitive areas.

Logging Methods

The most common forms of ground disturbance associated with forest management activities are roads, and timber harvesting using conventional, ground-based equipment. Spectrum modeling assumed that 60 percent of the total acres to be treated would be conventionally logged and 40 percent helicopter logged. This assumption was based on a combination of recent logging history and estimated resource concerns and conditions. The potential effects of conventional and helicopter logging are discussed in greater detail in the previous section and in the *Soil Resources* section. For the purposes of comparing alternatives, only the potential effects of conventional logging will be considered. The percentage of conventional and helicopter logging do not vary between alternatives, so the long-term trends are similar to each other and to the total acres treated. Figure WA-4 displays the projected acres of conventional logging by alternative.

Figure WA-4. Potential Acres Conventionally Logged by Alternative by Decade
(From Spectrum modeling)



Alternative 3 has the lowest level of conventional logging during the life of the plan, followed by Alternative 2, 2M, 4, and 1. The long-term trends are similar to those discussed for total acres treated. The preference for protection of watershed resources is to have less potential ground disturbance to reduce the risk of erosion and sedimentation. Alternatives that have higher levels of conventional logging are also the ones that can potentially affect more watersheds. This is a concern given the highly erosive soils on the Forest, the presence of Mauch Chunk geology in many watersheds, and the potential for soil nutrient loss in areas sensitive to acid deposition.

Spectrum also modeled the proximity of potential harvest activities to the existing road system. Table WA-4 displays the projected level of conventional harvest for each alternative in Decade 1, and the proximity to existing roads. The assumption is that harvest acres that are located away from existing roads may require additional roads to access the units and result in additional ground disturbance and road-related problems.

Table WA-4. Conventional Timber Harvest Acres by Alternative in Decade 1
(Figures represent total acres for the 10-year period)

Activity	Alt. 1	Alt. 2	Alt. 2M	Alt. 3	Alt. 4
Conventional Harvest Acres	32,893	27,178	27,203	24,458	30,944
Distance to Road: 0/0 to 3/8 mi.	24,219	25,649	25,142	22,848	25,886
Distance to Road: 3/8 to 6/8 mi.	6,529	1,425	2,061	1,057	4,270
Distance to Road: 6/8 to 9/8 mi.	1,045	80	0	553	500
Distance to Road: 9/8 mi. +	1,100	24	0	0	288
Total Distance Greater than 3/8 mile	8,674	1,529	2,061	1,610	5058

More specifically, the assumption is that acres within 3/8 mile of an existing road could be conventionally harvested without the need for additional roads. If the distance is over 3/8 mile, then additional roads would need to be constructed or reconstructed to access the units. See the *Road Transportation System* section for additional information. Alternative 2 has the fewest overall acres that would need road access, followed by Alternatives 3, 2M, 4, and 1. The preference for maximum protection of watershed and aquatic conditions is to minimize the road density and potential road-related impacts.

Comparison of Alternatives – The alternatives were ranked by their potential for direct and indirect effects and the scope of potential activities. Alternatives that were considered to pose the least risk were ranked 1, and alternatives that posed the greatest risk were ranked 5. Table WA-5 displays the rankings by indicator.

From a watershed, riparian and aquatic resources perspective, Alternative 3 poses the least amount of risk for potential effects in five out of the six indicators, followed by Alternatives 2, 2M, 4, and 1. Alternatives 2 and 2M are virtually the same, especially considering that the main difference is the road access to harvest units in Decade 1, and Alternative 2 requires more road access than 2M by Decade 5 (see *Road Transportation System* section).

Table WA-5. Ranking of Alternatives by their Potential Effects and Treatment Area

Issue	Alt. 1	Alt. 2	Alt. 2M	Alt. 3	Alt. 4
Suitable Acres in Management Areas	4	3	2	1	5
Number of Watersheds Potentially Affected	3	2	2	1	2
Potential Harvest Area (Decade 1)	5	2	3	1	4
Potential Harvest Volume (Decade 1)	3	3	2	1	4
Potential Conventional Logging (Decade 1)	5	2	3	1	4
Road Access to Conventional Units (Decade 1)	5	1	3	2	4
Totals	25	13	15	7	23

Management Indicator Species

Alternatives that result in the lowest level of potential disturbance to watershed, riparian, and aquatic conditions also pose the lowest risk to native brook trout populations. Forest Plan and Revision direction is to maintain or improve habitat conditions for MIS. Native brook trout populations on the MNF are well distributed and considered stable, except in streams draining areas with acid sensitive geology and are susceptible to acid deposition. Direction within the 1986 Forest Plan has allowed for the protection of aquatic habitat conditions and contributed to the viability of trout populations on the Forest. Direction within the revised 2006 Plan is also expected to protect habitat conditions and native brook trout viability.

Although native brook trout populations remain well distributed and stable on the Forest, the productivity of these populations is likely impaired by a number of factors. Effects to aquatic ecosystems are often subtle, difficult to measure, and hard to relate back to any one activity or event. An action may not result in a noticeable effect on habitat conditions or populations, but may create or contribute to the overall stress on the system. These stressors may reduce the productivity of the system, its resiliency to other disturbance events, and affect its ability to recover between disturbance events. Forest management activities can contribute to the impairment even when the potential effects are minimized. The preference for maximum protection of the aquatic resources is to reduce the potential risk to populations by reducing the potential level of activity and the number of watersheds that are affected. Alternative 3 generally has the lowest level of harvest-related management activity of all the alternatives, followed by Alternative 2 and 2M, 4, and then 1.

As noted in the Current Conditions section, Tier 2.5 streams are those that support naturally reproducing trout populations, are identified as reference streams, or have a high biological rating that indicates high water quality. Using Tier 2.5 streams as a representative of native trout streams on the Forest, Table WA-6 displays the number of Tier 2.5 stream miles that are located within active management prescriptions (3.0, 4.1, 6.0) by alternative.

Table WA-6. Miles of Tier 2.5 Streams Within Active Management Prescriptions

Indicator	Alt. 1	Alt. 2	Alt. 2M	Alt. 3	Alt. 4
Miles within Active Management Prescriptions	380	460	451	353	507
Percent of Tier 2.5 on NFS lands in active MPs	65%	78%	77%	60%	86%

From an aquatic MIS perspective, Alternative 3 poses the least amount of risk for potential effects to native trout streams. Alternative 1 is second, followed by Alternatives 2M, 2 and then 4. The results shown in Table WA-6, however, are oversimplified because the active MPs are not equal in their potential to affect trout streams, and they vary widely in their application by alternative. Most of MP 4.1, for example, has West Virginia northern flying squirrel habitat, where very little management activity would occur. Therefore, MP 4.1 may actually have an overall beneficial effect on trout streams, and this high-elevation prescription area has a large percentage of coldwater streams. Alternative 1 has no MP 4.1, and Alternative 3 has far fewer 4.1 acres compared to Alternatives 4, 2M, and 2. Also, management direction within the 2006 Plan would have a somewhat neutralizing effect on the potential for any of the alternatives to degrade trout streams. The Plan has direction that is designed to avoid or minimize the potential effects of management activities on native brook trout habitat and populations. In active MPs, opportunities would also exist to enhance existing conditions through watershed and fish habitat improvement projects.

Cumulative Effects

The area considered for cumulative effects includes the fifth-level watersheds within the Forest proclamation boundary, and the analysis includes the potential effects of Forest, state and private activities on the waters within and leaving the Forest. Cumulative effects address the environmental consequences from activities implemented or projected within the watersheds in the past, present and reasonably foreseeable future. The combination of activities on NFS, state and private lands can create an effect at a watershed scale that otherwise would not be perceived as a problem at the project or subwatershed scale. In addition to their natural variability, watersheds differ by their management history, ownership patterns, and the types and levels of contemporary management activity. The combination of natural variables, ownership patterns and management activities contribute to the cumulative effects that shape the current conditions of the aquatic ecosystems within the analysis area. Given the variability in watershed conditions, both natural and management related, the discussion of cumulative effects will be general in nature.

The current watershed and aquatic resource conditions in the analysis area are a reflection of the cumulative effects of past and present actions. Streams are deficient in LWD largely due to historic logging activities, sediment levels are elevated due to past and present management activities, and the hydrology of the watersheds is altered due to past and present land uses. Future activities can contribute to these effects or alleviate some of the problems. On NFS lands, the reasonably foreseeable future actions are considered to be the continuation of existing programs such as timber management, roads, developed and dispersed recreation, gas and mineral development, grazing allotments, special uses, fish and wildlife management, and other activities. On a broad scale, the effects of future management on NFS lands may result in some localized effects, but overall should not contribute to any measurable downstream impacts. This is due in part to Forest Plan direction for the protection of soil, water, and riparian resources, the continued natural recovery of watershed conditions across the Forest, and the implementation of watershed, riparian, and aquatic restoration projects. The level of potential harvest, and its distribution across watersheds, should not result in any hydrologic effects at the fifth-level

watershed scale. With the exception of areas where roads, trails, or other facilities cross channels, riparian standards and guidelines should maintain the current level of stream shading and LWD recruitment. Opportunities also exist to revegetate and restore areas of degraded riparian conditions.

One concern is that future ground-disturbing activities have the potential to contribute to existing sediment sources, primarily associated with the Forest-wide transportation system. Roads continue to be a chronic source of sediment and additional inputs may be detrimental to the health of aquatic ecosystems depending on the existing site-specific conditions. The recovery of disturbed soils can be relatively quick, which reduces the erosion potential following the disturbance. But sediment that enters a channel can remain in the system for years, even decades, depending on the level of inputs and channel characteristics. Potential new sources could be off-set, in part or wholly, by correcting existing problems and reducing current inputs.

The potential cumulative effects of soil nutrient loss, base cation depletion and acid deposition are discussed in greater detail in the *Soil Resource* section.

The influence of NFS land on cumulative effects for waters draining the analysis area largely depends on the level of ownership. NFS lands average 54 percent of the fifth-level watersheds within the proclamation boundary, ranging from 13 percent in the Upper Gauley River to 100 percent in Lunice Creek. NFS lands are typically located in the higher elevations and headwaters, and the influence of state and private lands increases going downstream. In watersheds where NFS lands are limited, the influence of state and private activities is greater.

Assuming the activities on state and private lands remain relatively constant, existing watershed and stream conditions within those areas should persist in the foreseeable future. Watershed, riparian, and aquatic conditions are modified by roads, rural and agricultural developments, logging, mining, housing developments, and other activities. Direct impacts to aquatic habitats occur through road crossings and flood control efforts. Reduced riparian vegetation effects stream shading, bank stability, LWD recruitment, and channel stability. A wide range of ground-disturbing activities result in soil erosion and sedimentation in streams.

Implementation of Forest-wide standards and guidelines would minimize the potential effects of land management activities on NFS lands and the Forest's potential contribution to cumulative effects. The existing transportation system continues to affect aquatic resources and water quality, and foreseeable actions that improve road-related problems can reduce the potential effects and the contribution to cumulative effects. Foreseeable harvest activities have the potential to contribute to sedimentation and cumulative effects associated with conventional logging and road-related impacts. Future harvest activities also provide an opportunity to correct or reduce existing road-related problems and sediment source. Alternative 3 has the lowest potential for ground-disturbing activities associated with timber management activities, followed by Alternatives 2, 2M, 4, and 1.

Aquatic Species Viability

Similar to protecting the habitat and populations of MIS, the Forest is charged with protecting species viability for native and desired non-native species on NFS lands. Direction within the 1986 and 2006 Forest Plans is intended to protect the elements that support healthy aquatic ecosystems, including the aquatic biota. However, cumulative impacts from past and present activities, both on and off-Forest, continue to affect populations. The stream conditions on the Forest today are impaired for a number of reasons. Loss of channel structure, loss of riparian vegetation, effects to stream temperatures, elevated sediment levels, and acid deposition stress the resistance and resiliency of the stream ecosystems. Many of the mechanisms that created those stresses are still in place, so the issue of minimizing potential impacts associated with future actions becomes a greater concern for systems that are already stressed than if the aquatic ecosystems were healthy and functioning properly. The disturbance history within the watersheds is probably a greater influence on the existing population distribution and dynamics than the potential effects associated with future management actions. However, future management actions can contribute, either positively or negatively, to the factors that are limiting populations in the analysis area.

Viability outcomes were determined for each of the aquatic species of concern including 30 fish species, two crayfish, two mollusks, and one amphibian. Because of the variability within watershed conditions, including ownership patterns and the potential for cumulative effects, the viability outcomes were made for each species in each watershed in which they are reported to inhabit (see Appendix E). Table WA-7 summarizes the viability outcomes by alternative.

Table WA-7. Viability Outcomes by Alternative

Outcome	Number of Species With the Specified Outcome				
	Alt. 1	Alt. 2	Alt. 2M	Alt. 3	Alt. 4
A	1	1	1	1	1
B	11	11	11	11	11
C	4	4	4	4	4
D	11	22	22	25	22
E	65	60	60	57	60
F	58	52	52	52	52

Overall, the outcomes are relatively similar between the alternatives, with viability outcomes A, B, and C identical between all alternatives. The alternatives differ slightly by the viability outcomes for D, E, and F due to differences in the management prescriptions and suitable timber lands by alternative. Some watersheds that had suitable timber lands in Alternative 1, had zero suitable acres in Alternatives 2, 2M, 3, and 4. This relationship resulted in a lower potential risk to aquatic species in those watersheds, and shifted the viability outcomes.

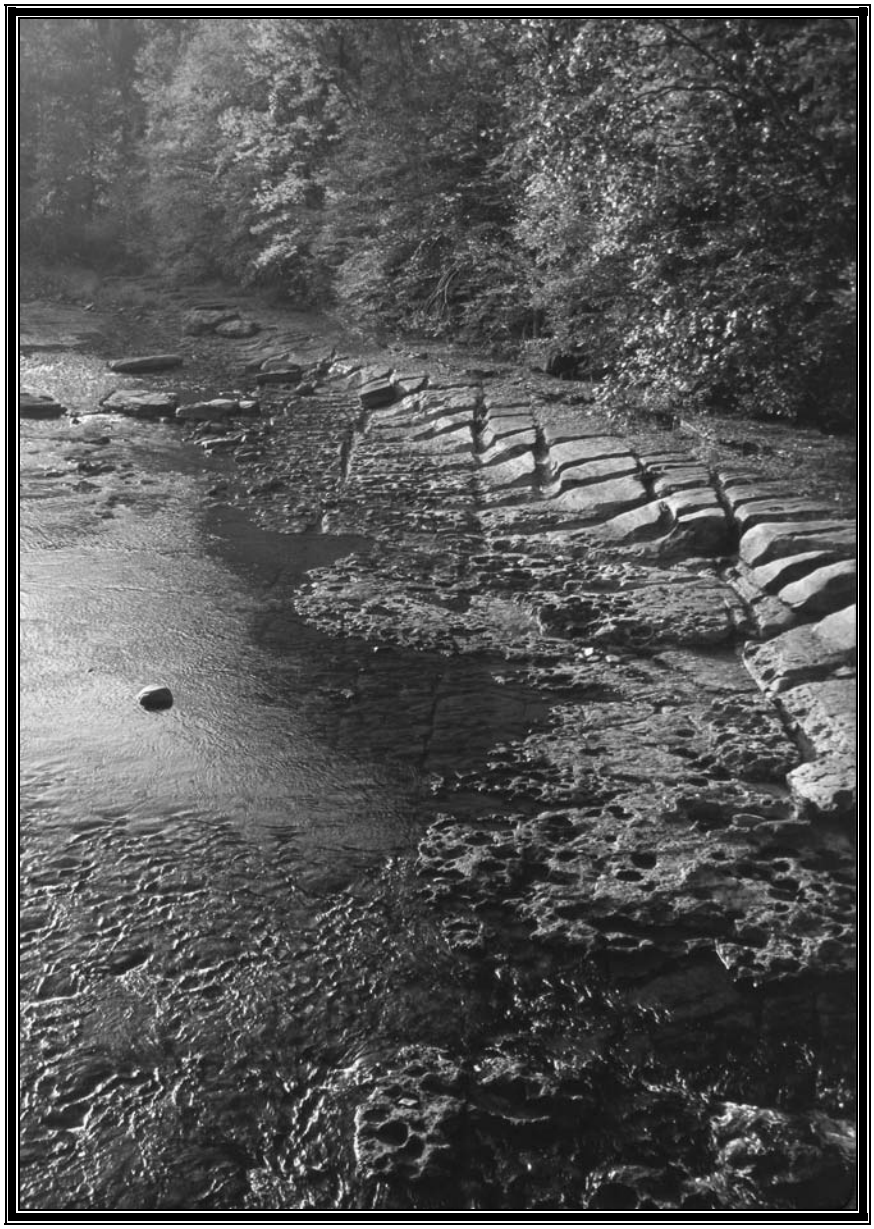
The predominantly low outcomes may be a reflection of the disturbance history and degraded habitat conditions the species have experienced, the influence of other limiting factors, or potentially the result of the sampling data and reporting (e.g., some areas are sampled more than

others, some species are more readily captured than others, etc.). We suspect that some species are more common than reported, but the records in the WVDNR fish sampling database and Heritage database do not necessarily support that conclusion. It also stands to reason that a viability assessment for species that are recognized as species of concern or locally rare is, by definition, an assessment for species whose numbers are limited to begin with, and therefore their populations are more vulnerable to disturbance.

Similar to brook trout, the preference for aquatic species viability is to reduce the potential effects associated with land management activities that might limit their productivity. This is especially true in watersheds that support large numbers of species of concern. In this regard the Upper Greenbrier River (12 species), Williams River (12 species) and Greenbrier River 1 (10 species) could be considered hot spots for aquatic species of concern.

There are other factors and values associated with these and other watersheds that also need to be considered when setting watershed restoration priorities, such as current conditions, designated uses, ownership patterns, restoration potential, and potential costs. The aquatic diversity values associated with the Upper Greenbrier River and Williams River watersheds are part of the reason why recent watershed assessments and restoration efforts have been targeted in those watersheds. Road improvements, road decommissioning, and culvert inventories have all been conducted in the Upper Greenbrier River in recent years. A watershed assessment in the upper Williams River watershed was completed in 2000, and watershed improvement projects are being planned and designed for implementation in 2007.

Watershed, riparian, and aquatic resource management direction is similar for the alternatives and would provide protection of these resources at the project level. Mitigation measures and modification of project design can be used to address site-specific concerns, including not implementing projects due to the sensitivity of the area or the potential impacts on aquatic species of concern. Project-level decisions are not based solely on what is best for aquatic resources, so effects can and do occur to aquatic resources in order to achieve other resource management objectives. Those effects are considered tolerable as long as they are within the limits prescribed by applicable laws, regulations, policies, and Forest Plan direction.



Dry Fork near Otter Creek