INTRODUCTION

Chapter 3 describes reference, current, and desired conditions for each of the major resource areas and issues identified in Chapter 1 and 2. Desired conditions from the 2006 Forest Plan have been added to this assessment for two reasons.

First, where reference conditions for resources can be estimated, Forest managers may not be able to achieve or reproduce them (or may not even want to), given the many dramatic changes that have occurred since the time when reference conditions were the norm. For instance, there were no constructed roads or highways during reference times, but the Forest has no intention of removing all of the current roads now just so that we can return to reference conditions. Some roads are needed for public/private access and Forest management. Therefore, we look to the Forest Plan desired conditions that paint a more realistic picture of how we want to manage the transportation system over the long term. This picture includes the removal or decommissioning of unneeded roads in order to reduce impacts to other resources, as well as maintenance costs.

Second, many of the "Human Uses" resources did not exist, or exist in their present form, during reference times or prior to the establishment of the Monongahela National Forest. Examples include minerals, special uses, facilities, and even recreation to a large extent. Here again, we need to have desired conditions to provide a basis of comparison with current conditions. The discrepancies between current and desired conditions help us determine where we should focus and prioritize our management actions. The ultimate objective of this assessment, after all, is to identify recommendations to address management needs, concerns, or opportunities.

SOILS AND EROSION PROCESSES

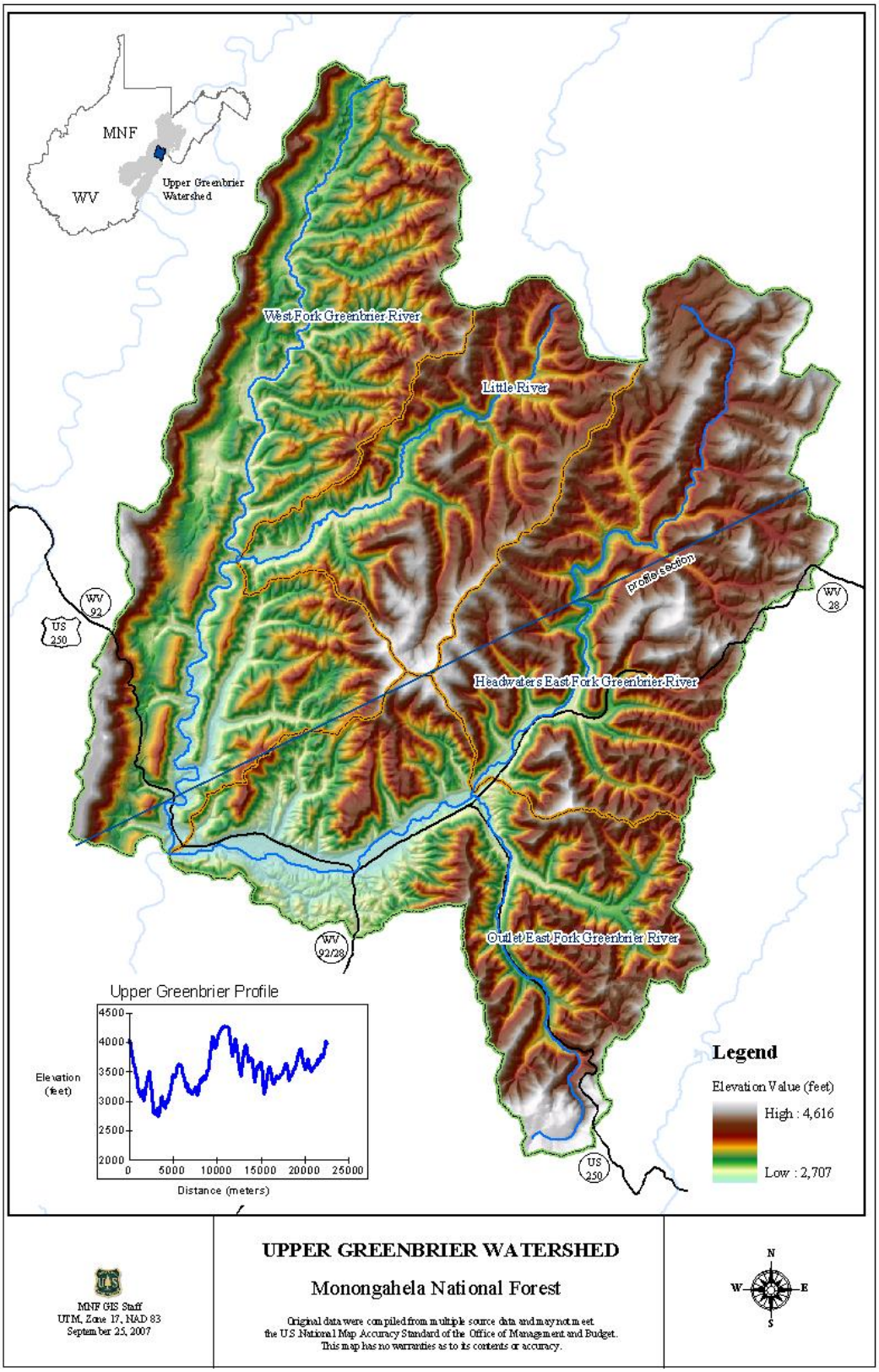
Soils are typically formed through a combination of five factors: climate, landscape, biological influence, parent material, and time. A sixth influential factor is human activity, and this factor can sometimes have major effects on soil development and productivity.

Reference Conditions

Geology

The bedrock geology within the Upper Greenbrier Watershed Assessment Area includes sedimentary rock units that range from the (oldest) Devonian-age Chemung Group rocks to the (youngest) Pennsylvanian-age New River Group. Mountain building created folds in which older rock was thrust upward as the Horton Anticline on the eastern edge of the watershed area, and the Blackwater Anticline west of the center of the watershed area. Between these two anticlines, younger rock underlies the surface marking the Job Syncline. Younger rocks on the western fourth of the watershed area dip or slope toward the west on the east flank of the North Potomac (Georges Creek) Syncline (Price 1929).

Map SL-1. Elevation Profile of the Upper Greenbrier Watershed



Alternating beds of gray to brown siltstone and sandstone with shale and conglomerate rock types of the Chemung Group occur at the surface over more than half of watershed area. Non-marine shales and fine mica-rich sandstones, mostly red to brownish gray, including siltstone, sandstone and conglomerate of the Devonian-age Hampshire Formation also occur over a large portion of the watershed area.

Mississippian-age Pocono Group rocks, comprised of predominantly hard gray massive sandstone with some shale, overlie the Hampshire Formation, and often produce prominent benches or ridges on the landscape. Stratigraphically above the Pocono Group and only several tens of feet in thickness, the Maccrady Formation consists of red shale and mudrock, red and green sandstone and minor limestone.

The Greenbrier Group, containing limestone and red and gray shale and minor sandstone beds, outcrops along the western edge of the watershed area on the eastern slope of Shavers Mountain and in an area along the northern boundary of the watershed area. Numerous caves and karst features are present where the Greenbrier Group outcrops in the watershed area (Medville et.al., 1976; Unpublished, 1992. Cave Resources of the Monongahela National Forest).

The Mississippian-age Mauch Chunk Group, occurring stratigraphically and topographically above the Greenbrier Group, underlies the mid- to upper-east-facing slope of Shavers Mountain on the western edge of the watershed area. Rock types present in the Mauch Chunk Group include red, green and medium gray shale and sandstone, with a few thin limestones.

The bottom several hundred feet Pennsylvanian-age New River Group rocks occur within a narrow band along the Shavers Mountain ridge at the western watershed area boundary. Rock type includes sandstone, siltstone, shale with some coal and conglomerate.

Soils

Soil Erosion and Sedimentation – Soil erosion and sedimentation are natural processes that have existed for billions of years. However, just as large natural mudslides can accelerate these processes with impacts to other resources, so can large-scale ground-disturbing human activities such as road building and ground-based timber harvest.

The soils of the watershed have parent material comprised of sedimentary geology that makes up the Appalachia Ridge and Valley and the Allegheny Plateau Provinces. These soils have been subject to the effects of extensive tree cutting and slash burning, most of which occurred between 1900 and 1920 in this area. These human-induced activities resulted in damaging floods, severe erosion, topsoil loss, and pollution of streams used for water supply. Subsequent fires further increased erosion. The fires at the turn of the century burned so hot that soil carbon was lost to the atmosphere, and lost soil productivity in some areas of the Forest was irreversible. Although there has been recovery over the past century, soils on many forested landscapes on the Forest still have relatively thin surface horizons.

In this portion of the assessment, erosion is considered as soil movement and not soil loss. Soil material may or may not move from a site or to a stream channel. Many factors influence soil

movement, and when soil moves, it is deposited somewhere. Depositional areas may benefit from this eroded soil. Gully erosion is an extreme case of soil movement that is considered a long-term negative effect to soil productivity. Gully erosion is evidence that large amounts of soil have moved away and can only be replaced over the long term (over 100 years). Other forms of erosion are not as detrimental and only persist until vegetative cover is established.

Gully erosion is difficult to predict and depends on several factors. There is evidence that some soil types are more susceptible to gully erosion and mass movement than others. For example, soil series forming from Mauch Chunk geologies are susceptible to mass movement, as are soils forming in unstable landscape positions in coves. In some areas, hidden ancient landslides dot the landscape, posing potential risk for mass movement when disturbed. Steep slopes and the dip of the geologic formation also increase the risk of mass movement. These areas are typically identified in watershed assessments and are further scrutinized when planning for a project. Many times avoidance is the best mitigation.

Soil Sensitivity – Soil sensitivity represents a fairly recent way of looking at soils on the Forest. This methodology uses physical and chemical properties to develop interpretations of how soils react to various management on those soils. These properties include wetness, slippage, slope, limestone content, and predilection to flooding. All of these attributes can affect how the environment responds to management on soils, and more than one attribute can be present on a given site. For example soils can be both sensitive to wetness and form over limestone geology, which may indicate the present of underground caves. From a management standpoint, it is advantageous to know where inherent soil sensitivities may exist prior to proposing ground-disturbing activities that may exacerbate those sensitivities. Highly sensitive areas can be avoided, and mitigation measures can be applied in other areas to allow activities to proceed without greatly increasing the risk of unwanted soil movement, ground water contamination, surface water contamination, or risk to the project from hazards that are known to occur on those soil series such as landslides or flooding.

Soil Acidification - Soil acidification is a natural occurring process on the landscape in forested ecosystems. Soils are continually leached of nutrients naturally by both vegetation growing and infiltration of precipitation. Normal ranges of precipitation are in the pH 5.3 - 5.5 range. Since European settlement and the coming of the industrial age, natural soil acidification has been substantially supplemented by human-caused acid deposition. Soil acidification can be seen as a balance between acid inputs and mineral weathering. Therefore, when soil-acidifying processes (such as acid deposition and forest growth) exceed mineral weathering inputs of base cations, acidification occurs. Base cations are non-acid positively charged ions of calcium, magnesium, potassium, and sodium.

In more recent times, the Monongahela Forest has been the recipient of some of the highest sulfate and nitrate deposition in the nation, mainly due to its location downwind of many older coal-fired power plants that have had minimal or no pollution control required. Historically high sulfate (SO_4^{-2}) deposition from sources in the Ohio River Valley has contributed to acidification of streams and may affect soil productivity on parts of the Forest. There are recent and ongoing research studies on nutrient depletion related to acid deposition occurring on or near the Forest.

Sulfates are formed from emissions of sulfur dioxide from power plants and industrial sources. The Forest lies downwind of Ohio, Pennsylvania, Indiana, Illinois and parts of West Virginia; states that continue to produce the highest sulfur dioxide emissions in the nation, in spite of significant reductions made during the 1990s. The combination of high emissions and limited buffering capacity of certain geologies and soil types found on the Forest, has led to increased acidity in stream water and possible nutrient depletion in soils.

Current Conditions

Soil Series and Attributes

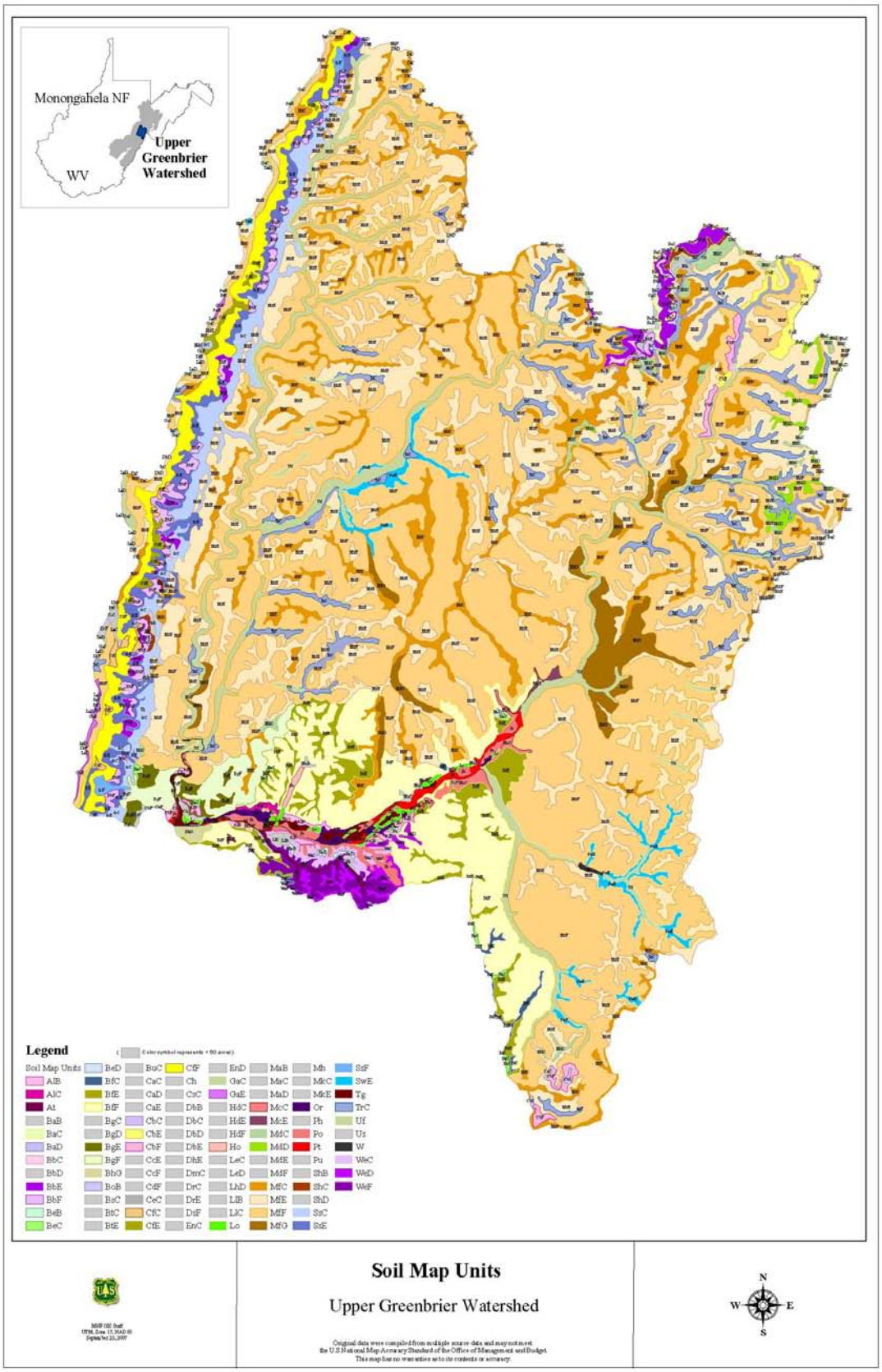
Soil surveys of the watershed span three Counties; primarily Pocahontas (>99%), with minor inclusions (<1%) of Randolph and Pendleton. The surveys indicate that 110 soil map units have been identified within the watershed, with 10 of those units representing 88 percent of the area (Map SL-2). Within those 10 map units, seven soil series are dominant. Those seven soil series are described below. Map units descriptions can be found within the county soil survey reports referenced in this document. See Appendix C for a complete list of the soil units (Table C-1).

Berks: The Berks series consists of moderately deep, well-drained soils that form in acid material weathered from interbedded shale, siltstone, and fine-grained sandstones. The soils are mostly found on uplands. The available water capacity of Berks soil is very low to moderate, permeability is moderate or moderately rapid, and runoff is very rapid. The root zone of some types of plants is restricted by the depth of bedrock, 20 to 40 inches. Erosion on logging roads and skid trails is a major management concern, and placing the roads and trails on the contour helps to control erosion. Soil erosion and sedimentation would be lessened by maintaining vegetative cover on unprotected areas and providing for proper surface water diversion.

Cateache: The Cateache series consists of moderately deep well-drained soils with moderate permeability. These soils directly overlay the parent material from which they develop and are described as being "residual." This soil series weathered mainly from red interbedded siltstone and shale. Cateache soils are on steep and very steep side slopes of mountains and ridges and on gently sloping to moderately steep benches and ridgetops. Slope ranges from 3 to 80 percent. Permeability is moderate, the available water capacity is moderate, and runoff is medium to very rapid. In areas that have not been limed, Cateache soils are strongly acid to moderately acid. These soils are highly erosive and prone to mass movement and slippage. These soils have moderate shrink-swell potential and low shear strength. The depth to bedrock is 20 to 40 inches and may restrict root growth. The bedrock is soft and weathers relatively easily.

Shouns: The Shouns series consists of very deep, well-drained, moderately permeable soils on footslopes and in coves. These are colluvial soils formed from weathered sandstone, siltstone, and shale. Colluvial soils are soils that have moved downslope from the landscape position where they originally developed. The Shouns soil series primarily is located on the lower part of hillsides, benches, and foot slopes. Runoff is medium to very rapid, permeability is moderate, and available water capacity is moderate or high. In areas that have not been limed, reaction is strongly acid to moderately acid. These soils are highly erosive and prone to mass movement and slippage. These soils have moderate shrink-swell potential and low shear strength.

Map SL-2. Soil Map Units in the Upper Greenbrier Watershed



Udifluvents and Fluvaquents: Udifluvents are very deep, well-drained to somewhat poorly drained soils that form in alluvial material derived from soils underlain by siltstone, sandstone, or limestone. These soils in general have less clay than Fluvaquents. They are found on nearly level floodplains along minor stream channels. The hazard of flooding ranges from frequent to rare. The available water capacity, permeability, fertility, and many other characteristics vary. Reaction ranges from extremely acid to strongly acid. The depth to bedrock is more than 60 inches. The major limitations of these soils are wetness and flooding. Major management concerns are road construction in wet areas and across intermittent stream channels, operating equipment on wet soils, and erosion generated by these activities.

Mandy: Mandy soils are moderately deep, well-drained, and gently sloping to very steep. They are on ridgetops and side slopes. Mandy soils are medium-textured in the surface layer and subsoil. Soils are dark brown and channery in the surface layer and dark yellowish brown to yellowish brown, channery to very channery in the subsoil. The Mandy series consists of loamy soils that formed in sandstone, siltstone, and shale on mountainous uplands and foot slopes. The landscape is characterized by rough, rugged mountainous topography. It is a greatly dissected, high plateau that has broad, gently sloping (1 to 8 percent slopes) ridgetops and knobs and very steep (> 45 percent slopes) side slopes. This soil is found generally at elevations of more than 4,000 feet. Sandstone outcrops and stones and boulders on the surface are common. The native vegetation is dominantly red spruce, red maple, yellow birch, and American beech.

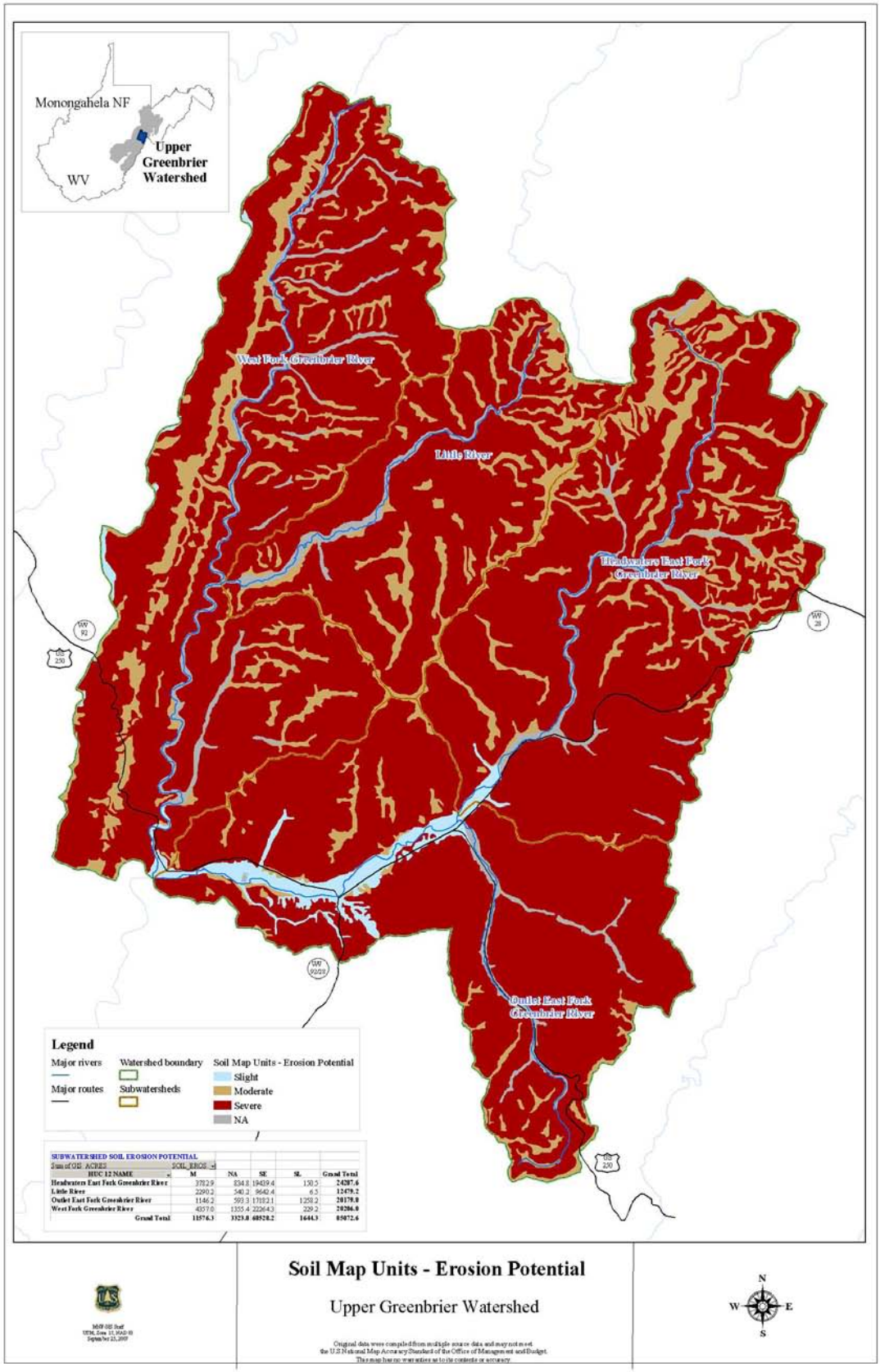
Trussel: Trussel soils are very deep (>60 inches), poorly drained soils that form in colluvial material derived from acid shale, siltstone, and sandstone. These soils are on gently sloping to strongly sloping foot slopes and benches at elevations above 3,000 feet. Trussel soils are most commonly located near the head of the East Fork of the Greenbrier River within the Upper Greenbrier watershed. The available water holding capacity is very low or low, permeability is moderate above the fragipan, and slow or moderately slow in the fragipan (dense layer). Runoff is medium or rapid. The seasonal high water table is within a depth of 6 inches. It restricts the root zone of most plants. The potential productivity of Red Spruce is high on this soil. Plant competition and the wetness are the major management concerns. These soils are in the areas of the Kanawha, New River, Bluestone, Princeton, Hampshire, and Chemung geologic deposits.

Soil Erosion and Sedimentation

Soil erosion and sedimentation are natural processes that can be accelerated by human-caused soil disturbance. The effects of soil erosion to streams and water quality via sedimentation are discussed in the Hydrology and Aquatic Resources sections of this assessment and will not be repeated here. This section will instead describe erosion potential in the watershed.

Map SL-3 displays the erosion potential hazard rating as defined by the NRCS for soils in the watershed. The majority of the soils (80 percent, 68,528 acres) are rated as having a severe potential. This designation means that these soil types may be highly susceptible to erosion when disturbed or used as road surface. This susceptibility has to do with factors such as slope, texture, and rock fragment content. Steepness of slope is a major factor to consider in this watershed, as a high portion of the soils fall into the 30-70 percent category.

Map SL-3. Soil Erosion Potential in the Upper Greenbrier Watershed



SUBWATERSHED SOIL EROSION POTENTIAL					
Sum of OSL ACRES	SOIL_EROS				
HUC 12 NAME	M	NA	SE	SL	Grand Total
Headwaters East Fork Greenbrier River	3712.9	834.8	19439.4	130.5	24287.6
Little River	2290.2	540.2	9642.4	6.5	12479.2
Outlet East Fork Greenbrier River	1146.2	593.3	17182.1	1258.2	20179.8
West Fork Greenbrier River	4357.0	1355.4	22264.3	229.2	28206.0
Grand Total	11576.3	3323.8	68528.2	1644.3	85072.6

Management implications may vary on a localized basis depending on how steep the soils are on the landscape. Soils on 30-50 percent slopes are typically going to be more resilient to disturbance than soils on 50-70% slopes, for which the Forest Plan generally prohibits wheeled/tracked motorized equipment operation. However, wetness, degree of disturbance, and other factors can also influence soil stability, which is why the potential effects of ground-disturbing projects need to be analyzed and mitigated on a case-by-case basis. Mitigation may include erosion controls, up to and including cancellation or relocation of the project.

Sensitive Soils

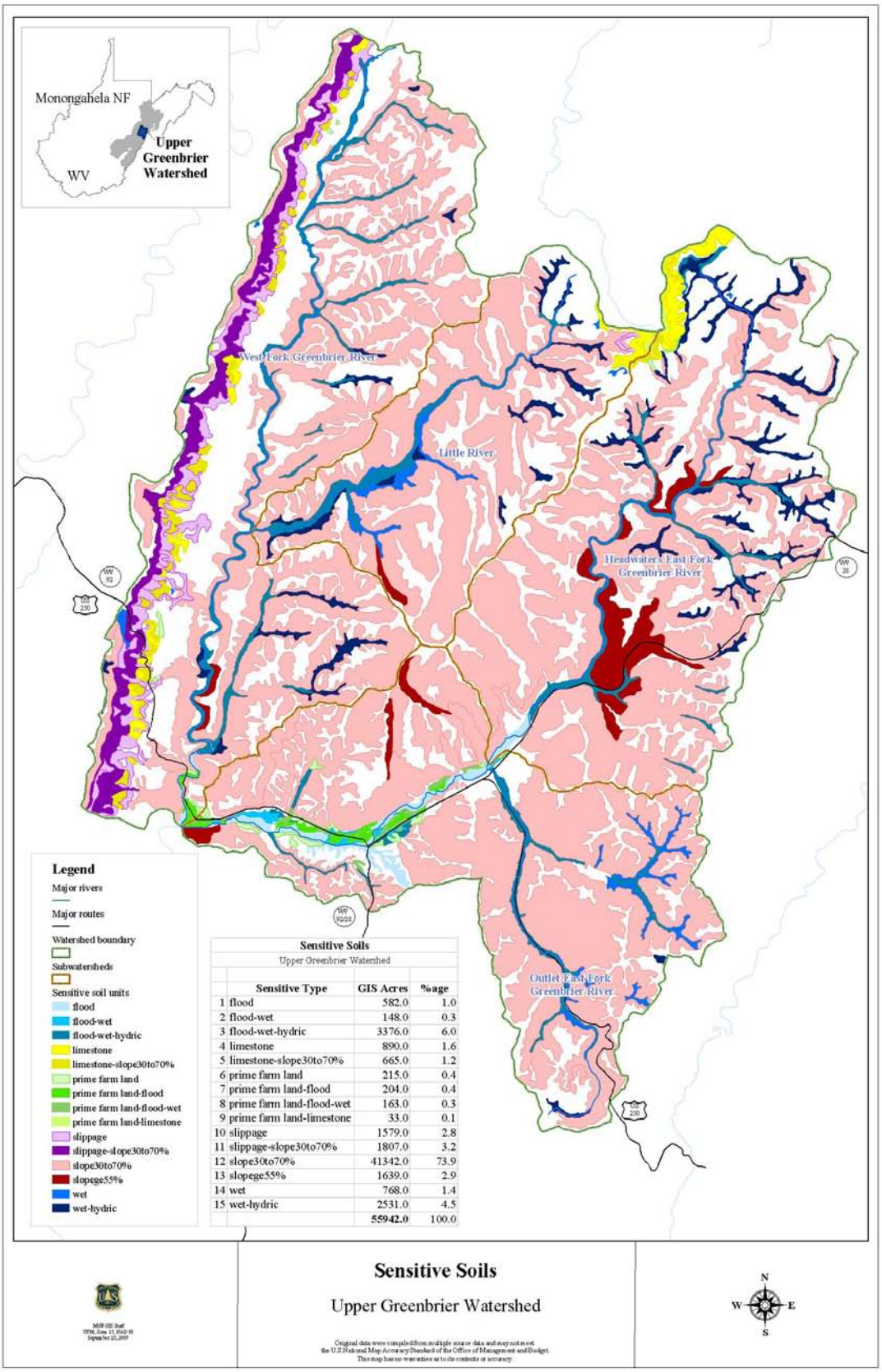
Soils in the Upper Greenbrier Watershed are sensitive for flooding, hydric soil (a designation often used in wetland delineations), slippage, steepness of slopes (30 to 70 percent), and wetness (moderately well-drained or wetter). Table C-1 in Appendix C displays all of the soil map units, and Table C-2 displays their respective sensitivity. This information can be used when planning site-specific projects in the watershed that include activities such as road building, timber harvesting, range management, or restoration activities. Table SL-1 displays the acres of soils by sensitivity group within the Upper Greenbrier Watershed. Map SL-3 features a graphic depiction of these sensitive soil groups.

Table SL-1. Acres by Soil Sensitivity Group on NFS Lands

Sensitivity Group	Acres
Flood	582
Flood-Wet	148
Flood-Wet-Hydric	3,376
Limestone	890
Limestone-Slope 30 to 70%	665
Prime Farm Land	215
Prime Farm Land-Flood	204
Prime Farm Land-Flood-Wet	163
Prime Farm Land-Limestone	33
Slippage	1,579
Slippage-Slope 30 to 70%	1,807
Slope 30 to 70%	41,342
Slope equal to or greater than 55%	1,639
Wet	768
Wet-Hydric	2,531
Total	55,942

An estimated 55,952 acres of soils in the watershed are considered sensitive; this represents 66 percent or about two thirds of the watershed, including NFS and private lands. About 81 percent of the sensitive soils within the watershed have relatively steep slopes, 30 to 70 percent or greater than 55 percent. Most all of the back slopes of the watershed fit into this sensitivity group. An estimated 13 percent of the sensitive soils in the watershed are wet soils with perched water tables or with ground water tables in floodplains. The wet soils are located in the drainages and along flatter ridgelines. Other wet soils are located in floodplains and bogs.

Map SL-3. Sensitive Soils in the Upper Greenbrier Watershed



Sensitive Soils
Upper Greenbrier Watershed

	Sensitive Type	GIS Acres	%age
1	flood	582.0	1.0
2	flood-wet	148.0	0.3
3	flood-wet-hydric	3376.0	6.0
4	limestone	890.0	1.6
5	limestone-slope30to70%	665.0	1.2
6	prime farm land	215.0	0.4
7	prime farm land-flood	204.0	0.4
8	prime farm land-flood-wet	163.0	0.3
9	prime farm land-limestone	33.0	0.1
10	slippage	1579.0	2.8
11	slippage-slope30to70%	1807.0	3.2
12	slope30to70%	41342.0	73.9
13	slopege55%	1639.0	2.9
14	wet	768.0	1.4
15	wet-hydric	2531.0	4.5
		55942.0	100.0

Landslides and slumps are a management concern when soil is disturbed in this type of topography with these types of soils and geology. Constructing roads and landing sites for timber operations may be difficult in some areas without increasing the risk of mass movement.

Soils are susceptible to slippage in the head slope positions in the southeastern end of the watershed. Also in this watershed are frigid soils that are not necessarily rated as sensitive because of soil temperature but are considered to be noteworthy for this assessment. Soils at higher elevations have different physical and chemical properties than soils at lower elevations. This is due to several soil forming factors including soil temperatures and precipitation rates (climate), native vegetation (primarily spruce ecosystems), and high-elevation unusual landforms that allow wetlands to develop on mountain tops.

Acid Deposition

The majority of the geologic formations in this watershed are known to have moderate to high potential capacity for acid buffering or neutralization (ANC) related to the geochemistry of the formations. The amount of buffering or alkalinity that each formation has beneath the soil profile is unknown exactly; however, water quality data suggests that acidity is being buffered (Forest Water Quality Monitoring Reports from 2003-2007) to varying degrees. Data showing ANC and stream pH levels for the watershed show adequate buffering capacity to acidic inputs.

The USDA Natural Resource Conservation Service (NRCS) has sampled soil series in the recent past on the Forest (2002-2007). Data from these soil series for certain criteria (base saturation, effective cation exchange capacity, calcium to aluminum ratios, and pH) indicate that the soils in this area are still able to adequately buffer acidic inputs from the atmosphere. The Acid Deposition Soil Nutrient Sensitivity Risk Assessment Map (Map C-1 in Appendix C) shows the area as having a predominantly (79 percent) moderate risk for such effects. Table SL-2 summarizes the sensitivity of soil nutrients to acid deposition in the watershed.

Table SL-2. Acres by Soil Nutrient Sensitivity (High, Moderate, Low) to Acid Deposition

Soil Nutrient Sensitivity	Acres	Percent of Entire Watershed
Low	6,014	7.1
Moderate	67,149	78.9
High	5,318	6.3
Not applicable (water, pavement, etc.)	3,409	4.0
Data not available	3,182	3.7
Totals	85,072	100

Only 6 percent (5,318 acres) of the entire area is considered to be at high risk for soil nutrient loss related to effects from acid deposition. These acres are broken out in descending order by subwatershed as follows:

- West Fork Greenbrier River: 2,309 acres or 8 percent of the subwatershed
- Headwaters East Fork Greenbrier River: 829 acres, or 3 percent of the subwatershed
- Little River: 217 acres, or 2 percent of the subwatershed

- Outlet East Fork Greenbrier River: 0 acres, or 0 percent of the subwatershed

The available data for soils forming on the same geologic formation in other watersheds—such as the Hogback project area (Horseshoe Run watershed), Glady watershed, and other data associated with soil surveys of the counties done by NRCS—suggest that there would be little to no effect to soil productivity decline in the area. (The available data for these soil types is stored in the USDA – National Soil Survey Center (Lincoln, Nebraska) Soil Survey Laboratory Research Database accessible via the internet at http://ssldata.nrcs.usda.gov. Specific lab data for the area mentioned above can be found under Tucker County, Randolph County for 2002 and 2004 at the above website. Other Forest data is located in the Hogback EA project file and the Little Beech Mountain EA project file on file at the Monongahela National Forest.

Harvesting can remove significant amounts of nutrients from a stand. However, because of the relatively dispersed nature of past and probable harvesting patterns on the Forest, the removals are not expected to be significant, particularly for nitrogen (Adams 1999.) Much of the watershed is underlain by the Hampshire and Chemung geologic groups. Compared to other geologies on the Forest, these geologies have moderate amounts of minerals that add nutrients back into the system upon weathering.

Management Implications and Recommendations

Most soils concerns in this watershed revolve around management-created disturbance on steep slopes and wet areas. Soil disturbance related to constructing/reconstructing roads and operating heavy equipment in steep/wet areas is of particular concern. The Forest Plan has many management requirements that address this concern, and additional measures can be identified and used at the project level to reduce risks to soil stability and movement.

For example, the Forest Plan provides guidance for activities that include the use of wheeled and/or tracked motorized equipment on steep and very steep slopes (Standard SW07, p. II-10)). Slopes 40 to 50 percent allow the operation of this type of equipment on a case-by-case basis to determine the best method of operation and the associated risks. Wheeled and/or tracked motorized equipment is prohibited on slopes 50 percent or greater on all soil types unless the site is analyzed by an interdisciplinary team and the activities receive line officer approval. To calculate acreages of slopes 50 percent or greater, 30-meter Digital Elevation Model software was used. There are an estimated 6,182 acres (roughly 7 percent of the watershed) in the Upper Greenbrier Watershed that have slopes 50 percent or greater (Map C-2 in Appendix C). It is recommended that activities that require ground disturbance or add to the risk of slope instability be avoided in these areas.

Other management-related recommendations are described below.

Road Management – Completion of a transportation management plan would help identify roads that can be abandoned, stored, or obliterated to reduce erosion and protect water quality. Road-related opportunities also include identifying culverts that may restrict the movement of aquatic organisms and are considered passage barriers. It is advised that no new road

construction or improvements occur to roads that will not be needed in the future. This may help prevent or discourage an increase in illegal ATV activity in the watershed.

Trail Management – Trails will be maintained primarily for resource protection. A range of trail maintenance levels may apply depending on the amount of trail use and needed resource protection measures as well as the management prescription of the area. Trails should be designed and maintained for specific uses such as hiking, backpacking, and mountain biking.

Erosion Control – Sources of sedimentation should be identified and measures taken to stabilize affected sites. This would include identifying road-related sources and areas of slope instability. Sediment sampling will help determine what streams are impaired by sedimentation and help prioritize the areas for erosion control. Some measures to help control erosion and sedimentation are listed below; others may be identified during project planning:

- Weed-free mulch should be used for short-term protection of disturbed soils.
- Seed mixtures should consist of native species and mixtures should be developed appropriately for soil types and elevation. A nurse cover crop (small annual grain crop) should be added to the mixture to provide immediate erosion control and mulch for the following growing season.
- Biodegradable biogeotextiles should be used on unstable soils to control erosion for such activities as restoring stream crossings on decommissioned roads.
- Energy dissipaters may need to be designed for culverts that direct surface flow onto highly erosive soils.
- When opportunity exists trails should be moved from wet or hydric soils to a position on the landscape where soils are better drained. Restoration of the former trail may include scarification, seeding, mulching, and outsloping all done by hand. The new trail system should be designed using BMPs and Forest Plan S&Gs.

Desired Conditions

Geologic processes, structure and materials are taken into account in the management of appropriate Forest resources. Geologic resources—including cave and karst features, springs and groundwater, ancient and recent landslides and debris flow, waterfalls, fossils and unique geologic features—are managed for public safety and to provide a balance between public enjoyment and protection of Forest resources (Forest Plan, p. II-45).

Soil protective cover, soil organic matter, and coarse woody material are at levels that maintain the natural infiltration capacity, moisture regime, and productivity of the soil. Soils also have adequate physical, biological, and chemical properties to support desired vegetation growth. Exposed mineral soil and soil compaction from human activity may be present but are dispersed and do not impair the productivity and fertility of the soil (Forest Plan, p. II-9).

Additional direction for reducing impacts to soils is found on pages II-9 through II-11 of the Forest Plan.