APPENDIX G – AQUATIC ECOLOGICAL SUSTAINABILITY ANALYSIS

George Washington National Forest

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1. INTRODUCTION

National Forest Management Act (NFMA) regulation, adopted in 1982, requires that habitat be managed to support viable populations of native and desirable non-native vertebrates within the planning area (36 CFR 219.19). For planning purposes, a viable population is one that has numbers and distribution of reproductive individuals to insure its continued existence and is well distributed in the planning area. USDA regulation 9500-004, adopted in 1983, reinforces the NFMA viability regulation by requiring that habitats on national forests be managed to support viable populations of native and desired non-native plants, fish, and wildlife. These regulations focus on the role of habitat management in providing for species viability. Supporting viable populations involves providing habitat in amounts and distributions that can support interacting populations at levels that result in persistence of the species over time.

Aquatic habitats are unique in that they are found in and adjacent to streams and lakes. The mobility of aquatic species is usually limited to these habitats. Habitat alteration is probably the major cause of decline of aquatic diversity in the South. Channelization, impoundment sedimentation, and flow alterations are the most common physical habitat alterations associated with the decline of aquatic species (Walsh et al. 1995; Etnier 1997; Burkhead et al. 1997). Other human-induced impacts to aquatic species include pollutions, introduced species, and over-harvesting (Miller 1989).

The initial focus of this aquatic ecological sustainability analysis is on ecosystem diversity of aquatic habitats within the GWNF, and the key factors within those habitats for maintaining aquatic ecological integrity. This approach is supplemented with a complementary species-specific approach that focuses on quantifying the habitats where individual species are found within the GWNF.

The goals of this analysis are:

1) Develop plan components for a framework that provides characteristics of ecosystem diversity and contributes to the diversity of native plant and animal species.
2) Evaluate if additional provisions are needed for specific federally listed species, FS sensitive species, and locally rare species consistent with the limits of agency authorities, the capability of the plan area, and overall multiple use objectives.

2. ECOSYSTEM DIVERSITY

Ecosystem diversity is defined as the variety and relative extent of ecosystem types including their composition, structure, and processes.

The GWNF developed an aquatic habitat classification to facilitate the Aquatic Ecological Sustainability Analysis (see Appendix G1). The methods used in this classification follow the basic structure of The Nature Conservancy (TNC) aquatic community classification, and the Virginia and West Virginia Comprehensive Wildlife Action Plans, yet habitat classifications were focused on land managed by the GWNF.

As described in Appendix G1, this habitat classification is hierarchical and is based on an understanding of how habitat influences the composition and distribution of aquatic biological communities. It is based on four assumptions (Higgins et al. 1998):

1. Physiographic and climatic patterns influence the distribution of organisms, and can be used to predict the expected range of biological community types (Jackson and Harvey 1989; Tonn 1990; Maxwell et al. 1995; Angermeier and Winston 1998; Burnett et al. 1998).
2. The physical structure of aquatic habitats (or ecosystems) can be used to predict the distribution of aquatic communities (Gorman and Karr 1978; Schlosser 1982).
3. Aquatic habitats are continuous; however, generalizations about discrete patterns in habitat use can be made (Vannote et al. 1980; Schlosser 1982).
4. Using a nested classification system, (i.e. stream reach habitat types within species ranges), we can account for community diversity that is difficult to observe or to measure (taxonomic, genetic, or ecological) (Frissell et al. 1986; Angermeier and Schollsser 1995).

2.1 Spatial Scales for Ecosystem Diversity

Physiographic Provinces

The GWNF lies in two physiographic provinces or ecoregions, the Blue Ridge and Ridge and Valley. Both of these ecoregions have their own unique geology and landtype characteristics. The following descriptions are summarized from Jenkins and Burkhead (1993).

Blue Ridge
This montane-upland province extends northeast-southwest from southern Pennsylvania to northern Georgia. The GWNF is in the narrow Northern Blue Ridge province (north of the Roanoke River) which is an irregular chain of mountains one to a few peaks wide, about 2-12 miles wide overall; its maximum elevation is about 4,000 feet. It is effectively the frontal mountain range of the adjacent Valley and Ridge Province. Together they apparently represent an erosional system that had been uplifted.

The rocks of the Blue Ridge are largely resistant types; thus Blue Ridge streams tend to be the softwater type. A chief feature of small Blue Ridge streams is high gradient, reflected by a high frequency of rapids, by cascades and falls in many headwaters, and by bottoms chiefly of large gravel, rubble boulder, and bedrock. Small streams are cool or cold during summer; rain-caused turbidity clears quickly.

Ridge and Valley
This province consists of parallel, northeast-southwest lines of mountains and valleys adjoining the northwest boarder of the Blue Ridge. It is marked by long narrow parallel ridges oriented with the long axis of the province. Consequently its streams form a rectilinear trellis drainage pattern of parallel-flowing stream in the valleys that are connected by right-angle valleys through the ridges. Mountain ridges are capped by protruding edges of resistant sandstone and quartzite formations; the tops of many are 3,200-4,100 feet in elevation. Intermontane valleys are floored by easily erodible carbonate (limestone and dolomite) and shale rocks; in transecting the province, carbonate valleys often alternate with shale valleys.

Small montane streams of the Valley and Ridge closely resemble the tumbling streams at similar elevations in the Blue Ridge. Streams in the valleys are of moderate gradient; shoals, runs and riffles usually compose one-third to one-sixth or less of the length. In valley streams, gravel rubble, and boulder bottoms are characteristic of both pools and riffles; bedrock is a common substrate. Substrates in calm pools of most valley streams often are quite silted; notable patches of sand are rare throughout the province. Montane streams of the province tend to carry soft water, whereas valley streams typically are the hard-water type. Almost all streams generally are clear but become heavily turbid from moderate or heavy rain. The Valley and Ridge is noted for watered caves and high-volume spring streams.

River Drainages

Within the GWNF, the two physiographic provinces are drained by two major river drainages, the James and Potomac. Both of these drainages are Atlantic slope, and drain into the Chesapeake Bay. Geological history has shaped the evolution and distribution of modern aquatic fauna. Former climates have strongly influenced this fauna as well. The following descriptions of the drainages are summarized from Jenkins and Burkhead (1993).

James Drainage
This drainage is nearly wholly within Virginia; only a short segment of each of two streams originates in West Virginia. The watershed encompasses 10,102 sq. miles. The main channel of 432 miles is the longest in the state. The James River takes its name at the confluence of the Cowpasture and Jackson rivers near Clifton Forge; 94 miles of the Jackson are included in the total length. Major portions of the drainage are in the Coastal Plain, Piedmont, and Valley and Ridge; many tributaries drop from the Blue Ridge.

The James drainage fish assemblage is fairly specious for an Atlantic slope drainage, with 109 total taxa; 73 native (3 endemic), 26 introduced, and 10 estuarine or diadromous taxa. Many range terminations fall in and adjacent to the James. Three fish are endemic to the drainage: roughhead shiner (*Notropis semperasper*), longfin darter (*Etheostoma longimanum*), and a stripeback darter subspecies (*Percina notogramma montuosa*).

Potomac Drainage

The portion of the Potomac watershed in Virginia is 5,706 sq. miles in surface area, 39% of the whole Potomac watershed; the remainder is in Pennsylvania, Maryland, and West Virginia. The Shenandoah system is the largest division of the Potomac in Virginia. The Shenandoah system is partitioned into the large North Fork and South Fork subsystems and the smaller lower Shenandoah subsystem. The Shenandoah system meanders through the Valley and Ridge for 205 miles.

Two Valley and Ridge portions of the upper Potomac system proper (above the Shenandoah mouth) drain Virginia and cross into West Virginia. The portion in the small northern area just west of the lower Shenandoah River flows directly to the Potomac River. The few short, cool or cold streams heading in Highland County go to the South Branch Potomac River.

The Potomac drainage has 61 native, 30 introduced, and 11 diadromous or estuarine taxa – 102 in all. Its endemic taxon is an undescribed sculpin, either a subspecies of *Cottus cognatus* (slimy sculpin) or a closely related species. The Shenandoah River system has a montane and upland fauna that basically is typical of other western Chesapeake basin fauna; however, several species unexpectedly are localized or missing. No consistent basis was discerned for any of the odd Shenandoah patterns; long-standing deforestation of the broad divisions of the fertile valley may be involved. The system may have suffered higher silt levels earlier than most others in Virginia. European settlers found the valley to be a huge, partly cultivated prairie the Indians had maintained through burning. Siltation associated with extensive tilling by the settlers certainly worsened stream conditions.

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Within this framework of physiographic provinces and river drainages, the GWNF manages 1,065,389 acres of land (see Figure G-1). The characteristics of the aquatic habitats (streams, rivers, lakes, and wetlands) managed by the GWNF are described in the next section.

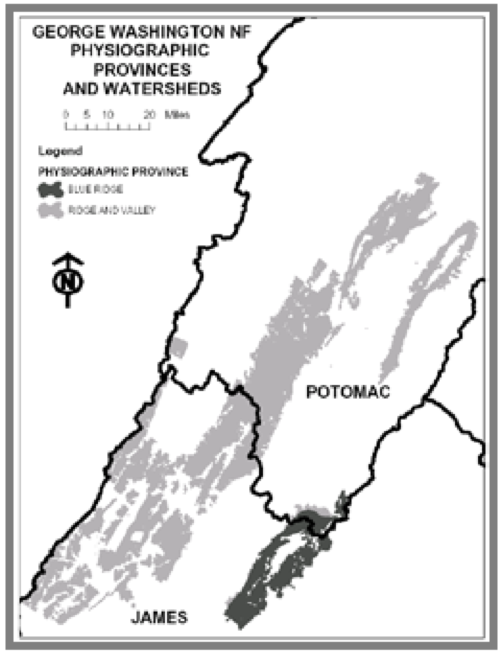

Figure G-1. GWNF Land within the Potomac and James Watersheds and the Blue Ridge and Ridge and Valley Provinces.

2.2 Characteristics of Ecosystem Diversity

Stream Reach Classification

Streams display continuous changes in physical and chemical characteristics from headwaters to mouth, which may influence the structure and function of biological communities along this continuum (Vannote et al. 1980). Factors of watershed size, elevation, and geology are interrelated along the continuum. These are the factors that were used to classify the lotic (stream) habitat on the GWNF. See Appendix G1 for a detailed description of the factors and classification process. Springs and seeps were not included in this classification because of modeling constraints. The importance of springs and seeps is recognized and they should be treated as an aquatic component of the riparian area during project planning and implementation.

Based on five categories for size, two categories for elevation, and five categories for geology (see Table G-1), there were 38 different stream habitat types (within 1,178.7 miles of perennial water) identified within GWNF ownership (see Table G-2). However, over 82% are characterized by only 10 different stream habitat types, with only three habitat types comprising almost 50% of the Forest streams. These include 20% in the headwater, higher elevation, sandstone/quartzite classification (121); and another 28% in the headwater, lower elevation, shale and sandstone/quartzite classifications (113 and 111).

Table G-1. Aquatic Habitat Classification Categories Used For Continuous Variables

Category	Range of Values	Assigned Number
Stream Size:	Watershed area (sq. miles)	Class
Headwater	<2	100
Stream	2-10	200
Large stream	10-20	300
Small River	20-70	400
Large River	>70	500
Elevation (temperature regime):	Elevation (ft):	Class
Lower elevation (warm/cool water)	≤2000	10
Higher elevation (cold water)	>2000	20
Geology:	Rock Types:	Class
Sandstone/quartzite	sandstone & quartzite	1
Limestone	limestone	2
Shale	shale	3
Granite	granite, metabasalt, proxene, gneiss	4
Charnokite/mylonite	charnikite & mylonite	5

Table G-2. Lotic Habitat Classification

Stream Type	Sum of Miles	Percent of Miles	Description	Example
121	240.60	20.41%	Headwater, higher elevation, sandstone/quartzite	Locust Spring Run, Highland Co.
113	181.61	15.41%	Headwater, lower elevation, shale	Downy Branch, Allegheny Co.
111	153.41	13.02%	Headwater, lower elevation, sandstone/quartzite	Buck Lick Run, Rockingham Co.
211	100.01	8.49%	Stream, lower elevation, sandstone/quartzite	Slate Lick Branch, Rockingham Co.
213	74.76	6.34%	Stream, lower elevation, shale	Little Fork, Pendleton Co.
221	61.43	5.21%	Stream, higher elevation, sandstone/quartzite	Little Back Creek, Bath Co.
112	50.38	4.27%	Headwater, lower elevation, limestone	Upper Kelly Run, Bath Co.
123	47.98	4.07%	Headwater, higher elevation, shale	Upper Pitt Spring Run, Page Co.
212	36.46	3.09%	Stream, lower elevation, limestone	Cub Run, Page Co.
122	24.93	2.11%	Headwater, higher elevation, limestone	Jordan Run, Bath Co.
411	21.21	1.80%	Small river, lower elevation, sandstone/quartzite	North River, Augusta Co.
513	20.62	1.75%	Large river, lower elevation, shale	Cowpasture River, Bath Co.
114	18.44	1.56%	Headwater, lower elevation, granite	King Creek, Amherst Co.
313	16.88	1.43%	Large stream, lower elevation, shale	Wilson Creek, Bath Co.
512	13.91	1.18%	Large river, lower elevation, limestone	Jackson River, Bath Co.
124	12.93	1.10%	Headwater, higher elevation, granite	Crabtree Creek, Nelson Co.
311	12.52	1.06%	Large stream, lower elevation, sandstone/quartzite	Lower Cove Run, Hardy Co.
321	11.27	0.96%	Large stream, higher elevation, sandstone/quartzite	Skidmore Fork, Rockingham Co.
214	10.45	0.89%	Stream, lower elevation, granite	Shoe Creek, Nelson Co.
223	9.06	0.77%	Stream, higher elevation, shale	Little Mill Creek, Bath Co.
115	8.08	0.69%	Headwater, lower elevation, charnokite/mylonite	Cedar Creek, Amherst Co.

Stream Type	Sum of Miles	Percent of Miles	Description	Example
413	8.07	0.68%	Small river, lower elevation, shale	Dunlap Creek, Allegheny Co.
222	5.59	0.47%	Stream, higher elevation, limestone	Muddy Run, Bath Co.
224	5.39	0.46%	Stream, higher elevation, granite	S.F. Piney River, Amherst Co.
314	5.38	0.46%	Large stream, lower elevation, granite	Pedlar River, Amherst Co.
312	4.14	0.35%	Large stream, lower elevation, limestone	Smith Creek, Allegheny Co.
421	3.86	0.33%	Small river, higher elevation, sandstone/quartzite	Laurel Fork, Highland Co.
125	3.85	0.33%	Headwater, higher elevation, charnokite/mylonite	Upp. N.F. Piney R., Nelson/Amherst
414	3.84	0.33%	Small river, lower elevation, granite	Pedlar River, Amherst Co.
215	3.61	0.31%	Stream, lower elevation, charkonite/mylonite	Browns Creek, Amherst Co.
415	2.30	0.19%	Small river, lower elevation, charnokite/mylonite	Tye River, Nelson Co.
511	2.09	0.18%	Large river, lower elevation, sandstone/quartzite	Passage Creek, Shenandoah Co.
412	2.04	0.17%	Small river, lower elevation, limestone	Trout Run, Hardy Co.
315	1.08	0.09%	Large stream, lower elevation, charnokite/mylonite	Piney River, Nelson/Amherst Co.
322	0.28	0.02%	Large stream, higher elevation, limestone	Dry Run, Bath Co.
423	0.14	0.01%	Small river, higher elevation, shale	Back Creek, Highland Co.
225	0.06	0.00%	Stream, higher elevation, charkonite/mylonite	Lower N.F. Piney R., Nelson/Amherst
323	0.03	0.00%	Large stream, higher elevation, shale	Shaws Fork, Highland Co.
Total	1178.66	100.00%		

The Ecosystem Diversity Report for the George Washington National Forest identified two aquatic-related ecological systems that cross-walk with the stream reach classification.

Ecological System from Ecosystem Diversity Report	Lotic Habitat Classification
Central Appalachian Floodplain	Stream size classes of: Small River and Large River
Central Appalachian Riparian	Stream size classes of: Headwater, Stream and Large Stream

Lake, Pond, and Wetland Classification

Lentic aquatic habitat has standing water and includes lakes, ponds, and swamps. It is primarily determined by slope (or gradient) and substrate or storage capacity.

Lakes and ponds were classified by size and connectivity to a stream. A waterbody greater than five acres was called a lake; a waterbody equal to or less than five acres was called a pond. Wetlands were classified according to the type of vegetation within the wetland. Six habitat types were identified (see Table G-3). The category of “Lake Connected to A Stream” covered the greatest amount of acres on the Forest because this category included the 2,530-acre Lake Moomaw.

Table G-3. Lentic Habitat Classification

Category	Abbreviation	Number	Acres on GWNF	Percent
Lake Connected To A Stream	LCS	34	2830.6	87.7%
Woody Wetland	WW	189	185.7	5.8%
Emergent Herbaceous Wetland	EHW	139	85.0	2.6%
Pond Not Connected To A Stream	PNCS	81	70.5	2.2%
Pond Connected To A Stream	PCS	29	36.0	1.1%
Lake Not Connected To A Stream	LNCS	2	20.9	0.6%
TOTAL		474	3228.7	100.0%

The Ecosystem Diversity Report for the George Washington National Forest identified four aquatic-related ecological systems that cross-walk with the lake, pond and wetland classification.

Ecological System from Ecosystem Diversity Report	Lentic Habitat Classification
Central Interior Highlands and Appalachian Sinkhole and Depression Pond	Pond not connected to a stream, Woody wetland, Emergent Herbaceous Wetland
Southern and Central Appalachian Bog and Fen	Woody wetland, Emergent Herbaceous Wetland
North-Central Appalachian Acidic Swamp	Woody wetland
North-Central Appalachian Seepage Fen	Emergent Herbaceous Wetland

2.3 Key Factors

Aquatic ecological integrity must include physical, chemical, and biological integrity. Furthermore, biological integrity is dependent on physical and chemical integrity. Key factors related to physical, chemical, and biological integrity have been identified that are important for maintaining aquatic ecological sustainability.

Aquatic Ecological Integrity	Key Factors
Physical Integrity	Riparian Areas, Instream Habitat, Lake and Wetland Habitat, Thermal Regime
Chemical Integrity	Dissolved Oxygen, pH and Alkalinity, Other Elements
Biological Integrity	Species Occurrence, Watershed Health

Physical Integrity

Riparian Areas

Riparian areas sustain the aquatic environment by influencing water temperature, light, habitat diversity, channel morphology, food webs and productivity, and the species diversity of stream and lake systems. Intact riparian areas are important in all aquatic habitats.

Maintenance of consistent daily and seasonal fluctuations in water temperature and ambient light levels is crucial to the viability of plant and animal populations. Riparian forests dampen fluctuations in stream water temperature; blocking out heat to keep water cooler during the day and summertime, and capturing heat as it radiates from the soil and water to keep the stream environment warmer during the night and wintertime. The

net effect is an environment more conducive to life with fewer tendencies for wide fluctuations in stream temperature. Light levels are regulated in similar fashion.

Litterfall and algal production are the two primary sources of food energy inputs to streams. Both are intimately tied to the presence of riparian forest. Litterfall (leaves, twigs, fruit seeds, and other organic debris), is most abundant when riparian forests are present. Because large pieces of litter do not travel very far away from their origin, a streamside forest is often desirable along the entire length of a stream to provide the necessary balance of food inputs appropriate to the food chain of native species. In addition, terrestrial insects falling into the water from riparian vegetation can comprise a major portion of the summer diet of fish in headwater streams (LaRoche 2008).

Instream macroinvertebrate populations are affected by changes in litter inputs, as well. The metabolic activity of some of these organisms may increase as streamside plants are removed. This allows woody material to be decomposed more quickly, making nutrients in this material less available to fish and other aquatic species.

The type and amount of algae produced in a stream is affected by the amount of light striking the water surface. Studies show that the algal community of a stream well shaded by older trees is dominated by single celled algae (diatoms) throughout the year. Streams in deforested areas often contain many threadlike (filamentous) green algae, and few diatoms. While some macroinvertebrates such as crayfish and waterboatmen insects readily consume filamentous green algae, most herbivorous species of stream macroinvertebrates have evolved mouth parts specialized for scraping diatoms from the surface of rocks and wood. They cannot eat filamentous algae. Macroinvertebrate diversity tends to decline if a streamside zone is deforested (Austin 2005).

In addition, riparian forests remove, sequester, or transform nutrients, sediments and other pollutants. Pollution removal depends on (1) the capability to intercept surface water and groundwater borne pollutants, and (2) the activity levels of certain pollutant removal processes. Rain and sediment that runs off the land in sheet flow can be slowed and filtered in the forest, settling out sediment, nutrients, and other potential pollutants before they reach the water. Some potential pollutants, such as fertilizers or pesticides, which originate on land, are taken up by plant roots. Nutrients are stored in leaves, limbs, and roots instead of reaching the stream or lake.

Riparian areas will be discussed in Section 2.5 in terms of the current condition and trend on the Forest for stable and complex riparian vegetation community and recreation impacts.

Instream Habitat

The substrate is the bottom of, or bottom material in, the stream. The substrate is directly determined by the underlying geologic material. Many aquatic species require specific substrates for their different feeding, hiding, and reproductive strategies. Loose coarse substrate has abundant spaces between and under stones to support the invertebrate foods of many fishes and to serve as egg deposition sites and cover from predators. Freshwater mussels generally need a mixture of loose gravel and sand in which to burrow. Siltation occurs when suspended solids settle from the water column. This fine sediment tends to smother gravel and rubble and fill interstices around boulders, and thus reduces benthic biota and buries breeding sites.

Generally, the more complex the stream habitat, the more complex the stream community. Habitat complexity can come from substrate, gradient, and outside influences such as large woody debris (LWD). In streams with steep gradient and large substrate, boulders often are the dominant structure in the channel (ex. stream type 221, Stream, higher elevation, sandstone/quartzite). In high gradient streams, there is a large range of particle sizes. In contrast, lower gradient streams have primarily smaller particle sizes. Where substrate sizes are small, LWD is an important feature in channel morphology. Lower elevation small streams with smaller particle sizes where LWD could be an important feature include stream types 212 (Stream, lower elevation, limestone) and 213 (Stream, lower elevation, shale). In addition to habitat formation, LWD retains organic and inorganic matter, provides food for invertebrates, and serves as habitat for both invertebrates and fish

Instream habitat will be discussed in Section 2.5 in terms of the current condition and trend on the Forest for LWD and stream habitat complexity.

Lake and Wetland Habitat

There are only two natural lakes in Virginia, Lake Drummond in the Dismal Swamp, and Mountain Lake near the top of a mountain in Giles County. Neither of which is on the GWNF. One natural lake/pond, Trout Pond, exists in West Virginia on the GWNF. However, there are numerous smaller natural ponds and wetlands, in addition to human-built impoundments (reservoirs). Because they vary in size, depth, chemistry, hydro-period, and vegetation, there are often unique flora and fauna associated with these habitats. Beaver ponds, especially, offer a unique habitat that stores water, traps sediment, reduces erosion, and enhances riparian vegetation. Because of their location on gentle terrain, and easy access, natural ponds and wetlands are often vulnerable to human exploitation and alteration; while man-made reservoirs are usually a center for water-based recreation.

Thermal Regime

Water temperature is a characteristic that can vary widely and is influenced by a number of variables including latitude, altitude, season, weather, shade, and proximity to springs.

Geology directly affects water temperature through elevation changes, and the influence of springs and groundwater. Groundwater influence is a function of watershed storage capacity. The greater the storage, the higher the percent of flow from groundwater, and the cooler the stream water temperature. Watersheds with a large amount of limestone geology generally have a greater amount of groundwater influence because of the presence of large underground aquifers, springs and seeps (ex. stream types 112 (Headwater, lower elevation, limestone) and 222 (Stream, higher elevation, limestone)).

Temperature has a great influence in determining what organisms can survive in a waterbody. Temperature directly affects the amount of oxygen that can be dissolved in water; the rate of photosynthesis by algae and larger aquatic plants; the metabolic rates of aquatic organisms; and the sensitivity of organisms to toxic wastes, parasites and diseases. Fish such as trout depend upon cool, oxygen-rich waters.

Human activities influence water temperature. Thermal pollution and streamside clearing can create changes in water temperature. Soil erosion and sedimentation raises water temperature by increasing the amount of suspended solids in the water. Suspended solids make water cloudy. Cloudy water absorbs more radiation (and warmth) from the sun than clear water does.

Chemical Integrity

Dissolved Oxygen

Dissolved oxygen (DO) comes from a variety of sources. The action of waves and water tumbling over rocks helps mix oxygen in the atmosphere with moving water. Geology directly affects DO by controlling not only elevation, but also stream gradient. Rock with higher mass strength produces larger stream particle sizes (for example, granitic formation), and thus steeper gradients.

Plants release oxygen into the water as a byproduct of photosynthesis during daylight hours, but plants and animals also use oxygen during respiration and produce carbon dioxide. Both oxygen and carbon dioxide are more soluble in water at low temperatures than at high ones. Large amounts of carbon dioxide are a sign of accumulating organic material and low dissolved oxygen.

Human activities have great potential to influence dissolved oxygen levels because they are so closely linked to temperature and nutrient levels. Increased nutrients (like phosphorus and nitrogen) stimulate algal growth. Eventually the algae die and accumulate. Animal waste, sewage and other industry discharges, agricultural and urban runoff, in addition to the dead algae, create a large amount of organic material.

Bacteria and fungi use oxygen to break down this organic material and cause the biochemical oxygen demand within the system to increase. Biochemical oxygen demand refers to the amount of oxygen required by microorganisms to oxidize an amount of organic materials. A high demand lowers the availability of dissolved oxygen in the water.

When oxygen is consumed by aerobic bacteria, there is less available for other aquatic organisms. Only organisms, such as carp, midge flies and leeches that are tolerant of low dissolved oxygen levels will survive. This reduces the diversity within the system, creating a system that is less stable ecologically.

pH and Alkalinity

The pH of a water body is affected by its age, geology and the chemicals discharged into it by communities and industries. Alkalinity refers to the ability of a solution to resist changes in pH. Alkalinity buffers waters against dramatic changes in pH.

Geology directly affects pH because the main sources of natural alkalinity are rocks that contain carbonate, bicarbonate and hydroxide compounds. Borates, silicates and phosphates also may contribute to alkalinity. Waters flowing through limestone typically have good buffering capacity (ex. stream classifications 222, 512, 312). Waters flowing through granite and quartzite areas typically have low alkalinity and poor buffering capacity (ex. stream classifications 111, 211).

Since buffering capacity ultimately depends on the weathering of acid-neutralizing material from the bedrock, hard bedrock types produce less buffering capacity for streams than soft bedrock types. Mountains by their very nature are more resistant to weathering than surrounding lowlands, so mountain streams and lakes are usually the most sensitive to acidification. In contrast, large valley streams and lakes are the recipients of upstream weathering products and are often less sensitive to acidification.

Human activities also affect the pH of water bodies. Acid precipitation is the result of nitrogen oxide gases and sulfur dioxide combining with water in the atmosphere to produce nitric and sulfuric acids. These gases are produced and released into the atmosphere during the burning of fossil fuels such as gas, oil and coal. Acid precipitation falls into water bodies and makes some of them acidic. Runoff from acidic Soils also contributes to acid waters. Waterbodies that have limestone geology are less susceptible because the alkaline carbonates of limestone help neutralize the effects of acid precipitation.

Unpolluted rain has a pH of around 5.6 (slightly acid). Currently, the average rain and snowfall in most states east of the Mississippi River measures between 4 and 5 on the pH scale. Some individual storms go as low as 3.0.

Most aquatic organisms survive best within a limited pH range. Even small changes in pH are harmful to acid sensitive species. Most fish can tolerate pH values of about 5.0 to 9.0. pH values outside that range can create problems for reproduction and survival. Alkalinity helps fish and aquatic life because it protects against pH changes and makes water less vulnerable to acid precipitation. When alkalinity falls below 2 mg/l the pH of waters can change easily. During the spring alkalinity is especially important for protecting aquatic organisms in their early life stages from large amounts of acidic snowmelt and runoff.

Other Elements

Magnesium, calcium, sodium, potassium, chloride, aluminum, iron, manganese, copper, and zinc are just a few of the elements that can occur in stream water. The level of these elements in stream water is directly related to the underlying bedrock material. Often these elements are in excess in stream water as a result of human activity (such as mining).

A note about aluminum is warranted because it is extremely toxic to aquatic life, and it has a unique relationship to pH. Aluminum is the most abundant metal on the earth's surface, and the third most abundant element. It is non-toxic and insoluble under acid-neutral conditions, but very toxic to fish and other aquatic species under acidic conditions. Unfortunately, the solubility of aluminum increases exponentially as pH falls below 5.6; its maximum toxicity occurs at about pH 5.0. Acid deposition results in the release of aluminum from Soils and its transport in solution to streams and lakes.

Biological Integrity

Species Occurrence

Aquatic species are not found uniformly distributed across all habitat types; many are tied to specific habitat needs or preferences. The specific habitat associations for Threatened and Endangered, FS sensitive species and locally rare species are found later in this report. In general, aquatic species distributions are determined by major river drainage, size of the water body, and local characteristics (substrate, light, velocity, temperature, energy sources, and chemistry).

Biogeography

Geography directly influences the distribution of aquatic organisms at a large scale through the division of major river drainages. For example, some species are naturally found in the James River watershed, and not the Tennessee River watershed, or vice versa. Those species that are native and restricted to a given area or watershed are called "endemic". Species richness, as well as degree of endemism varies greatly by major river drainage.

Longitudinal Zonation

As previously stated in this report, most species occupy streams or stream reaches of particular size ranges, thus their distributions are longitudinally zoned. Species richness in stream reaches is related to longitudinal zonation. Headwaters nearly universally have fewer species than do medium and large streams in the same system.

The River Continuum Concept (paraphrased from Cushing 1995).

This concept explains how geology, light, current velocity, temperature, and energy sources interact to produce the changing mosaic of aquatic insects from headwaters to river mouth.

- In the headwaters, the stream is narrow and generally well-shaded by the riparian canopy. Primary producer energy for the stream comes from riparian vegetation. The stream is dominated by insects that are shredders and collectors.
- The stream's mid-reaches have a wider bed, warmer temperatures, more light, and nutrients. Algae is abundant on the stream bottom, and the stream is dominated by insects that are grazers and collectors.
- The lower reaches of a river are slow-flowing and deeper. Increased turbidity prevents sunlight from supporting algal growth on the bottom. In-stream primary production takes place within the water column where suspended algae and macrophytes are abundant. The insect community is largely made up of collectors, both filterers and gatherers.

Species occurrence will be discussed in Section 2.5 in terms of Management Indicator Species in the current GW Forest Plan and barriers to aquatic organism passage. It also will be discussed in terms of habitat on the Forest for FS sensitive species or locally rare species in Section 3.2.

Watershed Health

The living systems of a water body are the product of millennia of adapting to climatic, geological, chemical, and biological factors. Their very existence integrates everything that has happened where they live, as well as what has happened upstream and upland. When something alters the landscape around a river's headwaters, life in lowland reaches feels the effects (Karr and Chu 1999).

Recent research comparing stream segments having 30 meter wide buffers to stream segments with 15 meter wide buffers, found that those with 15 meter buffers have: 1) higher peak temperatures, and 2) more fine sediments (Jones et al. 2006). In addition, trout populations were shown to respond markedly to these habitat changes. Streams with 15 meter buffers would not be able to maintain the temperatures necessary to sustain young trout. Furthermore, studies in deforested watersheds (e.g., intensive agriculture and urban systems) have shown that wide land-use alterations can overwhelm the capacity of riparian buffers to support high-quality instream habitats and associated biotic communities (Roth et al. 1996; Wang et al. 2003; Roy et al. 2005).

Terrestrial and aquatic invasive species can alter habitat and biologic interactions. Examples of forest-altering species include the gypsy moth and hemlock woolly adelgid. Examples of non-native invasive aquatic species are didymo algae and Asian clams.

Watershed health will be discussed in Section 2.5 in terms of benthic macroinvertebrate monitoring on the Forest, and invasive species examples.

2.4 Range of Variation

The physical and biological characteristics of ecosystems do not remain constant over time, as plant and animal communities are continually altered in response to changes in physiographic and climatic conditions. In many cases, periodic disturbance is required to foster ecological processes (e.g., flooding promotes nutrient cycling in riparian soils), or to complete the life cycles of various organisms (e.g., pond drying/filling to facilitate marbled salamander reproduction). A certain amount of change is therefore unavoidable and essential in watershed ecosystems. For this reason, a key element in maintaining aquatic ecological integrity is the ecosystem's ability to evolve over time and to self-regulate following disturbance (Helfield et al. 1998).

Floods and Droughts

The watersheds of the GWNF periodically experience extreme flow events. Virginia lies in the path of cyclone storms that originate in the Gulf of Mexico and the Atlantic Ocean and carry large amounts of moisture. Flooding is common in the state, especially in the western mountain regions, where high precipitation and steep topography produce rapid runoff. The lands of the GWNF have been touched by floods of magnitude greater than 50-year recurrence interval in 1940, 1969, 1972, 1977, and 1985, as well as 1996 (van der Leeden, 1993). Most of these were produced by hurricanes. The potential for flooding is greatest when Soils are near saturation as they are in the spring or at any time of year following several days of rain. The presence of a forest canopy in a watershed can reduce flood peaks from small-to-moderate storms during the growing season because the growing trees utilize soil moisture and transpire it to the atmosphere. However, this soil moisture difference becomes negligible during large-storm events. A small mountain watershed on the GWNF can produce flood peaks approaching 1,000-cubic feet per second, per square mile. In contrast, a larger river basin like the James River at Holcomb Rock will have a maximum peak discharge of only 50-cubic feet per second, per square mile.

Historically, the great floods in western Virginia have been associated with hurricanes, which form part of the ecological disturbance regime for aquatic ecosystems. The way that a watershed responds to a hurricane event is strongly influenced by watershed condition and also by natural factors of sensitivity. A healthy watershed is resilient and can rapidly recover from the effects of a large flood. A watershed under stress from historic or ongoing land uses may show disproportionately more watershed damage and channel impacts, and will take much longer to recover. The watersheds of the Appalachians are in the process of seeking a new equilibrium partly, in response to the loss of American chestnut from the forests. Because of its resistance to rot, large woody debris produced from downed chestnuts would persist for decades and add stability to headwaters streams. In addition to increased longevity in the aquatic system, the mature chestnut trees were much larger than the trees of the second growth forests of today. When compared to streams in virgin forests in the Appalachian Mountains, the streams in second growth forests have significantly less large woody debris.

Low flows typically occur during late summer and early autumn when precipitation is low and soil moisture is utilized by growing vegetation. Water in the stream represents the release of water from groundwater and soil storage. Because of the wide range in topography, rock types, and soils, there is a wide variation of low flows in the streams of the GWNF. Where soils are deep, slopes are gentle, and drainage density is low, precipitation can be stored within the watershed and released slowly. Thus, peak flows are moderated and low flows are sustained. As greater flow contributions are from groundwater, water temperature is usually lower and less variable. Based on years of data from U.S. Geological Survey (USGS) stream gages across the Forest, for the same low flow recurrence interval, streams in the Ridge and Valley have one half of the flow rates of Blue Ridge streams.

Sediment

There is a great deal of variability in the sediment yield from year to year, which is termed "interannual variability." In part, this is because sediment yield is much greater during high runoff years with more stormflow to erode and transport sediment. Conversely, sediment yield is much less during drought years when high flows may be less than bankfull. However, interannual variability is a function of much more than the weather.

Data from the USGS gage on the Rappahannock River at Remington provides an expression of the variability of annual sediment yield. For the 42 years with flow and sediment data, each year's percent difference from the long-term mean ranges from plus 184 percent to minus 82 percent. A change of annual sediment yield of plus or minus 60 percent represents one standard deviation from the long-term mean. This value is also termed the coefficient of variation. According to Bunte and MacDonald (1999), "very few records of annual sediment yield have a coefficient of variation of less than 50%, and most values are closer to 100%." Therefore, the data from the Rappahannock provide a good but conservative estimate of the coefficient of variation for watershed systems on the George Washington National Forest. Figure G-2 displays the interannual sediment variability for the Rappahannock River at Remington.

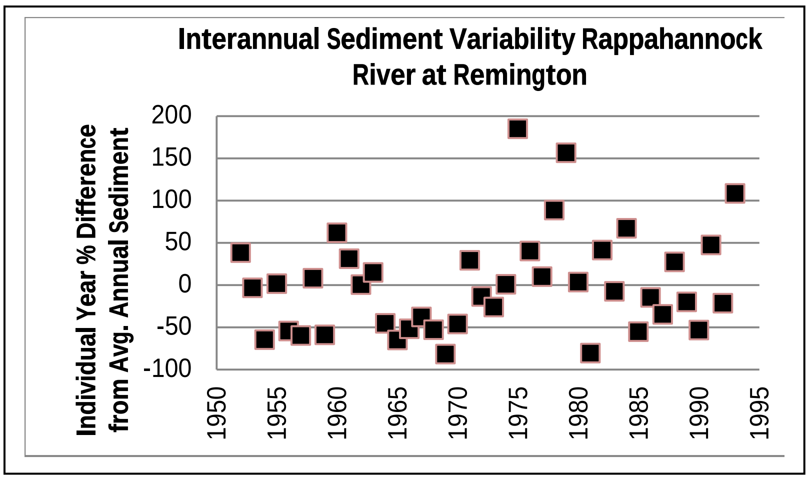

Figure G-2. Interannual Sediment Variability Example

2.4a Disturbance Processes

Natural Change Processes

Natural disturbance processes are typically characterized according to the frequencies at which they occur, and the intensity of their effects. Intensity of disturbance is typically defined according to the magnitude of effects on biotic communities. Frequency and intensity are generally inversely proportional to one another, as plant and animal communities associated with frequently disturbed habitats tend to develop adaptations that allow them to persist or even thrive under those conditions.

Within the watershed, upper reaches (low order streams or headwaters) are affected primarily by infrequent, high-intensity events (e.g., landsides, debris flows), whereas lower reaches (high order streams or rivers) tend to be affected by frequent, low-intensity events (e.g., flood scour/deposition) (Helfield et al. 1998). A description of these streams follows:

Low Order Streams (Headwaters)
The channel morphology of a low order stream is characterized by high gradient step-pools formed by large substrate particles (boulders) and large wood. The floodplain is narrow and constrained. Disturbance is infrequent, but often extreme, in the form of landslides and debris flows. The effects of the disturbance are severe hillslope and channel erosion, and channel aggradation and degradation.

Mid-Order Streams (Streams to Large Streams)
The channel morphology of a mid-order stream is characterized by a moderate gradient assemblage of pools, riffles, and runs. Particle sizes are mixed, but predominantly cobble size, with some exposed bedrock. The floodplain ranges from unconstrained to constrained. Disturbance is more frequent, and in the form of debris flows, landslide/dam break floods (torrents), and bank erosion. The effects are cycles of aggradation and degradation, mass transfer and deposition of LWD, and alteration of riparian zone.

High Order Streams (Small to Large Rivers)
The channel morphology of a high order stream is characterized by low gradient pools, riffles and runs. Particle sizes are smaller, dominated by sand and gravel. The floodplain is wide to accommodate the sinuous channel. Disturbance is frequent, but of lower intensity, in the form of floods, and treefall. The effects of disturbance are bank erosion, evulsions, and alteration of the riparian zone.

Wetlands and natural lakes and ponds are likewise affected and maintained by natural change processes. As described by Euliss and others (2008), these habitats "occur at positions in the landscape where the underlying geology creates hydrologic conditions suitable for their development". The fundamental ecological processes at work in these lentic systems are a balance of hydrodynamics (including flooding and drought), erosional properties, and nutrient cycling (Euliss et al. 2008; Pearson 1994). An example of a natural disturbance process in these systems is the never ending cycle of beaver ponds filling with debris and being abandoned to the forces of erosion and terrestrial recolonization. Hackney and Adams (1992) state that beavers have probably created more aquatic and wetland habitats than human efforts have ever done.

Anthropogenic Change Processes

A biota can sustain itself- it is very resilient- when faced with normal environmental variation, even when that variation is large (e.g., variation in river flow). But the same biota may not be able to withstand even the smallest disturbance outside the range of its evolutionary experience (Karr and Chu 1999). Habitat alteration is the major cause of decline of aquatic diversity in the South (Clingenpeel and Leftwich 2008). Channelization, impoundment, sedimentation, and flow alterations are the most common physical habitat alterations associated with the decline of aquatic species (Walsh et al. 1995; Etnier 1997; Burkhead et al. 1997). Other human-induced impacts to aquatic species include pollution, introduced species, and over-harvesting (Miller 1989). Euliss and others (2008) likewise note that human stressors on lake and wetland habitat include: shoreline alteration, altered sediment supply and transport, altered hydrology, land-use change, development on uplands, invasive species, introduction of non-native organisms, and disruption of fire regimes.

Habitat quality within a freshwater ecosystem is determined by activities within the watershed (Abell et al. 2000; Scott and Helfman 2002). A resource assessment was conducted using information from the Eastern Watershed Assessment Protocol (EWAP 2002) and is documented in Appendix G5. Fifth code HUC watersheds were evaluated in a GIS environment to characterize the watersheds based on the following conditions, or human-caused disturbances that can affect aquatic biota outside their normal range of variation.

Disturbance or Condition	Watershed Parameter	Data Management from EWAP 2002*
Characterization	National Forest ownership	Percent of national forest within the watershed
Characterization	Land Use (forested)	Percent of forest cover within the watershed
Deforestation/channelization/grazing streambanks	Forested riparian	Length of streams flowing through forested land cover divided by total length of streams in watershed
Sediment and impacts from roads	Road Density	Length of highway divided by watershed area expressed as a percentage
Sediment and impacts from roads	Road – riparian interaction	Percent of total stream length in each HUC that has road within 30 meters.

Disturbance or Condition	Watershed Parameter	Data Management from EWAP 2002*
Point and non-point source pollution	Point sources of pollution	Sum of ricris, cercla, pcs, and ifd sites
Dams/impoundment construction	Dams / Diversions	Number of dams found in the watershed
Point and non-point source pollution	State Impaired Waters	Total length of impaired streams divided by total stream length expressed as a percentage.
Acid deposition	Acid deposition sensitivity	Percent of watershed with high acid deposition sensitivity
Characterization	Public water supply sources	Number of drinking water sources found in the watershed
Characterization	Drainage Density	Length of streams divided by watershed area expressed as a percentage.
Characterization	Number of aquatic TE/S/LR	Number of aquatic TE/S/LR not counting birds and non-TE plants

* Except for Number of aquatic TE/S/LR, these are from 2009 analysis.

The analysis in Appendix G5 is a description of the major resource components within the watersheds that contain the GWNF; it is a coarse evaluation of the interactions among the physical, biological and human aspects of the watersheds and the processes influencing them (Regional Ecosystem Office 1995). As seen in Chart G-1, the percent forested land use in a watershed generally mirrors the percent National Forest in that watershed, with the exception of the east side of the Blue Ridge Mountains on the Pedlar District where there are large tracts of private forested land (HUC codes 0208020301-0208020306). HUCs 0207000102 and 0208020108 are Laurel Fork and Craig Creek, respectively, where a large part of the watersheds are on other National Forests (the Monongahela (41% NF) and Jefferson (62%NF)). This watershed analysis is a snapshot in time, incorporating many human disturbances outside the control of, and area managed by, the Forest Service. For example, the percent of impaired streams in a watershed is generally the inverse of the percent National Forest in that watershed (see Chart G-2). The analysis shows the relative condition of the watersheds, and the relative importance of Forest lands to aquatic TE/S/LR species and their habitat (see Charts G-3 and G-4). As outlined by Kershner (1997), this characterization step is followed by the identification of current conditions related to issues and current plan management (Section 2.5), and finally, development of recommended goals and guidelines to maintain the key factors of ecological integrity (Section 2.6).

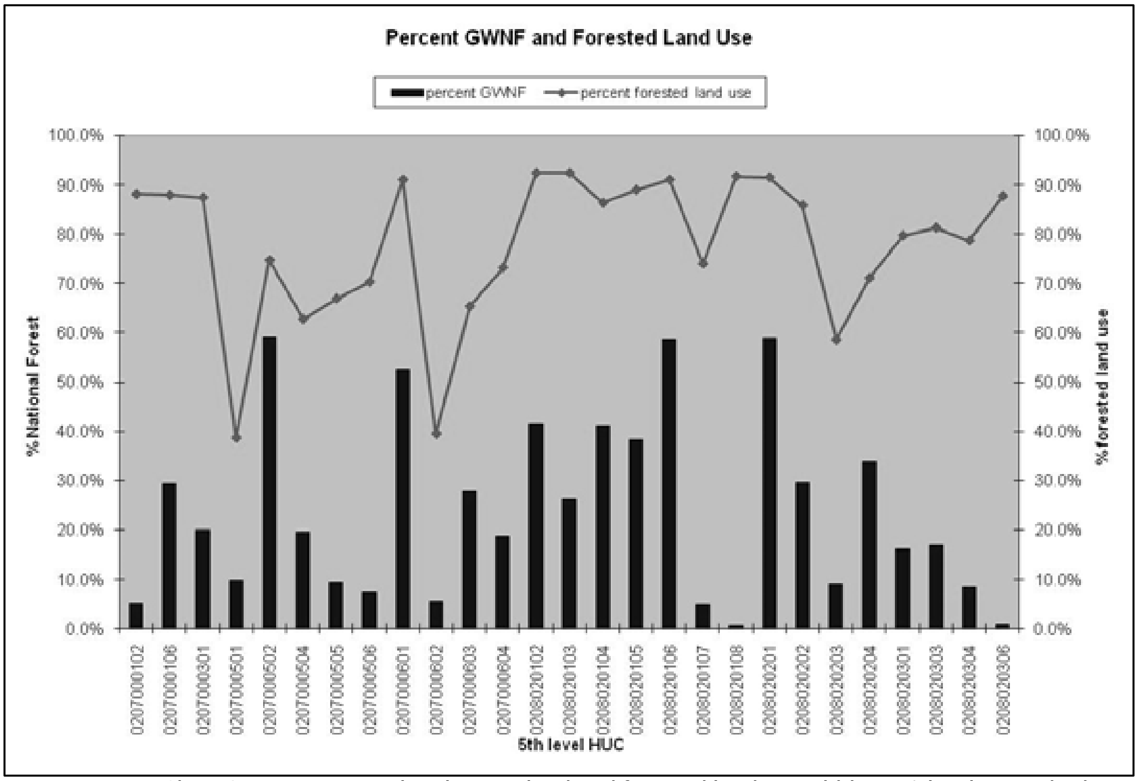

Chart G-1. Percent National Forest land and forested land use within a 5th level watershed

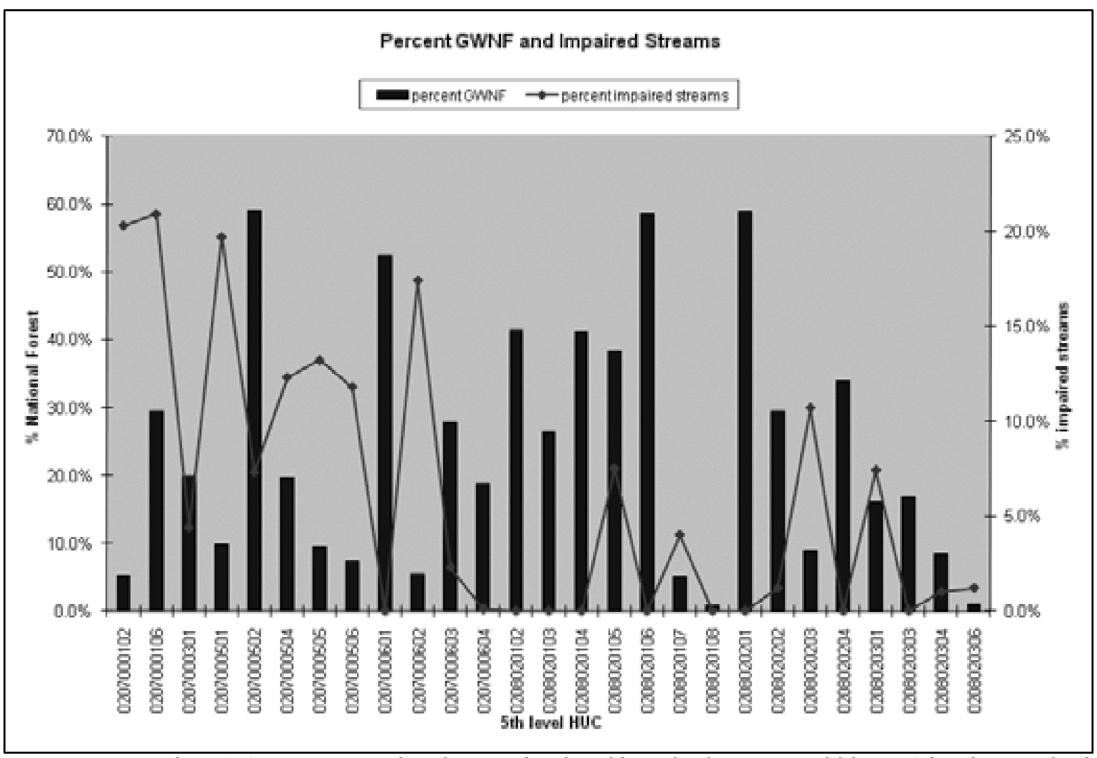

Chart G-2. Percent National Forest land and impaired streams within a 5th level watershed

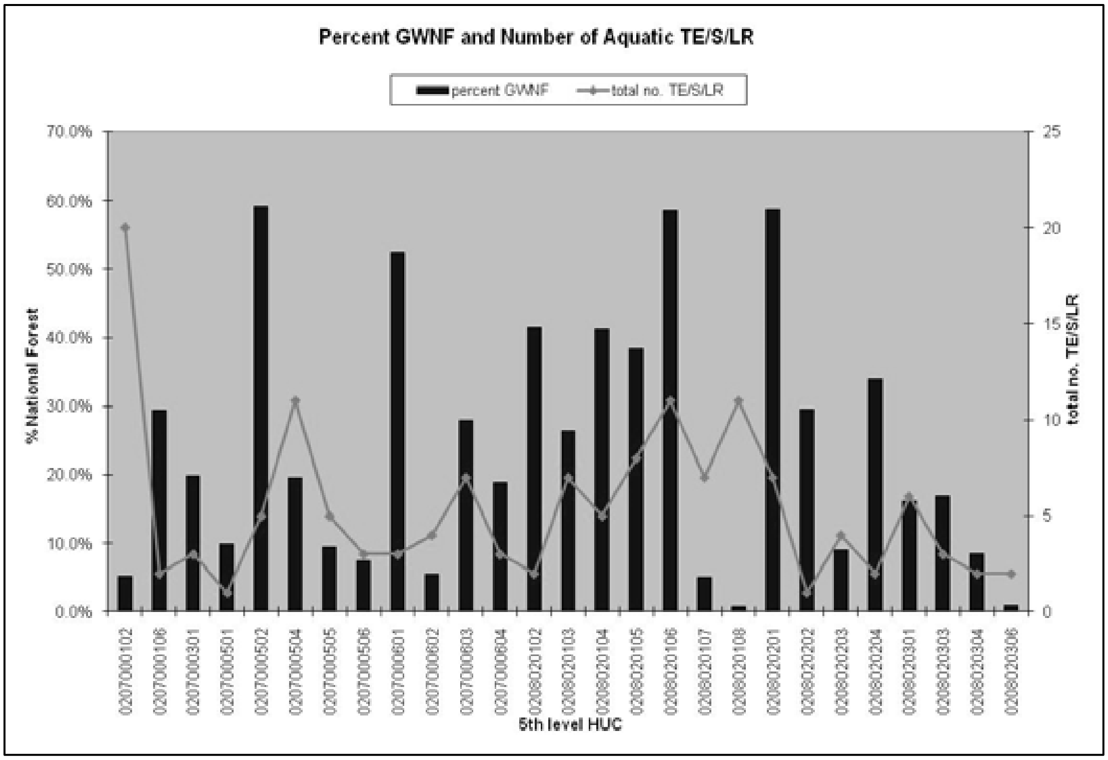

Chart G-3. Percent National Forest land and total number of aquatic TE/S/LR species within a 5th level watershed

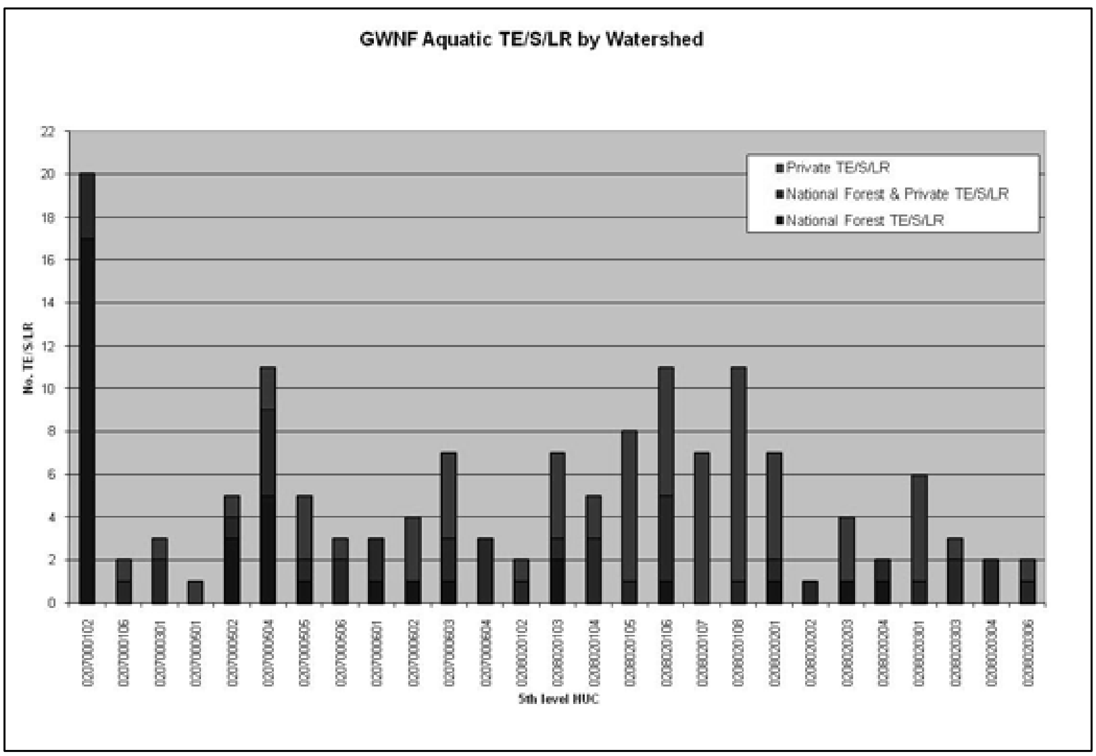

Chart G-4. Number of Aquatic TE/S/LR species on National Forest, National Forest and Private land, and Private land within a 5th level watershed

2.5 Current Condition and Trend of Ecosystem Characteristics and Status of Ecosystem Diversity

Physical Integrity

Riparian Areas

Stable and complex vegetation community

Current Condition: The 1993 Forest Plan allows up to 20% basal area removal of trees along perennial non-native trout streams and 50% basal area removal along intermittent streams. There is no regulation of vegetation management along ephemeral streams. One timber sale was designed to specifically address the issue of removing non-native pine plantations along the North River. Otherwise, no projects were known to have removed any vegetation within riparian areas of the GWNF.

See discussion under *invasive species*, about the hemlock woolly adelgid and riparian vegetation.

Trend: Riparian vegetation across most of the Forest is undisturbed and growing older, except in areas where hemlock woolly adelgid and gypsy moth have caused mortality, and in developed or dispersed recreation areas.

Dispersed Recreation opportunities and impacts

Current Condition: Projects that were done to improve riparian conditions included closing or moving roads and trails, improving stream crossings, and planting a forested riparian buffer. This is not an all-inclusive list, and it is recognized that many more projects have occurred to improve watershed conditions. It is also recognized that many more dispersed recreation opportunities and problems exist across the Forest, and have yet to be addressed.

Trend: Mitigation of recreation impacts to riparian areas is an on-going process; as some areas are rehabilitated; other user-created areas are degraded.

Instream Habitat

Large Woody Debris (LWD) and instream habitat surveys

Current Condition: Forest personnel surveyed stream habitat to measure desired future condition (DFC) parameters identified in the 1993 Revised GWNF Forest Plan. Surveys were conducted on portions of the Pedlar Ranger District in 1995 and 2005, Lee District in 2001, Dry River District in 2002, 2003, 2004 and 2005, and the Warm Springs in 2005. Overall, 631 km (392 miles) of streams were surveyed using a modified Basinwide Visual Estimation Technique (BVET [Dolloff et al. 1993]) to estimate woody debris loading, percentage of pool and riffle area, and the width of the riparian area of streams. The distribution of woody debris was also mapped. See Table G-4 for a summary of LWD and % pool area.

Table G-4. Miles of Stream Habitat Surveyed In 1995-2005
George Washington National Forest

Year Surveyed	# of Stream Miles Surveyed	% of Streams Below Minimum Pool Area DFC	% of Streams Below Minimum LWD DFC
1995	113	48	44
2001	75	75	35
2002	57	62	33
2003	55	70	19
2004	35	71	78
2005	57	96	83

A comparison of individual streams surveyed in 1995 and again in 2005 on the Pedlar District showed a decrease in the median number of pools, number of riffles, and total LWD per km, while the median pool and riffle surface area increased. This report suggests that in 1995 only 25% of streams met the DFC for stream area in pools and less than half of streams met the DFC for total LWD. By 2005 no streams met the DFC for pool area and 75% of streams did not meet the DFC for total LWD. The changes in pool/riffle ratio, number of pools and riffles per km, and pool and riffle surface area are all consistent with decrease in total LWD. The largest decrease of LWD was in the smallest size class. These pieces most often form pool habitat by combining with other small woody debris to form debris jams. In general the smallest size classes are the most easily dislodged and transported downstream or out of the active stream channel during high flows (Hilderbrand et al. 1998; Montgomery et al. 2003). Loss of debris accumulations from long riffle areas following flood events could result in the changes in stream habitat observed. The median amount of the largest size classes of LWD either remained the same or increased in the reaches between 1995 and 2005.

Following Plan approval, across all Ranger Districts, large woody debris was deliberately added to many streams that did not meet the DFC. In addition, efforts were made in the North River to return a highly modified stream channel to a more natural condition. Past hydrological modifications of the North River include bank armoring with rock gabions and channelization to protect the road from frequent floods. These modifications resulted in a wide, shallow channel that lacks fisheries habitat complexity. Under a recent project, rock veins and weirs, and other structures made of natural materials were placed in the stream channel to consolidate streamflow and increase sinuosity. Non-functional rock gabions blocking the natural floodplain were removed.

Trend: Management actions such as adding large woody debris and other types of in-stream structures moved particular streams toward meeting the DFC. However, the vast majority of the Forest's streams received no direct management action. Although comparisons of 1995 and 2005 stream surveys showed a decrease in streams meeting the desired future conditions for pool/riffle ratio and total LWD, the median amount of the largest size classes of LWD either remained the same or increased during that time period. The largest size classes (size 3: > 5 m long, 10-50 cm diameter; size 4: >5 m long, >50 cm diameter) are most stable and can easily have residence times of greater than 10 years in Appalachian streams with relatively little movement (Andy Dolloff, unpublished data). Continued supply of these size classes to the stream may result in increases in total pool habitat in the future.

Such differences highlight the fact that LWD dynamics are governed by a wide array of chronic and acute events, both natural and anthropogenic, including flooding, fires, stand maturation, riparian composition, and timber harvest (Dolloff and Warren 2003; Benda et al. 2003). For example, insect infestations such as gypsy moth or hemlock woolly adelgid can result in the relatively rapid death of many trees. Smaller size classes of LWD are added to the stream as dead trees standing in the riparian area begin to shed branches, and larger size classes are added as these trees continue to decompose and eventually fall across the stream channel. Natural additions of LWD can come through slow attrition or in large pulses if stands are impacted by events such as hurricanes. It is expected that streams will move toward the DFC through natural process if riparian forests are allowed to mature and more trees are left in the vicinity for recruitment of future LWD (Benda et al. 2003; Boyer and Berg 2003; Dolloff and Warren 2003; Morris et al. 2007; Reich et al. 2003).

Lake and Wetland Habitat

Current Condition: National Forest lakes and reservoirs have been managed to support balanced, productive self-sustaining recreational fisheries, in addition to other water-based recreation (swimming and boating). Fisheries Management was practiced in cooperation with State agencies to provide fishing opportunities to the public. Management practices included angler access improvement, liming and fertilization, aquatic weed control, fish habitat improvement, and fish stocking.

Wetlands and natural ponds have been managed to support self-sustaining populations of native species associated with permanent pond, wetland, and vernal pool habitat. The benefit of fishless ponds and vernal pools to many amphibians and insects is recognized and stocking fish has been discouraged. In several cases, fish have been removed from these ponds.

Trend: Many of the reservoirs on the Forest were built in the 1950s for flood control or water supply. They are becoming increasingly filled with sediment, and many are in need of dredging. Wetlands and natural ponds are protected on the Forest, and beaver ponds and meadows are increasing in number with the expanding beaver population in Virginia (Feis 2009).

Thermal Regime

Current Condition: Water temperatures have not been systematically tracked across the Forest. The Virginia Department of Environmental Quality has listed six streams in the 2008 303d report as being impaired for temperature within the GW proclamation boundary. In addition, Switzer Lake was listed as impaired for temperature. These impairments are attributed to natural conditions, drought-related impacts, or unknown sources; they are not attributed to any Forest management activities.

Trend: It is expected that with the warming climate over the past several decades and into the future, stream temperatures will likely increase (Flebbe et al. 2006). A multi-agency cooperative project is being planned to look at short and long term temperature changes in headwater streams throughout western Virginia. Protecting and restoring riparian forests will help moderate these changes. See Section 3.4, temperature change species group for additional discussion.

Chemical Integrity

Dissolved Oxygen

Current Condition: The 2008 303d reports for Virginia and West Virginia list 49 streams that run through the Forest as being impaired, none for DO. The sources of these impairments are off-Forest (acid deposition, fecal coliform, E. coli, agriculture), or are described as “natural.” Of the five reservoirs listed, none are impaired for DO. Their impairments are pH and temperature.

Trend: Two streams and two reservoirs that are within the National Forest have been removed from the impaired waters list since the 2006 report.

pH and Alkalinity

Current Condition: Water quality has been systematically monitored on Forest streams since 1987. As expected, the general water quality of any given stream is strongly tied to the underlying geology coupled with prevailing air quality. The collected data has been used to determine trends and changes in stream water composition, and to project the future chemical status of native trout streams. A 1998 report (Bulger et al. 1998) found that of the study streams in non-limestone geology, 50 percent are “non-acidic.” An estimated 20 percent are extremely sensitive to further acidification; another 24 percent experience regular episodic acidification at levels harmful to brook trout and other aquatic species. The remaining 6 percent of streams are “chronically acidic” and cannot host populations of brook trout or any other fish species.

Atmospheric deposition is listed as the cause of impairment for 21 of the 49 impaired streams running through the Forest, and 4 of the 5 reservoirs, in the 2008 303d reports.

Trend: Modeling conducted by the Southern Appalachian Mountain Initiative (SAMI) and reported in their 2002 publication on acid deposition showed that even with the sulfate deposition declining considerably, as new air regulations are implemented, stream recovery will be slow or non-existent over the next 100 years. Chronically acidic streams may improve slightly and be only episodically acidic by 2100, but they will still be marginal for brook trout (see Figure G-3).

Due to the lengthy recovery time anticipated for acidified streams on the Forest, selective liming to improve water chemistry should continue to be considered.

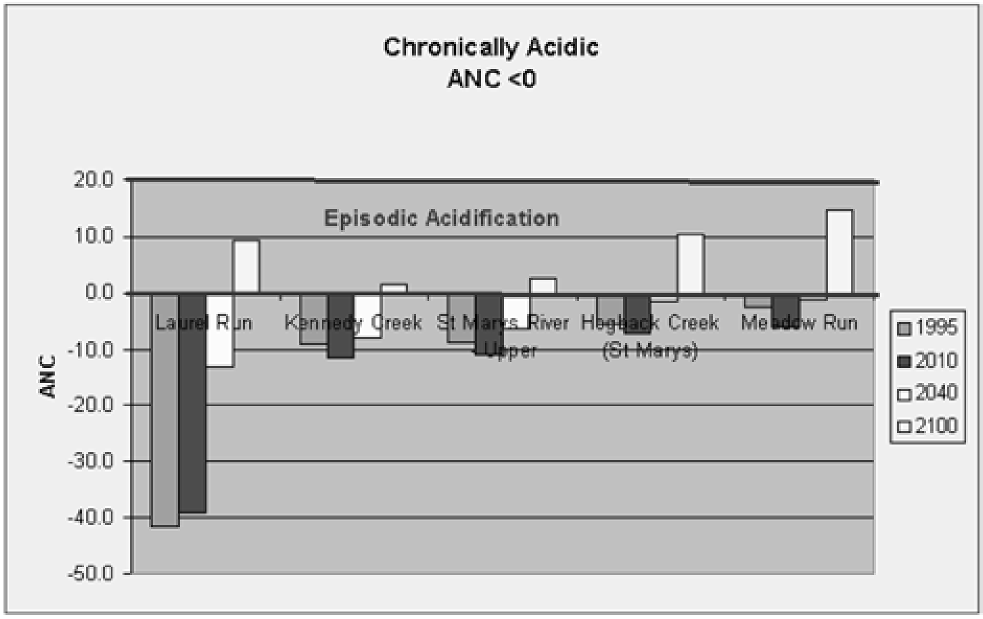

Figure G-3. SAMI Modeling Results for Selected Streams on the GWNF.

The following streams have been limed on the GW Forest since 1989:

Table G-5. Streams Limed on GWNF

Date	Stream	County
1990, 1997	Cedar Creek	Shenandoah
1993, 1994, 1997, 2006	Laurel Run	Shenandoah
1997, 2000, 2003, 2006, 2009	Little Passage Creek	Shenandoah
1989, 1990,1991, 1998, 2001, 2004, 2007, 2010	Little Stony Creek	Shenandoah
1990, 1998, 2001, 2007	Mill Creek	Shenandoah
1993,1997, 1999, 2002, 2005, 2008	Mountain Run	Rockingham
1999	St. Mary's River & 5 tribs	Augusta
2005	St. Mary's River & 6 tribs	Augusta
1995, 1996, 1997, 1998, 1999	Trout Pond Run	Hampshire, WV

Trends in pH for several of the limed streams are shown in Figures G-4 and G-5.

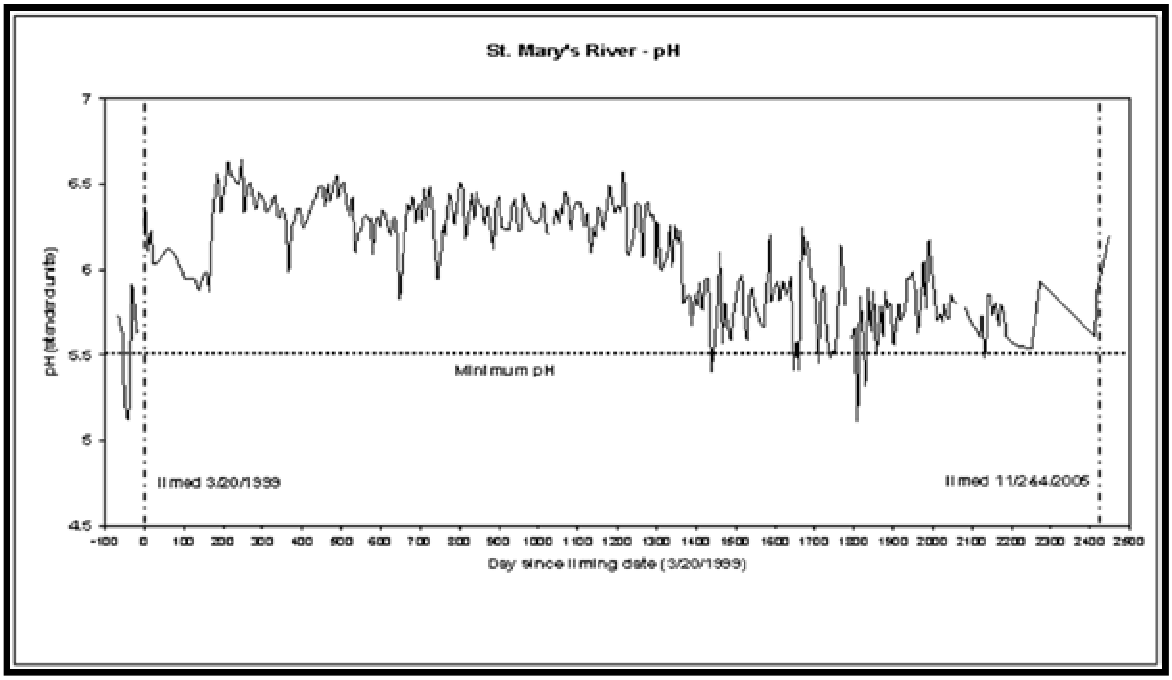

Figure G-4. St. Mary's River pH following liming

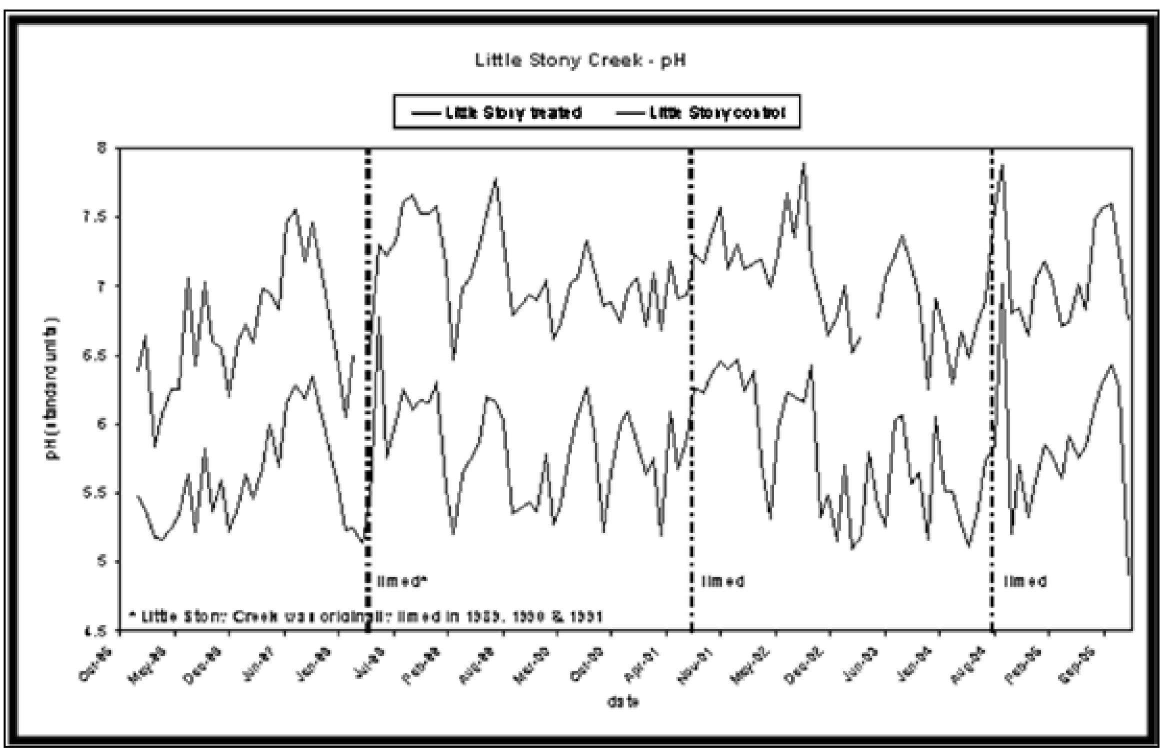

Figure G-5. Little Stony Creek pH following liming

Additional trend information on the effects of acidification and liming is documented in Appendix G, Brook Trout and Wild Trout section, of the annual M&E reports since the 1997-1998 report.

Other Elements

Current Condition: Aluminum is soluble and toxic to aquatic organisms under acidic conditions as described in Section 2.3, and warrants further discussion.

Trend: Aluminum levels were monitored in stream water following a liming treatment at St. Mary's River. Total aluminum concentration levels above 130 g / L are considered hazardous for aquatic life and thus were chosen as the maximum acceptable amount for this study. Figure G-6 below shows the total aluminum concentration for the St. Mary's River in the weekly samples taken at the gauging location (site 1) on the top graph and the quarterly aluminum values taken at the control site (site 11) upstream of the limestone treatment. The graphs show that aluminum was mobilized during high flow periods due to low pH and flushing in the untreated reach of the stream. Episodic short-term spikes in aluminum concentrations as well as the base flow concentrations were less than the target value downstream of limestone treatment. Aluminum concentration at site 1 averaged 39.3 + 16.9 ppb prior to liming and 21.3 + 18.0 ppb since the liming.

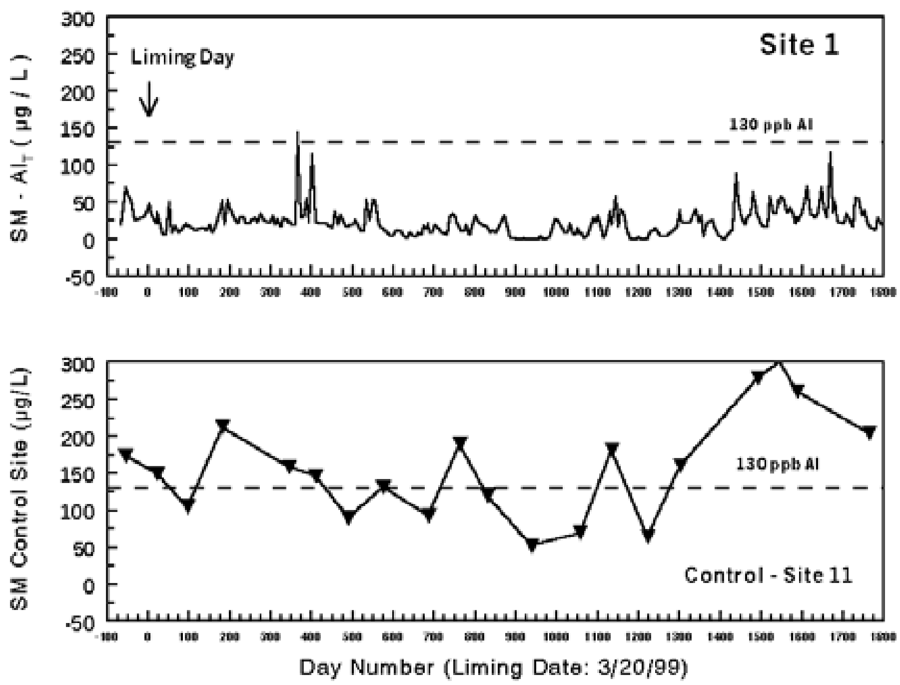

Figure G-6. Total aluminum concentration for the St. Mary's River

Biological Integrity

Species Occurrence

Management Indicator species

Current Condition: The 1993 GWNF included brook trout as a Management Indicator Species (MIS) for cold water stream habitat, the centrarchid family for warmwater/lake habitat, and the James spinymussel as a T&E species. The trends for these aquatic species on the Forest are discussed below. Occurrences of other FS sensitive species or locally rare species are discussed elsewhere in this report.

Trend: *Brook Trout* - As shown in Figure G-7 below, populations of brook trout tend to fluctuate greatly over time. These findings do not necessarily suggest negative impacts to those streams from management activities, but rather that trout numbers are often highly variable due to natural occurrences (drought, floods, high temperatures, etc.). As documented in Appendix G of the annual M&E reports, timber harvesting and other management activities did not significantly decrease habitat or populations of brook trout. Furthermore, some management activities, such as stream liming and habitat restoration, were specifically designed to improve brook trout habitat and increase their populations. Because of ecological and recreational interest in this species, we recommend wild brook trout as a MIS in the revised Forest Plan. Additional discussion of brook trout is in Section 3.4 under Temperature Change Species group.

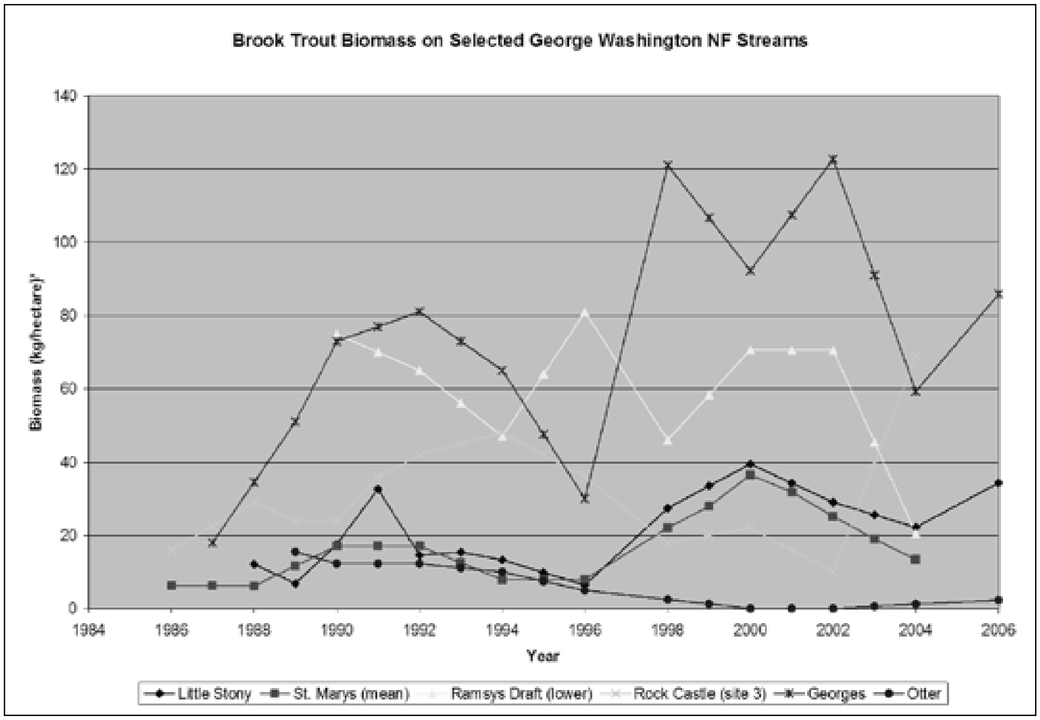

Figure G-7. Brook Trout Biomass on Selected GWNF streams

*Not all streams were surveyed every year. For those years without a survey, an average was added to the data table in order to draw a continuous trend line.

Centrarchid (Sunfish) Family - As documented in Appendix G of the annual M&E reports, Forest Service activities, such as the creation of structures in reservoirs, are beneficial to members of the sunfish family. However, even though the addition and maintenance of underwater structures in Forest reservoirs is necessary for healthy self-sustaining warm water fish populations, these populations are heavily manipulated through fishing regulations and harvest pressure (Noble 2002; Quinn 2002; Spotte 2007; Swennson 2002; Wilson and Dicenzo 2002). Reservoirs are not a natural system, supporting native fish communities. Because of this, we recommend that the Forest continue to work with State agencies to monitor warm water fish and enhance habitat on the Forest land, but not include the sunfish family as a MIS in the revised Forest Plan.

James spinymussel - As documented in Appendix G of the annual M&E reports, several new occurrences of the James spinymussel were located from surveys conducted on streams in Bath County in 2000-2004. The James spinymussel does occur in watersheds that contain NFS land and occurs both upstream and downstream from the Forest. Current Forest management provides for water quantity and quality that contributes to the persistence of mussel populations.

Overall, viability remains a concern for the James spinymussel on the GWNF, yet management has little ability to affect its overall viability. Factors outside the authority of this agency affect the viability of the James spinymussel.

The Forest is currently working with the US Fish and Wildlife Service and VDGIF to locate James spinymussel populations on National Forest and habitat suitable for augmentation. This Federally endangered species should be considered in the revised Plan.

Aquatic Organism Passage (AOP)

Current Condition: Recent National and Regional attention has focused on the issue of aquatic organism passage. Land managers recognized that instream barriers can prevent migration, dispersal, and colonization, leading to genetic isolation and possible extirpation. Specifically, culverts, where roads cross streams, can be barriers to fish or other aquatic organisms (Gibson et al. 2005; Verry 2000).

Forest Service researchers used the 'National Inventory and Assessment Procedure for Identifying Barriers to Aquatic Organism Passage at Road-Stream Crossings' developed by the USFS San Dimas Technology and Development Center to assess road stream crossings on the Forest. On the GWNF, over 500 stream-road crossing surveys were conducted between 2003 and 2006. The majority of crossings (i.e. culverts or low-water fords) were not passable for all fish types (strong, moderate, or weak swimmers and leapers). This inventory can be used to identify barriers to aquatic passage and prioritize them for replacement/repair based on maximum benefit to aquatic organisms or habitat.

Streams where bottomless arch culverts were installed at road crossings to improve aquatic organism passage on the GWNF include:

- Laurel Run and Hunkerson Gap on the Lee District
- Pitts Spring Run and Roaring Run on the Lee District
- Middle River and Slatelick on the North River District
- Mill Creek on the Pedlar District
- Little Irish Creek on the Pedlar District.

Trend: Culverts are being replaced/repaired with designs that allow for AOP where appropriate. Likewise, new road crossings are designed to allow for AOP when it is desirable (does not provide a pathway for invasive species). AOP is increasing across the Forest.

Watershed Health

Benthic macroinvertebrates

Current Condition: Benthic macroinvertebrates are organisms that live in or on the bottom substrates of rivers, streams, or other waterbodies. These organisms are primarily insect larvae, but also include worms, crustaceans and mollusks. The use of macroinvertebrates has proven to be a reliable monitoring tool, as they are sensitive to changes in aquatic habitat and water quality, which in turn reflects the overall health of the watershed. Benthic macroinvertebrates are included as a monitoring item in the current GW Forest Plan, and have been monitored on the GWNF since 1993.

Sample sites were selected downstream of management activity areas to monitor the impacts on stream health of projects including but not limited to timber sales and prescribed burns. Other samples were collected to create a baseline of stream conditions within the forest. Across the Forest, 728 samples were collected, analyzed and assigned an overall MAIS (Macroinvertebrate Aggregated Index for Streams) score. The MAIS incorporates nine metrics to evaluate the current condition of a stream relative to others within the ecological unit. It ranges from 0 to 18. Less than 6 is very poor, between 7 and 12 is poor/fair, between 13 and 16 is good, and between 17 and 18 is very good.

Of these samples, 84% were in the "good" and "very good" categories.

Trend: Trends for aquatic macroinvertebrates have been fully documented in Chapter 2 (Management Area 18) of the annual M&E reports since the 1997-1998 report.

A paired t-test was used to compare the MAIS scores of 18 streams before and after timber harvests that occurred at various locations across the Forest. Only samples collected from March through the first week in June were compared to minimize seasonal variability in structure of macroinvertebrate communities. There was no significant difference between the pre and post timber harvest MAIS scores; both the pre and post mean scores were in the "Good" category (See Table G-6 below).

Table G-6. Paired samples t-test on pre and post MAIS scores from 18 different timber sales

Mean MAIS pre	16
Mean MAIS post	15
95% CI	-0.365 to 2.365
P value	0.140

A paired t-test was used to compare the MAIS scores of 7 streams before and after prescribed burn that occurred at various locations across the Forest. There was no significant difference between the pre and post prescribed burn MAIS scores; both the pre and post mean scores were in the "Good" category (see Table G-7 below).

Table G-7. Paired samples t-test on pre and post MAIS scores from 7 different prescribed burns

Mean MAIS pre	16
Mean MAIS post	16
95% CI	-1.098 to 1.669
P value	0.631

Invasive Species – several examples

Current Condition: *Adelges tsugae* (Hemlock woolly adelgid) - The Hemlock woolly adelgid, is native to Asia and was first introduced to North America in British Columbia in the 1920s and was later discovered in the Shenandoah Mountains of Virginia in the 1950s. Adelgids feed by sucking sap from hemlock twigs and when they reach very high densities they can cause dieback and mortality of their hosts. In the eastern US, the adelgid's principal host is eastern hemlock, *Tsuga Canadensis*, a tree typically associated with streams and riparian areas. Heavy infestations have killed trees in as little as four years, but some trees have survived infestations for more than 10 years.

Currently, hemlock woolly adelgid has only invaded part of the range of eastern hemlock in the United States and Canada. On average, the insect has spread about 15-20 miles per year. Wind, birds, animals, and accidental movement by people cause this rapid spread. In Asia, the insect is found in very cold climates. Thus, it is likely to colonize most or all of the range of the eastern hemlock species. Eastern hemlocks contribute to stream habitat by providing dense shade in the summer and thermal control in the winter. The wood of the hemlock decays relatively slowly and can contribute long-lasting LWD and to the stream's overall stability.

Forest inventories list 1,092 acres of hemlock stands on the GWNF. Another 5,584 acres are listed as hemlock-hardwood, meaning that they are greater than 70% hemlock. The GWNF sprays individual trees or injects the soil with a systemic insecticide within recreation areas to protect them from the adelgid. At this time it is not economically or technically feasible to treat large stands of hemlock within the forest.

Trend: It is expected that there will be a large increase in LWD to streams with hemlocks in their riparian corridor. In addition, for those streams with a significant portion of the riparian forest in hemlock, summer temperatures may increase with the loss of streamside shading.

Current Condition: *Didymosphenia geminata* (Didymo) – Didymo is a freshwater diatom (type of alga) that historically was only found in pristine lakes and streams of northern latitudes. Its range is now expanding

in North America to include lower elevation clear, cool streams. It can form massive blooms on the bottoms of streams and rivers where it attaches itself to the streambed by stalks. These stalks can form a thick brown mat that smothers rocks, submerged plants and other materials. Established mats form flowing streamers that can turn white at their ends and look similar to tissue paper. Although the alga appears slimy, it feels like wet cotton wool. Didymo was found in the Jackson River and Smith River tailwaters in Virginia in spring of 2006, the Pound River tailwater in 2007, and Dan River in 2008. Information sheets were posted at Forest Service angler access points along the Jackson River to inform anglers and instruct them on how to prevent the spread of this invasive species. The Smith and Dan Rivers are not on or near National Forest land.

Trend: Didymo colonization was monitored monthly over a 12 month period at a single transect in the Jackson River downstream of Gathright Dam to observe its growth over time. In 2008, didymo density steadily increased from February – April, peaked in May - June, then rapidly declined in the period from July – October. Transect scores were plotted against discharge, water temperature, and depth to evaluate relationships between alga density and non-biological factors. Positive, but weak, relationships were determined with all three criteria, but the strongest was between transect score and discharge. Biological response to didymo infestation was also examined by electrofishing and benthic macroinvertebrate monitoring before and after 2006. Post-infestation catch rates for wild rainbow trout (*Onchorhynchus mykiss*) in the Gathright Dam area were not significantly different than historic values (t0.05, 5 = 0.949). Stream metrics calculated for macroinvertebrates from the Gathright Dam area in 2007-08 showed a decline in ecological health from 1992-93 samples. Results from this preliminary investigation indicated that didymo infestation has had a variable impact on aquatic fauna in one reach of the Jackson River Tailwater.

2.6 Plan Components for Ecosystem Diversity

The 1993 GWNF Plan went a long way in providing sound direction for managing aquatic resources. Aquatic and riparian Desired Future Conditions (DFCs) were allocated to riparian ecosystems associated with ponds, lakes, and perennial streams. These areas were managed to restore, maintain, and/or enhance the inherent ecological processes and functions of the associated aquatic and riparian communities as described by the DFC for Management Area 18. Management did focus on providing habitat for species that depend on riparian resources for at least a part of their life-cycle. Yet, some more can be done. The GWNF Plan revision effort should recognize and address the following:

1. Recognize riparian values other than, and in addition to, aquatic resources and buffering streams from other management practices;
2. Recognize the important role of intermittent and channeled ephemeral headwater streams in maintaining water quality and quantity, recycling nutrients, and providing habitat for plants and animals. It is appropriate to provide management direction for the areas around not only perennial stream channels, but also intermittent and channeled ephemeral streams;
3. The Forest also developed a Federally Listed Mussel and Fish Conservation Plan cooperatively with the USFWS and state partners. The intent was to provide pro-active and consistent management direction for watersheds that contained T&E fish and mussels. The USFWS Federally Listed Mussel and Fish Conservation Plan needs to be incorporated into the revised plan as guidelines for site-specific projects;
4. Address a new issue over aquatic organism passage; and
5. Address whether grazing should continue within riparian areas as a suitable use.

Aquatic and riparian Desired Future Conditions (DFCs) should be allocated to all riparian areas across the George Washington National Forest. Riparian corridors should be managed to restore, maintain, and/or enhance the inherent ecological processes and functions of the associated aquatic and riparian communities as described by the DFC. Management should focus on providing habitat for species that depend on riparian resources for at least a part of their life-cycle. The following Plan Components should be carried forward from the 1993 Plan or developed to address either a Key Factor in maintaining Aquatic Ecological integrity, or a disturbance process. These plan components were developed from previous Forest Plans, state Best

Management Practices, and current research. They are building on the approach that was used in the 1993 Plan, an approach that was successful in maintaining aquatic integrity as documented by the monitoring and evaluation reports.

PHYSICAL INTEGRITY

Goal 1 Watershed

Manage watersheds to maintain or restore resilient and stable conditions to support the quality and quantity of water necessary to protect ecological functions and support beneficial water uses. Channeled ephemeral streams maintain the ability of the land to filter sediment from upslope disturbances and to provide forest material as nutrient input while achieving the Desired Conditions of the adjacent management prescription area. (Corresponding standards: 002, 007, 008, 013, 014, 015, 016, 019, 020, 021, 022, 029, 030, 031)

Goal 2 Sediment Regime

Restore and maintain the sediment regime under which the aquatic system evolved. Sediment regime elements include the timing, volume, rate, and character of sediment input, storage, and transport. Maintain sedimentation rates that are in dynamic equilibrium with the watershed, and stabilize or improve the biological condition of the stream. (Corresponding standards: 001, 002, 005, 006, 012, 013, 014, 015, 017, 018, 019, 020, 021, 022, 023, 024, 025, 026, 028, 029, 030, 031, 032, 033, 034, 035, 036, 037, 038, 043)

Objective: Streams are managed in a manner that results in sedimentation rates that stabilize or improve the biological condition category of the stream as monitored using aquatic macroinvertebrates.

Goal 3 Instream Flow

Instream flows (or lake levels) provide the amounts necessary to: 1) maintain the capacity of the channels to transport water and sediment; 2) protect aquatic organisms and provide habitat for all life history stages and migration; 3) transport nutrients; and 4) sustain or restore riparian habitats and communities. (Corresponding standards: 008, 023, 024, 025, 027, 042)

Goal 4 Connectivity

Maintain and restore spatial and temporal connectivity within and among stream segments and watersheds. Maintain physically unobstructed routes to areas that fulfill critical life history requirements of aquatic and riparian-dependent species; and prevent further human caused fragmentation of aquatic habitats. (Corresponding standards: 023, 027, 043, 044)

Goal 5 Riparian - Aquatics

Restore and maintain native species composition and the structural diversity of plant communities in riparian zones and wetlands to provide adequate thermal regulation, nutrient filtering, appropriate rate of surface and bank erosion, and sufficient amount and distributions of large wood to sustain physical habitat complexity and stability. Riparian areas will contain a minimum amount of exposed mineral Soil and effective mitigation measures will be taken where surface disturbances or modifications concentrate runoff, accelerate soil erosion, or transport sediment to stream channels. Management will focus on restoring and/or maintaining riparian-dependent plant and animal species. (Corresponding standards: 003, 004, 009, 010, 011, 043)

Objective: Streamsides are managed in a manner that restores and maintains amounts of large woody debris (LWD) sufficient to maintain habitat diversity for aquatic and riparian species (approximately 200 pieces per stream mile).

Goal 6 Riparian - Terrestrial

Restore and maintain taxonomically diverse vegetation (both living and dead) with both horizontal and vertical structural diversity consisting of distinct vegetation layers from the water surface to the canopy top. Riparian diversity can be enhanced by habitat differences along the length of the ecosystem. Rehabilitation of past and future impacts (both natural and human-caused) may be necessary to protect resource value and facilitate recovery of riparian structure and functions. geomorphic and Soil bioengineering, vegetation management, and other rehabilitation techniques should follow ecological principals and emphasize recovery of the diversity and complexity of native vegetative communities. (Corresponding standards: 005, 009, 010, 011)

CHEMICAL INTEGRITY

Goal 7 Water Quality

Maintain or exceed State water quality standards for aquatic biodiversity and beneficial downstream uses. Maintain and restore water quality necessary to support healthy riparian, aquatic and wetland ecosystems. (Corresponding standards: 018, 035, 039, 040, 045, 046, 047, 048)

Objective: Streams are managed in a manner that ensures water quality remains in the range that ensures survival, growth, reproduction, and migration of individual aquatic and riparian-dependent species and individual organisms.

BIOLOGICAL INTEGRITY

Goal 8 Aquatic Biodiversity

Manage aquatic habitats to maintain or restore native aquatic biodiversity. Streams and other aquatic habitats should foster the species composition, diversity, and functional organization that is common and comparable to natural habitat. Exceptions can be made for desired, non-native sport fish species, especially in modified habitats such as reservoirs. (Corresponding standards: 041, 043, 044, 045, 046, 047, 048)

STANDARDS (The Goals that are addressed by that guideline are listed in parentheses at the end.) The Plan should adopt the Jefferson Forest Plan Riparian Corridor and Forestwide Channeled Ephemeral standards (consistent with the Federally Listed Mussel and Fish Conservation Plan).

001 Any human caused disturbances or modifications that may concentrate runoff, erode the soil, or transport sediment to the channel or water body are rehabilitated or mitigated to reduce or eliminate impacts. Channel stability of streams is protected during management activities. (Goal 2)

002 Motorized vehicles are restricted to designated crossings. Motorized vehicles may be allowed on a case-by-case basis, after site-specific analysis, outside of designated crossings where it can be shown to benefit riparian resources. (Goal 1, Goal 2)

003 The removal of large woody debris (pieces greater than 4 feet long and 4 inches in diameter on the small end) is allowed if it poses a risk to water quality, degrades habitat for aquatic or riparian wildlife species, impedes water recreation (e.g. rafting) or when it poses a threat to private property or Forest Service infrastructure (e.g., bridges). The need for removal must be determined on a case-by-case basis. (Goal 5)

004 The addition of large woody debris for stream habitat diversity will generally favor stream reaches with an average bank full width of less than 30 feet in Rosgen B channel types. Log length will generally be 50% greater than bank full width. In stream reaches where there may be potential debris impacts to downstream private or public infrastructure (e.g., bridges) or to water-based recreation (e.g. rafting), the active recruitment (placement) of large woody debris will be limited in quantity and scope. (Goal 5)

005 Existing permanent wildlife openings may be maintained within the riparian corridor. However, permanent wildlife openings identified as causing environmental degradation through concentrated runoff, Soil erosion, sediment transport to the channel or water body are mitigated or closed and restored. New permanent wildlife openings within the riparian corridor are permitted where needed to provide habitat for riparian species, or threatened, endangered, sensitive, and locally rare species. (Goal 2, Goal 6)

006 Use no-till mechanical cultivation methods for maintenance of wildlife openings. (Goal 2)

007 Management actions that may negatively alter the hydrologic conditions of wetland rare communities are prohibited. Such actions may include livestock grazing and construction of roads, plowed or bladed firelines, and impoundments in or near these communities. (Goal 1)

008 Allow beaver pond complexes to develop naturally where not impacting developed recreation sites or open system roads. (Goal 1, Goal 3)

009 Insect and disease control measures will be determined on the basis of risk to adjacent resources, long-term sustainability, and appropriate needs for the function and condition of the riparian area. Cut and leave is the preferred method for control and suppression of insects and disease in the core of the riparian corridor. Cut and remove is permitted in the extended area beyond the core. Other control measures may be used when a condition poses a risk to stream stability, degrades water quality, adversely affects habitat for aquatic or riparian species, poses a threat to public safety or facilities, or when “cut and leave” is not effective. (Goal 5, Goal 6)

010 Tree removals from the core of the riparian corridor may only take place if needed to:

- Enhance the recovery of the diversity and complexity of vegetation native to the site;
- Rehabilitate both natural and human-caused disturbances;
- Provide habitat improvements for aquatic or riparian species, or threatened, endangered, sensitive, and locally rare species;
- Reduce fuel buildup;
- Provide for public safety;
- For approved facility construction/renovation (Goal 5, Goal 6)

011 Permitted firewood cutting within the riparian corridor must take into consideration large woody debris needs. Ranger Districts will identify areas where firewood cutting is not permitted due to large woody debris concerns. (Goal 5, Goal 6)

012 Construction of firelines with heavy mechanized equipment (e.g. bulldozers) in riparian corridors is prohibited. Hand lines, wet lines, or black lines are used to create firelines within the riparian corridor to minimize Soil disturbance. Water diversions are used to keep sediment out of streams. Firelines are not constructed in stream channels, but streams may be used as firelines. (Goal 2)

013 New trails will normally be located outside of the riparian corridor except at designated crossings or where the trail location requires some encroachment (e.g. to accommodate stream crossings in steep terrain, etc.), or to manage access to water bodies. (Goal 1, Goal 2)

014 New motorized trails are prohibited within the riparian corridor except at designated crossings or where the trail location requires some encroachment; for example, to accommodate steep terrain. When existing OHV trails within riparian corridor are causing unacceptable resource damage, appropriate mitigation measures (which may include OHV trail closure) will be implemented. (Goal 1, Goal 2)

015 Proposed recreation facilities will be located outside of the riparian corridor or 100-year floodplain (Executive Order 11988) and wetlands (Executive Order 11990) unless no practicable alternative location exists. Where future facilities cannot be located out of the 100-year floodplain, structural mitigation and best management practices will be used. Trails, campsites, and other recreational developments are located, constructed, and maintained to minimize impacts to channel banks and other resources. When existing facilities are causing unacceptable resource damage appropriate mitigation measures will be implemented. Soils are stabilized on eroding trails and recreational sites. (Goal 1, Goal 2)

016 Where grazing is currently allowed and under a permit, grazing is controlled and mitigated to restore, maintain or enhance the integrity of stream channels and banks and prevent unacceptable resource damage. Reauthorizing grazing in riparian corridors within these existing allotments may occur if continued grazing would have no unacceptable resource damage on riparian resources. New grazing allotments or new permits for inactive allotments will exclude the riparian corridor. (Goal 1)

017 Where authorized by permit, livestock watering areas, stream crossings, and stream banks are managed to maintain bank stability. Designated entry points, crossings, and watering points are located, sized, and maintained to minimize the impact to riparian vegetation and function. (Goal 2)

018 Feeding troughs and salt and mineral blocks are not allowed inside the riparian corridor unless the entire pasture is within the riparian corridor, in which case they are located as far away from streams as possible. Watering troughs are appropriately located to protect the streams. (Goal 2, Goal 7)

019 New roads are located outside the riparian corridor except at designated crossings or where the road location requires some encroachment; for example to accommodate steep terrain, or are allowed within the corridor if the road will cause more resource damage if it were located outside the corridor. When existing roads within riparian corridor are causing unacceptable resource damage, appropriate mitigation measures will be implemented. (Goal 1, Goal 2)

020 In-stream use of heavy equipment or other in-stream disturbance activities is limited to the amount of time necessary for completion of the project. Construction of crossings is completed on all streams as soon as possible after work has started on the crossing. Permanent and temporary roads on either side of stream crossings within the riparian corridor are graveled. (Goal 1, Goal 2)

021 When constructing roads, each road segment will be stabilized prior to starting another segment. Stream crossings will be stabilized before road construction proceeds beyond the crossing. (Goal 1, Goal 2)

022 To minimize the length of streamside disturbance, ensure that approach sections are aligned with the stream channel at as near a right angle as possible. Locate riparian corridor crossings to minimize the amount of fill material needed and minimize channel impacts. Generally, permanent structures or temporary bridges on permanent abutments are provided when developing new crossings on perennial streams. Permanent structures, temporary bridges or hardened fords are used when crossing intermittent streams. (Goal 1, Goal 2)

023 Design structures (culverts, bridges, etc.) to accommodate storm flows expected to occur while the structures will be in place. Use scientifically accepted methods for calculating expected storm flows. (Goal 2, Goal 3, Goal 4)

024 Design crossings so stream flow does not pond above the structure during normal flows in order to reduce sediment deposition immediately above the crossing and maintain the channel's ability to safely pass high flows. (Goal 2, Goal 3)

025 Design the crossing so that stream flow will not be diverted along the road if the structure fails, plugs with debris, or is over-topped. (Goal 2, Goal 3)

026 Fords associated with new road construction are not used in perennial streams without site-specific environmental analysis. Establish fords only under conditions that will not cause significant streambank erosion. Erosion stone or larger rock is used to increase load bearing strength at the water/land interface. (Goal 2)

027 Riparian corridors are generally unsuitable for new human created stream channel impoundments, but may be considered on a project specific basis, consistent with appropriate Federal and state regulations. Impoundments will generally be designed to allow complete draining, with minimum flows, cold-water releases, and re-aeration in trout waters and other specific waters when needed. Downstream catch basins and fish ladders are constructed for fish salvage/passage, if necessary. New human-constructed impoundments are unsuitable on streams where federally listed species will be negatively affected. (Goal 3, Goal 4)

028 For activities not already covered in the above standards, ground disturbing activities are allowed within the corridor if the activity will cause more resource damage if it were located outside the corridor, on a case-by-case basis following site-specific analysis. Any activity allowed under these conditions is minimized and effective sediment trapping structures such as silt fences, brush barriers, hay bale barriers, gravelling, etc., are required. Sediment control, prior to, or simultaneous with, the ground disturbing activities, is provided. (Goal 2)

029 Within the channeled ephemeral zone, up to 50% of the basal area may be removed down to a minimum basal area of 50 square feet per acre. Removal of additional basal area is allowed on a case-by-case basis when needed to benefit riparian-dependent resources. (Goal 1, Goal 2)

030 At least partial suspension is required when yarding logs over channeled ephemeral streams. (Goal 1, Goal 2)

031 The addition of large woody debris in channeled ephemeral reaches will primarily be through passive recruitment rather than active placement. (Goal 1, Goal 2)

032 When crossing channeled ephemeral streams, culverts, temporary bridges, hardened fords, or corduroy are used where needed to protect channel or bank stability. (Goal 2)

033 New motorized trails are prohibited within the channeled ephemeral zone except at designated crossings or where the trail location requires some encroachment; for example, to accommodate steep terrain. (Goal 2)

034 Where grazing is currently allowed and under a permit, control and mitigate to restore, enhance, or maintain the integrity of channels and banks. Grazing permit reauthorization is allowed, provided progress towards mitigation of negative impacts on the channeled ephemeral zones has occurred. New grazing permits will be designed to prevent negative impacts to the channeled ephemeral zone. Livestock will be excluded from channeled ephemeral zones whenever the zone cannot be maintained or restored otherwise. (Goal 2)

035 Feeding troughs, watering troughs, and salt and mineral blocks are not allowed inside the channeled ephemeral zone. Watering troughs are appropriately located to protect the streams. (Goal 2, Goal 7)

036 During prescribed fire operations in the channeled ephemeral zone, use the least ground disturbing method of fireline construction, favor blacklines and handtools. (Goal 2)

037 Do not disk, blade, or plow fireline within the ephemeral stream channels, use them as natural firebreaks (This applies to the actual stream channel, not the entire 25 foot zone). (Goal 2)

038 Revegetate and water bar firelines as quickly as possible, where necessary to prevent erosion. Use water diversions to keep sediment out of channels. (Goal 2)

039 Restoration of chemical integrity of aquatic ecosystems (from impacts such as acid deposition and acid mine drainage) is allowed on a site-specific basis for protection or for restoration of aquatic species. (Goal 7)

040 Fire retardants should not be applied directly over open water. (Goal 7)

041 Stocking of new non-native species and stocking of previously unstocked areas is not allowed where it will negatively impact native aquatic species or communities. Prior to any stocking, national forests coordinate with the appropriate State and Federal agencies to ensure that populations and habitats of native species are maintained. (Goal 8)

042 Instances where the flow regime is modified for other purposes (such as reservoir releases for recreational sports or hydroelectric demand), evaluate instream flow needs in accordance with the national strategy for water rights and instream flows. (Goal 3)

043 In-stream habitat improvements and stream-connected disturbance will be designed and implemented after consideration of the life-cycle requirements of aquatic species. (Goal 2, Goal 4, Goal 5, Goal 8)

044 All new stream crossings will be constructed to allow the passage of aquatic organisms, and maintain natural flow regime. Exceptions may be allowed in order to prevent the upstream migration of undesired species. (Goal 4, Goal 8)

045 Insecticides known to have adverse impact on aquatic ecosystems are not applied within 200 feet of perennial or intermittent streams, or open bodies of water. (Goal 7, Goal 8)

046 No herbicide is broadcast on rock outcrops or sinkholes. No Soil-active herbicide with a half-life longer than 3 months is broadcast on slopes over 45 percent, erodible Soils, or aquifer recharge zones. Such areas are clearly marked before treatment so applicators can easily see and avoid them. (Goal 7, Goal 8)

047 No herbicide is aerially applied within 200 horizontal feet, nor ground-applied within 30 horizontal feet of lake, wetlands, perennial or intermittent springs and streams. No herbicide is applied within 100 horizontal feet of any public or domestic water source. Selective treatments (which require added site-specific analysis and use of aquatic-labeled pesticides may occur within these buffers only to prevent significant environmental damage such as noxious week infestations. Buffers are clearly marked before treatment, so applicators can easily see and avoid them. (Goal 7, Goal 8)

048 Pesticide mixing, loading, or cleaning areas in the field are not located within 200 feet of open water or wells, or other sensitive areas. (Goal 7, Goal 8)

3. SPECIES DIVERSITY

3.1 Ecosystem Context for Species

The second purpose of this sustainability analysis was to provide a dataset that can be used to describe species-habitat associations for specific federally listed species, other locally rare species, and species of management concern. All aquatic species are contained in the habitats described above, and the Forest Plan components are to be designed to maintain the key characteristics that are necessary to sustain aquatic habitat.

A determination was made regarding how much of a particular habitat is on the GWNF, and whether or not it currently supports the associated species. This level of classification does not capture finer scale habitat attributes (i.e. pool/riffle composition depth, specific substrate composition, etc.) that may be important to refine the predictive habitat maps. However, it is useful in determining general patterns in species distributions, and may indicate areas to survey for a species, or areas in which to promote habitat restoration and private land conservation measures. In addition, since each species is associated with a particular habitat, the Forest Plan components designed to maintain key characteristics of that particular habitat can be tracked. From this documented review, recommendations may be forthcoming to the Forest Supervisor on whether additional aquatic species-specific plan components may be necessary.

3.2 Identification and Screening of Species

Three categories of species were identified for consideration in planning:

- Species that are federally listed as T&E under the Endangered Species Act (ESA).
- Species for which management actions may be necessary to prevent listing under the ESA.
- Species for which management actions may be necessary to achieve ecological or other multiple-use objectives. They may be species for which there are local concerns resulting from declines in habitat, population, and/or distribution, species that are of high public interest, or species such as invasives for which control measures may be desirable.

Only species whose ranges overlap the GWNF proclamation boundary were considered.

A comprehensive list of species of potential viability concern was compiled for the GWNF that include those species found, or potentially found, on the GWNF that are (a) listed as proposed, threatened, or endangered under the federal Endangered Species Act, (b) listed on the regional Forester's Sensitive Species list, (c) identified as locally rare on the National Forest within the ecoregion by Forest Service biologists, or (d) included in either the Virginia or West Virginia Wildlife Action Plans. Each species was assessed according to the criteria below and then placed into the appropriate category, or dropped from further consideration (see Appendix G6 for a list of species dropped from further consideration).

3.2a Federally Listed Species

The Forest worked cooperatively with the U.S. Fish and Wildlife Service to determine the list of threatened or endangered species appropriate to address in this Forest Plan Revision.

There are four aquatic species listed by the Department of Interior, U.S. Fish and Wildlife Service as threatened or endangered that have been documented on GWNF (see Table G-8 for a summary of habitat on the GWNF). A more detailed habitat description for these species is found in Appendix G2.

Table G-8. Federally Threatened or Endangered Aquatic Species on the GWNF

Group	Scientific Name	Common Name	G-Rank	S-Rank VA	S-Rank WV	Status	Stream Habitat	Lake Habitat	Potential Habitat
mussel	*Pleurobema collina*	James spinymussel	G1	S1	S1	FE	312, 313, 415, 513		14.3 mi
plant	*Helenium virginicum*	Virginia sneezeweed	G3	S2		FT		EHW, PNCS, WW	4.0 ac
plant	*Helonias bullata*	swamp pink	G3	S2S3		FT	111, 121, 123, 211, 221		7.3 mi
plant	*Scirpus ancistrochaetus*	northeastern bulrush	G3	S2	S1	FE		WW, PNCS	1.1 ac

Despite extensive searches, no occurrences of the spinymussel have been located on the GWNF (Watson 2010). The 14 miles of potential habitat modeled for this species (Table G-8) assumes all of the river mileage is suitable substrate, which is not probable; in all of the watersheds with spinymussels near the GWNF, the occurrences are all on private land (Appendix G5, Table 3). The direct importance of Forest lands to spinymussel habitat from a global and eco-regional perspective is very limited. However, the Forest contributes indirectly by providing good water quality to downstream spinymussel habitat. In addition, the several isolated reaches of habitat on the Forest could provide sites for augmentation if the substrate was suitable, and thus become locally important.

The Virginia sneezeweed is found only in Virginia and Missouri. Although there is only approximately four acres of habitat on the GWNF (Table G-8), one of the two 5th level HUC watersheds in Virginia where this plant is found includes occurrences on the GWNF (Appendix G5, Table 3). The Forest is important to this species at a global, eco-regional, and local level.

Both swamp pink and northeastern bulrush are found in a total of 8 states, thus, the GWNF is moderately important at a global scale. There are occurrences on both private and Forest land (Appendix G5, Table 3). For swamp pink, much of the in-tact habitat in Virginia is on the GWNF, therefore, at the eco-regional and local level, the Forest is very important. For the bulrush, there are only a few acres of habitat on the GWNF, but the Forest is still important at the eco-regional and local level. More information on the threats and importance of Forest land to these plant species can be found in the Terrestrial Ecological Sustainability Analysis.

3.2b Other at Risk Species and Species of Management Concern

Criteria for identifying other species to be addressed are as follows:

- Species identified as proposed and candidate species under ESA.
- Species ranked G-1, G-2 and G-3 by NatureServe.
- Subspecific taxa ranked T-1, T-2 and T-3 by NatureServe.
- Species that have been petitioned for federal listing and for which a positive "90-day finding" has been made.
- Species that have been recently delisted including those delisted within the past five years and other delisted species for which regulatory agency monitoring is still considered necessary.
- Species with ranks of S-1, S-2, N-1 or N-2 on the NatureServe ranking system.
- State listed threatened and endangered species.
- Species identified as species of conservation concern in State Comprehensive Wildlife Strategies.
- Species on the U.S. Fish & Wildlife Service Birds of Conservation Concern National Priority List.
- Additional species that may be of regional or local conservation concern due to:
    - Significant threats to populations or habitat
    - Declining trends in populations or habitat
    - Rarity
    - Restricted ranges (e.g., narrow endemics, disjunct populations, species at the edge of their ranges)
- Species hunted or fished.
- Other species of public interest.
- Invasive or other species for which control measures are needed.

One hundred thirty-two aquatic species that occur on the GWNF have been identified for further consideration in the planning process (see Tables G-9 & G-10 for a summary of these species by habitat on the GWNF). A more detailed habitat description for most of the faunal species is found in Appendix G2.

Table G-9. Aquatic At-Risk Species Addressed on the GWNF

Group	SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK VA	S-RANK WV	STATUS	STREAM HABITAT	LAKE HABITAT	POTENTIAL HABITAT
fish	*Notropis semperasper*	Roughhead shiner	G2G3	S2S3	_	S	413, 423, 512, 513, 123		73.7 mi
fish	*Noturus gilberti*	Orangefin madtom	G2	S2	_	S	512, 513		6.5 mi
insect	*Hydraena maureenae*	Maureen's shale stream beetle	G1G3	S1S3	_	S	113		150.9 mi
insect	*Cicindela ancocisconensis*	Appalachian tiger beetle	G3	S2	S3	S	513		6.20 mi
mammal	*Sorex palustris punctulatus*	southern water shrew	G5T3	S1S2	S1	S	121, 221, 321, 411, 421		13.5 mi
mussel	*Alasmidonta varicosa*	Brook floater	G3	S1	S1	S	513		1.3 mi
mussel	*Elliptio lanceolata*	Yellow lance	G2G3	S2S3	_	S	512, 513		30.8 mi
mussel	*Fusconaia masoni*	Atlantic pigtoe	G2	S2	_	S	313		0.2 mi
mussel	*Lasmigona subviridis*	Green floater	G3	S2	S2	S	415, 513		21.9 mi
bird	*Haliaeetus leucocephalus*	Bald eagle	G5	S23B/ S3N	S2B/ S3N	S			Riparian
plant	*Boltonia montana*	Doll's daisy	G1G2	S1	_	S			Riparian

Group	SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK VA	S-RANK WV	STATUS	STREAM HABITAT	LAKE HABITAT	POTENTIAL HABITAT
plant	*Iliamna remota*	Kankakee globe-mallow	G1Q	S1	_	S			Riparian
plant	*Isoetes virginica*	Virginia quillwort	G1Q	S1?	_	S			Riparian
plant	*Peltigera hydrothyria*	waterfan	G3G5	S1	_	S	113, 114, 121, 124, 221		515.0 mi
plant	*Poa paludigena*	bog bluegrass	G3	S2	S1	S			Riparian
plant	*Potamogeton hillii*	Hill's pondweed	G3	S1	_	S			Riparian
plant	*Potamogeton tennesseensis*	Tennessee pondweed	G2	S1	S2	S			Riparian
plant	*Sida hermaphrodit a*	Virginia mallow	G3	S1	S2	S			Riparian
plant	*Vitis rupestris*	sand grape	G3	S1?	S2	S			Riparian

Both the roughhead shiner and Maureen’s shale stream beetle are endemic to Virginia. They are found both on Forest land and private land (Appendix G5, Table 3). The GWNF not only provides some habitat directly, but indirectly contributes by providing good water quality to downstream habitat. The Forest is important to these species at the global, eco-regional, and local level.

The orangefin madtom is known only from Virginia and North Carolina. There are no documented occurrences of orangefin madtoms on the GWNF (Appendix G5, Table 3), and only 6.5 miles of potential habitat (Table G-9). Therefore, the direct importance of Forest lands to orangefin madtom habitat from a global and eco-regional perspective is very limited. However, the Forest contributes indirectly by providing good water quality to the downstream madtom habitat, and thus could be locally important.

The Appalachian tiger beetle is known from 15 states and Quebec. It is found on both Forest and private land (Appendix 5, Table 3) in Virginia, but there are only 6.2 miles of potential habitat on the GWNF (Table G-9). The direct importance of Forest lands to Appalachian tiger beetle habitat from a global and eco-regional perspective is very limited. However, the Forest contributes indirectly by providing good water quality to the downstream tiger beetle habitat, and thus could be locally important.

The southern water shrew is found in six states; in Virginia it is found in two watersheds, on both Forest and private land (Appendix G5, Table 3). With only about 13 miles of potential habitat on the Forest (Table G-9), the direct importance of Forest lands to southern water shrew habitat from a global and eco-regional perspective is moderate. However, the Forest is very important to this species at a local level.

There are no documented occurrences of the four FS Sensitive mussel species on the GWNF (Appendix G5, Table 3); with potential habitat ranging from less than a mile for the Atlantic pigtoe to approximately 31 miles for the yellow lance (Table G-9). Therefore, the direct importance of Forest lands to these mussel species from a global and eco-regional perspective is very limited. However, the Forest contributes indirectly by providing good water quality to the downstream mussel habitat, and thus could be locally important.

Information on the importance of Forest land to FS Sensitive plant and bird species can be found in the Terrestrial Ecological Sustainability Analysis.

Table G-10. Aquatic Species of Management Concern Addressed on the GWNF. Under Status, LR= locally rare, SMC=species of management concern, and MIS=Management Indicator Species.

Group	SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK VA	S-RANK WV	STATUS	STREAM HABITAT	LAKE HABITAT	POTENTIAL HABITAT
amphib	*Ambystoma tigrinum*	eastern tiger salamander	G5	S1		LR		WW, PNCS, EHW	39.1 ac
bird	*Anas rubripes*	Amer. black duck	G5	S4	S2B/S4N	LR	511,512, 513	WW	36.6 mi & 185.7 ac
bird	*Empidonax alnorum*	alder flycatcher	G5	S1B	S3B/S4N	LR		WW	185.7 ac
bird	*Emidonax virescens*	Acadian flycatcher	G5	S5	S5B	MIS			Riparian
bird	*Melospiza georgiana*	swamp sparrow	G5	S1B/S4S5N	S3B/S4N	LR		EHW	85.0 ac
bird	*Nycticorax nycticorax*	black-crowned night-heron	G5	S3B/S4N	SHB	LR	511,512, 513	WW	36.6 mi & 185.7 ac
bird	*Nyctanassa violacea*	yellow-crowned night-heron	G5	S2S3B/S3N	S1N	LR	511,512, 513	WW	36.6 mi & 185.7 ac
bird	*Seiurus noveboracensis*	northern waterthrush	G5	S1B	S2B	LR		WW, EHW	270.7 ac
crayfish	*Cambarus monongalensis*	A Crayfish	G5	S1?	S3	LR	121, 221, 321, 411, 421		17.6 mi
fish	*Anguilla rostrata*	American eel	G4	S5	S2	SMC	114, 115, 211, 212, 214, 215, 314, 411, 413, 415, 513		145.6 mi
fish	*Cottus cf. cognatus*	Checkered sculpin	G4Q	_	_	LR			Riparian
fish	*Salvelinus fontinalus*	Brook trout	G5	S4	S5	MIS	111, 112, 113, 114, 115, 121, 122, 123, 124, 211, 212, 213, 214, 215, 221, 223, 224, 311, 312, 321, 411, 413, 421, 512		1,119.9 mi
insect/ odonate	*Aeshna canadensis*	Canada darner	G5	S1	S1	LR		EHW, PCS, PNCS	34.7 ac
insect/ odonate	*Aeshna tuberculifera*	black-tipped darner	G4	S2S3	S2	LR		WW, EHW, PCS, PNCS	89.4 ac
insect/ odonate	*Aeshna verticalis*	green-striped darner	G5	S1	S2	LR		EHW, PCS, PNCS	34.7 ac
insect/ odonate	*Anax longipes*	comet darner	G5	S3	S1	LR		WW, EHW, PCS, PNCS	49.4 ac

Group	SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK VA	S-RANK WV	STATUS	STREAM HABITAT	LAKE HABITAT	POTENTIAL HABITAT
insect/ odonate	*Calopteryx amata*	Superb jewelwing	G4	S1	-	LR	121, 221, 321, 411, 421		17.6 mi
insect/ odonate	*Calopteryx angustipennis*	Appalachian jewelwing	G4	S2	S2	LR	513		.09 mi
insect/ odonate	*Celithemis martha*	Martha's penant	G4	S2	_	LR		WW, EHW, PCS, PNCS, LCS	54.7 ac
insect/ odonate	*Cordulegaster diastatops*	delta-spotted spiketail	G5	S1	S2	LR	121		10.23 mi
insect/ odonate	*Enallagma annexum (AKA cyathigerum)*	northern bluet	G5	S1	S2	LR		EHW, PCS, PNCS	34.7 ac
insect/ odonate	*Epitheca canis*	beaverpond baskettail	G5	S1	S1S2	LR		EHW, PCS, PNCS	34.7 ac
insect/ odonate	*Gomphus adelphus*	mustached clubtail	G4	S1	S2	LR	413, 513		23.9 mi
insect/ odonate	*Gomphus quadricolor*	rapids clubtail	G3/G4	S2	S2S3	LR	413, 513		23.9 mi
insect/ odonate	*Ladona julia (AKA Libellula julia)*	chalk-fronted corporal skimmer	G5	S1	S2	LR		EHW, PCS, PNCS	34.7 ac
insect/ odonate	*Lanthus parvulus*	double-striped clubtail	G4	S2	S2	LR	111, 112, 121, 122, 123		13.2 mi
insect/ odonate	*Lestes disjunctus*	northern spreadwing	G5	S2	S2S3	LR		EHW, PCS, PNCS	34.7 ac
insect/ odonate	*Leucorrhinia hudsonica*	Hudsonian whiteface	G5	S1	S1	LR		EHW, PCS, PNCS	34.7 ac
insect/ odonate	*Nehalennia irene*	sedge sprite	G5	S1	S3	LR		EHW, PCS, PNCS	34.7 ac
insect/ odonate	*Neurocordulia yamaskanensis*	stygian shadowdragon	G5	S2	S2	LR	512, 513		34.5 mi
insect/ odonate	*Rhionaeschna mutata (AKA Aeshna mutata)*	spatterdock darner	G3G4	S2	S1	LR		WW, EHW, PCS, PNCS	49.4 ac
insect/ odonate	*Somatochlora elongata*	Ski-tipped emerald	G5	S1S2	S2	LR		EHW, PCS, PNCS	34.7 ac
insect/ odonate	*Sympetrum obtrusum*	white-faced meadowhawk	G5	S1	S2	LR		EHW, PCS, PNCS	34.7 ac
insect	*Autochton cellus*	Golden banded skipper	G5	S3	S1S2	LR			Riparian
insect	*Boloria selene*	Silver-bordered fritillary	G5	S2	S3	LR			Riparian
insect	*Colias interior*	Pink-edged sulphur	G5	S1S2	S2	LR			Riparian

Group	SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK VA	S-RANK WV	STATUS	STREAM HABITAT	LAKE HABITAT	POTENTIAL HABITAT
insect	*Isonychia hoffmani*	Hoffman's Isonychia mayfly	G1/G3	S1	-	LR	121, 221, 321, 411, 421		17.6 mi
insect	*Nemotaulius hostilis*	a limnephilid caddisfly	G5	S1	SNR	LR		EHW, PCS, PNCS	34.7 ac
insect	*Speyeria atlantis*	Atlantis fritillary	G5	S2	S3	LR			Riparian
mammal	*Castor canadensis*	beaver	G5	S5	S5	SMC			Riparian
mammal	*Lontra canadensis*	River otter	G5	S4	S1	LR			Riparian
mussel	*Villosa constricta*	Notched Rainbow	G3	S3	_	LR	415, 512, 513		33.1 mi
reptile	*Clemmys guttata*	spotted turtle	G5	S4	S1	LR		EHW, PNCS	6.45 ac
reptile	*Glyptemys insculpta*	wood turtle	G3	S2	S2	LR	111, 112, 113, 123, 211, 212, 213, 221, 313, 311, 312, 411, 413, 412, 513		217.6 mi
plant	*Alnus incana ssp. rugosa*	speckled alder	G5T5	S2		LR			Riparian
plant	*Arethusa bulbosa*	Dragon's mouth	G4	S1		LR			Riparian
plant	*Aster radula*	rough-leaved aster	G5	S1		LR			Riparian
plant	*Bromus ciliatus*	fringed brome grass	G5	S1	S4	LR			Riparian
plant	*Calopogon tuberosus*	Grass pink	G5	S1	S2	LR			Riparian
plant	*Carex aquatilis*	water sedge	G5	S1	S1	LR			Riparian
plant	*Carex arctata*	Black sedge	G5	S1	S1	LR			Riparian
plant	*Carex barrattii*	Barratt's sedge	G4	S2	_	LR			Riparian
plant	*Carex buxbaumii*	Buxbaum's sedge	G5	S2	S2	LR			Riparian
plant	*Carex conoidea*	field sedge	G5	S1S2	S1	LR			Riparian
plant	*Carex cristatella*	crested sedge	G5	S2	S4	LR			Riparian
plant	*Carex interior*	inland sedge	G5	S1	S1	LR			Riparian
plant	*Carex lasiocarpa var. americana*	slender sedge	G5T5	S1	?	LR			Riparian
plant	*Carex schweinitzii*	Schweinitz's sedge	G3G4	S1	_	LR			Riparian
plant	*Carex vesicaria*	inflated sedge	G5	S1S2	S2	LR			Riparian
plant	*Cyperus dentatus*	toothed flatsedge	G4	S1	SNR	LR			Riparian
plant	*Cypripedium reginae*	showy lady's-slipper	G4	S1	S1	LR			Riparian
plant	*Echinodorus tenellus*	dwarf burhead	G5?	S1	_	LR			Riparian
plant	*Eleocharis compressa*	flattened spikerush	G4	S2	S2	LR			Riparian

Group	SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK VA	S-RANK WV	STATUS	STREAM HABITAT	LAKE HABITAT	POTENTIAL HABITAT
plant	*Eleocharis melanocarpa*	black-fruited spikerush	G4	S2	_	LR			Riparian
plant	*Eleocharis robbinsii*	Robbins spikerush	G4G5	S1	_	LR			Riparian
plant	*Elymus canadensis*	nodding wild rye	G5	S2?	S5	LR			Riparian
plant	*Epilobium leptophyllum*	linear-leaved willow-herb	G5	S2	S3	LR			Riparian
plant	*Equisetum sylvaticum*	Woodland horsetail	G5	S1	S1	LR			Riparian
plant	*Eriocaulon aquaticum*	white buttons	G5	S1	_	LR			Riparian
plant	*Eupatorium maculatum*	spotted joe-pye weed	G5	S2	S1	LR			Riparian
plant	*Glyceria acutiflora*	sharp-scaled manna-grass	G5	S3	S2	LR			Riparian
plant	*Glyceria grandis*	American manna-grass	G5T?	S1	S1	LR			Riparian
plant	*Huperzia appalachiana*	Appalachian fir clubmoss	G4/G5	S2	_	LR			Riparian
plant	*Hypericum boreale*	northern St. John's-wort	G5	S2	SH	LR			Riparian
plant	*Hypericum ellipticum*	pale St. John's-wort	G5	SH	S4	LR			Riparian
plant	*Isoetes lacustris*	lake quillwort	G5	S1?	_	LR			Riparian
plant	*Juncus brachycephalus*	small-head rush	G5	S2	_	LR			Riparian
plant	*Juncus brevicaudatus*	narrow-panicled rush	G5	S2	S4	LR			Riparian
plant	*Lachnanthes caroliniana*	Carolina redroot	G4	SH	_	LR			Riparian
plant	*Liparis loeselii*	Loesel's twayblade	G5	S2	S2	LR			Riparian
plant	*Lycopodiella inundata*	northern bog clubmoss	G5	S1	S2?	LR			Riparian
plant	*Lythrum alatum*	winged loosestrife	G5	S2	S1	LR			Riparian
plant	*Muhlenbergia glomerata*	marsh muhly	G5	S2	SNR	LR			Riparian
plant	*Osmunda cinnamomea var. glandulosa*	glandular cinnamon fern	G5TNR	S1	SNR	LR			Riparian
plant	*Panicum hemitomon*	maidencane	G5?	S2	_	LR			Riparian
plant	*Parnassia grandiflora*	Large-leaved grass of parnassus	G3	S2	S1	LR			Riparian
plant	*Platanthera grandiflora*	large purple fringed orchid	G5	S1	S4	LR			Riparian
plant	*Platanthera peramoena*	purple fringeless orchid	G5	S2	S4	LR			Riparian
plant	*Poa palustris*	fowl bluegrass	G5	S1S2	S4	LR			Riparian
plant	*Polanisia dodecandra*	common clammy-weed	G5QT?	S2		LR			Riparian

Group	SCIENTIFIC NAME	COMMON NAME	G-RANK	S-RANK VA	S-RANK WV	STATUS	STREAM HABITAT	LAKE HABITAT	POTENTIAL HABITAT
plant	*Potamogeton amplifolius*	Large leaf pondweed	G5	S1S2	S4	LR			Riparian
plant	*Potamogeton oakesianus*	Oakes pondweed	G4	S2	SH	LR			Riparian
plant	*Ribes americanum*	Wild black currant	G5	S1?	S2	LR			Riparian
plant	*Sabatia campanulata*	slender marsh rose-pink	G5	S2	_	LR			Riparian
plant	*Sagittaria calycina var calycina*	long-lobed arrowhead	G5T5?	S1	SH	LR			Riparian
plant	*Sagittaria rigida*	sessile-fruited arrowhead	G5	S1	SNA	LR			Riparian
plant	*Schoenoplectus subterminalis*	water bulrush	G4G5	S1S2	_	LR			Riparian
plant	*Scirpus torreyi*	Torrey's bulrush	G5?	S1	S1	LR			Riparian
plant	*Solidago rupestris*	riverbank goldenrod	G4?	S1	_	LR			Riparian
plant	*Solidago uliginosa*	bog goldenrod	G4G5T?	S2		LR			Riparian
plant	*Sparganium chlorocarpum*	narrow-leaf burreed	G5	S1		LR			Riparian
plant	*Spartina pectinata*	freshwater cordgrass	G5	S2	S4	LR			Riparian
plant	*Sphagnum russowii*	Russow's peatmoss	G5	S1S2		LR			Riparian
plant	*Spiranthes lucida*	shining ladies'-tresses	G5	S1	S1S2	LR			Riparian
plant	*Spiranthes ochroleuca*	yellow nodding ladies'-tresses	G4	S1	S5	LR			Riparian
plant	*Triadenum fraseri (Hypericum v.)*	Fraser's marsh St. John's-wort	G5	S1	S4	LR			Riparian
plant	*Triantha racemosa*	coastal false-asphodel	G5	S1	_	LR			Riparian
plant	*Vaccinium macrocarpon*	large cranberry	G4	S2	S2	LR			Riparian
plant	*Verbena scabra*	sandpaper vervain	G5	S2	S1	LR			Riparian
plant	*Veronica scutellata*	marsh speedwell	G5	S1	S2	LR			Riparian
plant	*Viburnum lentago*	nannyberry	G5	S1	S1S2	LR			Riparian
plant	*Vicia americana*	American purple vetch	G5	S1S2	S4	LR			Riparian
plant	*Woodwardia virginica*	Virginia chainfern	G5	S5	SNR	LR			Riparian

3.3 Information Collection

Species collection records were compiled from the Virginia Department of Game and Inland Fisheries (VDGIF) collections database, Virginia Department of Conservation and Recreation's Division of Natural Heritage (VDNH) records, West Virginia Division of Natural Resources (WVDNR) records, and USFS records. Using

ArcMap®, records of selected species were connected to the attributed stream reaches or lakes/wetlands, allowing for characterization of the species' habitats as noted in the above tables.

3.4 Species Groups

All of the above federally listed species, sensitive species and species of management concern are tied to the specified aquatic habitats. The following groups address threats that could affect habitat for a number of species.

Acid Sensitive Stream Species

Acid deposition rates and the underlying geology were used to analyze Forest watersheds for their sensitivity to acidification. They were put into three categories; high, moderate, and low sensitivity. When cross-walked with stream habitat types, 793 miles (67%) of perennial streams on the GWNF were within the highly sensitive watersheds. See Table G-11 for a list of stream habitats by watershed sensitivity. Of those, the smallest streams at the highest elevations are most susceptible. As discussed in the pH and alkalinity section, even if acid emissions are reduced, streams will continue to acidify for a number of years. It should be expected that species living in those streams will be negatively affected by acidification. Table G-12 is a list of those species found in the stream habitat types that occur in watersheds that are highly sensitive to acidification. Management strategies in the acid sensitive watersheds should address this issue and maximize nutrient replacement when planning vegetation management and/or look for alternative solutions (such as stream or watershed liming or fertilization), if negative effects to biota are to be avoided.

Table G-11. GWNF Stream Habitat Type by Watershed Acid Sensitivity

Watershed Sensitivity to Acidification	Stream Habitat Type	Miles	Percent of Miles
HIGH	111, 113, 114, 115, 121, 123, 125, 211, 213, 215, 221, 223, 225, 311, 313, 315, 321, 323, 411, 413, 415, 421, 423, 511, 513	792.9	67%
MODERATE	124, 214, 224, 314, 414	232.0	20%
LOW	112, 122, 212, 222, 312, 322, 412, 512	153.8	13%

Table G-12. Species Found in Watersheds with a High Sensitivity to Acidification

SCIENTIFIC NAME	COMMON NAME
Alasmidonta undulata	triangle floater
Alasmidonta varicosa	brook floater
Anas rubripes	northern black duck
Anguilla rostrata	American eel
Calopteryx angustipennis	Appalachian jewelwing
Cambarus monongalensis	a crayfish
Clemmys insculpta	wood turtle
Cordulegaster diastatops	delta-spotted spiketail
Elliptio lanceolata	yellow lance
Fusconaia masoni	Atlantic pigtoe
Gomphus viridifrons	green-faced clubtail
Helonias bullata	swamp pink
Hydraena maureenae	Maureen's shale stream beetle
Lanthus parvulus	double-striped clubtail
Lasmigona subviridis	green floater

SCIENTIFIC NAME	COMMON NAME
Notropis semperasper	roughhead shiner
Noturus gilberti	orangefin madtom
Nyctanassa violacea	yellow-crowned night-heron
Pleurobema collina	James spinymussel
Salvelinus fontinalus	brook trout
Sorex palustris punctulatus	southern water shrew
Villosa constricta	notched rainbow

Temperature Change Species

It is recognized that climate change will impact the ability of the Nation's forest to provide water and other critical watershed services (Knapp et al. 2008). Warming over the past several decades has fundamentally altered the hydrologic cycle, and these changes are percolating through our watersheds. Projected climate changes to the hydrologic cycle through warmer water temperatures, more intense storms, and greater inter-annual variability in precipitation, indicate the importance of maintaining and protecting healthy watersheds. Bakke (2008) describes three key components relating climate change processes to management and conservation of aquatic resources; resilient habitat, refugia, and restoration.

Resiliency refers to the ability of a system to return to its original condition after being disturbed. In ecology, resiliency carries the additional meaning of how much disturbance a system can "absorb" without crossing a threshold and entering an entirely different state of equilibrium. This requires that certain key habitat characteristics or processes will change little; with respect to stream aquatic habitat, these key elements are temperature and disturbance regime. Rivers and streams most resilient to temperature change include those dominated by groundwater input. Aspect, riparian shading, and valley shape also play a role in thermoregulation. A resilient disturbance regime would be one where peak flows and available sediment sources do not become altered. Likewise, streams most resilient to changes in disturbance regime would include those with flow dominated by groundwater. Resiliency can only function if the landscape offers a redundancy of habitat opportunities; there must be enough habitat and connectivity so that a disturbance to one area allows populations to recover and recolonize from another area.

Refugia are places in the landscape where organism can go to escape extreme conditions, be it short term or long term. Protecting these areas, and maintaining or improving connectivity will be increasingly important.

Restoration should include activities which reestablish the structures and function of the stream ecosystem in a manner that the ecosystem will become self-maintaining. High priority actions would be protection of good habitat, improving connectivity and access to existing habitat. If active restoration, such as enhancement of instream habitat with large wood, is to be performed in potentially unstable settings, it will be important to design these projects with the appropriate level of redundancy to accommodate greater rates of channel migration and flood magnitudes. Passive restoration techniques, such as establishment of wider riparian buffers, may be a more sustainable alternative in light of increased geomorphic instability.

Species that are non-tolerant of warmer water will find their habitat reduced (see brook trout discussion, below). As streams and lakes change, species that are unable to adapt will need to move to suitable habitat; this emphasizes the need for maintaining connectivity between habitat units. Management and land use decisions should be designed to maintain and protect healthy watersheds, and support watershed resilience. Specific management strategies the George Washington National Forest can adopt to address the management and conservation of aquatic resources in light of predicted effects from climate change are:

- Protect and restore beaver meadows, wetlands, and floodplains to improve natural storage, reduce flood hazards, and prolong seasonal flows. Beaver ponds and wetlands recharge groundwater, raise the water table, retain sediment and organic matter, store water during floods and release it slowly, mitigate low flows and drought, reduce carbon turnover rate, raise pH and ANC, while reducing SO^2, Al, and NO^3 .

- Protect and restore riparian forests to moderate changes in stream temperature, maintain stream bank stability, and provide instream habitat.
- Remove migration barriers and re-establish habitat connectivity so that species can more to more suitable habitat, or move to or from refugia.
- Reduce flood and wildfire risks in vulnerable watersheds to prevent increased surface erosion and mass wasting leading to aggradation of river channels.
- Improve or decommission roads to reduce adverse impacts during large storms to prevent surface erosion and fill slope failure and landslides. Construct stream crossings and bridges to withstand major storm and runoff events.

Brook trout are not only a MIS, but a coldwater species that depend on relatively low stream temperatures to survive. A recent study (Flebbe et al. 2006) projects that rising temperature changes from climate change (and the loss of hemlock along streams) will shrink natural trout habitat. Using the Hadley Centre and the Canadian Centre climate change models, Flebbe found that between 53 and 97 percent of wild trout populations in the Southern Appalachians could die out as streams become warmer by the year 2100. However, Trumbo (2010) used a direct measurement approach pairing air and water temperature relationships to classify the sensitivity and exposure (vulnerability) of individual brook trout populations to various climate change scenarios. Trumbo et al. (2010) identified potential refugia for brook trout at lower elevations and with higher air temperatures than previous larger scale modeling efforts. Site specific characteristics such as watershed area, percent riparian canopy, solar insolation, percent groundwater, elevation, and percent watershed in forest cover were useful for predicting individual brook trout population persistence. Combining the sensitivity scores with the vulnerability scores resulted in four classification categories: (high sensitivity/high vulnerability (HS-HV); high sensitivity/low vulnerability (HS-LV); low sensitivity/high vulnerability (LS-HV) and low sensitivity/low vulnerability (LS-LV). Out of the 1120 miles of potential brook trout habitat on the Forest, 309 miles are in the HS-HV category; 4 miles are in the HS-LV category; 233 miles are in the LS-HV category; and 65 miles are in the LS-LV category.

Currently, Virginia has one of the strongest native brook trout resources in the Southeast. Of the 2,350 miles of wild trout resource identified by the State, approximately 80% remains brook trout. Wild brook trout populations are generally limited to higher elevations in the western mountains of the state. However, brook trout were once found throughout the limestone spring creeks in the Great Valley region located between the Blue Ridge and Allegheny mountain ranges and along some of the smaller tributaries of the Potomac at least as far east as Fairfax County. Most of the valley limestone stream populations were likely extirpated a century or more ago with the agricultural development of the valley but some persisted as late as the mid-1960s. The populations within Potomac River tributaries were known to be strong through the 1950s and still persisted as late as the early 1980s. These populations were eliminated with residential development of the region. Recent research supports the relationship between forested watersheds and presence of brook trout; conversely, watersheds with extensive development (with as little as 4% impervious cover) were unable to support brook trout in their streams (Stranko et al. 2008). It is estimated that at least 38% of the original brook trout populations have been extirpated from Virginia.

Most of the remaining populations are well protected from land use changes due to public ownership by land management agencies such as the George Washington and Jefferson National Forest, the Shenandoah National Park and scattered holdings of the Virginia Department of Game and Inland Fisheries. However, they will not be immune to thermal and hydrologic effects resulting from climate change. Impacts to trout and other cold-water species can hopefully be reduced by implementing the management strategies outlined above that are designed to maintain and protect healthy watersheds, and support watershed resilience.

3.5 Plan Components for Species Diversity & Evaluation of Plan Components on Species Diversity

Plan components for ecosystem diversity identified in Sections 2.6 and 3.4 should satisfy most aquatic species diversity objectives on the GWNF. In addition, many of the species listed above are within existing or proposed

Special Biological Areas (SBA). With an SBA designation, management is focused on the unique species or biological communities that occur in the area. See Appendix G3 for a crosswalk of the aquatic species found in SBAs and Appendix G4 for those found in proposed SBAs.

Managing watersheds, riparian areas, and perennial, intermittent, and channeled ephemeral streams to maintain or restore resilient and stable conditions to support the quality and quantity of water necessary to protect ecological functions and support beneficial water uses will improve and maintain habitat conditions and habitat connections for aquatic species habitat groups and will maintain suitable habitat that is not currently occupied but has a likelihood of being occupied in the future by species identified in this analysis.

However, this analysis does recommend additional plan components specifically for two aquatic/riparian species on the GWNF: tiger salamander, and wood turtle. Each is discussed next along with the rationale as to why additional Plan components are necessary.

Tiger Salamander

The 1993 Plan created the Maple Flats SBA in part to protect the Easter tiger salamander. Appendix G of the 2004 M&E report states "Delineation of the Maple Flats Special Biological Area containing the eastern tiger salamander appears to have encompassed much, if not all, habitat used by this species on the GWNF. Observations made since this species was discovered on the Forest indicate that this species is still present at all locations where previously found. Population size and trend studies are ongoing, as are inventories of potential habitat. As new information on population trends and habitat use surface, management activities will be adjusted to protect the eastern tiger salamander where they occur on the Forest. Forest Service management activities are having no effect on the eastern tiger salamander since all sinkhole ponds in the Maple Flats area are avoided and buffered from management activities." In 2005-2007 eastern tiger salamander egg masses and adults were found at 6 sinkhole ponds outside, and 4-5 miles west, of the Maple Flats Sinkhole Complex. It is recognized that local amphibian population persistence requites sufficient terrestrial habitat, the maintenance of habitat quality, and connectivity among local populations (Harper et al. 2008). New Special Biological Areas should be created to protect the newly found eastern tiger salamander populations. This should include habitat management between all the ponds to allow for long-range dispersal, including mature forest and low stem densities.

Wood Turtle

Based on the assessment information (Huber et al. 2009), the agencies have identified strategies with the highest likelihood of improving wood turtle habitat and with the highest likelihood of mitigating the impacts of other activities on the Forest. It is recognized that the primary limiting factors affecting the viability of the wood turtle in the region are, illegal collection, habitat loss and fragmentation, and vehicular mortality (Buhlmann et al. 2008). Habitat maintenance and improvement is where the forest can make the biggest gains on conserving the wood turtle.

The assessment information on habitat indicates that wood turtles have both aquatic and terrestrial habitat needs. They benefit from high quality streams with some level of stream disturbance (beaver ponds, cut banks, large woody debris, alluvial depositions). Their terrestrial habitat needs for nesting and foraging appear to be best met by a variety of settings, including openings, shrub habitat and forested habitat. Aside from habitat needs, the main threats on the National Forest appear to be collection and mortality from vehicles.

Wood turtle conservation on the Forest will consist of goals and strategies designed to enhance habitat and reduce potential threats. Forest Plan riparian standards or guidelines will be followed if they are more restrictive than those in the wood turtle conservation strategy.

Goals and Conservation Measures (CM)

The following goals and strategies apply to perennial streams, seeps, riparian areas, and adjacent upland areas on the Forest (GW) within the range of the wood turtle. Currently, this range includes the North Fork Shenandoah and the South Fork of the South Branch of the Potomac River and the Cacapon River watersheds on the Lee and North River Ranger Districts.

Goal 1 Watersheds are managed to maintain or enhance the terrestrial summer foraging habitat of wood turtles.

CM 1.01 Maintain or create openings in riparian areas for turtle foraging and thermoregulation.

Goal 2 Watersheds are managed to maintain or enhance the nesting habitat of wood turtles.

CM 2.01 Manage and protect known existing nest sites.

CM 2.02 Create additional suitable nest sites where appropriate.

Goal 3 Watersheds are managed to maintain or enhance the overwintering aquatic habitat of wood turtles.

CM 3.01 Maintain or create in stream woody debris.

CM 3.02 Minimize sediment, pollutant, and pesticide loading to stream channels.

CM 3.03 Avoid stream channelization, artificial impoundments (i.e. dams), and bank stabilization that would decrease potential overwintering habitat.

CM 3.04 Allow beaver activities that create suitable habitat.

Goal 4 Human interactions, such as motorized vehicle use and recreation, are managed to minimize impacts to wood turtles.

CM 4.01 The Forest Service, working cooperatively with the Virginia Department of Game and Inland Fisheries and the West Virginia Division of Natural Resources, will identify hibernacula with significant turtle concentrations and/or other areas where there is a high potential for human interaction with wood turtles. They will evaluate the need for seasonal restrictions on road use or other activities to protect the turtle. The time that turtles are nesting or foraging away from the stream and most subject to terrestrial impact would be from April through October. In stream activities would be of greatest concern during the period of November through March.

CM 4.02 When mowing within 1000 feet (300 m) of a perennial stream, mowing decks will be raised a minimum of 8 inches (20 cm) above the ground between April 1 and November 15.

CM 4.03 Work with law enforcement to help identify law enforcement activities to curtail illegal collection activities (e.g. encourage wildlife road checks, increased law enforcement surveillance).

Goal 5 Manage riparian and aquatic habitats to protect water quality and enhance conditions for riparian dependent species.

CM 5.01 Riparian and aquatic habitat will be managed using the standards and guidelines in the Forest Plan.

Goal 6 Recognize the Paddy Run watershed on the Lee District as an emphasis area for wood turtle management; "Because of its relatively intact forest, remote location, position within the Cedar Creek watershed, connection to the Capon River watershed, and relatively protected status inside of the George Washington National Forest, Vance's Cove probably represents the best potential for long-term protection of a viable metapopulation of wood turtles" (Akre and Ernst, 2006).

The Paddy Run emphasis area includes National Forest land within the Paddy Run watershed,

including Vance's Cove, starting at the National Forest boundary at Paddy Gap (see attached map). Long term desired future management direction for this area comes from the George Washington Forest Revised Land and Resource Management Plan. (Forest Plan). Project desired future conditions will be derived from management area designations 4, 9, 15, 18, 21, all of which are located within the emphasis area.

Within this emphasis area the following activities will be implemented:

CM 6.01 No logging activities allowed within 100 feet (30 m) of the edge of perennial streams and seeps, except to enhance habitat for wood turtles. No logging activities (including those for wood turtle enhancement) allowed within 300 feet (100 m) of the edge of perennial streams and seeps from April 1 to November 15. In coordination with VDGIF and Forest Service biologists, logging activity restrictions in the 300 ft buffer zone may be modified on a case-by-case basis. Regeneration harvest will be limited to no more than 6% of the watershed in a 10 year period.

CM 6.02 Forest Road 93 will be closed to the public at the end of spring gobbler season, established by VDGIF, until July 1 to reduce vehicular traffic during times of the year when the turtles are most active, especially nesting season.

CM 6.03 Create and/or maintaining openings with a mixture of grass, forbs and shrubs in the riparian corridor for turtle foraging areas.

CM 6.04 Create and/or maintain nest sites away from roads and trails as appropriate.

CM 6.05 Place LWD and root wads into the stream channel to provide over-wintering habitat as appropriate.

CM 6.06 Look for opportunities to reduce human-turtle interactions such as moving existing trails and roads away from riparian areas, and eliminating stocking from the upper reaches of Paddy Run.

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APPENDIX G1. AQUATIC HABITAT CLASSIFICATION PROCESS PAPER
George Washington National Forest

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A. Introduction

The George Washington National Forest (GWNF) developed an aquatic habitat classification to facilitate the Aquatic Ecological Sustainability Analysis. The methods used in this classification follow the basic structure of The Nature Conservancy (TNC) aquatic community classification, and the Virginia and West Virginia Wildlife Action Plans, yet habitat classifications were focused on land managed by the GWNF.

There were multiple goals in this effort. One was to provide a means to describe and catalog the diversity of aquatic habitats in the GWNF (coarse filter). The second was to provide a dataset that can be used to describe species-habitat associations for specific federally listed species, FS sensitive species, and locally rare species (fine filter). A determination could then be made regarding how much of a particular habitat is on National Forest, and whether or not it currently supports the associated species. This level of classification does not capture finer scale habitat attributes (i.e. pool/riffle composition depth, specific substrate composition, etc.) that may be important to refine the predictive habitat maps. However, it is useful in determining general patterns in species distributions, and may indicate areas to survey for a species, or areas in which to promote habitat restoration and private land conservation measures.

This habitat classification is hierarchical and is based on an understanding of how habitat influences the composition and distribution of biological communities. It is based on four assumptions (Higgins et al. 1998):

1. Physiographic and climatic patterns influence the distribution of organisms, and can be used to predict the expected range of biological community types (Jackson and Harvey 1989; Tonn 1990; Maxwell et al. 1995; Angermeier and Winston 1998; Burnett et al. 1998).
2. The physical structure of aquatic habitats (or ecosystems) can be used to predict the distribution of aquatic communities (Gorman and Karr 1978; Schlosser 1982).
3. Aquatic habitats are continuous; however, generalizations about discrete patterns in habitat use can be made (Vannote et al. 1980; Schlosser 1982).
4. Using a nested classification system, (i.e. stream reach habitat types within species ranges), we can account for community diversity that is difficult to observe or to measure (taxonomic, genetic, or ecological) (Frissell et al. 1986; Angermeier and Schollsser 1995).

B. Watersheds and Species Range

The Forest stratified GWNF habitat by an individual species known range on or near the Forest using hydrologic units or watersheds. Hydrologic units have been consistently developed across both Virginia and West Virginia, and cover the extent of the Forest land. Specifically, habitat was identified as potential habitat for a species only if it was within a watershed that was within the known range of the species. For example, potential habitat for the roughhead shiner was limited to the James River Drainage, since it is not known from the Potomac Drainage. This captured both the geographic and physiographic aspects of species distribution.

Angermeier and Winston (1999) found that physiography and drainage together described 27% of the variance in fish species composition. In addition, they found that fish community types described by the drainage-physiography combination were more distinct than those described by drainage or physiography alone. The Ecoregional Drainage Unit (EDU) is a spatial representation of this variable. The EDU concept was incorporated by TNC. They developed aggregations of 8-digit hydrologic units based on similarities in several variable including geology, flow characteristics, and topography (Smith et al. 2002). The TNC dataset included size-1

Aquatic Ecological Systems that were extensively explored by the Forest for use in this process. Above the Forest Service boundary, aquatic ecosystems were smaller than what was defined by TNC as a size-1 Aquatic Ecological System, and a portion of Forest land was not classified; therefore, the TNC classification was not used.

Virginia's Wildlife Action Plan defined a total of 34 EDUs in Virginia, compiling 14 drainages and six ecoregions. Since Virginia's dataset did not include the land that the GWNF manages in WV, and since a WV stream classification system has not been completed, the GWNF decided to use hydrologic units stratified by species range.

C. Stream Reach Classification

Streams and rivers display continuous changes in physical and chemical characteristics from headwaters to mouth, which may influence the structure and function of biological communities along this continuum (Vannote et al. 1980). Factors of elevation, watershed size, and geology are interrelated along the continuum. These factors in turn influence the distribution, abundance, and productivity of stream flora and fauna.

The lotic (stream and river) aquatic ecosystems of the George Washington National Forest were characterized in a GIS environment using combinations of watershed size, elevation, and geology.

Table G1-1. Habitat attributes assigned to each stream reach.

Attribute	Description	Data Source
Stream Size	Determined by watershed area	DEM, NHD
Elevation	Stream segments above or below 610 meters (2000 feet)	DEM
Geology	The geological class intersection of the stream segment	GIS coverage of USGS geologic maps

Stream Size

Most species occupy streams or stream reaches of particular size ranges, thus their distributions are longitudinally zoned. Species richness in stream reaches is related to longitudinal zonation. Headwaters nearly universally have fewer species than do medium and large streams in the same system.

Stream size is directly related to watershed area, and was determined using the watershed area. Stream size classes were assigned that are consistent with what was used in Virginia's Wildlife Action Plan.

Watershed area was derived in GIS from a 10 meter digital elevation model (DEM). The DEM was downloaded from: http://fsweb.clearinghouse.fs.fed.us/

Individual quads were merged in ArcMap to create a mosaic covering the GWNF. Watershed information was then extracted from the DEM using an ArcMap extension called HydroTools available from the following web site: http://www.crwr.utexas.edu/gis/archydrobook/ArcHydroTools/Tools.htm

The first step that ArcHydro Tools does is called "DEM Reconditioning". This step is unique to this extension and forces the DEM generated streams to coincide with the blue line stream locations. The extension creates a folder called "Layers" and generates a new DEM called AgreeDEM. Subsequent steps in Preprocessing that need to be done include Fill Sinks, Flow Direction, and Flow Accumulation. The Flow Accumulation grid is the useful product. The value in each grid expresses the number of grids that flow into it. In a 10 meter DEM each grid represents an area of 100 square meters (10m X 10m). Area in grids can be later translated into area in square miles or acres. The stream network can be extracted with the next ArcHydro Tools step of Stream Definition. This identifies flow accumulation cells greater than a specified number and gives each a value of one. A flow accumulation value of 500 represents 12.4 acres and approximates the drainage needed to support a channeled ephemeral stream in the Southeast. The resulting grid is labeled STR. Using the Map

Calculator in Spatial Analyst, the STR grid can be multiplied by the Flow Accumulation grid to create a gridded stream network with watershed area in grids at intervals equal to the size of the grid (10 meters). Spatial Analyst was used to convert the grid (raster) to features as a polyline shapefile with a field called GRIDCODE that represents the watershed area upstream from each line segment in number of grids. Fields were then added to the attribute table of the shapefile. Use the calculate function to populate the fields with area in square miles (for a 10 meter grid, multiply "gridcode" by 0.00003861022). This value converts 10 meter – square grids into square miles. Thus, each segment of the stream polyline will have an attribute of watershed area attached to it.

Elevation

Stream temperature has been identified as an important factor to predict species distributions. However, it is difficult to predict in a landscape scale classification. Since stream temperature decreases predictably with increasing elevation in mountains, largely due to the temperature lapse rate of the atmosphere, we have included reach elevation (in feet) as a surrogate attribute for temperature (Flebbe et al. 2006). A reach elevation of 2000 ft was used as the break point between cold water and cool/warm water habitat. This corresponds with findings by Meisner (1990), and was validated by reviewing the aquatic community in selected reaches. In addition, recent research by Owen (2006) found that the threshold for year-round temperatures sufficient to sustain trout in the Monongahela National Forest of West Virginia was at 2000 ft elevation.

The DEM was used to select stream segments as being above or below 610 meters (2000 feet) and attributed accordingly.

Geology

Geologic structure and rock type influence local substrate, slope, and longitudinal profiles of the streambed, as well as influencing water chemistry. These factors in turn influence the distribution, abundance, and productivity of stream flora and fauna.

The topographical features of the GWNF are the result of differential erosion of rocks of different resistance. Ridges are made up of more resistant quartzites and granites, and valleys are composed of less resistant shales and limestones (Hack 1957). Thus, the smaller headwater streams are associated with higher elevations and more resistant geology. Conversely, the larger river systems are more commonly found in the valleys at lower elevations and on less resistant shales and limestones. The size of the stream bed material (substrate) is determined by rock type and drainage area. Resistant quartzites and granites produce stream channels with boulders and large cobbles. Shales produce stream bed material dominated by gravel and small cobble. The size of the stream bed material and the drainage area of the watershed determine stream channel gradient (slope). Stream channels dominated by boulders are commonly found to have steeper gradients than those dominated by gravels.

Bedrock and surficial geology, including Soils, also strongly influence the flow regime and water quality of a stream.

The flow of a stream or river varies over time in response to precipitation events over its watershed. Different rocks and Soils have different water infiltration and storage capacities. Watersheds underlain by rocks and Soils with large storage capacity will have smaller flood peaks and higher low flows than will watersheds whose rocks and Soils lack storage capacity. Differences in storage capacity are reflected in differences in the watershed's drainage density, expressed as the miles of stream channel per square mile or watershed. As storage capacity decreases, drainage density increases. As drainage density increase, flood peaks increase and low flows decrease.

Geology influences physical water quality of a stream because rock types decompose at different rates, and have different rates of denuation. Estimates of denudation rates for ridge-forming sandstones, and valley-forming shale for the Appalachians in Virginia are:

Sandstone	0.000078 inches per year	15 tons/sq. mile/year
Shale	0.00039 inches per year	75 tons/sq. mile/year

These translate into very different sediment yields. The annual sediment yield from shale is five times that of the sandstone. Similarly, turbidity (amount of solid particles suspended in water) differs by geology. Rock types that weather to produce colloidal size particles of silt and clay (ex. shales and impure limestone) will result in streams with greater potential turbidity. In contrast, sand and larger size particles will show little to no turbidity for the same or grater sediment concentrations.

Geology influences water chemistry as rocks are weathered and dissolved in water. The chemistry of the water can determine the heath or distribution of biota. For example, dissolved calcium can be a limiting factor in the distribution of many aquatic organisms, mollusks and crayfish in particular. Calcium levels would be highest in streams that flow through rocks that contain carbonate, such as limestone. Waters flowing through limestone also typically have high alkalinity and would be better able to buffer against dramatic changes in pH (such as from acid deposition). Waters flowing through granite and quartzite, typically have low alkalinity and poor buffering capacity.

Geology was obtained from the GWNF polygon GIS coverage created by manually digitizing available USGS geologic maps at scales of 1:24000 and 1:100,000.

Stream Types

Once the reaches were attributed, we divided the continuous variables into meaningful categories after some literature review and preliminary analyses of the data. We decided upon five categories for size, two categories for elevation, and five categories for geology (see Table G1-2).

Table G1-2. Aquatic habitat classification categories used for continuous variables

Stream Size:	Watershed area (sq. miles)	Class
Headwater	<2	100
Stream	2-10	200
Large stream	10-20	300
Small River	20-70	400
Large River	>70	500
Elevation (temperature regime):	Elevation (ft):	Class
Lower elevation (warm/cool water)	≤2000	10
Higher elevation (cold water)	>2000	20
Geology:	Rock Types:	Class
Sandstone/quartzite	Sandstone & quartzite	1
Limestone	limestone	2
Shale	shale	3
Granite	granite, metabasalt, proxene, gneiss	4
Charnokite/mylonite	charnikite & mylonite	5

The categories were concatenated by their assigned number to come up with a stream type for each reach that described the size, elevation, and geology (see Table G1-3).

Table G1-3. Miles of Lotic Habitat on GWNF by Stream Type.

Stream Type	Sum of Miles	Percent of Miles	Description	Example
111	153.41	13.02%	Headwater, lower elevation, sandstone/quartzite	Buck Lick Run, Rockingham Co.
112	50.38	4.27%	Headwater, lower elevation, limestone	Upper Kelly Run, Bath Co.
113	181.61	15.41%	Headwater, lower elevation, shale	Downy Branch, Allegheny Co.
114	18.44	1.56%	Headwater, lower elevation, granite	King Creek, Amherst Co.
115	8.08	0.69%	Headwater, lower elevation, charnokite/mylonite	Cedar Creek, Amherst Co.
121	240.60	20.41%	Headwater, higher elevation, sandstone/quartzite	Locust Spring Run, Highland Co.
122	24.93	2.11%	Headwater, higher elevation, limestone	Jordan Run, Bath Co.
123	47.98	4.07%	Headwater, higher elevation, shale	Upper Pitt Spring Run, Page Co.
124	12.93	1.10%	Headwater, higher elevation, granite	Crabtree Creek, Nelson Co.

Stream Type	Sum of Miles	Percent of Miles	Description	Example
125	3.85	0.33%	Headwater, higher elevation, charnokite/mylonite	Upp. N.F. Piney R., Nelson/Amherst
211	100.01	8.49%	Stream, lower elevation, sandstone/quartzite	Slate Lick Branch, Rockingham Co.
212	36.46	3.09%	Stream, lower elevation, limestone	Cub Run, Page Co.
213	74.76	6.34%	Stream, lower elevation, shale	Little Fork, Pendleton Co.
214	10.45	0.89%	Stream, lower elevation, granite	Shoe Creek, Nelson Co.
215	3.61	0.31%	Stream, lower elevation, charkonite/mylonite	Browns Creek, Amherst Co.
221	61.43	5.21%	Stream, higher elevation, sandstone/quartzite	Little Back Creek, Bath Co.
222	5.59	0.47%	Stream, higher elevation, limestone	Muddy Run, Bath Co.
223	9.06	0.77%	Stream, higher elevation, shale	Little Mill Creek, Bath Co.
224	5.39	0.46%	Stream, higher elevation, granite	S.F. Piney River, Amherst Co.
225	0.06	0.00%	Stream, higher elevation, charkonite/mylonite	Lower N.F. Piney R., Nelson/Amherst
311	12.52	1.06%	Large stream, lower elevation, sandstone/quartzite	Lower Cove Run, Hardy Co.
312	4.14	0.35%	Large stream, lower elevation, limestone	Smith Creek, Allegheny Co.
313	16.88	1.43%	Large stream, lower elevation, shale	Wilson Creek, Bath Co.
314	5.38	0.46%	Large stream, lower elevation, granite	Pedlar River, Amherst Co.
315	1.08	0.09%	Large stream, lower elevation, charnokite/mylonite	Piney River, Nelson/Amherst Co.
321	11.27	0.96%	Large stream, higher elevation, sandstone/quartzite	Skidmore Fork, Rockingham Co.
322	0.28	0.02%	Large stream, higher elevation, limestone	Dry Run, Bath Co.
323	0.03	0.00%	Large stream, higher elevation, shale	Shaws Fork, Highland Co.
411	21.21	1.80%	Small river, lower elevation, sandstone/quartzite	North River, Augusta Co.
412	2.04	0.17%	Small river, lower elevation, limestone	Trout Run, Hardy Co.
413	8.07	0.68%	Small river, lower elevation, shale	Dunlap Creek, Allegheny Co.
414	3.84	0.33%	Small river, lower elevation, granite	Pedlar River, Amherst Co.
415	2.30	0.19%	Small river, lower elevation, charnokite/mylonite	Tye River, Nelson Co.
421	3.86	0.33%	Small river, higher elevation, sandstone/quartzite	Laurel Fork, Highland Co.
423	0.14	0.01%	Small river, higher elevation, shale	Back Creek, Highland Co.
511	2.09	0.18%	Large river, lower elevation, sandstone/quartzite	Passage Creek, Shenandoah Co.
512	13.91	1.18%	Large river, lower elevation, limestone	Jackson River, Bath Co.
513	20.62	1.75%	Large river, lower elevation, shale	Cowpasture River, Bath Co.
	1178.66	100.00%		

D. Lake, Pond, and Wetland Classification

Lentic aquatic habitat has standing water and includes lakes, ponds, and swamps. It is primarily determined by slope (or gradient) and substrate or storage capacity. On the GWNF there are numerous small natural ponds and wetlands, in addition to human-built impoundments (reservoirs). Because they vary in size, depth, chemistry, hydro-period, and vegetation, there are often unique flora and fauna associated with these habitats.

Lentic habitat was identified on the George Washington National Forest using the National Land Cover Database (NLCD) for Virginia and West Virginia produced by the U.S. Geological Survey. This portion of the NLCD was created as part of land cover mapping activities for Federal Region III that includes the States of Maryland, Delaware, Pennsylvania, Virginia, West Virginia, and the District of Columbia. The NLCD classification contains 21 different land cover categories with a spatial resolution of 30 meters.

Citation_Information:
Originator: U.S. Geological Survey (USGS)
Publication_Date: 19990527
Title: Virginia Land Cover Data Set
Edition: 1
Geospatial_Data_Presentation_Form: raster digital data
Publication_Information:
Publication_Place: Sioux Falls, SD USA
Publisher: U.S. Geological Survey
http://erg.usgs.gov/isb/pubs/factsheets/fs10800.html

The NLCD layer has three lentic water cover classes, their definitions are below:

- Open water (NLCD 11) – All areas of open water: typically 25% or greater cover of water (per pixel).
- Woody Wetlands (NLCD 91) – Areas where forest or shrubland vegetation accounts for 25-100% of the cover and the Soil or substrate is periodically saturated with or covered with water.
- Emergent Herbaceous Wetlands (NLCD 92) – Areas where perennial herbaceous vegetation accounts for 75-100% of the cover and the Soil or substrate is periodically saturated with or covered with water.

Open water was further stratified by size and connectivity to lotic ecosystems (flowing water). Waterbodies greater than 5 acres were classified as lakes. Waterbodies smaller than 5 acres were classified as ponds. Lakes and ponds that intersected the NHD streams layer in GIS were classified as "connected to stream". Those that did not intersect were classified as "not connected to stream".

Thus, six unique lentic aquatic habitats were differentiated. The number of features, acres, and percent of each and total acres of lentic aquatic habitat are summarized in Table G1-4.

Table G1-4. Acres of Lentic Habitat on GWNF by Category.

Category	Abbreviation	Number	Acres on GWNF	Percent
Lake connected to a stream	LCS	34	2830.6	87.7%
Lake not connected to a stream	LNCS	2	20.9	0.6%
Pond connected to a stream	PCS	29	36.0	1.1%
Pond not connected to a stream	PNCS	81	70.5	2.2%
Emergent herbaceous wetland	EHW	139	85.0	2.6%
Woody wetland	WW	189	185.7	5.8%
TOTALS		474	3228.7	100.0%

The category of “Lake connected to a stream” covered the greatest amount of acres on the Forest because this category included the 2,530 acre Lake Moomaw.

E. Species-Habitat Relationships

Species collection records were compiled from the Virginia Department of Game and Inland Fisheries (VDGIF) collections database, Virginia Department of Conservation and Recreation’s Division of Natural Heritage (VDNH) records, West Virginia Division of Natural Resources (WVDNR) records, and USFS records. Using ArcMap®, records of selected species were connected to the attributed stream reaches or lakes/wetlands, allowing for remote characterization of the species’ habitats.

Once the connections were complete, we exported the data to a Microsoft Excel® spreadsheet and compiled a list of habitat classifications for each species. A query was run using ArcMap® to identify all the associated habitat types on the GWNF for each species, within their known range. The habitat types were identified first, and then clipped to the size HUC watershed appropriate to their known distribution near the Forest. For

example, based on known occurrences, the James River spinymussel was associated with habitat types 312, 313, 415, and 513 within the upper and middle James River watersheds.

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APPENDIX G2. DETAILED HABITAT OF AQUATIC SPECIES ON THE GWNF

Habitat Code	Stream (miles) or Lake (acres) Habitat	*Pleurobema collina* James spinymussel	*Scirpus ancistrochaetus* northeastern bulrush	*Helenium virginicum* Virginia sneezeweed	*Helonias bullata* swamp pink	*Notropis semperasper* Roughhead shiner	*Noturus gilberti* Orangefin madtom	*Hydraena maureenae* Maureen's shale stream beetle
111	Headwater, lower elevation, sandstone/quartzite				1.5			
112	Headwater, lower elevation, limestone							
113	Headwater, lower elevation, shale							150.9
114	Headwater, lower elevation, granitic							
115	Headwater, lower elevation, charnokite/mylonite							
121	Headwater, higher elevation, sandstone/quartzite				2.4			
122	Headwater, higher elevation, limestone							
123	Headwater, higher elevation, shale				0.1	37.6		
124	Headwater, higher elevation, granitic							
125	Headwater, higher elevation, charnokite/mylonite							
211	Stream, lower elevation, sandstone/quartzite				3.2			
212	Stream, lower elevation, limestone							
213	Stream, lower elevation, shale							
214	Stream, lower elevation, granitic							
215	Stream, lower elevation, charkonite/mylonite							
221	Stream, higher elevation, sandstone/quartzite				0.0			
222	Stream, higher elevation, limestone							
223	Stream, higher elevation, shale							
224	Stream, higher elevation, granitic							
225	Stream, higher elevation, charkonite/mylonite							
311	Large stream, lower elevation, sandstone/quartzite							
312	Large stream, lower elevation, limestone	0.2						
313	Large stream, lower elevation, shale	5.9						
314	Large stream, lower elevation, granitic							
315	Large stream, lower elevation, charnokite/mylonite							
321	Large stream, higher elevation, sandstone/quartzite							
322	Large stream, higher elevation, limestone							
323	Large stream, higher elevation, shale							
411	Small river, lower elevation, sandstone/quartzite							
412	Small river, lower elevation, limestone							
413	Small river, lower elevation, shale					5.1		
414	Small river, lower elevation, granitic							
415	Small river, lower elevation, charnokite/mylonite	1.6						
421	Small river, higher elevation, sandstone/quartzite							
423	Small river, higher elevation, shale					0.1		
511	Large river, lower elevation, sandstone/quartzite							
512	Large river, lower elevation, limestone					12.0	0.4	
513	Large river, lower elevation, shale	6.6				18.8	6.1	
TOTALS	Miles of stream habitat	14.3			7.3	73.7	6.5	150.9
WW	Woody wetland		1.1	0.22				
EHW	Emergent herbaceous wetland			1.56				
PNCS	Pond not connected to a stream			2.22				
PCS	Pond connected to a stream							
LNCS	Lake not connected to a stream							
LCS	Lake connected to a stream							
TOTALS	Acres of lake habitat		1.1	4				

Habitat Code	Stream (miles) or Lake (acres) Habitat	*Cicindela ancocisconensis* Tiger beetle	*Alasmidonta varicosa* Brook floater	*Elliptio lanceolata* Yellow lance	*Fusconaia masoni* Atlantic pigtoe	*Lasmigona subviridis* Green floater	*Villosa constricta* Notched Rainbow	*Ambystoma tigrinum* eastern tiger salamander
111	Headwater, lower elevation, sandstone/quartzite							
112	Headwater, lower elevation, limestone							
113	Headwater, lower elevation, shale							
114	Headwater, lower elevation, granitic							
115	Headwater, lower elevation, charnokite/mylonite							
121	Headwater, higher elevation, sandstone/quartzite							
122	Headwater, higher elevation, limestone							
123	Headwater, higher elevation, shale							
124	Headwater, higher elevation, granitic							
125	Headwater, higher elevation, charnokite/mylonite							
211	Stream, lower elevation, sandstone/quartzite							
212	Stream, lower elevation, limestone							
213	Stream, lower elevation, shale							
214	Stream, lower elevation, granitic							
215	Stream, lower elevation, charkonite/mylonite							
221	Stream, higher elevation, sandstone/quartzite							
222	Stream, higher elevation, limestone							
223	Stream, higher elevation, shale							
224	Stream, higher elevation, granitic							
225	Stream, higher elevation, charkonite/mylonite							
311	Large stream, lower elevation, sandstone/quartzite							
312	Large stream, lower elevation, limestone							
313	Large stream, lower elevation, shale				0.2			
314	Large stream, lower elevation, granitic							
315	Large stream, lower elevation, charnokite/mylonite							
321	Large stream, higher elevation, sandstone/quartzite							
322	Large stream, higher elevation, limestone							
323	Large stream, higher elevation, shale							
411	Small river, lower elevation, sandstone/quartzite							
412	Small river, lower elevation, limestone							
413	Small river, lower elevation, shale							
414	Small river, lower elevation, granitic							
415	Small river, lower elevation, charnokite/mylonite					2.3	2.3	
421	Small river, higher elevation, sandstone/quartzite							
423	Small river, higher elevation, shale							
511	Large river, lower elevation, sandstone/quartzite							
512	Large river, lower elevation, limestone			12.0			12.0	
513	Large river, lower elevation, shale	6.2	1.3	18.8		19.6	18.8	
TOTALS	Miles of stream habitat	6.2	1.3	30.8	0.2	21.9	33.1	
WW	Woody wetland							8
EHW	Emergent herbaceous wetland							26.02
PNCS	Pond not connected to a stream							5.12
PCS	Pond connected to a stream							
LNCS	Lake not connected to a stream							
LCS	Lake connected to a stream							
TOTALS	Acres of lake habitat							39.14

Habitat Code	Stream (miles) or Lake (acres) Habitat	*Empidonax alnorum* alder flycatcher	*Melospiza georgiana* swamp sparrow	*Seiurus noveboracensis* northern waterthrush	*Cambarus monongalensis* A Crayfish	*Salvelinus fontinalus* Brook trout	*Aeshna canadensis* Canada darner	*Aeshna tuberculifera* black-tipped darner	*Aeshna verticalis* green-striped darner
111	Headwater, lower elevation, sandstone/quarzite					153.4			
112	Headwater, lower elevation, limestone					50.4			
113	Headwater, lower elevation, shale					181.6			
114	Headwater, lower elevation, granitic					18.4			
115	Headwater, lower elevation, charnokite/mylonite					8.1			
121	Headwater, higher elevation, sandstone/quarzite				10.2	240.6			
122	Headwater, higher elevation, limestone					24.9			
123	Headwater, higher elevation, shale					48.0			
124	Headwater, higher elevation, granitic					12.9			
125	Headwater, higher elevation, charnokite/mylonite								
211	Stream, lower elevation, sandstone/quarzite					100.0			
212	Stream, lower elevation, limestone					36.5			
213	Stream, lower elevation, shale					74.8			
214	Stream, lower elevation, granitic					10.4			
215	Stream, lower elevation, charkonite/mylonite					3.6			
221	Stream, higher elevation, sandstone/quarzite				0.6	61.4			
222	Stream, higher elevation, limestone								
223	Stream, higher elevation, shale					9.1			
224	Stream, higher elevation, granitic					5.4			
225	Stream, higher elevation, charkonite/mylonite								
311	Large stream, lower elevation, sandstone/quarzite					12.5			
312	Large stream, lower elevation, limestone					4.1			
313	Large stream, lower elevation, shale								
314	Large stream, lower elevation, granitic					5.4			
315	Large stream, lower elevation, charnokite/mylonite								
321	Large stream, higher elevation, sandstone/quarzite				3.5	11.3			
322	Large stream, higher elevation, limestone								
323	Large stream, higher elevation, shale								
411	Small river, lower elevation, sandstone/quarzite				0.1	21.2			
412	Small river, lower elevation, limestone								
413	Small river, lower elevation, shale					8.1			
414	Small river, lower elevation, granitic								
415	Small river, lower elevation, charnokite/mylonite								
421	Small river, higher elevation, sandstone/quarzite				3.2	3.9			

423	Small river, higher elevation, shale								
511	Large river, lower elevation, sandstone/quarzite								
512	Large river, lower elevation, limestone					13.9			
513	Large river, lower elevation, shale								
TOTALS	Miles of stream habitat				17.6	1119.9			
WW	Woody wetland	185.7		185.7				26.47	
EHW	Emergent herbaceous wetland		84.95	84.95			26.47	35.81	26.47
PNCS	Pond not connected to a stream						3.56	9.12	3.56
PCS	Pond connected to a stream						4.67	12.68	4.67
LNCS	Lake not connected to a stream								
LCS	Lake connected to a stream							5.34	
TOTALS	Acres of lake habitat	185.7	84.95	270.65			34.7	89.42	34.7

Habitat Code	Stream (miles) or Lake (acres) Habitat	*Calopteryx amata* Superb jewelwing	*Calopteryx angustipennis* Appalachian jewelwing	*Celithemis martha* Martha's penant	*Cordulegaster diastatops* delta-spotted spiketail	*Enallagma annexum* northern bluet	*Epitheca canis* beaverpond baskettail	*Leucorrhinia hudsonica* Hudsonian whiteface
111	Headwater, lower elevation, sandstone/quartzite							
112	Headwater, lower elevation, limestone							
113	Headwater, lower elevation, shale							
114	Headwater, lower elevation, granitic							
115	Headwater, lower elevation, charnokite/mylonite							
121	Headwater, higher elevation, sandstone/quartzite	10.2			10.23			
122	Headwater, higher elevation, limestone							
123	Headwater, higher elevation, shale							
124	Headwater, higher elevation, granitic							
125	Headwater, higher elevation, charnokite/mylonite							
211	Stream, lower elevation, sandstone/quartzite							
212	Stream, lower elevation, limestone							
213	Stream, lower elevation, shale							
214	Stream, lower elevation, granitic							
215	Stream, lower elevation, charkonite/mylonite							
221	Stream, higher elevation, sandstone/quartzite	0.6						
222	Stream, higher elevation, limestone							
223	Stream, higher elevation, shale							
224	Stream, higher elevation, granitic							
225	Stream, higher elevation, charkonite/mylonite							
311	Large stream, lower elevation, sandstone/quartzite							
312	Large stream, lower elevation, limestone							
313	Large stream, lower elevation, shale							
314	Large stream, lower elevation, granitic							
315	Large stream, lower elevation, charnokite/mylonite							
321	Large stream, higher elevation, sandstone/quartzite	3.5						
322	Large stream, higher elevation, limestone							
323	Large stream, higher elevation, shale							
411	Small river, lower elevation, sandstone/quartzite	0.1						
412	Small river, lower elevation, limestone							
413	Small river, lower elevation, shale							
414	Small river, lower elevation, granitic							
415	Small river, lower elevation, charnokite/mylonite							
421	Small river, higher elevation, sandstone/quartzite	3.2						
423	Small river, higher elevation, shale							
511	Large river, lower elevation, sandstone/quartzite							
512	Large river, lower elevation, limestone							
513	Large river, lower elevation, shale		0.087					
TOTALS	Miles of stream habitat	17.6	0.1		10.2			
WW	Woody wetland			26.47				
EHW	Emergent herbaceous wetland			9.34		26.47	26.47	26.47
PNCS	Pond not connected to a stream			5.56		3.56	3.56	3.56
PCS	Pond connected to a stream			8.01		4.67	4.67	4.67
LNCS	Lake not connected to a stream							
LCS	Lake connected to a stream			5.34				
TOTALS	Acres of lake habitat			54.72		34.7	34.7	34.7

Habitat Code	Stream (miles) or Lake (acres) Habitat	*Gomphus adelphus* mustached clubtail	*Gomphus quadricolor* rapids clubtail	*Ladona julia* chalk-fronted corporal skimmer	*Lanthus parvulus* double-striped clubtail	*Lestes disjunctus* Northern spreadwing	*Nycticorax nyciticorax* Black-crowned night heron	*Nyctanassa violacea* Yellow-crowned night heron
111	Headwater, lower elevation, sandstone/quarzite				0.31			
112	Headwater, lower elevation, limestone				1.51			
113	Headwater, lower elevation, shale							
114	Headwater, lower elevation, granitic							
115	Headwater, lower elevation, charnokite/mylonite							
121	Headwater, higher elevation, sandstone/quarzite				10.84			
122	Headwater, higher elevation, limestone				0.11			
123	Headwater, higher elevation, shale				0.39			
124	Headwater, higher elevation, granitic							
125	Headwater, higher elevation, charnokite/mylonite							
211	Stream, lower elevation, sandstone/quarzite							
212	Stream, lower elevation, limestone							
213	Stream, lower elevation, shale							
214	Stream, lower elevation, granitic							
215	Stream, lower elevation, charkonite/mylonite							
221	Stream, higher elevation, sandstone/quarzite							
222	Stream, higher elevation, limestone							
223	Stream, higher elevation, shale							
224	Stream, higher elevation, granitic							
225	Stream, higher elevation, charkonite/mylonite							
311	Large stream, lower elevation, sandstone/quarzite							
312	Large stream, lower elevation, limestone							
313	Large stream, lower elevation, shale							
314	Large stream, lower elevation, granitic							
315	Large stream, lower elevation, charnokite/mylonite							
321	Large stream, higher elevation, sandstone/quarzite							
322	Large stream, higher elevation, limestone							
323	Large stream, higher elevation, shale							
411	Small river, lower elevation, sandstone/quarzite							
412	Small river, lower elevation, limestone							
413	Small river, lower elevation, shale	5.1	5.1					
414	Small river, lower elevation, granitic							
415	Small river, lower elevation, charnokite/mylonite							
421	Small river, higher elevation, sandstone/quarzite							
423	Small river, higher elevation, shale							
511	Large river, lower elevation, sandstone/quarzite						2.09	2.09
512	Large river, lower elevation, limestone						13.91	13.91
513	Large river, lower elevation, shale	18.8	18.8				20.62	20.62
TOTALS	Miles of stream habitat	23.9	23.9		13.2		36.6	36.6
WW	Woody wetland						185.7	185.7
EHW	Emergent herbaceous wetland			26.47		26.47		
PNCS	Pond not connected to a stream			3.56		3.56		
PCS	Pond connected to a stream			4.67		4.67		
LNCS	Lake not connected to a stream							
LCS	Lake connected to a stream							
TOTALS	Acres of lake habitat			34.7		34.7	185.7	185.7

Habitat Code	Stream (miles) or Lake (acres) Habitat	*Nehalennia irene* sedge sprite	*Neurocordulia yamaskanensis* stygian shadowdragon	*Rhionaeschna mutata* spatterdock darner	*Somatochlora elongata* Ski-tipped emerald	*Sympetrum obtrusum* white-faced meadowhawk	*Anas rubripes* Amer. Black duck
111	Headwater, lower elevation, sandstone/quarzite						
112	Headwater, lower elevation, limestone						
113	Headwater, lower elevation, shale						
114	Headwater, lower elevation, granitic						
115	Headwater, lower elevation, charnokite/mylonite						
121	Headwater, higher elevation, sandstone/quarzite						
122	Headwater, higher elevation, limestone						
123	Headwater, higher elevation, shale						
124	Headwater, higher elevation, granitic						
125	Headwater, higher elevation, charnokite/mylonite						
211	Stream, lower elevation, sandstone/quarzite						
212	Stream, lower elevation, limestone						
213	Stream, lower elevation, shale						
214	Stream, lower elevation, granitic						
215	Stream, lower elevation, charkonite/mylonite						
221	Stream, higher elevation, sandstone/quarzite						
222	Stream, higher elevation, limestone						
223	Stream, higher elevation, shale						
224	Stream, higher elevation, granitic						
225	Stream, higher elevation, charkonite/mylonite						
311	Large stream, lower elevation, sandstone/quarzite						
312	Large stream, lower elevation, limestone						
313	Large stream, lower elevation, shale						
314	Large stream, lower elevation, granitic						
315	Large stream, lower elevation, charnokite/mylonite						
321	Large stream, higher elevation, sandstone/quarzite						
322	Large stream, higher elevation, limestone						
323	Large stream, higher elevation, shale						
411	Small river, lower elevation, sandstone/quarzite						
412	Small river, lower elevation, limestone						
413	Small river, lower elevation, shale						
414	Small river, lower elevation, granitic						
415	Small river, lower elevation, charnokite/mylonite						
421	Small river, higher elevation, sandstone/quarzite						
423	Small river, higher elevation, shale						
511	Large river, lower elevation, sandstone/quarzite						2.09
512	Large river, lower elevation, limestone		13.9				13.91
513	Large river, lower elevation, shale		20.6				20.62
TOTALS	Miles of stream habitat		34.5				36.6
WW	Woody wetland			26.47			185.7
EHW	Emergent herbaceous wetland	26.47		9.34	26.47	26.47	
PNCS	Pond not connected to a stream	3.56		5.56	3.56	3.56	
PCS	Pond connected to a stream	4.67		8.01	4.67	4.67	
LNCS	Lake not connected to a stream						
LCS	Lake connected to a stream						
TOTALS	Acres of lake habitat	34.7		49.38	34.7	34.7	185.7

Habitat Code	Stream (miles) or Lake (acres) Habitat	*Isonychia hoffmani* Hoffman's Isonychia mayfly	*Nemotaulius hostilis* limnephilid caddisfly	*Sorex palustris punctulatus* southern water shrew	*Clemmys guttata* spotted turtle	*Glyptemys insculpta* wood turtle	*Anguilla rostrata* American eel	*Anax longipes* comet darner
111	Headwater, lower elevation, sandstone/quarzite					60.9		
112	Headwater, lower elevation, limestone					25.4		
113	Headwater, lower elevation, shale					29.0		
114	Headwater, lower elevation, granitic						15.5	
115	Headwater, lower elevation, charnokite/mylonite						8.1	
121	Headwater, higher elevation, sandstone/quarzite	10.2		6.8				
122	Headwater, higher elevation, limestone							
123	Headwater, higher elevation, shale					6.4		
124	Headwater, higher elevation, granitic							
125	Headwater, higher elevation, charnokite/mylonite							
211	Stream, lower elevation, sandstone/quarzite					38.3	64.8	
212	Stream, lower elevation, limestone					13.8	17.3	
213	Stream, lower elevation, shale					23.0		
214	Stream, lower elevation, granitic						9.7	
215	Stream, lower elevation, charkonite/mylonite						3.5	
221	Stream, higher elevation, sandstone/quarzite	0.6		0.6		6.3		
222	Stream, higher elevation, limestone							
223	Stream, higher elevation, shale							
224	Stream, higher elevation, granitic							
225	Stream, higher elevation, charkonite/mylonite							
311	Large stream, lower elevation, sandstone/quarzite					2.0		
312	Large stream, lower elevation, limestone					1.7		
313	Large stream, lower elevation, shale					4.0		
314	Large stream, lower elevation, granitic						4.0	
315	Large stream, lower elevation, charnokite/mylonite							
321	Large stream, higher elevation, sandstone/quarzite	3.5		2.7				
322	Large stream, higher elevation, limestone							
323	Large stream, higher elevation, shale							
411	Small river, lower elevation, sandstone/quarzite	0.1		0.1		2.5	15.7	
412	Small river, lower elevation, limestone					0.2		
413	Small river, lower elevation, shale					3.0	3.0	
414	Small river, lower elevation, granitic							
415	Small river, lower elevation, charnokite/mylonite						2.3	
421	Small river, higher elevation, sandstone/quarzite	3.2		3.3				
423	Small river, higher elevation, shale							
511	Large river, lower elevation, sandstone/quarzite							
512	Large river, lower elevation, limestone							
513	Large river, lower elevation, shale					1.3	1.8	
TOTALS	Miles of stream habitat	17.6		13.5		217.6	145.6	
WW	Woody wetland							26.47
EHW	Emergent herbaceous wetland		26.47		1.11			9.34
PNCS	Pond not connected to a stream		3.56		5.34			5.56
PCS	Pond connected to a stream		4.67					8.01
LNCS	Lake not connected to a stream							
LCS	Lake connected to a stream							
TOTALS	Acres of lake habitat		34.7		6.45			49.4

APPENDIX G3. AQUATIC SPECIES WITHIN GWNF SPECIAL BIOLOGICAL AREAS

Group	SCIENTIFIC NAME	COMMON NAME	Big Levels	Browns Pond	Coal Road	Dabney Lancaster Shale Barren	Loves Run Ponds	Maple Flats	Maple Springs	Peters Mill Run	Pines Chapel Pond	Potts Pond	Powells Fort Camp
amphib	*Ambystoma tigrinum*	eastern tiger salamander	X				X	X			X		
insect/ odonate	*Aeshna tuberculifera*	black-tipped darner						X				X	
insect/ odonate	*Celithemis martha*	Martha's penant						X					
plant	*Boltonia montana*	no common name						X					
plant	*Carex aquatilis*	water sedge	X										
plant	*Carex barrattii*	Barratt's sedge						X					
plant	*Carex buxbaumii*	Buxbaum's sedge						X					
plant	*Carex vesicaria*	inflated sedge		X									
plant	*Cypripedium reginae*	showy lady's-slipper								X			X
plant	*Eleocharis melanocarpa*	black-fruited spikerush					X	X					
plant	*Eleocharis robbinsii*	Robbins spikerush						X					

Group	SCIENTIFIC NAME	COMMON NAME	Big Levels	Browns Pond	Coal Road	Dabney Lancaster Shale Barren	Loves Run Ponds	Maple Flats	Maple Springs	Peters Mill Run	Pines Chapel Pond	Potts Pond	Powells Fort Camp
plant	*Eriocaulon aquaticum*	white buttons						X					
plant	*Helenium virginicum*	Virginia sneezeweed	X		X		X	X			X		
plant	*Helonias bullata*	swamp pink	X					X					
plant	*Hypericum boreale*	northern St. John's-wort					X	X					
plant	*Isoetes virginica*	Virginia quillwort						X					
plant	*Juncus brachycephalus*	small-head rush										X	
plant	*Liparis loeselii*	Loesel's twayblade								X			
plant	*Lycopodiella inundata*	northern bog clubmoss						X					
plant	*Panicum hemitomon*	maidencane						X					
plant	*Potamogeton oakesianus*	Oakes pondweed					X	X					
plant	*Sabatia campanulata*	slender marsh rose-pink						X					

Group	SCIENTIFIC NAME	COMMON NAME	Big Levels	Browns Pond	Coal Road	Dabney Lancaster Shale Barren	Loves Run Ponds	Maple Flats	Maple Springs	Peters Mill Run	Pines Chapel Pond	Potts Pond	Powells Fort Camp
plant	*Schoenoplectus subterminalis*	water bulrush						X					
plant	*Scirpus ancistrochaetus*	northeastern bulrush							X			X	
plant	*Vaccinium macrocarpon*	large cranberry	X					X					
plant	*Vitis rupestris*	sand grape				X							
plant	*Woodwardia virginica*	Virginia chainfern					X						
reptile	*Clemmys guttata*	spotted turtle						X					

APPENDIX G4. AQUATIC SPECIES WITHIN PROPOSED SPECIAL BIOLOGICAL AREAS

Group	SCIENTIFIC NAME	COMMON NAME	CAST STEEL POND	CELLAR MTN	COLD SPRINGS BRANCH	GRASSY POND	HIDDEN VALLEY	HUMPBACK MTN	INDIAN GRAVE RIDGE	JAMES RIVER GORGE	LAUREL FORK	MTN VIEW CHURCH	OVERALL RIVERSIDE	POND RUN POND	UPPER CRABTREE	UPPER ST. MARYS	WATERFALL MTN
amphib	*Ambystoma tigrinum*	eastern tiger salamander				X											
fish	*Notropis semperasper*	Roughhead shiner					X										
insect/ odonate	*Aeshna canadensis*	Canada darner									X						
insect/ odonate	*Aeshna tuberculifera*	black-tipped darner									X						
insect/ odonate	*Aeshna verticalis*	green-striped darner									X						
insect/ odonate	*Calopteryx amata*	Superb jewelwing									X						
insect/ odonate	*Cordulegaster diastatops*	delta-spotted spiketail									X						
insect/ odonate	*Enallagma annexum (AKA cyathigerum)*	northern bluet									X						
insect/ odonate	*Epitheca canis*	beaverpond baskettail									X						
insect/ odonate	*Ladona julia (AKA Libellula julia)*	chalk-fronted corporal skimmer									X						
insect/ odonate	*Lanthus parvulus*	double-striped clubtail									X						
insect/ odonate	*Lestes disjunctus*	northern spreadwing									X						
insect/ odonate	*Leucorrhinia hudsonica*	Hudsonian whiteface									X						
insect/ odonate	*Nehalennia irene*	sedge sprite									X						
insect/ odonate	*Rhionaeschna mutata (AKA Aeshna mutata)*	spatterdock darner				X					X						

Group	SCIENTIFIC NAME	COMMON NAME	CAST STEEL POND	CELLAR MTN	COLD SPRINGS BRANCH	GRASSY POND	HIDDEN VALLEY	HUMPBACK MTN	INDIAN GRAVE RIDGE	JAMES RIVER GORGE	LAUREL FORK	MTN VIEW CHURCH	OVERALL RIVERSIDE	POND RUN POND	UPPER CRABTREE	UPPER ST. MARYS	WATERFALL MTN
insect/ odonate	*Somatochlora elongata*	Ski-tipped emerald									X						
insect/ odonate	*Sympetrum obtrusum*	white-faced meadowhaw k									X						
insect	*Isonychia hoffmani*	Hoffman's Isonychia mayfly									X						
mammal	*Sorex palustris punctulatus*	southern water shrew									X						
plant	*Eleocharis compressa*	flattened spikerush							X								
plant	*Epilobium leptophyllum*	linear-leaved willow-herb									X				X		
plant	*Glyceria grandis*	American manna-grass									X						
plant	*Helenium virginicum*	Virginia sneezeweed				X											
plant	*Helonias bullata*	swamp pink		X	X							X				X	
plant	*Juncus brevicaudatus*	narrow-panicled rush									X						
plant	*Liparis loeselii*	Loesel's twayblade															X
plant	*Muhlenbergia glomerata*	marsh muhly						X									
plant	*Polanisia dodecandra*	common clammy-weed								X							
plant	*Sagittaria calycina var calycina*	long-lobed arrowhead					X										

Group	SCIENTIFIC NAME	COMMON NAME	CAST STEEL POND	CELLAR MTN	COLD SPRINGS BRANCH	GRASSY POND	HIDDEN VALLEY	HUMPBACK MTN	INDIAN GRAVE RIDGE	JAMES RIVER GORGE	LAUREL FORK	MTN VIEW CHURCH	OVERALL RIVERSIDE	POND RUN POND	UPPER CRABTREE	UPPER ST. MARYS	WATERFALL MTN
plant	*Scirpus ancistrochaetus*	northeastern bulrush	X											X			
plant	*Solidago rupestris*	riverbank goldenrod							X				X				
plant	*Solidago uliginosa*	bog goldenrod									X						
plant	*Sparganium chlorocarpum*	narrow-leaf burreed									X						
plant	*Spartina pectinata*	freshwater cordgrass								X							
plant	*Sphagnum russowii*	Russow's peatmoss									X						
plant	*Spiranthes ochroleuca*	yellow nodding ladies'-tresses									X						

APPENDIX G5. WATERSHED ANALYSIS FOR GWNF PLAN REVISION

The introduction, purpose and need, objectives, methods, and watershed parameters in the following analysis (except for the species information) are derived from A Watershed Analysis For Forest Planning on the George Washington & Jefferson National Forests, January 17, 2002, George Washington and Jefferson National Forests, Roanoke, Virginia.

INTRODUCTION

At the direction of the Regional Forester, a team was assembled to develop a watershed analysis process that would pertain directly to the forests under revision in the Southern Region. Watershed analysis at this scale is a relatively new concept and few examples exist to emulate. The team relied on the publication, Ecosystem Analysis at the Watershed Scale: Federal Guide for Watershed Analysis (1995 Version 2.2, Regional Interagency Executive Committee, Portland, Oregon), Inland West Watershed Reconnaissance efforts, White River National Forest Watershed Analysis, Chattooga River Ecosystem Demonstration Project and procedures used in the Ozark-Ouachita Highland Assessment.

PURPOSE AND NEED

The Federal Guide for Watershed Analysis (1995) defines Watershed Analysis as:

> "A procedure to characterize the human, aquatic, riparian and terrestrial features, conditions, processes, and interactions within a watershed. It provides a systematic way to understand and organize ecosystem information. In doing so, watershed analysis enhances our ability to estimate direct, indirect and cumulative effects of our activities and guide the general type, location and sequence of appropriate management activities within a watershed."

The Forest Service has routinely debated and struggled to understand watershed condition, cumulative effects, and how management activities and human interactions impact aquatic resources. By approaching these issues spatially on a watershed scale it will add to our understanding of these processes and human interactions. Once we clearly understand the watershed processes and disturbances over time that creates the existing condition, we can then determine social needs and make better informed and science based management decisions for the future.

The Region 8 "Watershed Analysis Procedure" is a starting point for determining and ranking watershed health. The procedure follows a rapid characterization of 5th level Hydrologic Units, also referred to as watersheds in this document. Descriptive indicators of watershed condition and watershed vulnerability are used that are indicative of the relative health of a watershed. Watershed analysis must include complete watershed areas at the 5th field level. There the data represent private as well as public lands.

OBJECTIVES

The objective of the watershed analysis procedure is to provide an assessment of watershed health for 5th level watersheds containing portions of the George Washington and Jefferson National Forests. This assessment produces a comparison of watershed condition and watershed vulnerability among these watersheds. From this assessment the Forest Planning Team should be able to:

- Incorporate watershed analysis into the Forest Plan revision process
- Discuss desired future conditions at the watershed scale,
- Facilitate discussion of effects of forest management activities at the watershed level,
- Prioritize watershed restoration needs,
- Determine riparian prescriptions based on watershed condition and vulnerability,

- Recommend alternative management emphases based on watershed health and
- Prioritize where subsequent finer detailed watershed assessments should occur. At the next lower scale.

A goal for watershed management in the East is to "save the best and restore the rest" where feasible. This assessment provides a basis for establishing management strategies that will help achieve this goal.

OVERVIEW OF THE PROCESS

The EWAP is a rapid characterization of 5th level Hydrologic Units that are termed watersheds in this document. The assessment process follows a logical sequence that provides the basis for describing the existing conditions within a watershed in an objective and credible format:

A. Develop set of watershed parameters based on core set and any supplemental parameters;
B. Assemble pertinent data (appropriate GIS coverages, aquatic information, etc.);
C. Build database of information for each watershed based on a set of parameters already developed;
D. Rank the parameter values among watersheds;
E. Summarize ranks to derive condition and vulnerability scores per watershed; and
F. Compile results (graphics, data, ranks) into an assessment report.

METHODS

Recognizing time constraints within the revision process, the proposed watershed analysis relies only on existing or readily derived data sets. The following guidelines were adopted for the development of the watershed analysis process to insure consistency between each forest:

1. The resolution of data would be at Forest Planning scale (usually 1:100,000). Finer resolution could be used if the data were available for all the watersheds within the area of interest.
2. The watershed boundaries would follow 5th level Hydrologic Units as defined by NRCS / Multi-agency Maps. The Forest may choose to redefine some Hydrologic Unit boundaries as long as the watershed retained the 5th level size (40,000 - 250,000 acres). Watersheds (5th level Hydrologic Units) where National Forest land was inconsequential (less than 1 percent of the watershed) were dropped from analysis.
3. The data for the analysis (excluding watershed boundaries) would already exist or be readily derived. The data would include non-Forest Service lands within the watershed.
4. Stream coverages would be represented by EPA RF3 stream reach streams.

The *Federal Guide* (referenced above) describes a six-step process for watershed analysis that sets the stage for subsequent decision-making. The information, organized by watershed, is to be used as a prelude to NEPA analysis and help prioritize ecological needs. Since the Southern Appalachian Forest Plan revision process is already well past issue identification and alternative development, the team decided to adapt the portions of the *Federal Guide* that would best fit the revision process. In brief, the watershed analysis process was based on parameters that described the existing physical and ecological conditions within a watershed as well as the parameters that are susceptible to change as a result of Forest Service management activities. Other parameters were used that reflected trends. These parameters formed the basis for ranking watersheds.

WATERSHED PARAMETERS

Core watershed parameters were identified (Table G5-1) that would be applicable on all forests. Further examination of the parameters revealed that the parameters grouped into two broad categories: condition and vulnerability. Condition parameters reflected natural and human factors that potentially affected watershed health. Vulnerability parameters denoted characteristics that could be changed (positive or negative) as a result of Forest Service management activities. The core parameters were grouped as shown in Table G5-1.

Road density and drainage density were derived data and the accuracy of information was recognized as being marginal at the 1; 100,000 scale. Both of these parameters were selected as core parameters since their information is very useful in comparison between watersheds and, together, they serve as an indirect measure of the density of road-stream crossings.

Table G5-1. Core Parameters for Watershed Analysis

Category	Watershed Parameter	Data Management	Data Source
Condition	National Forest ownership	Percent of national forest within the watershed	Forest Derived
	Road Density	Length of highway divided by watershed area expressed as a percentage	MAIA Data
	Forested Land Use	Percent of forest cover within the watershed	MAIA Data
	Mines	Number of mines found in the watershed	MAIA Data
	Agricultural land slopes > 3%	Spatial query of MAIA cropland or pasture land use and DEM slope coverage.	MAIA Derived
	Forested Riparian	Length of streams flowing through forested land cover divided by total length of streams in watershed	MAIA Data
	Road – riparian interaction	Percent of total stream length in each HUC that has road within 30 meters.	MAIA Derived
	Point sources of pollution	Sum of ricris, cercla, pcs, and ifd sites	EPA - Basins data
	Recreation pressure	A ranking by the forest recreation staff of recreation pressure.	Forest Derived
	Impoundments	Number of dams found in the watershed	EPA - Basins data
	Native Fish	Number of native fish species divided by total number of fish species expressed as a percentage.	Forest Derived
Vulnerability	Erodible Soils	Percent of area with (Soil erodibility factor X sq. root of max slope range) greater than 1.20	NRCS STATSGO
	State Impaired Waters	Total length of impaired streams divided by total stream length expressed as a percentage.	Forest Derived
	Acid Deposition Sensitivity	Percent of watershed with high acid deposition sensitivity	Forest Derived
	Number Aquatic TES Species	Number of species found in watershed	Forest Derived
	Occurrences of TES species	Number of occurrences of TES species by watershed	Forest Derived
	Endemic Fish	Number of species found in watershed	Forest Derived
	Public Water Supply Sources	Number of drinking water sources found in the watershed	EPA - Basins data
	Drainage Density	Length of streams divided by watershed area expressed as a percentage.	MAIA Data

ANALYSIS FOR AQUATIC ECOLOGICAL SUSTAINABILITY 2010

A subset of the above parameters was used to characterize the GWNF watersheds for the 2010 aquatic ecological sustainability analysis. In addition, the number of aquatic TE, S, and LR within each watershed was tabulated (see Table G5-2). Birds and non-TE plants were not included in this analysis because species occurrence locations were not readily available in GIS format. In order to assess the importance of Forest lands to the species from an eco-regional and planning area perspective, it was noted whether the species occurrence was only on National Forest, on both National Forest and private land, or only on private land within each watershed (see Table G5-3). The potential habitat on the GWNF for individual species is detailed in Appendix G2, and can be used to assess the importance of Forest lands to species habitat from a unit perspective.

Table G5-2. Characterization of the 5th level watersheds containing GWNF land

5TH LEVEL HUC WATERSHEDS (2002)	PERCENT GWNF	PERCENT FORESTED LAND USE	PERCENT RIPARIAN AREA IN FORESTED LAND USE	ROAD DENSITY	ROAD-RIPARIAN INTERACTION	POINT SOURCES OF POLLUTION	NO. DAMS	DRAINAGE DENSITY	PUBLIC WATER SUPPLY SOURCES	PERCENT IMPAIRED STREAMS	ACID DEPOSITION SENSITIVITY	TOTAL NO. TE/S/LR	NATIONAL FOREST TE/S/LR	NATIONAL FOREST & PRIVATE TE/S/LR	PRIVATE TE/S/LR
0207000102	5.2%	88.1%	82.1%	1.22	3.920	7	0	1.15	2	20.3%	0.80	20	17	3	0
0207000106	29.4%	87.9%	81.7%	1.37	4.762	11	23	1.53	2	20.9%	1.00	2	0	1	1
0207000301	19.9%	87.4%	83.4%	1.44	5.030	20	6	1.41	0	4.4%	1.00	3	0	2	1
0207000501	9.8%	38.7%	40.2%	2.72	5.296	60	4	1.40	2	19.7%	0.36	1	0	0	1
0207000502	59.1%	74.7%	71.0%	1.59	4.600	15	10	1.42	2	7.3%	0.71	5	3	1	1
0207000504	19.6%	62.8%	63.3%	2.57	3.356	53	15	1.44	2	12.3%	0.41	11	5	4	2
0207000505	9.5%	66.9%	64.1%	2.08	3.501	24	4	1.71	2	13.2%	0.45	5	1	1	3
0207000506	7.4%	70.3%	66.9%	2.52	4.249	59	4	1.61	6	11.8%	0.35	3	0	2	1
0207000601	52.5%	91.0%	86.4%	1.50	5.019	0	4	1.52	0	0.0%	1.00	3	1	2	0
0207000602	5.5%	39.5%	44.1%	2.62	3.946	41	1	1.54	12	17.4%	0.22	4	1	0	3
0207000603	27.9%	65.3%	65.6%	2.47	4.307	70	9	1.62	7	2.3%	0.73	7	1	2	4
0207000604	18.8%	73.2%	78.3%	1.77	3.154	16	4	1.48	0	0.1%	0.69	3	0	3	0
0208020102	41.5%	92.4%	86.0%	1.10	4.088	2	1	1.47	1	0.0%	1.00	2	0	1	1
0208020103	26.4%	92.4%	87.2%	1.16	3.236	1	1	1.73	3	0.0%	1.00	7	2	1	4
0208020104	41.2%	86.3%	73.7%	1.32	3.360	13	5	1.48	0	0.0%	0.98	5	0	3	2
0208020105	38.3%	89.0%	82.6%	1.90	2.573	34	4	1.52	7	7.5%	1.00	8	0	1	7
0208020106	58.6%	91.0%	85.5%	1.32	2.480	3	3	1.59	0	0.0%	1.00	11	1	4	6
0208020107	5.0%	74.0%	66.7%	1.81	3.057	7	0	1.76	2	4.0%	0.59	7	0	0	7
0208020108	0.8%	91.7%	87.5%	1.16	2.624	5	4	1.69	0	0.0%	1.00	11	0	1	10
0208020201	58.8%	91.5%	87.5%	1.32	3.094	2	2	1.65	0	0.0%	1.00	7	1	1	5
0208020202	29.5%	85.8%	80.6%	2.03	4.672	0	1	1.85	0	1.2%	1.00	1	0	1	0
0208020203	9.0%	58.6%	54.0%	2.32	3.971	26	2	1.49	4	10.7%	0.30	4	1	0	3
0208020204	33.9%	71.1%	72.2%	1.60	3.039	0	3	1.30	0	0.0%	0.41	2	1	1	0
0208020301	16.2%	79.7%	79.2%	2.98	2.775	130	30	1.73	15	7.4%	0.16	6	0	1	5
0208020303	16.9%	81.3%	76.7%	1.86	2.995	5	4	1.52	0	0.0%	0.13	3	0	2	1
0208020304	8.4%	78.7%	76.3%	2.08	2.442	5	8	1.59	5	1.0%	0.22	2	0	2	0
0208020306	0.9%	87.7%	80.3%	1.71	4.452	4	9	1.63	2	1.2%	0.21	2	0	1	1

Table G5-3. Species occurrence by watershed and land ownership (NF = on National Forest only, NFP = on both National Forest and private land, P = on private land only)

SCIENTIFIC NAME	COMMON NAME	0207000102	0207000106	0207000301	0207000501	0207000502	0207000504	0207000505	0207000506	207000601	0207000602	0207000603	0207000604	0208020102	0208020103	0208020104	0208020105	0208020106	0208020107	0208020108	0208020201	0208020202	0208020203	0208020204	0208020301	0208020303	0208020304	0208020306
Pleurobema collina	James spinymussel														P			P	P	P	P				P			
Helenium virginicum	Virginia sneezeweed						NF P	P																				
Helonias bullata	swamp pink						NF P																	NF				
Scirpus ancistrochaetus	northeastern bulrush					NF	P	P							NF	P												
Notropis semperasper	Roughhead shiner													P	P	NF P	P	NF P	P	P	P							
Noturus gilberti	Orangefin madtom																	P		P								
Hydraena maureenae	Maureen's shale stream beetle									NF							P	NF P		P	NF							
Cicindela ancocisconensis	a tiger beetle																P	NF P										
Sorex palustris punctulatus	southern water shrew	NF P														NF P												
Alasmidonta varicosa	Brook floater								P		P	P																
Elliptio lanceolata	Yellow lance																P	P	P	P			P		P			
Fusconaia masoni	Atlantic pigtoe																		P	P	P							
Lasmigona subviridis	Green floater											P													P	P		
Villosa constricta	Notched Rainbow														P			P	P	P			P		P			
Ambystoma tigrinum	eastern tiger salamander						NF P																					
Cambarus monongalensis	A Crayfish	NF																										
Anguilla rostrata	American eel				P	P	P	P	NF P		P	P	NF P							P					P	NF P	NF P	P
Salvelinus fontinalus	Brook trout	NF P	NF P	NF P		NF P	NF P	NF P	NF P	NF P	NF	NF P	NF P	NF P	NF P	NF P	NF P	NF P	P	NF P	NF P	NF P	NF	NF P	NF P	NF P	NF P	NF P
Aeshna canadensis	Canada darner	NF																										
Cottus cf. cognatus	Checkered sculpin			P																								
Aeshna tuberculifera	black-tipped darner	NF				NF	NF	NF							NF		P		P									
Aeshna verticalis	green-striped darner	NF																										
Anax longipes	comet darner						NF																					
Calopteryx amata	Superb jewelwing	NF																										
Calopteryx angustipennis	Appalachian jewelwing											NF						NF		P			P					

SCIENTIFIC NAME	COMMON NAME	0207000102	0207000106	0207000301	0207000501	0207000502	0207000504	0207000505	0207000506	207000601	0207000602	0207000603	0207000604	0208020102	0208020103	0208020104	0208020105	0208020106	0208020107	0208020108	0208020201	0208020202	0208020203	0208020204	0208020301	0208020303	0208020304	0208020306
Celithemis martha	Martha's penant						NF																					
Cordulegaster diastatops	delta-spotted spiketail	NF																										
Enallagma annexum (AKA cyathigerum)	northern bluet	NF																										
Epitheca canis	beaverpond baskettail	NF																										
Gomphus adelphus	mustached clubtail																	P			P							
Gomphus quadricolor	rapids clubtail																	P		P	P							
Ladona julia (AKA Libellula julia)	chalk-fronted corporal skimmer	NF																										
Lanthus parvulus	double-striped clubtail	NF P																										
Lestes disjunctus	northern spreadwing	NF														P	P											
Leucorrhinia hudsonica	Hudsonian whiteface	NF																										
Nehalennia irene	sedge sprite	NF																										
Neurocordulia yamaskanensis	stygian shadowdragon											P					P											
Rhionaeschna mutata (AKA Aeshna mutata)	spatterdock darner	NF													P													
Somatochlora elongata	Ski-tipped emerald	NF																										
Sympetrum obtrusum	white-faced meadowhawk	NF																										
Isonychia hoffmani	Hoffman's Isonychia mayfly	NF																										
Nemotaulius hostilis	a limnephilid caddisfly	NF																										
Clemmys guttata	spotted turtle						NF																					
Glyptemys insculpta	wood turtle		P	NF P						NF P	P	NF P	NF P															

APPENDIX G6. AQUATIC SPECIES DROPPED FROM FURTHER CONSIDERATION

Species Name	Common Name	Taxa	Forest	NatureServe Global Rank	Virginia DNH Rank	West Virginia NHP Rank	Va State Con Concern Plan (WAP)	West Va State Con Concern Plan (WAP)	Hunted or Public Interest (Y or N)	Known occurrences on Forest?	Final Plan Species Categories	Rationale
Ixobrychus exilis exilis	least bittern	Bird	?	G5	S2B/S3N	S1B	Y		N	?	DROP	not known from FS
Rallus elegans	King rail	Bird	GWJ	G4	S2B/S3N	S1B	Y	Y	N	?	DROP	not known from FS
Cottus cognatus	slimy sculpin	Fish	GW	G5	S2	S1	Y	Y	N	N	DROP	LR, Not on FS. In Virginia known from cold, alkaline spring-fed brooks with strong flows. These are found mainly in valley bottoms. (from Jenkins' Fishes of Virginia). South Branch Potomac, South Fork Shenandoah.
Cottus girardi	Potomac sculpin	Fish	GW	G4	S3	S3	N	Y	N	Y	DROP	LR, Not S1 or S2, or VASOC
Margariscus margarita	pearl dace	Fish	GW	G5	S3S4	S3S4	Y	Y	N	N	DROP	LR, not on FS, not S1 or S2
Percina rex	Roanoke logperch	Fish	J	G1G2	S1S2		Y	N	N	N	DROP	NOT ON THE GWNF (only on the Jeff)!
Hansonoperla appalachia	Appalachian stonefly	Insect	GWJ	G3	S1S3	S2	Y	Y	N	N	DROP	LR not known from FS, not a lot of info
Isonychia tusculanensis	a mayfly	Insect	J	G4	S2		Y	N	N	N	DROP	Not on GW
Leuctra mitchellensis	Mitchell needlefly	Insect	?	G3	S1S2		Y	N	N	N	DROP	LR not known from FS, not a lot of info
Leuctra monticola	montane needlefly	Insect	J	G1Q	S1		Y	N	N	N	DROP	Not on GW
Megaleuctra flinti	Shenandoah needlefly	Insect	GW	G2	S2	S1	Y	Y	N	N	DROP	LR not known from FS, not a lot of info
Paragnetina ishusa	widecollar stonefly	Insect	GW	G3G4	S1S3		Y	N	N	N	DROP	LR not known from FS, not a lot of info
Paraleptophlebia jeanae	a mayfly	Insect	?	G3G4	S1S3		Y	N	N	N	DROP	LR not known from FS, not a lot of info
Perlesta frisoni	Blue Ridge stonefly	Insect	GWJ	G3G4	S1S2		Y	N	N	N	DROP	LR not known from FS, not a lot of info
Alasmidonta undulata	triangle floater	Mollusk	GW	G4	S3S4	S1	Y	Y	N	N	DROP	LR, not on FS

Species Name	Common Name	Taxa	Forest	NatureServe Global Rank	Virginia DNH Rank	West Virginia NHP Rank	Va State Con Concern Plan (WAP)	West Va State Con Concern Plan (WAP)	Hunted or Public Interest (Y or N)	Known occurrences on Forest?	Final Plan Species Categories	Rationale
Lampsilis cariosa	yellow lampmussel	Mollusk	GW	G3	S2	S1	Y	Y	N	N	DROP	LR, not on FS
Arigomphus furcifer	lilypad clubtail	Odonata	GW	G5	SH		Y	N	N	N	DROP	LR, possibly extirpated
Gomphus borealis	beaverpond clubtail	Odonata	GW	G4	SH		Y	N	N	N	DROP	LR, possibly extirpated
Gomphus descriptus	harpoon clubtail	Odonata	GW	G4	S1	S3	Y	Y	N	N	DROP	LR, not on FS
Leucorrhinia frigida	frosted whiteface	Odonata	GW	G5	SH		Y	N	N	N	DROP	LR, possibly extirpated
Somatochlora williamsoni	Williamson's emerald	Odonata	GW	G5	SH		Y	N	N	N	DROP	LR, possibly extirpated
Gomphus viridifrons	green-faced clubtail	Odonata	GW	G3	S2	S3	Y	Y	N	N	DROP	Dropped on 2/3/2009 as per 12/2/2008 Roble comments that it is not on the GWNF
Cordulia shurtleffi	American emerald	Odonata	GW	G5	S3	S3	N	N	N	Y	DROP	Dropped on 2/3/2009 as per 12/2/2008 Roble comments that it is S3 and should be deleted from LR list
Enallagma hageni	Hagen's bluet	Odonata	GW	G5	S3	S3S4	N	N	N	Y	DROP	Dropped on 2/3/2009 as per 12/2/2008 Roble comments that it is S3 and should be deleted from LR list
Leucorrhinia intacta	dot-tailed whiteface	Odonata	GW	G5	S3	S3	N	N	N	Y	DROP	Dropped on 2/3/2009 as per 12/2/2008 Roble comments that it is S3 and should be deleted from LR list
Nehalennia integricollis	southern sprite	Odonata	GW	G5	S3	-	N	N	N	Y	DROP	Dropped on 2/3/2009 as per 12/2/2008 Roble comments that it is S3 and should be deleted from LR list
Tramea onusta	red-mantled glider	Odonata	GW	G5	S1	-	Y	N	N	Y	DROP	Dropped on 2/3/2009 as per 12/2/2008 Roble comment that this spp. Is probably just a casual visitor to VA, and should be deleted from list.