National Park Service
U.S. Department of the Interior

Northeast Region
Philadelphia, Pennsylvania

Vegetation Classification and Mapping of New River Gorge National River, West Virginia

Technical Report NPS/NER/NRTR—2007/092

ON THE COVER

The Endless Wall. Above the cliff face is Cliff Top Virginia Pine Forest. Below the cliff is Oak – Hickory Forest grading downslope to Oak –Hickory – Sugar Maple Forest. In the foreground is a regenerating burned area.
Photograph by: J. P. Vanderhorst.

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Abstract

A vegetation classification and map were developed by the West Virginia Natural Heritage Program for New River Gorge National River following the standards of the U.S. Geological Survey / National Park Service Vegetation Mapping Program. Classification was based, in part, on multivariate analysis of complete floristic data from 277 plots. The classification for the park was cross-walked to the U.S. National Vegetation Classification in consultation with NatureServe. A digital vegetation map was produced using Geographic Information System software. The base layer for vegetation mapping was a digital orthophoto mosaic of the park developed by North Carolina State University from aerial photography flown for this project in April 2003. Spatial and thematic accuracy assessments were performed by North Carolina State University.

The vegetation classification for the park consists of 41 community types (39 associations in the U.S. National Vegetation Classification) including 16 upland forest and woodland types, one lichen type, one sparse vegetation type, 15 riparian types, five headwater wetland types, and three cultural types. Most map classes represent individual community types, but a few represent complexes of multiple classified community types and others represent cultural, disturbed, and non-vegetated areas and features which are not included in the vegetation classification. The vegetation map consists of 47 map classes, including 15 upland forest and woodland vegetation types, one lichen and sparse vegetation type, 15 riparian vegetation types, two headwater wetland vegetation types, three aquatic feature types, eight cultural and disturbed types, and three transportation feature types. Approximately 83% of the park is occupied by upland deciduous forests, but a large proportion of the ecological and species diversity in the park is represented by relatively small areas of cliff, riparian, and wetland communities. Overall thematic accuracy of the vegetation map was estimated to be 96.2%.

Executive Summary

A vegetation classification and map were developed by the West Virginia Natural Heritage Program for New River Gorge National River following the standards of the U.S. Geological Survey / National Park Service Vegetation Mapping Program. These standards include a minimum mapping unit of 0.5 ha (1.2 ac) and classification accuracy of 80% or greater for each map class. The U.S. National Vegetation Classification was used as the classification standard.

Classification was based in part on complete floristic data from 277 plots. Plots were stratified to cover the geographic and ecological ranges within the park. Multivariate analyses of plot data included hierarchical agglomerative cluster analysis, non-metric multidimensional scaling, and indicator species analysis. The vegetation classification for the park was cross-walked to the U.S. National Vegetation Classification in consultation with NatureServe. The vegetation classification for the park consists of 41 community types (39 associations in the U.S. National Vegetation Classification) including 16 upland forest and woodland types, one lichen type, one sparse vegetation type, 15 riparian types, five headwater wetland types, and three cultural types.

A digital vegetation map was produced as a personal geodatabase using Environmental Systems Research Institute ArcGIS software. The base layer for vegetation mapping was a digital orthophoto mosaic of the park developed by North Carolina State University from color infra-red aerial photography flown for this project in April 2003. The geodatabase includes separate point feature classes for plots, transects, and observations, and polygon feature classes (clipped and unclipped by the park boundary) for vegetation and non-vegetated map classes.

The vegetation map consists of 47 map classes, including 15 upland forest and woodland vegetation types, one lichen and sparse vegetation type, 15 riparian vegetation types, two headwater wetland vegetation types, three aquatic feature types, eight cultural and disturbed types, and three transportation feature types. Most map classes for natural and semi-natural vegetation represent individual community types. One map class is predominantly one community type (Sugar Maple - Yellow buckeye - American Basswood Forest) but may have a few inclusions of another community type (Successional Tuliptree / Northern Spicebush Forest) greater than the minimum mapping unit. Four composite map classes (Beaver-influenced Wetland, Cliff, Steep Riparian Edge, and Successional Tuliptree Forest) represent multiple community types. Map classes for aquatic features, cultural and disturbed areas, and transportation features do not correspond to community types in the vegetation classification.

Approximately 83% of the park is occupied by upland deciduous forests, and a large proportion of this is occupied by three major community types. The Sugar Maple - Yellow Buckeye - American Basswood Forest occupies moist, fertile sites on concave, lower, and northerly facing colluvial gorge slopes and has higher ecological amplitude on shale-derived soils. The Oak - Hickory Forest occupies dryer, less fertile sites and predominates on upper gorge slopes and on plateaus with residual soils derived primarily from sandstone. The Oak - Hickory - Sugar Maple Forest is intermediate and predominates on southerly facing, convex, and upper colluvial gorge slopes and on northerly aspects on the plateaus. Smaller, but significant, areas of upland are occupied by Oak / Ericad Forest, Eastern Hemlock - Sweet Birch - Tuliptree / Great Laurel Forest, Deciduous Tree / Great Laurel Forest, and successional forest types. Small patch

communities associated with cliffs, riparian zones, wetlands, and other specialized habitats cover a small area but represent a large proportion of the ecological and species diversity in the park. Several community types (Chinquapin Oak - Black Maple Forest, Cliff Top Pitch Pine Woodland, Cliff Top Virginia Pine Forest, Eastern Hemlock - Chestnut Oak / Catawba Rhododendron Forest, Yellow Birch Cold Cove Forest, Dry Sandstone Cliff, Black Willow Slackwater Woodland, Eastern Red-cedar - Virginia Pine Flatrock Woodland, Lizard's-tail Backwater Slough, Oak - Tuliptree / Mountain Silverbell Floodplain Forest, Riverscour Prairie, Sycamore - Ash Floodplain Forest, Sycamore - River Birch Riverscour Woodland, and Forest Seep) are likely to be state or globally rare.

Spatial and thematic accuracy assessments were performed by North Carolina State University. Thematic accuracy of 19 map classes was assessed, excluding classes for some rare natural vegetation types and all cultural and non-vegetated areas and features. Producer's and user's accuracy of individual map classes ranged from 84.6–100%. Overall thematic accuracy of the vegetation map was estimated to be 96.2%.

Acknowledgments

This project has spanned nine years of effort and many people have contributed in large and small ways. Major contributions were made by the following individuals. Dean Walton initiated and coordinated the project in 1998. Special recognition is due to the workers who helped collect vegetation data in the field: Pam Bailey, David Hulver, Paul Marcum, Leah Ceperley, Brian Streets, and Tom Vogt. GIS expertise was contributed by Joel Harrison, Jeremy Rowan, and Michael Dougherty. Administrative assistance was contributed by Brian McDonald, Walt Kordek, and Karen Eye. Elizabeth Byers assisted with database management and reviewed the draft manuscript of the final report. Celeste Good assisted with assembly of final products including metadata. John Bender developed GIS landform and ecological land unit models. Bryophyte collections were identified by Susan Studlar, and lichen collections were identified by Don Flenniken. North Carolina State University personnel who assisted with accuracy assessment and development of the orthophoto mosaic include Beth Eastman, Debra Savage, Hugh Devine, and Bill Milnor. NatureServe personnel who assisted with the USNVC crosswalk include Lesley Sneddon, Milo Pyne, and Mary Russo. NPS personnel who assisted with contracting, coordination, logistics, and data standards include Ken Stephens, John Perez, Beth Johnson, John Karish, Chris Lea, Laura Pickens, Andy Steele, Sammy Pugh, and Cliff Bobinski.

Introduction

This report describes vegetation classification and mapping for New River Gorge National River (NERI) in southern West Virginia. Work on this project was started in 1998, and a report, plots database, and GIS map products for the northern and southern thirds of the park were released three years later (Vanderhorst 2001). Following this initial effort, standards of the U.S. Geological Survey / National Park Service Vegetation Mapping Program (USGS 2001) were adopted for the completion of a vegetation classification and map for the entire park.

U.S. Geological Survey / National Park Service Vegetation Mapping Program products meet Federal Geographic Data Committee standards for vegetation classification and metadata, and national standards for spatial accuracy. Standards include a minimum mapping unit of 0.5 ha (1.23 ac) and classification accuracy of 80% or greater for each map class. The U.S. National Vegetation Classification (USNVC), maintained by NatureServe, is used as the standard for vegetation classification.

The USNVC represents the terrestrial component in the U.S. of an International Classification of Ecological Communities (Grossman et al. 1998). Ecological communities are classified and mapped to serve as a "coarse filter" for conservation of biological diversity. Although we use plants to classify terrestrial ecological communities, these units also include and represent species in all kingdoms.

The USNVC is a hierarchical system which uses physiognomy to define the coarsest levels, and floristic composition to define the finest levels of the classification (Grossman et al. 1998). The vegetation classification and mapping presented here for NERI utilize the finest level of the USNVC, the association, as the basic unit. The association is floristically based, and is named and described based on dominant and diagnostic plant species. Dominant species are those with the highest cover in each stratum (canopy layer) of vegetation. Diagnostic species are those which differentiate a community from others, either by abundance, constancy, or fidelity. Thus, a typical plant association may be named after dominants of one or two strata (species in the same stratum are divided by a dash, species in different strata are divided by a forward slash) with or without diagnostic taxa added for further refinement. For example *Platanus occidentalis - Fraxinus pennsylvanica / Carpinus caroliniana / Verbesina alternifolia* Forest indicates a forest where the tree canopy is typically dominated by *Platanus occidentalis* (sycamore) and *Fraxinus pennsylvanica* (green ash), the subcanopy is typically dominated by *Carpinus caroliniana* ssp. *virginiana* (American hornbeam), and *Verbesina alternifolia* (wingstem) has high constancy in the herb layer. Nominate species in parentheses are those which may be important in some examples or geographical range but which may be uncommon or absent in others. Because the USNVC covers a broad geographic range, the association names may not always represent local vegetation very well; it is important to consider the entire concept and description for the association.

This report and related database products also use local, park specific, NERI community type names for each association; thus, for the example above, "Sycamore - Ash Floodplain Forest." Throughout the main body of this report associations are referred to by the NERI community type name. Corresponding scientific names and alphanumeric identifiers ("CEGL" codes) for

associations in the USNVC are listed in tables and in the association descriptions in Appendix I. Because it represents the USNVC, the text of Appendix I refers to associations by their USNVC scientific name and USNVC identifier. The terms “association” and “community type” are conceptually synonymous within the scope of this report, except in one instance where a provisional NERI community type (Tributary Floodplain Forest) has no equivalent USNVC association, and in another instance where two NERI community types (Eastern Hemlock - Sweet Birch - Tuliptree / Great Laurel Forest and Deciduous Tree / Great Laurel Forest) represent two phases of a single USNVC association (*Liriodendron tulipifera - Betula lenta - Tsuga canadensis / Rhododendron maximum* Forest ([CEGL007543]).

Relationships between community types and map classes are usually one-to-one, but can sometimes be more complex. Most map classes for natural and semi-natural vegetation are more-or-less equivalent (excluding ectotones, inclusions, and errors) to community types (and corresponding USNVC associations) and these are named by the corresponding NERI community type name. For the example above, the Sycamore - Ash Floodplain Forest map class is equivalent to the Sycamore - Ash Floodplain Forest community type. However, due to patchiness of vegetation or mapping constraints of scale and/or photointerpretation, some map classes include multiple community types, thus the Steep Riparian Edge map class includes several riparian community types, including small patches of the Sycamore - Ash Floodplain Forest. Additional map classes which do not correspond to classified NERI community types include aquatic, cultural, and disturbed areas and features.

Vegetation classification and mapping for NERI was completed by the West Virginia Natural Heritage Program (WVNHP), part of the Wildlife Resources Section of the WV Division of Natural Resources (WVDNR). WVNHP classifies, conducts inventories for, maps, and maintains databases on the natural biological diversity of the state, including natural ecological communities and rare plants and animals. North Carolina State University Center for Earth Observation provided supporting products and services for this project, including development of a digital orthophoto mosaic and performance of spatial and thematic accuracy assessment. NatureServe, a private non-profit organization serving as the network coordinator for Natural Heritage Programs throughout the Americas, assisted with the crosswalk to the USNVC.

While contributing to the needs of the NPS, this project has also developed tools and information which can be applied to classification, mapping, and conservation of natural communities on public and private lands throughout the state and region.

Study Area

New River Gorge National River (NERI) is situated along approximately 85 km (53 mi) of the New River from Hinton downstream to Anstead (Figure 1). It is located in Summers, Raleigh, and Fayette counties in southern West Virginia. The proclamation boundaries of the park encompass approximately 29,202 ha (72,161 ac). It is mapped on eleven USGS 1:24,000 topographic maps, including the Hinton, Talcott, Meadow Bridge, Meadow Creek, Prince, Oak Hill, Thurmond, Danese, Winona, Fayetteville, and Beckwith quadrangles.

The park includes the river and numerous tributaries and their shores and floodplains, and extends upslope to include large areas of gorge slopes, rim rock cliffs, rolling plateaus, and mountains. Elevations range from 244 m (835 ft) along the New River near Anstead to 1,000 m (3,281 ft) on Swell Mountain near Hinton.

Ecoregional assignment of the park area is highly variable depending on which mapping system is used. The EPA (Woods et al. 2003) includes the entire park within the Forested Hills and Mountains Level III Ecoregion within the Central Appalachian Level IV Ecoregion. The USFS (Bailey et al. 1994) includes the entire park within the Northern Cumberland Mountains Section of the Central Appalachian Broadleaf Forest - Coniferous Forest - Meadow Province. The Nature Conservancy (TNC) (2003) includes the entire park within the Cumberlands and Southern Ridge and Valley Ecoregion.

The climate of the park is a humid continental type characterized by marked seasonal temperature changes and relatively uniform precipitation throughout the year. Mean monthly temperature normals (NOAA 2002) at the nearby Beckley Airport (elevation 763 m [2504 ft]) range from 30.4ºF in January to 70.7ºF in July. Normal annual precipitation at the Beckley airport is 105.74 cm (41.63 in) and monthly precipitation normals range from 6.70 cm (2.64 in) in October to 12.14 cm (4.78 in) in July (NOAA 2002).

The bedrock geology of the park is mapped as the Pottsville and Mauch Chunk groups with the Pottsville predominating in the north and the Mauch Chunk predominating in the south (Cardwell et al. 1968). The younger Pottsville lies on top of the older Mauch Chunk. The geology of the New River Gorge was described and mapped in detail by Englund et al. (1977, 1982). The Pennsylvanian-aged Pottsville group includes the Kanawha, New River, and Pocahontas formations which consist primarily of sandstones with abundant coal deposits and lesser amounts of siltstones and shale. The prominent cliff bands in the northern section of the park are composed of the Nuttall sandstone in the New River Formation. The Mississippian-aged Mauch Chunk group consists of the Bluestone, Princeton, Hinton, and Bluefield formations which consist primarily of shales and siltstones with lesser amounts of sandstones and limestone. Brooks Falls and Sandstone Falls in the southern section of the park are formed by resistant sandstone outcrops of the Stoney Gap member of the Hinton formation. The thickest limestone beds in the park are included in the Hinton formation.

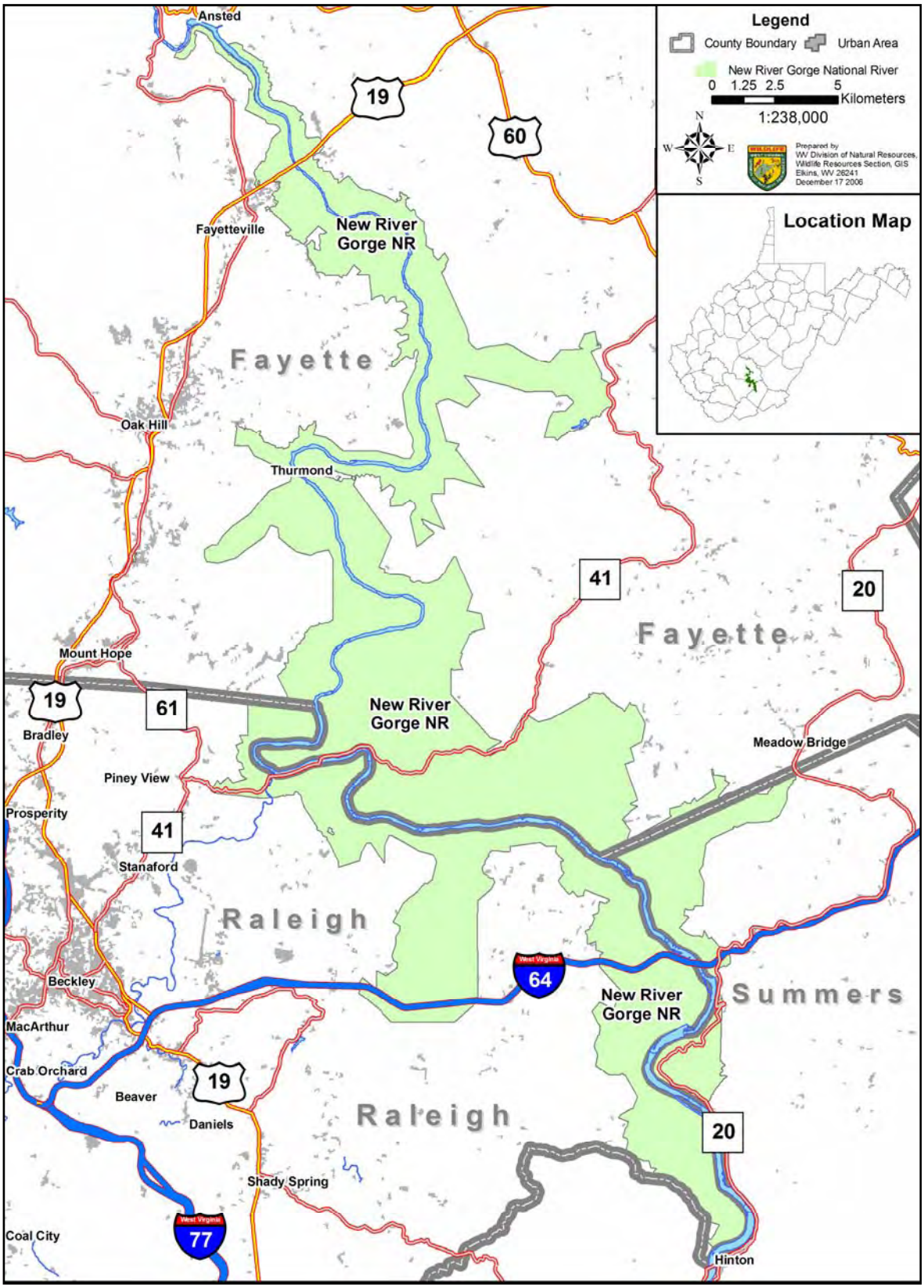

Figure 1. New River Gorge National River and vicinity.

The landforms and soils of the park vary in relation to underlying bedrock geology. In the northern section, on the more resistant formations of the Pottsville group, there is a narrow, steep-sided gorge which is rimmed by prominent cliff bands and nearly level plateaus. Soils derived from these parent materials tend to be coarse textured and highly acidic with relatively low fertility. The river in the northernmost section has a high gradient and nearly continuous rapids. In the southern section, on the more erodible formations of the Mauch Chunk group, there is higher relief, the gorge is wider, and landforms are more rounded. Soils derived from these parent materials tend to be finer textured and somewhat less acidic with higher fertility. The river in this section has a lower gradient and there are larger areas of floodplains. High gradient reaches in the southern section are located where sandstone outcrops occur.

Soils in the park are mapped in five associations (Gorman and Espy 1975; Sponaugle et al. 1984). The Dekalb - Gilpin - Ernest association is mapped on the plateaus in the northern section roughly corresponding to the Pottsville geologic group. The Steep rock land - Dekalb - Gilpin association is mapped on gorge slopes in the northern section roughly corresponding to the Pottsville geologic group. The Calvin - Gilpin association is mapped in areas of Fayette and Raleigh counties roughly corresponding to the Mauch Chunk geologic group. The Calvin high base substratum - Berks - Gilpin association is mapped in upland areas of Summers County roughly corresponding to the Mauch Chunk geologic group. The Monongahela - Kanawha - Chagrin association is mapped in small areas of floodplains in Summers County.

Previous botanical studies in NERI have included floristic inventories, rare plant surveys, and, more recently, ecological research. Phillips (1969) conducted a floristic inventory of several sites along the New River for her PhD dissertation. Grafton and McGraw (1976) surveyed the flora of the New River Gorge, and their pamphlet briefly described plant communities of the gorge with special reference to pioneer communities along the river and cold coves of tributary canyons. Grafton and Eye (1982) listed acreage by wetland class (Cowardin et al. 1979) and dominant and rare vascular plant species present at Kate's Branch wetland. Rouse and McDonald (1986) surveyed several sites in the park for rare plant species, and their report was the first to describe the unique "Appalachian river flatrock" communities at Camp Brookside, Keeney Creek, and Sandstone Falls. A set of vegetation maps was produced for the park in 1988, based on interpretation of 1986 leaf-on infra-red aerial photography. Map classes were based primarily on physiognomy. Details on authorship, methodology, and map class descriptions are lacking, but photos and Mylar quadrangle sheets with classified polygons are housed at NERI headquarters in Glen Jean. A reconnaissance study of vegetation in the vicinity of the Endless Wall was conducted by Fortney et al. (1994). Further qualitative assessment of plant communities at Camp Brookside was made by McDonald and Trianosky (1995). Additional rare plant surveys were conducted in the park by the WVNHP (McDonald 1989; McDonald and Hartman 1990; McDonald 2000a, b). Suiter (1995; Suiter and Evans 1999) conducted a floristic survey of 34 sites within the park for his Master's thesis and classified communities in accordance with early drafts of WVNHP's plant community classification (Trianosky 1994) and TNC's Eastern Region community alliance classification (Sneddon et al. 1994). Recent quantitative ecological studies in the park have focused on conifer-dominated communities, including eastern hemlock forests (Wood 1999), the flatrock woodland at Camp Brookside (Mitchem and Johnson 2001; Mitchem 2004), and the Virginia pine forests along the Endless Wall (Maxwell 2006). This report integrates information from previous reports

(Vanderhorst 2001b, 2002b) which cover the methods and results of early stages of our effort to classify and map the vegetation of NERI.

The vegetation of the park is characterized by extensive upland deciduous forests, smaller areas of conifer-dominated upland forest, and very small areas of specialized communities associated with cliffs, wetlands, and riparian zones. The park is included in the mixed mesophytic forest region of Braun (1950) which she considered to be the most ancient member of the deciduous forest formation. The mixed mesophytic climax forest is composed of a high diversity of tree species adapted to moist environments with no clear dominance by any one species. Important trees in the park include *Aesculus flava* (yellow buckeye), *Liriodendron tulipifera* (tuliptree), *Nyssa sylvatica* (blackgum), *Tilia americana* (American basswood), *Tsuga canadensis* (eastern hemlock), and species of *Acer* (maples), *Betula* (birches), *Carya* (hickories), *Fraxinus* (ashes), *Magnolia* (magnolias), *Pinus* (pines), and *Quercus* (oaks). Cliff areas include tall, sparsely vegetated rock faces with narrow strips of pine forest and woodland along their tops. Wetlands include small forested seeps and beaver-influenced herbaceous and shrub communities. Riparian zones include forests, woodlands, and prairies.

NERI was established as a National Park Service unit in 1978. In the two centuries before this, vegetation in almost all areas of the park was subject to direct impacts of human activities, including coal mining, logging, burning, farming, transportation, and residence. Many of the forests in the park have been logged multiple times, but currently there are large areas of maturing second-growth and possibly some small old-growth stands. Vegetation has also been impacted by the introduction of exotic species. Root sprouts of *Castanea dentata* (American chestnut) are today common in understories of dryer forests of the park and attest to the importance of this native tree prior to its decline brought on by an exotic fungus, *Cryphonectria parasitica* (chestnut blight), in the early 1900s. Today, eastern hemlock is similarly threatened by an exotic insect pest, *Adelges tsugae* (hemlock wooly adelgid), which has recently been found in the park. Exotic insects and/or diseases also threaten *Fagus grandifolia* (American beech), *Cornus florida* (flowering dogwood), *Morus rubra* var. *rubra* (red mulberry), and other native plant species. Early successional vegetation has reclaimed many areas which were cleared in the past, especially where abandoned farms and mines have been acquired by the NPS. Vegetation in these areas usually includes a large component of exotic plant species, including intentional introductions and adventive weeds. Weedy exotics have also become established in natural vegetation types, especially rich forests and riparian communities. Impacts on vegetation from recreational activities in the park are minimal in most areas of the park, but are concentrated and significant in some areas, especially along the river and cliffs. Natural disturbance processes which affect vegetation in the park include windfall, landslides, flooding, scouring, herbivory, fire, and ice storms.

Methods

Vegetation Classification

Vegetation classification for NERI was based on data from 277 plots sampled in 1998 through 2006 (Figure 2). Two hundred seventy-three plots are located within the proclamation boundaries of the park and four plots are located close to, but outside the park boundary. The strategy for plot sampling was guided by a combination of geographical representation, environmental gradient analysis, aerial imagery interpretation, and recognition of distinct communities and landscape patterns as they were encountered in the field, as constrained by logistics and budgets. For purposes of contract administration, the park was divided into three sections, and sampling methods varied somewhat between sections and years.

Fieldwork for classification and mapping of the lower (northern) section of the park, from Stone Cliff downstream to Anstead, commenced in 1998. Vegetation sampling in this early phase consisted of transects, mapping zones, and plots. Twelve transects were positioned to cross major ecological gradients, including landforms, elevation, and aspect (Figure 2). Coordinates of the start and end points were collected with Trimble Basic Global Positioning System (GPS) units and were post-process differentially corrected. Points were sampled at 50 m (164 ft) intervals along the transects. Data collected at each point included stand physiognomy, estimated cover by dominant vascular plants in each stratum, and environmental variables. A variation of the transect methodology was applied to eight selected areas (Figure 2), mostly floodplains, using mapping zones rather than points. Within each area, sketch maps were hand drawn for zones delineating areas of relatively uniform vegetation; data collected for each zone included stand physiognomy, estimated cover by dominant vascular plants in each stratum, and environmental variables. Data from transects and mapping zones were intended primarily to assist with vegetation mapping, but were also used as ancillary data for classification purposes. Plot sampling was also initiated in 1998 to form the basis for vegetation classification. Forty-one plots were sampled in the lower section in 1998 (Figure 2).

Fieldwork on the upper (southern) section of the park, from Hinton downstream to Prince, was conducted in 1999 when mapping zones in five selected areas and 93 plots were sampled (Figure 2). Data collected in 1998 and 1999 formed the basis for a vegetation classification and map produced for the lower and upper thirds of NERI (Vanderhorst 2001b).

In 2001 through 2006 an additional 143 plots were sampled (Figure 2), concentrating on the middle section of the park from Prince downstream to Stone Cliff and under-sampled areas and community types in the upper and lower sections. Landform and ecological land unit (ELU) models were developed for the park to assist with plot stratification for this final phase of fieldwork. These models were developed using ArcGIS following AML code developed by TNC (Biasi 2001) with modifications appropriate for the study area (Bender 2002). The landform model was developed from a 30 m digital elevation model, using moisture and topographic position indices combined with slope and aspect to classify 12 landform types (cove/ravine N/NE, cove/ravine S/SW, dry flat, flat summit/ridge, sideslope N/NE, sideslope S/SW, slope bottom, slope crest, steep slope N/NE, steep slope S/SW, stream, and upper slope). Due to the scale and precision of the digital elevation model many areas of floodplain along the

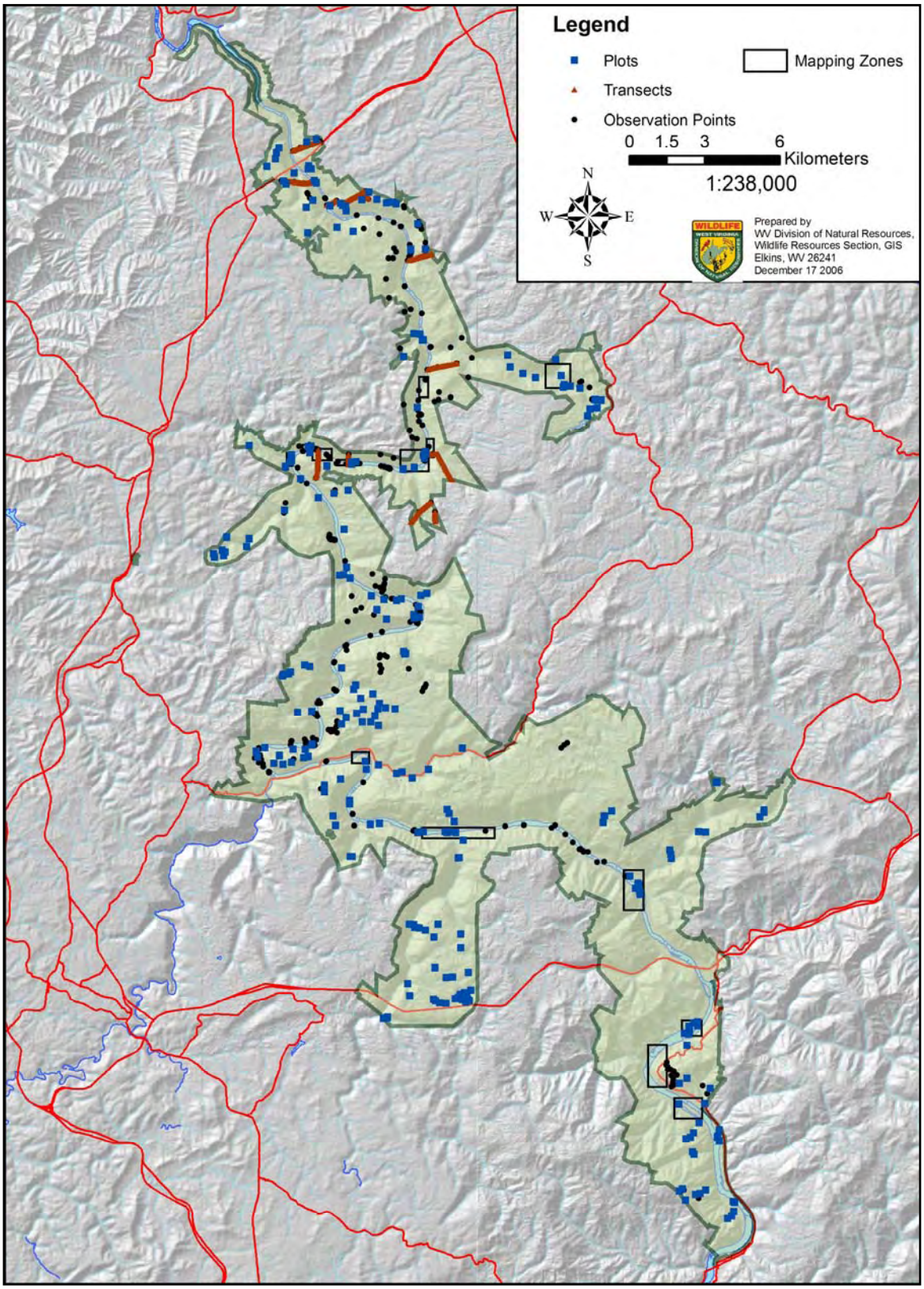

Figure 2. Locations of plots, transects, observation points, and mapping zones sampled for vegetation classification and mapping of New River Gorge National River.

New River were classified as stream. The ELU model concatenates the 12 landforms with 2 elevation classes <426 m and >426 m (<1,400 ft and >1,400 ft) and 2 geology classes (Pottsville and Mauch Chunk) to classify 48 units which occur in the park (Table 1). ELU types of existing plot locations were determined and an attempt was made to place additional plots within ELU types which were under-sampled. Despite this, due to poor GPS reception and other logistical difficulties, some uncommon ELU types were not sampled, and there is some remaining sampling inequity among more common types (Table 1). Plots were also sampled to document unique types which were recognized in the field or from aerial imagery.

Methods for sampling plots for this project are consistent with standards of the U.S. Geological Survey / National Park Service Vegetation Mapping Program (TNC and ESRI 1994a) and the Ecological Society of America (2002). The standard vegetation plot field form (Appendix A) used for this project was Form 3: quantitative community characterization (Sneddon 1993). Plots were placed in the field to sample homogenous vegetation representative of the larger stand (Mueller-Dombois and Ellenberg 1974) and, usually, to avoid disturbed sites and weedy areas. Plots were typically 20×20 m (65×65 ft) (circular in 1998-1999, square in 2001-2006) but size and shape were sometimes altered to accommodate small patch and linear communities. Coordinates for plot locations were collected using Trimble GPS units and these positions were post-process differentially corrected. Starting in 2002, photographs were taken of most plots. Three types of data were collected: metadata, environmental data, and vegetation data. Metadata included plot code, directions to the plot, representativeness, surveyors' names, sampling date, location coordinates, and associated GPS files.

Environmental plot data included environmental comments, landscape comments, slope, aspect, elevation, and information on geology, landform, topographic position, hydrology, and soils. Soil information included a profile description, texture determined by hand in the field, and pH determined in the field. Starting in 2002, soil was collected from plots for chemical analysis. The surface organic layer was scraped off and soil was collected from the top 10-15 cm (4-6 in) of the mineral horizon from three to five subsamples scattered around each plot. Subsamples from each plot were combined and mixed, the soil was dried and sieved, and 50 g (1.6 oz) samples were sent to Brookside Laboratories Inc. (New Knoxville, OH) for chemical analysis; tests included total exchange capacity, pH, % organic matter, estimated N release, and ppm S, P, Ca, Mg, K, Na, B, Fe, Mn, Cu, Zn, and Al.

Vegetation plot data included information on physiognomy (structure) and species composition. Height and percent cover of each stratum (canopy, subcanopy, tall shrub, short shrub, herb or field layer, and nonvascular) were estimated. Physiognomic type (forest, woodland, shrubland, herbaceous, non-vascular, and sparsely vegetated) of the stand was determined according to the definitions provided in Appendix B (adapted from Sneddon 1993; TNC and ESRI 1994a). Diameter at breast height (dbh) was measured for all woody stems greater than 7 cm (2.75 in) dbh. All vascular plants in plots were identified and percent cover in each stratum by each taxon was determined by ocular estimation. Starting in 2002, percent cover by individual bryophytes and lichens was recorded for species having greater than 1% cover. Unknown plant taxa were collected, pressed, and dried for identification in the herbarium. Primary references used in the field to key out vascular plants included Flora of West Virginia (Strausbaugh and Core 1977) and Manual of Vascular Plants of Northeastern United States and Canada (Gleason and Cronquist 1991). Bryophyte collections were identified by Susan Studlar (WV University) and

Table 1. Ecological Land Unit (ELU) specifications, area, and plot sampling stratification. ELUs are listed in order of abundance (hectares) within New River Gorge National River.

ELU	Elevation	Geologic group	Landform	Hectares	# Plots[a]
2230	>1400 ft	Pottsville	dry flat	2961.56	16
2214	>1400 ft	Pottsville	flat summit/ridge	2004.87	24
2233	>1400 ft	Pottsville	slope bottom	1628.75	23
2321	>1400 ft	Mauch Chunk	cove/ravine N/NE	1516.99	9
2323	>1400 ft	Mauch Chunk	cove/ravine S/SW	1443.67	9
2313	>1400 ft	Mauch Chunk	upper slope	1401.59	7
2213	>1400 ft	Pottsville	upper slope	1368.87	6
2223	>1400 ft	Pottsville	cove/ravine S/SW	1301.01	10
2221	>1400 ft	Pottsville	cove/ravine N/NE	1256.94	7
1340	<1400 ft	Mauch Chunk	stream	1109.64	19
2210	>1400 ft	Pottsville	steep slope N/NE	851.57	5
2314	>1400 ft	Mauch Chunk	flat summit/ridge	758.55	4
1333	<1400 ft	Mauch Chunk	slope bottom	737.32	19
2333	>1400 ft	Mauch Chunk	slope bottom	657.85	6
2330	>1400 ft	Mauch Chunk	dry flat	645.87	2
2211	>1400 ft	Pottsville	steep slope S/SW	632.88	6
2311	>1400 ft	Mauch Chunk	steep slope S/SW	547.42	3
2240	>1400 ft	Pottsville	stream	546.13	11
2310	>1400 ft	Mauch Chunk	steep slope N/NE	542.5	4
2320	>1400 ft	Mauch Chunk	sideslope N/NE	480.38	3
2322	>1400 ft	Mauch Chunk	sideslope S/SW	470.73	3
2212	>1400 ft	Pottsville	slope crest	469.79	6
2222	>1400 ft	Pottsville	sideslope S/SW	450.81	3
1323	<1400 ft	Mauch Chunk	cove/ravine S/SW	431.48	3
2220	>1400 ft	Pottsville	sideslope N/NE	424.17	2
1330	<1400 ft	Mauch Chunk	dry flat	413.84	20
1321	<1400 ft	Mauch Chunk	cove/ravine N/NE	413.61	4
1221	<1400 ft	Pottsville	cove/ravine N/NE	387.24	7
1223	<1400 ft	Pottsville	cove/ravine S/SW	382.64	2
2312	>1400 ft	Mauch Chunk	slope crest	324.82	6
2340	>1400 ft	Mauch Chunk	stream	302.41	3
1240	<1400 ft	Pottsville	stream	301.59	7
1233	<1400 ft	Pottsville	slope bottom	248.5	9
1210	<1400 ft	Pottsville	steep slope N/NE	198.81	2
1211	<1400 ft	Pottsville	steep slope S/SW	157.45	1
1310	<1400 ft	Mauch Chunk	steep slope N/NE	110.25	2
1311	<1400 ft	Mauch Chunk	steep slope S/SW	103.16	0
1322	<1400 ft	Mauch Chunk	sideslope S/SW	70.31	0
1320	<1400 ft	Mauch Chunk	sideslope N/NE	59.95	1
1220	<1400 ft	Pottsville	sideslope N/NE	58.91	1
1222	<1400 ft	Pottsville	sideslope S/SW	55.73	0
1230	<1400 ft	Pottsville	dry flat	49.2	0
1313	<1400 ft	Mauch Chunk	upper slope	47.23	1
1213	<1400 ft	Pottsville	upper slope	44.25	0
1314	<1400 ft	Mauch Chunk	flat summit/ridge	19.09	0
1212	<1400 ft	Pottsville	slope crest	5.36	0
1312	<1400 ft	Mauch Chunk	slope crest	2.52	0
1214	<1400 ft	Pottsville	flat summit/ridge	2.22	0
Totals				28400.43	276

[a]One plot is missing from this analysis because it is located outside the boundaries of the ELU model.

lichen collections were identified by Don Flenniken, author of the Macrolichens in West Virginia (Flenniken 1999).

Data from plots, transect points, and mapping zones were entered in the Plots 2.0 database, an Access database developed by NatureServe for the U.S. Geological Survey / National Park Service Vegetation Mapping Program. Plots were assigned alphanumeric plot codes beginning with NERI and transect points and mapping zones were assigned codes beginning with NEWT. Plant species nomenclature follows Harmon et al. (2006), except for *Dichanthelium* and *Panicum* which follow the Flora of North America (Freckmann and Lelong 2003). Alphanumeric plant codes from the Plants database Version 3.1 (USDA NRCS 2001) were used to facilitate data entry and data analysis; codes for those taxa which did not have codes in Plants were created with a "WV" suffix.

Multivariate analysis, utilizing PC-Ord software (McCune and Mefford 1999), was used to provide insight for classification of vegetation. This was an iterative process which involved analyses of various sets and subsets of plot data, using hierarchical agglomerative cluster analysis, non-metric multidimensional scaling (NMS), and indicator species analysis. An earlier iteration of vegetation analysis for the park (Vanderhorst 2001b) utilized two-way indicator species analysis (TWINSPAN), but this method has been criticized in recent years (McCune and Grace 2002) and was not used for this iteration. Data screening for all analyses included elimination of all nonvascular taxa, vascular taxa with uncertain identification or identified to the generic or higher taxonomic level, and taxa which occurred in only one plot. Outlier plots were identified and removed from analyses because they can have large effects on outcomes and conclusions (McCune and Grace 2002). Several data transformations were tried but most analyses performed best with cover values square-root transformed. Cluster analysis was performed on the entire data set and on various subgroups. Cluster analysis was run using the Sorenson distance measure and Flexible Beta group linkage method with Beta set to -0.25. Indicator species analysis (Dufrêne and Legendre 1997) was used to identify the species which help define the groups. NMS was run on smaller subgroups, either defined by the cluster analysis or by physiognomy (e.g. deciduous forest, herbaceous) or hydrology (e.g. wetland, upland, riparian). NMS was run using the Sorenson distance measure and the auto-pilot mode in PC-Ord set to "slow and thorough."

The final vegetation classification for the park also incorporates information gained from plot environmental data, transect points, mapping zones, plot data from other WV sites (Vanderhorst 2000a, 2001a, 2002a; Vanderhorst and Streets 2006; WVNHP 2006; Byers et al. 2007), and aerial imagery interpretation, and has been molded by a need for conformity with the USNVC. Because of this, and the realization that plot sampling is always an imperfect representation of reality, the classification does not conform to the results of any one multivariate analysis. This is illustrated by the graphic results of cluster analysis and NMS. These analyses were run on the classified plot data of natural and semi-natural associations, with plots divided into three subsets representing ecological groups (upland forests and woodlands, riparian communities, and wetlands) using the standard protocols described in the previous paragraph.

After the final classified NERI community types (putative associations) were decided upon, individual plots were attributed to each community type. Ten plots were not assigned to community types because they represented ectotones, disturbed areas, or seemingly unique

vegetation. Indicator species analysis was run on various subgroupings to identify plant species most useful for distinguishing types in the field. Floristic constancy/cover tables and plot floristic synthesis tables were developed for each community type using Access queries and Excel pivot tables. Similar summary tables were produced for environmental variables using Access queries. A key to community types was developed to facilitate identification of associations in the field based on floristic and environmental variables. This key was also used to classify the transect points and mapping zones to serve as an additional mapping tool.

The vegetation classification for the park was "cross-walked" to the USNVC in consultation with NatureServe ecologists. Data from each NERI community type was compared to existing associations in the USNVC and decisions were made either to place the local types in existing associations or to develop new associations. In one case, two NERI community types were lumped into one USNVC association. One other NERI community type was treated as a local provisional type without an equivalent USNVC association. Data from the floristic and environmental tables were used to write local association descriptions and new global USNVC association descriptions, and to edit existing global USNVC association descriptions to accommodate NERI vegetation. Local and global descriptions were entered in Biotics, the central database for biodiversity information maintained by NatureServe.

Aerial Photography Acquisition and Processing

Color infrared, stereo pair, 1:12,000 scale, aerial photography of New River Gorge National River was acquired on March 27, 2003, during leaf-off conditions, by Sanborn Mapping Company, Inc. The photography was delivered to the National Park Service (NPS), quality checked, accepted as provided, and sent to North Carolina State University (NCSU). Upon receipt at NCSU, the aerial photographs were counted to make sure that none were missing, scanned and saved in .tif format, and placed in the data archive that NCSU maintains for the NPS Northeast Region Inventory & Monitoring Program. Associated data and information provided by Sanborn Mapping Company, Inc. that are also stored in the data archive include the airborne global positioning system (GPS) and inertial mapping unit (IMU) data files, the camera calibration certificate, a hardcopy flight report for the photography that crosswalks the airborne GPS and IMU data to the photo frame numbers, and a digital flight index map.

A digital orthophoto mosaic was produced from 471 color infrared aerial photographs, scanned at 600 dpi with 24-bit color depth. Scanned .tif images of the aerial photographs were imported into ERDAS IMAGINE IMG format where a photo block was created using the airborne GPS and IMU data that Sanborn Mapping Company, Inc. supplied with the aerial photography. The photo block was manipulated until it could be triangulated with a root mean square error of less than 1. At this point, single frame orthophotos (one for each aerial photograph) were generated within IMAGINE and exported to IMAGINE LAN format. Then the .lan files were imported into ER Mapper's native (ERS) format, and an ER Mapper algorithm was created which contained the color balancing information and the cutlines created for the final mosaic. Band interleaved by line (BIL) image and header files for the mosaic were generated in ER Mapper, the BIL image was imported into IMAGINE IMG format, and, finally, the IMG image was compressed using MrSID software with a 20:1 compression ratio. The final mosaic, in both IMG and MrSID formats, is stored in the NCSU data archive.

A metadata record for the mosaic was prepared in accordance with the current Federal Geographic Data Committee standards (FGDC 1998a). Metadata were produced in notepad and parsed using the USGS metadata compiler (USGS 2004). After all errors and omissions identified by the parser were corrected, the metadata compiler was used to generate final TXT, HTML, and XML versions of the metadata record which are stored in the data archive. Key information for the mosaic is summarized in Table 2.

Vegetation Mapping

A vegetation map for NERI was developed as a personal geodatabase using ESRI ArcGIS software. The geodatabase includes separate point feature classes for locations of plots, transect points, and observation points, and polygon feature classes (clipped by the park boundary and unclipped) for vegetation and non-vegetated land cover.

Point feature classes (Figure 2) were produced from locational coordinates collected using GPS units (Trimble Basic, Explorer, and GeoExplorer; Garmin 76) or from points mapped by hand on topographic maps. Trimble GPS units were used to collect coordinates of plot locations whenever satellite reception was possible, and were also used for start and end points of transects and for some observation points. GPS data from Trimble units were post-process differentially corrected and exported as attributed GIS files using Trimble Pathfinder Office software. Garmin GPS units were used only for collecting coordinates of observation points. GPS data from Garmin units were exported as attributed GIS files using DNRGarmin software (MDNR 2001). Accuracy of Garmin GPS data was tested by collecting coincident points with Trimble units at several locations. These tests and obvious "mis-mapping" of Garmin GPS points based on interpretation of aerial imagery show that the Garmin units were often significantly less accurate than the Trimble units. When GPS reception was not possible due to poor satellite reception (most common on north slopes and in deep narrow canyons) points were hand mapped on topographic maps and in the geodatabase feature classes. Point feature classes for plots and observations include attribute information on GPS methods for each point. Transect points were mapped by hand in GIS, interpolating between the GPS start and end points with reference to aspect, elevation, and physiognomy recorded on field data sheets and interpretation of aerial imagery. Plot and transect points were attributed with NERI community type names determined by the vegetation classification. Observation points are less completely attributed and were intended primarily for use by the vegetation mapper; these are points with GPS coordinates that represent distinctive vegetation types that were already adequately sampled by plots, or ecotones and boundaries between distinctive vegetation types. A large proportion of the observation points were sampled during a three-day float of the New River from Meadow Creek downstream to Fayette Station in September 2003.

Delineation of vegetation map classes was based on interpretation of digital aerial imagery utilizing additional digital and non-digital data sources. The primary imagery used as a base layer for mapping was the digital orthophoto mosaic of leaf-off color infrared aerial photography flown for this project in late March 2003. Additional digital aerial imagery sets which were used included leaf-off color infra-red digital orthophoto quarter quads flown in spring 1996 (USGS 1995) and true color leaf-off orthophoto quarter quads flown in spring 2003 (WVSAMB 2005).

Table 2. Summary of key information for the New River Gorge National River (NERI) digital orthophoto mosaic.

Title of metadata record:	New River Gorge National River Color Infrared Orthorectified Photomosaic – Leaf-off (ERDAS IMAGINE .img and MrSID formats)
Publication date of mosaic (from metadata):	September 15, 2005
Date aerial photography was acquired:	March 27, 2003
Vendor that provided aerial photography:	Sanborn Mapping Company, Inc.
Scale of photography:	1:12,000
Type of photography:	Color infrared, stereo pairs
Number of aerial photographs delivered:	471
Archive location of aerial photographs, airborne GPS and IMU files, and camera calibration certificate:	North Carolina State University, Center for Earth Observation
Scanning specifications:	600 dpi, 24-bit color depth
Horizontal positional accuracy of mosaic:	1.31 meters, meets Class 1 National Map Accuracy Standard (Calculated for NERI, Gauley River National Recreation Area (GARI) and Bluestone National Scenic River (BLUE) together)
Number of ground control points upon which estimated accuracy is based:	147 (for NERI, GARI, and BLUE together)
Method of calculating positional accuracy:	Root mean square error
Archive location of mosaic and metadata:	North Carolina State University, Center for Earth Observation
Formats of archived mosaic:	IMG (uncompressed) and MrSID (20:1 compression)

Transparencies of leaf-on color infra-red aerial photography flown for this project in October 2003 were examined on a light table to help distinguish signatures, (e.g. oak and tuliptree canopies, American water-willow cobble bars) which are not apparent on leaf-off imagery. Original transparencies used to produce the leaf-off orthophoto mosaic were also examined on a light table to distinguish problematic signatures. Utilization of these multiple sets often helped to overcome deficiencies (e.g. shading) of the primary orthophoto mosaic. Ancillary GIS layers used to assist photointerpretation included digital rastor graphs of USGS topographic maps and the landform and Ecological Land Unit models developed for this project.

Aerial imagery interpretation was initiated by examining signatures throughout the park in relation to GIS-mapped plot, transect, and observation points, and hand-drawn mapping zones. Selection of map classes was driven by the imagery. When individual associations could be reliably mapped, these were chosen as map classes. Composite map classes were used when individual associations could not be distinguished due to tight zonation or patchiness. Map classes were also developed for aquatic and cultural features and vegetation. The stated minimum mapping unit for this project was 0.5 ha (1.23 ac), but smaller polygons were sometimes delineated for small patch (e.g. Cliff Top Virginia Pine Forest) or linear (e.g. roads) types with distinct signatures. Small creeks were mapped to the extent that their courses were visible on photography, with only short gaps estimated. Polygons were drawn using the ArcGIS editing tools with the screen set at various scales, commonly 1:3,000, depending on the vegetation patch size and distinctiveness of boundaries. Polygons were attributed with the name of the map class and, sometimes, comments related to the vegetation or its photo signature. After a relatively complete list of map classes was established, a domain was created to limit map class names to this list. The domain was altered as a few additional map classes were identified. Topology was established to enforce rules for no gaps or overlaps. Mapping was started at a central location of the park and worked outwards to adjacent areas until the entire park was mapped. All areas within the park boundary were mapped and mapping was usually extended somewhat beyond the boundary to insure complete coverage. The completed vegetation polygon feature class was clipped by the park boundary and aerial statistics were calculated to summarize the relative abundance of each map class within the park.

After the vegetation map was delivered to NCSU for thematic accuracy assessment in May 2006 a few changes were made to the geodatabse. One map class, Successional Forest, was eliminated, and the four polygons that were attributed to this class were changed to Successional Tuliptree Forest or Disturbed Area. Changes were also made to the vegetation classification crosswalk to the USNVC and to nomenclature of the NERI community types, but these do not affect the results of accuracy assessment for any map class.

Metadata records for each feature class in the vegetation map geodatabase were prepared in accordance with the current FGDC standards (FGDC 1998a). Metadata records were edited with ESRI ArcGIS, the NPS Metadata Tools and Editor, and Microsoft Notepad and were parsed using the USGS metadata compiler (USGS 2004). All errors and omissions identified by the parser were corrected. Metadata records are included within the final geodatabase for the vegetation map.

Accuracy Assessment

Positional Accuracy Assessment

For purposes of accuracy assessment, mosaics of Bluestone National Scenic River, Gauley River National Recreation Area, and New River Gorge National River were treated as a single entity because the photography was acquired in a single flight with the same camera and with one set of airborne GPS and IMU data. Horizontal positional accuracy of the mosaics was assessed using guidelines of the USGS/NPS Vegetation Mapping Program (ESRI, NCGIA, and TNC 1994). Well-defined positional accuracy ground control points were placed throughout all quadrants of each mosaic in ESRI ArcView 3.3. Ground control points and zoomed-in

screenshots of each point were plotted on hard copy maps with the mosaic as a background. These maps and plots were used to locate the ground control points in the field. Field staff recorded the ground control point coordinates with a Trimble Pro XRS. Mapped ground control points that were physically inaccessible were also noted. The field crew collected accuracy assessment data at 160 ground control points. The coordinate data were collected with real-time GPS and post processed with differential correction using Pathfinder Office software. Prior to calculating accuracy, 13 ground control points were identified as outliers with SAS's JMP program and removed. The field-collected GPS coordinates for the remaining 147 points were compared to the coordinates obtained from each mosaic viewed in ESRI ArcView 3.3. Both pairs of coordinates for each point were entered into a spreadsheet in order to calculate horizontal accuracy (in meters). The accuracy calculation formula is based on root mean square error (FGDC 1998b; MGCGI and MLMIC 1999). Figure 3 shows the distribution of the ground control points within the three parks.

Thematic Accuracy Assessment

The thematic accuracy of the vegetation map was assessed by NCSU's Center for Earth Observation. The assessment was performed on the digital vegetation map dated May 17, 2006, and delivered June 6, 2006, using the vegetation key dated May 30, 2006. The vegetation map was not clipped to the park boundary.

In preparation for selecting the sample of thematic accuracy assessment points, vegetation map polygons were excluded from the sampling frame based on the following criteria:

- Polygons on private land within the park boundary were excluded to avoid potential trespass issues during field data collection.

- Polygons smaller than the minimum mapping unit of 0.5 ha (1.23 ac) were excluded.

- Polygons representing non-vegetated land cover such as roads, railroads, etc., were excluded.

Based on these criteria, the following map classes were eliminated from the accuracy assessment: Black Willow Slackwater Woodland, Riverbank Tall Herbs, Riverscour Prairie, Silver Maple Floodplain Forest, Bridge, Creek, Developed Area, Pond, Railroad, River, Road, Tipple, Cobble, Flatrock Pavement, and Washout.

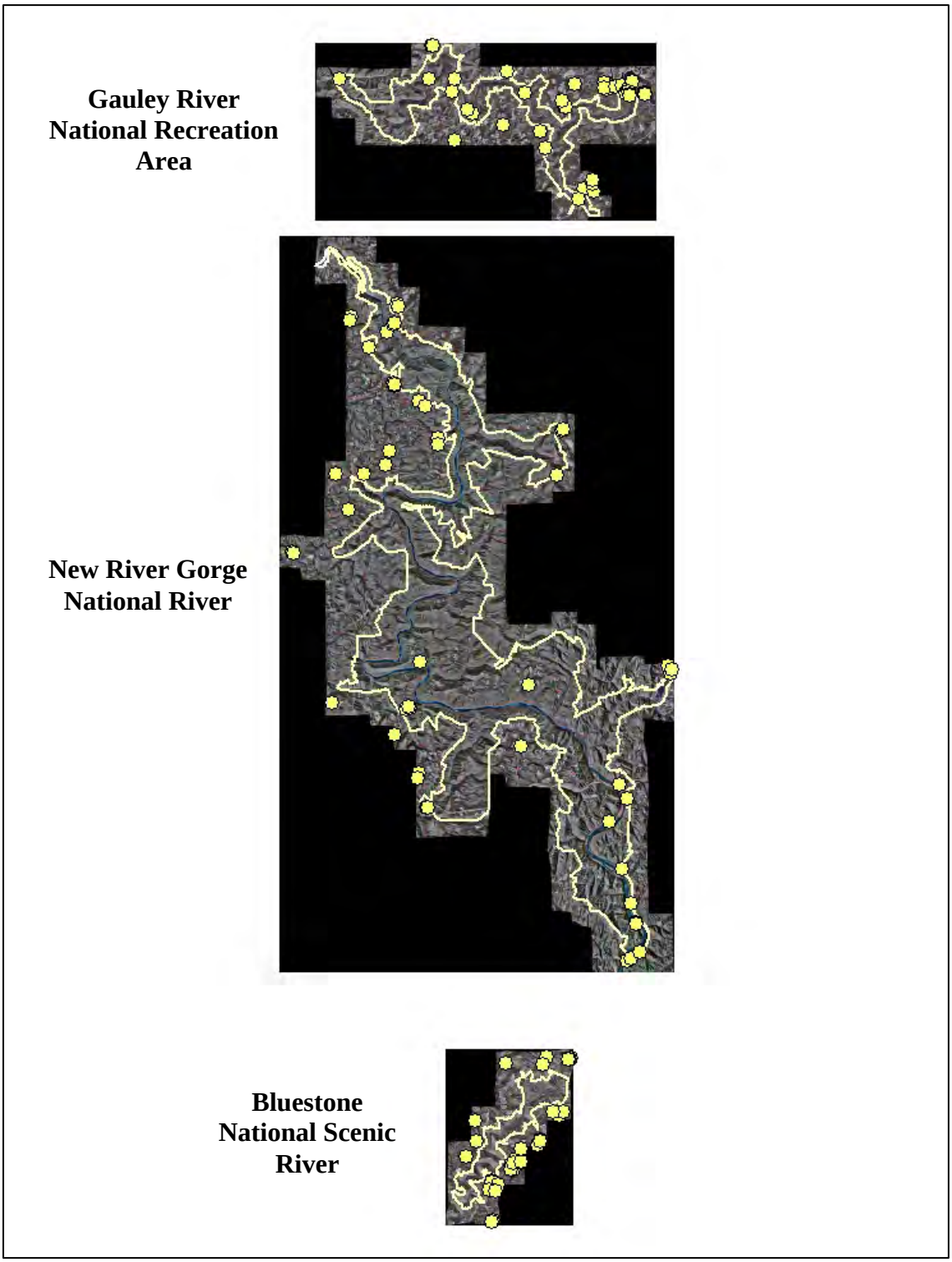

Figure 3. Ground control points used to calculate horizontal positional accuracy of the Gauley River National Recreation Area, New River Gorge National River, and Bluestone National Scenic River digital orthophoto mosaics.

Table 3 shows the map classes that were included in the accuracy assessment. A total of 3,296 polygons covering 24,493 ha (60,523 ac) was used to determine the recommended number of accuracy assessment points for each map class (see Table 3). The recommended number of sample points per map class varies according to the rarity of the class in terms of number of polygons and total area, as follows (TNC and ESRI 1994b):

Scenario A: The class is abundant. It covers more than 50 ha (123 ac) and consists of at least 30 polygons. In this case, the recommended sample size is 30.

Scenario B: The class is relatively abundant. It covers more than 50 ha (123 ac), but consists of fewer than 30 polygons. In this case, the recommended sample size is 20.

Scenario C: The class is relatively rare. It covers less than 50 ha (123.5 ac), but consists of more than 30 polygons. In this case, the recommended sample size is 20.

Scenario D: The class is rare. It has more than 5 but fewer than 30 polygons and covers less than 50 ha (123.5 ac). In this case, the recommended sample size is 5.

Scenario E: The class is very rare. It has fewer than 5 polygons and occupies less than 50 ha (123.5 ac). In this case, it is recommended that the existence of the class be confirmed by sampling one point per polygon.

The sampling frame was further modified to maximize efficiency of fieldwork. Ten regions and two segments of the New River from which the sample of accuracy assessment points would be selected were defined based on accessibility and diversity of vegetation classes. Figure 4 shows these regions and river segments consisting of 1,754 polygons covering 13,592.5 ha (33587.6 ac) (roughly 47% of the total area represented on the vegetation map). The objective was to concentrate field data collection in areas distributed throughout the park that were reasonably accessible and that contained diverse vegetation, and to exclude areas that would be inordinately difficult and time consuming to visit.

A stratified random sample of polygons was selected from the areas shown in Figure 4. Point locations within each sample polygon were generated using a random point generator in ArcGIS 9.1. (ESRI 2005). One random point was generated for each polygon unless accessibility of a particular vegetation class was extremely limited.

Multiple points were generated for polygons of rare, widely scattered, and less accessible vegetation classes such as Forest Seep, Cliff Top Virginia Pine Forest, and Yellow Birch Cold Cove Forest. When multiple points were generated for a polygon, they were adjusted, if necessary, to ensure that they were a minimum of 60 m (196 ft) apart. Sample points located close to polygon boundaries were moved to at least 30 m (98 ft) inside the polygon to avoid ecotones. In some cases, that was not possible, for example, where long, narrow polygons follow a linear pattern associated with the gorge or a riparian zone. Examples of these types of vegetation and land cover classes are Strip Mine Reclamation, Pine Plantation, Steep Riparian Edge, Sycamore - Ash Floodplain Forest, Yellow Birch Cold Cove Forest, and Cliff Top Virginia Pine Forest. In these cases, sample points were moved to a point approximately equidistant from the polygon perimeter. Fortunately, most of these vegetation and land cover classes had fairly discrete boundaries and there was little problem identifying them in the field.

Table 3. Thematic accuracy assessment (AA) sampling strategy for the New River Gorge National River vegetation map.

Map Class	Number of Polygons	Area Mapped (Hectares)	Number of AA Points Recommended by Protocol[a]	Number of AA Points Visited
Vegetation Class				
Cliff Top Pitch Pine Woodland	2	1.45	2	4
Successional Black Locust Woodland	2	3.32	2	1
Chinquapin Oak - Black Maple Forest	3	3.86	3	0
Eastern Red-cedar – Virginia Pine Flatrock Woodland	3	8.86	3	3
Successional Forest[b]	4	9.58	4	0
Successional Box-elder Forest	5	6.51	5	1
Backwater Slough	6	5.42	5	3
Beaver-influenced Wetland	7	18.51	5	2
Successional Virginia Pine Forest	7	13.59	5	2
Tributary Floodplain Forest	7	6.88	5	2
Oak - Tuliptree / Mountain Silverbell Floodplain Forest	11	21.82	5	1
American Water-willow Cobble Bar	25	5.62	5	1
Yellow Birch Cold Cove Forest	25	67.08	20	19
Forest Seep	29	26.84	5	20
Successional Eastern White Pine Forest	30	49.36	20	6
Sycamore - River Birch Riverscour Woodland	31	40.43	20	9
Pine Plantation	49	72.74	30	20
Sycamore - Ash Floodplain Forest	63	148.68	30	23
Steep Riparian Edge	84	254.16	30	27
Cliff Top Virginia Pine Forest	110	151.78	30	33
Successional Tuliptree Forest	125	563.33	30	33
Eastern Hemlock - Chestnut Oak / Catawba Rhododendron Forest	142	199.16	30	18
Deciduous Tree / Great Laurel Forest	145	395.35	30	32
Eastern Hemlock - Sweet Birch - Tuliptree / Great Laurel Forest	230	1,017.69	30	29
Oak - Ericad Forest	373	966.25	30	29
Sugar Maple - Yellow Buckeye - American Basswood Forest	434	7,005.69	30	29
Oak - Hickory - Sugar Maple Forest	473	5,504.89	30	39
Oak - Hickory Forest	534	6,581.81	30	53
Other Land Cover Class				
Cliff	2	5.01	2	0
Kudzu Patch	4	2.91	4	1
Utility Corridor	79	128.97	30	24
Distrubed Area	13	524.76	30	28
Strip Mine Reclamation	150	690.14	30	32
Total	3,296	24,492.97	565	524

[a]TNC and ESRI 1994b

[b]The map class “Successional Forest” appeared in the May 17, 2006 data set, but all polygons were later attributed by the vegetation mapper to other map classes.

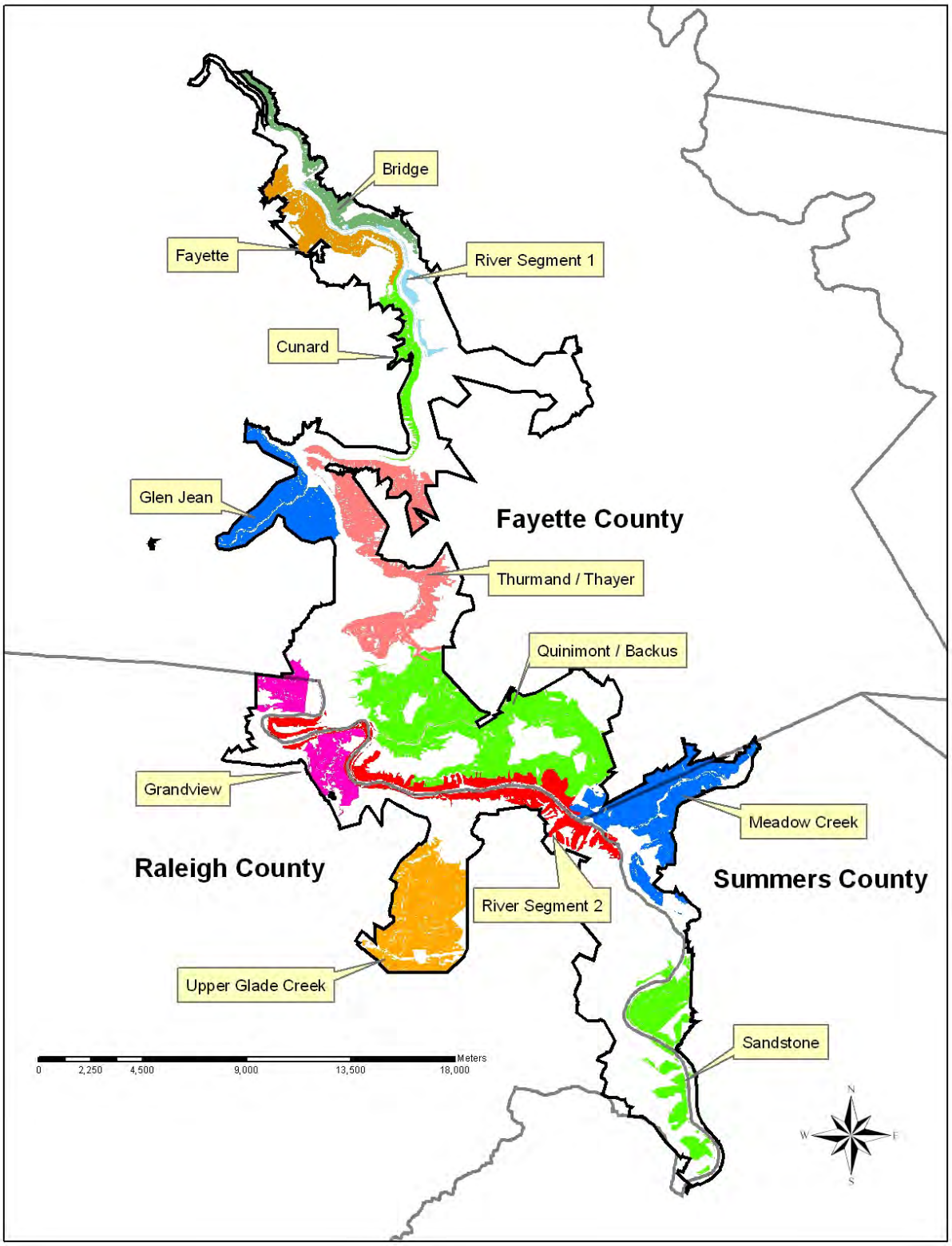

Figure 4. Regions and river segments from which the sample of thematic accuracy assessment points was selected.

An ArcGIS shapefile containing the sample points was created and the attribute table was edited to include fields needed to record the data to be collected at each point. The shapefile was imported into Trimble .ssf format and loaded into a Trimble GeoXP global positioning system (GPS) unit. This allowed the field ecologist to enter data directly into an electronic file in real time, eliminating the need for paper forms.

A field ecologist navigated to sample points using a Trimble GeoXP GPS unit. The following rules were established to deal with anticipated problems with site accessibility and/or GPS satellite signals.

1) Good GPS readings and good access to point
   a. Navigate to the point as close as possible.
   b. Enter field observation data and store the new GPS coordinates.

2) Good GPS readings and poor access to point (point extremely difficult to reach)
   a. Use GPS to navigate to well within the polygon boundary.
   b. Enter field observation data and store the new GPS coordinates.

3) Poor GPS readings and good access to point
   a. Use GPS to navigate as close as possible to the point, then use the Measure Tool in the GPS Navigation screen to obtain a bearing and distance to the point. Compass and pace to the point. Check the topographic map and aerial photography to make sure location is close to the sample point.
   b. Enter field observation data; do not alter GPS coordinates of the sample point.

4) Poor GPS readings and poor access to point (point extremely difficult to reach)
   a. Use GPS to navigate as close as possible to the polygon containing the point; use Measure Tool in the GPS Navigation screen to obtain a bearing and distance to a point well inside the polygon. Compass and pace to the point. Mark and label the point on the topographic map and aerial photograph.
   b. Enter field observation data; do not alter GPS coordinates of the sample point in the field. In the office, obtain coordinates of the point where data were collected from the topographic map and enter them into the shapefile, replacing coordinates of the original sample point.

Differentially correcting the GPS data collected using the first two methods indicated sub-meter accuracy of the planimetric (X, Y) coordinates. Based on uncorrected GPS navigation, compass and pacing, and interpretation of aerial photography, the third method yielded X, Y accuracies of ±10 m (32.8 ft). The last method, based mainly on compass and pacing and interpretation of aerial photography, yielded X, Y accuracies of ±20 m (65.6 ft).

The ecologist collected field data at a total of 524 accuracy assessment points in June 2006 (Figure 5). Prior to fieldwork, the key to NERI community types and tabular data provided with the vegetation map were studied to gain a general understanding of the different map classes. While most map classes have a direct 1:1 relationship with NERI community types, some composite map classes include multiple NERI community types. The vegetation key was used in the field until a thorough understanding of the range of variation of each NERI community type

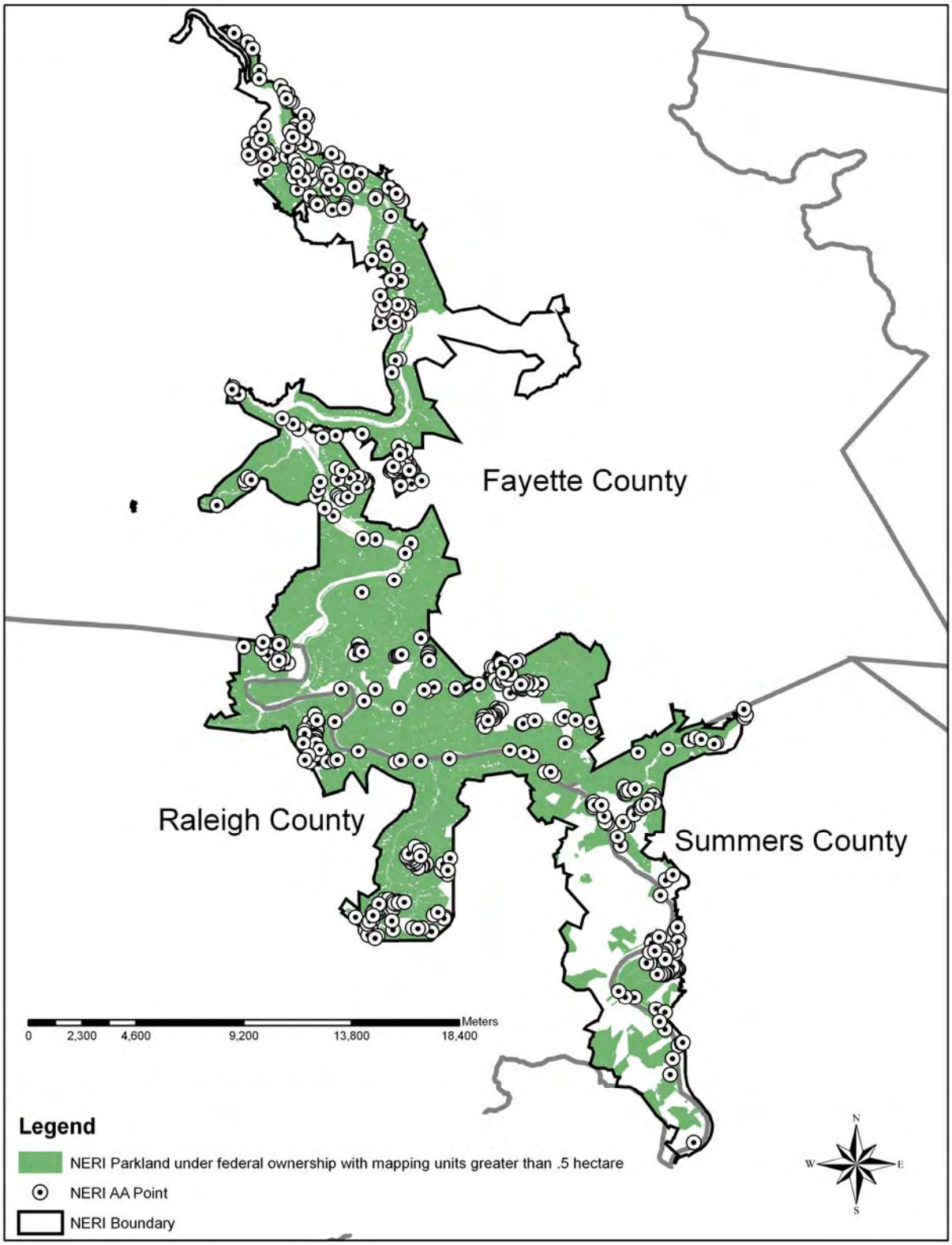

Figure 5. Locations of the 524 thematic accuracy assessment (AA) points in New River Gorge National River (NERI).

and map class was acquired. Following this, identification of composite map classes (Beaver-influenced Wetland, Disturbed Area, Steep Riparian Edge, Strip Mine Reclamation, and Utility Corridor) was based on recognition, rather than using the key. Map classes having a 1:1 relationship with NERI community types were identified according to the vegetation key. The Sugar Maple - Yellow Buckeye - American Basswood Forest map class was also identified according to the vegetation key; although the vegetation mapper had identified possible inclusions of Successional Tuliptree Forest within this map class, none were encountered during accuracy assessment fieldwork.

The minimum area of observation around the sampling point was a circle with a radius of 50 m (164 ft). Data collected for each sample point are described in Appendix C and include all items recommended in the USGS/NPS Vegetation Mapping Program protocol (TNC and ESRI 1994b). Photographs were taken at 258 sample points and are hyperlinked to the corresponding shapefile points. Example photographs are included in Appendix D.

Data from the 524 accuracy assessment points were entered in the AA Observations and AA-Species tables of the Plots 2.0 database. Accuracy assessment points are assigned alphanumeric codes beginning with NERI; therefore, there is overlap in the naming of plots and accuracy assessment points. Map class names, taxonomic nomenclature, and plant symbols entered in the database are consistent with those used for plot, transect, and mapping zone data and throughout this report.

Estimates of thematic accuracy (overall percent accuracy and the Kappa index) were calculated using a contingency matrix that compared the mapped vegetation and land cover classes with the actual vegetation and land cover classes observed in the field. Overall percent accuracy was calculated by dividing the number of correctly classified accuracy assessment points by the total number of accuracy assessment points. The Kappa index is the preferred method of reporting overall thematic accuracy because it takes into account that a certain number of correct classifications will occur by chance (Foody 1992). The USGS/NPS Vegetation Mapping Program protocol requires that the Kappa index exceeds 80% (TNC and ESRI 1994b).

Errors of omission and commission, referred to as Producer's Accuracy and User's Accuracy, respectively, were calculated for individual vegetation and land cover classes. Producer's Accuracy indicates the probability that an accuracy assessment point classification is correct. It is calculated by dividing the number of correctly classified points for a map class by the total number of sample points mapped as that map class. User's Accuracy indicates the probability that a mapped vegetation or land cover type actually represents the vegetation or land cover on the ground. It is calculated by dividing the number of correctly classified points for a map class by the total number of points that the field observer identified as being of that map class. Producer's and User's Accuracy should exceed 80% according to the USGS/NPS Vegetation Mapping Program protocol (TNC and ESRI 1994b).

Results

Vegetation Classification

Forty-one vegetation community types were classified in the park, representing 39 associations in the USNVC (Table 4). These include 16 upland forest and woodland types, one non-vascular type, one sparse vegetation type, 15 riparian types (including jurisdictional wetlands along the river and lower tributaries), five headwater wetland types, and three cultural types. Two upland forest types (Deciduous Tree / Great Laurel Forest and the Eastern Hemlock - Sweet Birch - Tuliptree / Great Laurel Forest) are classified and described as distinct NERI community types but are placed in the same USNVC association. One riparian type (Tributary Floodplain Forest) is a placeholder for poorly sampled NERI vegetation with no equivalent USNVC association.

A list of vascular and non-vascular plant taxa identified from plots, transect points, mapping zones, and accuracy assessment points is provided in Appendix E. The list is sorted by scientific name and includes plant symbol, usually as assigned in the Plants database (USDA NRCS 2001), common name, family, and division. One thousand forty-one taxa are listed representing 894 plant species; the additional 147 taxa represent multiple subspecific taxa per species and identifications made to the genus level. One hundred forty-nine families are represented in six divisions, including 113 families in the Magnoliophyta (flowering plants), two families in the Pinophyta (conifers), eight families in the Polypodiophyta (ferns), one family in the Lycopodiophyta (club mosses, spike mosses), one family in the Equisetophyta (horsetails), 17 families in the Bryophyta (mosses), four families in the Marchantiophyta (liverworts), and three families in the Ascomycota (limited to lichens for this project).

Examples of graphic results of cluster analyses and NMS ordinations are provided in Appendix F. These analyses are “middle level” iterations with the plot data set divided into three subsets: upland forests and woodlands, riparian communities, and wetland communities. The final classification of plots is indicated by symbology overlain on the graphics. “Misclassifications” of individual plots are apparent in the cluster analysis dendrograms, but the overall pattern of the classification is supported by the NMS ordinations.

Tables of plot floristic summary statistics (cover and constancy) for each community type are provided in Appendix G. The types are arranged alphabetically by the NERI community name listed in Table 4. To save space, the tables use the plant symbols listed in Appendix C. Plant taxa are sorted in descending order by mean cover, then constancy.

A dichotomous key to vegetation community types is provided in Appendix H.

Global alliance and association descriptions and local association descriptions are provided in Appendix I. Appendix J is the bibliography for the global descriptions. These are arranged within the hierarchical structure of the USNVC (Anderson et al. 1998); however, the hierarchy is not indicated in the table of contents for Appendix I. Vegetation classified in the park is grouped within six classes, arranged in the following order: forest, woodland, shrubland, herbaceous vegetation, non-vascular vegetation, and sparse vegetation. Classes are further divided into groups, formations, alliances, and associations.

Table 4. Associations of the U.S. National Vegetation Classification (USNVC) occurring in New River Gorge National River (NERI).

NERI Community Name	USNVC Association Name	USNVC ELCode
Upland Forests and Woodlands		
Chinquapin Oak - Black Maple Forest	*Quercus muehlenbergii - Quercus (alba, rubra) - Carya cordiformis / Viburnum prunifolium* Forest	CEGL004793
Cliff Top Pitch Pine Woodland	*Pinus rigida - Quercus coccinea / Vaccinium angustifolium* Woodland	CEGL006557
Cliff Top Virginia Pine Forest	*Pinus virginiana - Pinus (rigida, echinata) - (Quercus prinus) / Vaccinium pallidum* Forest	CEGL007119
Deciduous Tree / Great Laurel Forest	*Betula lenta - Liriodendron tulipifera - Acer rubrum / Rhododendron maximum* Forest (local subtype of *Liriodendron tulipifera - Betula lenta - Tsuga canadensis / Rhododendron maximum* Forest)	CELT007543 (CEGL007543)
Eastern Hemlock - Chestnut Oak / Catawba Rhododendron Forest	*Quercus prinus / Rhododendron catawbiense - Kalmia latifolia* Forest	CEGL008524
Eastern Hemlock - Sweet Birch - Tuliptree / Great Laurel Forest	*Liriodendron tulipifera - Betula lenta - Tsuga canadensis / Rhododendron maximum* Forest	CEGL007543
Oak / Ericad Forest	*Quercus (prinus, coccinea) / Kalmia latifolia / (Galax urceolata, Gaultheria procumbens)* Forest	CEGL006271
Oak – Hickory Forest	*Quercus prinus - (Quercus rubra) - Carya* spp. */ Oxydendrum arboreum - Cornus florida* Forest	CEGL007267
Oak – Hickory - Sugar Maple Forest	*Quercus prinus - Carya ovata - Quercus rubra / Acer saccharum* Forest	CEGL007268
Successional Black Locust Woodland	*Robinia pseudoacacia* Forest	CEGL007279
Successional Eastern White Pine Forest	*Pinus strobus* Successional Forest	CEGL007944
Successional Tuliptree / Northern Spicebush Forest	*Liriodendron tulipifera / (Cercis canadensis) / (Lindera benzoin)* Forest	CEGL007220
Successional Tuliptree - Oak Forest	*Liriodendron tulipifera - Quercus* spp. Forest	CEGL007221
Successional Virginia Pine Forest	*Pinus virginiana* Successional Forest	CEGL002591
Sugar Maple - Yellow Buckeye - American Basswood Forest	*Liriodendron tulipifera - Tilia americana* var. *heterophylla - Aesculus flava - Acer saccharum / (Magnolia tripetala)* Forest	CEGL005222
Yellow Birch Cold Cove Forest	*Betula alleghaniensis - (Tsuga canadensis) / Rhododendron maximum / Leucothoe fontanesiana* Forest	CEGL007861
Lichen and Sparse Vegetation		
Common Rocktripe Cliff Face	*Umbilicaria mammulata* Nonvascular Vegetation	CEGL004387
Dry Sandstone Cliff	Appalachian - Alleghenian Sandstone Dry Cliff Sparse Vegetation	CEGL006435
Riparian Communities		
American Water-willow Cobble Bar	*Justicia americana* Herbaceous Vegetation	CEGL004286
Black Willow Slackwater Woodland	*Salix nigra - Betula nigra / Schoenoplectus pungens* Wooded Herbaceous Vegetation	CEGL006463
Eastern Red-cedar - Virginia Pine Flatrock Woodland	*Juniperus virginiana* var. *virginiana - Pinus virginiana - Quercus stellata / Amelanchier stolonifera / Danthonia spicata - Melica mutica* Woodland	CEGL008449
Lizard's-tail Backwater Slough	*Peltandra virginica - Saururus cernuus - Boehmeria cylindrica / Climacium americanum* Herbaceous Vegetation	CEGL007696

Table 4. Associations of the U.S. National Vegetation Classification (USNVC) occurring in New River Gorge National River (NERI) (continued).

NERI Community Name	USNVC Association Name	USNVC ELCode
Riparian Communities (continued)		
Oak - Tuliptree / Mountain Silverbell Floodplain Forest	*Quercus (alba, rubra, velutina) / Halesia tetraptera* Forest	CEGL006462
Riverbank Annuals	*Eragrostis hypnoides - Ludwigia palustris - Lindernia dubia - Cyperus squarrosus* Herbaceous Vegetation	CEGL006483
Riverbank Tall Herbs	*Verbesina alternifolia - Teucrium canadense - Elymus riparius - (Solidago gigantea)* Herbaceous Vegetation	CEGL006480
Riverscour Prairie	*Andropogon gerardii - Panicum virgatum - Baptisia australis* Herbaceous Vegetation	CEGL006283
Silver Maple Floodplain Forest	*Acer saccharinum - Ulmus americana* Forest	CEGL002586
Submerged Aquatic Vegetation	*Potamogeton* spp. - *Ceratophyllum* spp. - *Elodea* spp. Permanently Flooded Herbaceous Vegetation	CEGL004725
Successional Box-elder Forest	*Acer negundo* Forest	CEGL005033
Sycamore - Ash Floodplain Forest	*Platanus occidentalis - Fraxinus pennsylvanica / Carpinus caroliniana / Verbesina alternifolia* Forest	CEGL006458
Sycamore - River Birch Riverscour Woodland	*Platanus occidentalis - (Betula nigra, Salix* spp.) Temporarily Flooded Woodland	CEGL003725
Tributary Floodplain Forest	Placeholder - no current USNVC association description	CEGL006487
Twisted Sedge Rocky Creekbed	*Carex torta* Herbaceous Vegetation	CEGL004103
Headwater Wetlands		
Bulrush - American Bur-reed Marsh	*Sparganium americanum - Epilobium leptophyllum* Herbaceous Vegetation	CEGL004510
Bushy St. John's-wort Shrub Wetland	*Hypericum densiflorum / Rubus hispidus* Shrubland	CEGL006464
Forest Seep	*Acer rubrum - Nyssa sylvatica / Ilex verticillata - Vaccinium fuscatum / Osmunda cinnamomea* Forest	CEGL007853
Rice Cutgrass Marsh	*Leersia oryzoides - Sagittaria latifolia* Herbaceous Vegetation	CEGL006461
Smooth Alder Shrub Wetland	*Alnus serrulata* Saturated Southern Shrubland	CEGL003912
Cultural Vegetation		
Kudzu Patch	*Pueraria montana* var. *lobata* Vine-Shrubland	CEGL003882
Old Field	*Lolium (arundinaceum, pratense)* Herbaceous Vegetation	CEGL004048
Pine Plantation	*Pinus strobus* Planted Forest	CEGL007178

Vegetation Mapping

The vegetation map (Figure 6) for NERI includes 47 map classes, arranged in seven categories: upland forests and woodlands, lichen and sparse vegetation (cliffs), riparian communities, headwater wetlands, aquatic features, cultural and disturbed areas, and transportation features.

Relationships between map classes and USNVC associations are usually simple but are sometimes somewhat complex (Table 5). Map classes for natural vegetation are typically equivalent to single associations with names of the map classes corresponding to the NERI community names listed in Table 4. However, extensive association level map classes may contain small inclusions of other associations, and boundaries between these types are likely to be gradual rather than abrupt as portrayed by the map. During the vegetation mapping phase it was thought that some polygons of one association level map class (Sugar Maple - Yellow Buckeye - American Basswood Forest) might have inclusions greater than the minimum mapping unit of the Successional Tuliptree / Northern Spicebush Forest association which could not be delineated on aerial imagery due to heavy shading; however, during the accuracy assessment phase, no inclusions of Successional Tuliptree / Northern Spicebush Forest were encountered within this map class. One association (*Liriodendron tulipifera - Betula lenta - Tsuga canadensis / Rhododendron maximum* Forest [CEGL007543]) is divided between two map classes (Deciduous Tree / Great Laurel Forest, Eastern Hemlock - Sweet Birch - Tuliptree / Great Laurel Forest) based on presence or absence of *Tsuga canadensis* (eastern hemlock).

Four vegetation complexes (Steep Riparian Edge, Beaver-influenced Wetland, Cliff, and Successional Tuliptree Forest) were mapped which are composed of multiple associations. Steep Riparian Edge is a diverse map class which occurs in a narrow strip along miles of shoreline of the New River. Polygons of Steep Riparian Edge may include small patches of up to 10 different associations and may also include disturbed areas (e.g. steep banks between a railroad and the river). A common pattern within the Steep Riparian Edge map class is for boundaries between associations to be blurred due to tight compression of environmental gradients (i.e. flooding regime) across a narrow zone. The Beaver-influenced Wetland map class is composed of small intermingling patches of up to four shrub and herbaceous wetland associations and also includes areas of open water. The Cliff map class includes two associations which occur in small adjacent patches with distributions related to aspect and seepage. Polygons of the Successional Tuliptree Forest map class may include one or two associations which have distributions related to soil moisture and fertility; the crosswalk to USNVC associations for this map class was changed after accuracy assessment was performed, but in order not to invalidate the accuracy assessment, no attempt was made to attribute individual polygons to individual associations.

Small areas of unvegetated natural riparian disturbance features (Cobble, Flatrock Pavement) were mapped which do not correspond to associations. Map classes for aquatic features, transportation features, disturbed areas, and most cultural areas do not correspond to, but may include, patches of associations. Two cultural vegetation types (Pine Plantation, Kudzu Patch) are mapped as associations. Many associations occur in more than one map class. Map classes in which each association is included are also listed in the key to vegetation types (Appendix H).

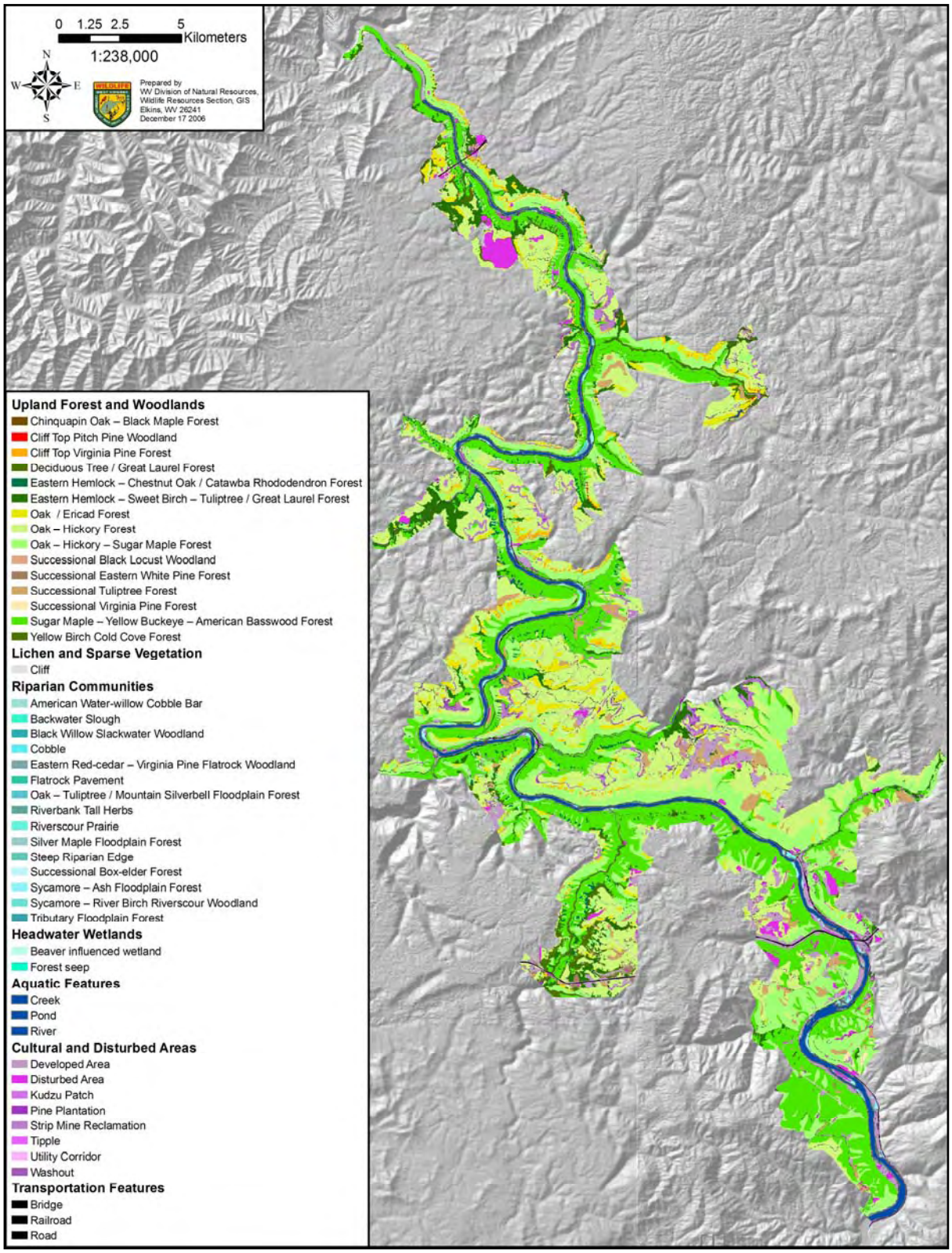

Figure 6. Vegetation map of New River Gorge National River, West Virginia

Table 5. Relationships between New River Gorge National River map classes and U.S. National Vegetation Classification (USNVC) associations.

Map class	USNVC Associations	Comments
Upland Forests and Woodlands		
Chinquapin Oak – Black Maple Forest	*Quercus muehlenbergii - Quercus (alba, rubra) - Carya cordiformis / Viburnum prunifolium* Forest [CEGL004793]	Additional small patches likely within the Oak – Hickory – Sugar Maple Forest and Sugar maple – Yellow Buckeye - American Basswood forest map classes.
Cliff Top Pitch Pine Woodland	*Pinus rigida – Quercus coccinea / Vaccinium angustifolium* Woodland [CEGL006557]	Small patch type with discrete boundaries.
Cliff Top Virginia Pine Forest	*Pinus virginiana – Pinus (rigida, echinata) – (Quercus prinus) / Vaccinium pallidum* Forest [CEGL007119]	Small patch type with discrete boundaries.
Deciduous Tree / Great Laurel Forest	*Betula lenta - Liriodendron tulipifera - Acer rubrum / Rhododendron maximum Forest* [CELT007543]	Local subtype of same association as the Eastern Hemlock – Sweet Birch – Tuliptree / Great Laurel Forest map class.
Eastern Hemlock – Chestnut Oak / Catawba Rhododendron Forest	*Quercus prinus / Rhododendron catawbiense – Kalmia latifolia* Forest [CEGL008524]	Small patch type with discrete boundaries.
Eastern Hemlock – Sweet Birch – Tuliptree / Great Laurel Forest	*Liriodendron tulipifera – Betula lenta – Tsuga canadensis / Rhododendron maximum Forest* [CEGL007543]	Same association as the Deciduous Tree / Great Laurel Forest map class.
Oak / Ericad Forest	*Quercus (prinus, coccinea) / Kalmia latifolia / (Galax urceolata, Gaultheria procumbens)* Forest [CEGL006271]	Grades to Oak – Hickory Forest on less dry sites.
Oak – Hickory Forest	*Quercus prinus – (Quercus rubra) – Carya* spp. / *Oxydendrum arboreum – Cornus florida* Forest [CEGL007267]	Grades to Oak / Ericad Forest on dryer sites and Oak – Hickory – Sugar Maple Forest on less dry sites.
Oak – Hickory – Sugar Maple Forest	*Quercus prinus – Carya ovata – Quercus rubra / Acer saccharum* Forest [CEGL007268]	Grades to Oak – Hickory Forest on dryer sites and Sugar Maple – Yellow Buckeye – American Basswood Forest on wetter sites.
Successional Black Locust Woodland	*Robinia pseudoacacia* Forest [CEGL007279]	Additional patches likely within the Disturbed Area and Strip Mine Reclamation map classes.
Successional Eastern White Pine Forest	*Pinus strobus* Successional Forest [CEGL007944]	Small patch type with discrete boundaries.
Successional Tuliptree Forest	*Liriodendron tulipifera – Quercus* spp. Forest [CEGL007221], *Liriodendron tulipifera / (Cercis canadensis) / (Lindera benzoin) Forest* [CEGL007220]	CEGL007221 occurs on dryer sites more abundant on plateaus. CEGL007220 occurs on wetter sites more abundant on gorge slopes. Additional patches likely within the Disturbed Area, Strip Mine Reclamation, and Sugar Maple – Yellow Buckeye – American Basswood Forest map classes.
Successional Virginia Pine Forest	*Pinus virginiana* Successional Forest [CEGL002591]	Small patch type with discrete boundaries.

Table 5. Relationships between New River Gorge National River map classes and U.S. National Vegetation Classification (USNVC) associations (continued).

Map class	USNVC Associations	Comments
Upland Forests and Woodlands (continued)		
Sugar Maple – Yellow Buckeye – American Basswood Forest	*Liriodendron tulipifera – Tilia americana* var. *heterophylla – Aesculus flava – Acer saccharum / (Magnolia tripetala)* Forest [CEGL005222], *Liriodendron tulipifera / (Cercis canadensis) / (Lindera benzoin)* Forest [CEGL007220]	Predominately CEGL005222 but probably includes patches of CEGL007220 on shaded north slopes not distinguishable on aerial imagery. Grades to Oak – Hickory – Sugar Maple Forest on dryer sites.
Yellow Birch Cold Cove Forest	*Betula alleghaniensis – (Tsuga canadensis) / Rhododendron maximum / Leucothoe fontanesiana* Forest [CEGL007861]	Grades to Deciduous Tree / Great Laurel Forest and Eastern Hemlock – Sweet Birch – Tuliptree / Great Laurel Forest.
Lichen and Sparse Vegetation		
Cliff	Appalachian – Alleghenian Sandstone Dry Cliff Sparse Vegetation [CEGL006435], *Umbilicaria mammulata* Nonvascular Vegetation [CEGL004387]	CEGL006435 is more likely to occur on south aspects and on cliffs without seepage. CEGL004387 is m ore likely on north aspects and on cliffs with seepage. Additional small cliffs likely in all map classes on gorge slopes.
Riparian Communities		
American Water-willow Cobble Bar	*Justicia americana* Herbaceous Vegetation [CEGL004286]	Additional patches within Steep Riparian Edge.
Backwater Slough	*Peltandra virginica – Saururus cernuus – Boehmeria cylindrica / Climacium americanum* Herbaceous Vegetation [CEGL007696]	May include areas of standing water and unvegetated mud.
Black Willow Slackwater Woodland	*Salix nigra – Betula nigra / Schoenoplectus pungens* Wooded Herbaceous Vegetation [CEGL006463]	Additional patches within Steep Riparian Edge.
Cobble	No USNVC association	Natural disturbance feature.
Eastern Red-cedar – Virginia Pine Flatrock Woodland	*Juniperus virginiana var. virginiana - Pinus virginiana - Quercus stellata / Amelanchier stolonifera / Danthonia spicata - Melica mutica* Woodland [CEGL008449]	Small patch type with discrete boundaries.
Flatrock Pavement	No USNVC association	Natural disturbance feature.
Oak – Tuliptree / Mountain Silverbell Floodplain Forest	*Quercus (alba, rubra, velutina) / Halesia tetraptera* Forest [CEGL006462]	Additional patches within Steep Riparian Edge.
Riverbank Tall Herbs	*Verbesina alternifolia – Teucrium canadense – Elymus riparius – (Solidago gigantea)* Herbaceous Vegetation [CEGL006480]	Additional patches within Steep Riparian Edge.
Riverscour Prairie	*Andropogon gerardii – Panicum virgatum – Baptisia australis* Herbaceous Vegetation [CEGL006283]	Additional patches within Steep Riparian Edge.

Table 5. Relationships between New River Gorge National River map classes and U.S. National Vegetation Classification (USNVC) associations (continued).

Map class	USNVC Associations	Comments
Riparian Communities (continued)		
Silver Maple Floodplain Forest	*Acer saccharinum – Ulmus americana* Forest [CEGL002586]	Additional patches within Steep Riparian Edge.
Steep Riparian Edge	*Salix nigra – Betula nigra / Schoenoplectus pungens* Wooded Herbaceous Vegetation [CEGL006463], *Quercus (alba, rubra, velutina) / Halesia tetraptera* Forest [CEGL006462], *Eragrostis hypnoides – Ludwigia palustris – Lindernia dubia – Cyperus squarrosus* Herbaceous Vegetation [CEGL006483], *Verbesina alternifolia – Teucrium canadense – Elymus riparius – (Solidago gigantea)* Herbaceous Vegetation [CEGL006480], *Andropogon gerardii – Panicum virgatum – Baptisia australis* Herbaceous Vegetation [CEGL006283], *Acer saccharinum – Ulmus americana* Forest [CEGL002586], *Acer negundo Forest* [CEGL005033], *Platanus occidentalis – Fraxinus pennsylvanica / Carpinus caroliniana / Verbesina alternifolia* Forest [CEGL006458], *Platanus occidentalis – (Betula nigra, Salix* spp.*)* Temporarily Flooded Woodland [CEGL003725], *Justicia americana* Herbaceous Vegetation [CEGL004286]	Narrow zone with one to several riparian associations often compressed along a steep elevational gradient without clear boundaries between associations. May also include narrow patches of vegetation which can be distinguished as individual associations. The most abundant associations are probably CEGL006458 and CEGL003725. The upper part of polygons may grade towards the adjacent upland association. Disturbed areas may often be included especially when polygons are located between the river and a railroad or road.
Successional Box-elder Forest	*Acer negundo* Forest [CEGL005033]	Additional patches within Steep Riparian Edge.
Sycamore – Ash Floodplain Forest	*Platanus occidentalis – Fraxinus pennsylvanica / Carpinus caroliniana / Verbesina alternifolia* Forest [CEGL006458]	Additional patches within Steep Riparian Edge.
Sycamore – River Birch Riverscour Woodland	*Platanus occidentalis – (Betula nigra, Salix* spp.) Temporarily Flooded Woodland [CEGL003725]	Additional patches within Steep Riparian Edge.
Tributary Floodplain Forest	No USNVC association	Local placeholder type.
Headwater Wetlands		
Beaver-influenced Wetland	*Alnus serrulata* Saturated Southern Shrubland [CEGL003912], *Sparganium americanum – Epilobium leptophyllum* Herbaceous Vegetation [CEGL004510], *Leersia oryzoides – Sagittaria latifolia* Herbaceous Vegetation [CEGL006461], *Hypericum densiflorum / Rubus hispidus* Shrubland [CEGL006464]	Vegetation complex, usually with patchy mosaic of two or more associations, may also include open water.
Forest Seep	*Acer rubrum – Nyssa sylvatica / Ilex verticillata – Vaccinium fuscatum / Osmunda cinnamomea* Forest [CEGL007853]	Additional small patches most likely on plateaus in Oak – Hickory Forest map class.

Table 5. Relationships between New River Gorge National River map classes and U.S. National Vegetation Classification (USNVC) associations (continued).

Map class	USNVC Associations	Comments
Aquatic Features		
Creek	May include small patches of *Carex torta* Herbaceous Vegetation [CEGL004103]	Mapped where visible on aerial imagery with small gaps interpolated.
Pond	No USNVC association	
River	May include small patches of *Potamogeton* spp. – *Ceratophyllum* spp. – *Elodea* spp. Permanently Flooded Herbaceous Vegetation [CEGL004725] and *Justicia americana* Herbaceous Vegetation [CEGL004286]	
Cultural and Disturbed Areas		
Developed Area	May include small patches of *Lolium (arundinaceum, pratense)* Herbaceous Vegetation [CEGL004048], *Pinus strobus* Planted Forest [CEGL007178]	Area maintained by human activities. Includes farms, residential areas, recreation areas, commercial areas, and industrial areas. Does not include strip mines.
Disturbed Area	May include patches of *Lolium (arundinaceum, pratense)* Herbaceous Vegetation [CEGL004048], *Robinia pseudoacacia* Forest [CEGL007279], *Liriodendron tulipifera – Quercus* spp. Forest [CEGL007221], *Liriodendron tulipifera / (Cercis canadensis) / (Lindera benzoin)* Forest [CEGL007220], *Pinus strobus* Successional Forest [CEGL007944], and degraded examples of natural vegetation types.	Area recently disturbed, but not maintained, by human activities. May include patches of semi-natural associations and degraded examples of natural associations. Does not include strip mines.
Kudzu Patch	*Pueraria montana* var. *lobata* Vine-Shrubland [CEGL003882)	
Pine Plantation	*Pinus strobus* Planted Forest [CEGL007178]	Additional small patches in Developed Area and Strip Mine Reclamation map classes.
Strip Mine Reclamation	May include patches of *Lolium (arundinaceum, pratense)* Herbaceous Vegetation [CEGL004048], *Pinus strobus* Planted Forest [CEGL007178], *Robinia pseudoacacia* Forest [CEGL007279], *Liriodendron tulipifera – Quercus* spp. Forest [CEGL007221], *Liriodendron tulipifera / (Cercis canadensis) / (Lindera benzoin)* Forest [CEGL007220], *Pinus strobus* Successional Forest [CEGL007944]	Areas disturbed in the past by strip mining. Includes semi-natural successional communities, reclamation plantings, bare ground, and roads. Larger patches of Pine Plantations are mapped as a distinct map class.
Tipple	No USNVC association	
Utility Corridor	May include patches of Lolium *(arundinaceum, pratense)* Herbaceous Vegetation [CEGL004048]	Herbaceous and shrub physiognomy usually maintained by humans (herbicides, cutting).
Washout	No USNVC association	

Table 5. Relationships between New River Gorge National River map classes and U.S. National Vegetation Classification (USNVC) associations (continued).

Map class	USNVC Associations	Comments
Transportation Features		
Bridge	No USNVC association	
Railroad	No USNVC association	
Road	No USNVC association	

The number of polygons and area of each map class are summarized in Table 6. Approximately 83% of the park area is mapped as upland forests and woodlands and 83% of this is mapped as three deciduous forest community types (Oak - Hickory Forest, Oak - Hickory - Sugar Maple Forest, and Sugar Maple - Yellow Buckeye - American basswood Forest). Mapped Cliffs occupy 0.024% of the park area. Although riparian communities occupy only about 2.2% of the park area, they include the highest number of map classes. Mapped headwater wetlands occupy 0.22% of the park area. Aquatic features occupy about 4.5% of the park area, most of this represented by the river. About 8.4% of the park is mapped as cultural and disturbed areas. About 1.8% percent is mapped as transportation features.

Accuracy Assessment

Positional Accuracy of Digital Orthophoto Mosaics

The horizontal positional accuracy of the three digital orthophoto mosaics together is 1.31 m (4.29 ft), which meets the Class 1 National Map Accuracy Standard (FGDC 1998b). A copy of the spreadsheet containing the x and y coordinates for each ground control point and the accuracy calculation formula is included in the data archive.

Thematic Accuracy

As described earlier, the sample of thematic accuracy assessment points was selected from accessible, but representative areas of the park (Figure 4). The objective was to concentrate field data collection efforts in areas that were reasonably accessible and that contained a representative diversity of vegetation, in line with recommendations of the USGS-NPS Vegetation Mapping Program Accuracy Assessment Procedures (TNC and ESRI 1994b).

Three map classes for which no accuracy assessment data were collected (see Table 3) were excluded from the thematic accuracy assessment analysis. Also, map classes for which less than five sample points were visited (Table 3) were not included in the contingency matrix, although for all of these there was 100% agreement between the field observation and the mapped class.

Based on the contingency matrix (Table 7), the Kappa index for the vegetation map is 96.0%±1.2% and the overall percent accuracy is estimated to be 96.2%. Both estimates meet the USGS/NPS Vegetation Mapping Program requirement of 80%. User's Accuracy (error of commission) is 100% for 10 of the 19 map classes analyzed and ranges from 84.6%–97.0% for the remaining nine map classes, while Producer's Accuracy (errors of omission) is 100% for 13 map classes and ranges from 86.4–97.0% for the remaining six map classes. Oak - Hickory Forest was the vegetation class most commonly misclassified (86.4% error of omission and 96.2% error of commission). It was most often misclassified as either Oak - Hickory - Sugar Maple Forest or as Oak - Ericad Forest. This is understandable because these three vegetation classes may have wide overlaps of ecotones depending on the environmental gradient. Oak - Hickory - Sugar Maple Forest was misclassified as Sugar Maple - Yellow Buckeye - American Basswood Forest twice in the sample of 39 accuracy assessment points. These two vegetation classes often occur close to each other, and in weak environmental gradients they may have considerable overlap as well. Three sample points mapped as Eastern Hemlock - Chestnut Oak / Catawba Rhododendron Forest were observed to be Deciduous Tree / Great Laurel Forest. Both

Table 6. Number of polygons and total area of map classes in New River Gorge National River.

Map class	# polygons	Total ha	Total ac
Upland Forests and Woodlands			
Chinquapin Oak - Black Maple Forest	5	4.30	10.63
Cliff Top Pitch Pine Woodland	10	4.39	10.85
Cliff Top Virginia Pine Forest	358	208.76	515.86
Deciduous Tree / Great Laurel Forest	298	487.14	1,203.74
Eastern Hemlock - Chestnut Oak / Catawba Rhododendron Forest	355	251.46	621.38
Eastern Hemlock - Sweet Birch - Tuliptree / Great Laurel Forest	500	1,088.08	2,688.74
Oak / Ericad Forest	577	1,124.19	2,777.95
Oak - Hickory Forest	889	6,871.02	16,978.67
Oak - Hickory - Sugar Maple Forest	689	5,805.46	14,345.59
Successional Black Locust Woodland	1	2.22	5.48
Successional Eastern White Pine Forest	96	73.29	181.11
Successional Tuliptree Forest	222	727.03	1,796.53
Successional Virginia Pine Forest	33	25.82	63.80
Sugar Maple - Yellow Buckeye - American Basswood Forest	622	7,408.17	18,305.99
Yellow Birch Cold Cove Forest	41	102.16	252.43
Total upland forests and woodlands	4,696	24,183.50	59,758.72
Lichen and Sparse Vegetation			
Cliff	23	7.04	17.38
Riparian Communities			
American Water-willow Cobble Bar	56	12.62	31.20
Backwater Slough	22	9.17	22.66
Black Willow Slackwater Woodland	18	3.40	8.40
Cobble	39	3.84	9.49
Eastern Red-cedar - Virginia Pine Flatrock Woodland	6	9.36	23.12
Flatrock Pavement	4	1.14	2.83
Oak - Tuliptree / Mountain Silverbell Floodplain Forest	17	23.43	57.89
Riverbank Tall Herbs	3	0.17	0.41
Riverscour Prairie	14	2.74	6.77
Silver Maple Floodplain Forest	4	1.32	3.27
Steep Riparian Edge	125	278.86	689.08
Successional Box-elder Forest	7	7.08	17.49
Sycamore - Ash Floodplain Forest	122	187.98	464.52
Sycamore - River Birch Riverscour Woodland	158	69.73	172.30
Tributary Floodplain Forest	77	17.29	42.73
Total riparian communities	672	628.14	1,552.18
Headwater Wetlands			
Beaver-influenced Wetland	28	21.43	52.95
Forest Seep	92	42.52	105.08
Total headwater wetland	120	63.95	158.03
Aquatic Features			
Creek	267	95.51	236.00
Pond	64	16.77	41.45
River	21	1,198.81	2,962.32
Total aquatic features	352	1,311.09	3,239.77

Table 6. Number of polygons and total area of map classes in New River Gorge National River (continued).

Map class	# polygons	Total ha	Total ac
Cultural and Disturbed Areas			
Developed Area	622	993.86	2,455.87
Disturbed Area	424	601.71	1,486.85
Kudzu Patch	10	4.46	11.03
Pine Plantation	142	93.70	231.53
Strip Mine Reclamation	230	614.83	1,519.28
Tipple	6	1.78	4.41
Utility Corridor	248	149.55	369.55
Washout	10	1.58	3.90
Total cultural and disturbed areas	1,693	2,461.46	6,082.42
Transportation Features			
Bridge	13	6.88	17.01
Railroad	44	174.80	431.94
Road	694	365.59	903.38
Total transportation features	751	547.27	1,352.34
Grand Total	8,307	29,202.45	72,160.84

of these forest types have a strong rhododendron component, tend to be found in close proximity to each other, and are differentiated by only slight changes in topographic position. Although the vegetation mapper had identified possible inclusions of Successional Tuliptree / Northern Spicebush Forest within the Sugar Maple - Yellow Buckeye - American Basswood Forest map class, none were encountered during accuracy assessment fieldwork.

Table 7. Contingency matrix and calculated errors for the thematic accuracy assessment of the New River Gorge National River vegetation map.

Accuracy Assessment Observation	Mapped Vegetation or Land Cover Class																			Total	Error of Commission-User's Accuracy, (% correct)
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S		
A – Cliff Top Virginia Pine Forest	33																			33	100.0
B – Deciduous Tree / Great Laurel Forest		29				3														32	90.6
C – Disturbed Area			27												1					28	96.4
D – Forest Seep				20																20	100.0
E – Eastern Hemlock - Chestnut Oak / Catawba Rhododendron Forest					18															18	100.0
F – Eastern Hemlock - Sweet Birch - Tuliptree / Great Laurel Forest					1	28														29	96.6
G – Oak - Ericad Forest							26		3											29	89.6
H – Oak - Hickory - Sugar Maple Forest			1					33	3						2					39	84.6
I – Oak - Hickory Forest						1		1	51											53	96.2
J – Pine Plantation			1							19										20	95.0
K – Steep Riparian Edge											27									27	100.0
L – Strip Mine Reclamation												32								32	100.0
M – Successional Tuliptree Forest									1				32							33	97.0
N – Successional Eastern White Pine Forest														6						6	100.0
O – Sugar Maple - Yellow Buckeye - American Basswood Forest									1						28					29	96.6
P – Sycamore - Ash Floodplain Forest																23				23	100.0
Q – Sycamore - River Birch Riverscour Woodland																	9			9	100.0
R – Utility Corridor																		24		24	100.0
S – Yellow Birch Cold Cove Forest																			19	19	100.0
Total	33	29	29	20	19	32	26	34	59	19	27	32	32	6	31	23	9	24	19	503	
Error of Omission – Producer's Accuracy (% correct)	100.0	100.0	93.1	100.0	94.7	87.5	100.0	97.0	86.4	100.0	100.0	100.0	100.0	100.0	90.3	100.0	100.0	100.0	100.0		

Total Points Correct	484
Overall Accuracy	96.22%
Kappa Index	95.98%
90% Confidence Interval	1.19%

Discussion

The vegetation map of NERI provides a comprehensive and detailed view of the vegetation and land cover of the park. A large proportion of the park is currently occupied by natural or semi-natural vegetation of various stand ages and qualities. Areas of natural vegetation are fragmented by cultural and disturbed areas and transportation features. Developed areas are concentrated in private inholdings, mostly on the plateaus and in a few areas along the river.

The predominant natural vegetation types of the park are upland deciduous forests. The distributions of the three major, intergrading, upland deciduous forest community types are probably best explained by soil moisture and fertility gradients which are affected by topographic position, aspect, and geology. The Sugar Maple - Yellow Buckeye - American Basswood Forest occupies moist, fertile sites on concave, lower, and northerly facing colluvial gorge slopes, and has higher ecological amplitude on shale derived soils. The Oak - Hickory Forest occupies dryer, less fertile sites and predominates on plateaus with residual soils derived primarily from sandstone. The Oak - Hickory - Sugar Maple Forest is intermediate and predominates on southerly facing, convex, and upper colluvial gorge slopes and on northerly aspects on the plateaus. The Oak / Ericad Forest is somewhat less extensive compared to the three major community types and occurs on dryer, less fertile sites than the Oak - Hickory Forest. The Chinquapin Oak - Black Maple Forest is an uncommon association restricted to areas with calcareous bedrock. The Yellow Birch Cold Cove Forest is an uncommon association restricted to deep canyons with low solar exposure.

Natural upland forests with a significant conifer component are less abundant than deciduous forests and occur in more specialized habitats. The tops of sandstone cliffs are hot, dry habitats which support small patches and linear zones of Cliff Top Virginia Pine Forest and Cliff Top Pitch Pine Woodland on southerly aspects, and Eastern Hemlock - Chestnut Oak / Catawba Rhododendron Forest on northerly aspects. The Eastern Hemlock - Sweet Birch - Tuliptree / Great Laurel Forest and the related Deciduous Tree / Great Laurel Forest are fairly abundant community types which occur in moist sites (coves, ravines) with acidic, low fertility soils.

Semi-natural vegetation has developed in areas which were cleared by humans then abandoned. Four successional forest community types are represented as map classes and additional patches of these community types and early successional Old Field also occur within the Strip Mine Reclamation and Disturbed Area map classes.

Riparian communities cover a small area but contribute greatly to the overall biological diversity of the park. The riparian data set for multivariate analysis (results presented in Appendix F) included 568 vascular plant species in 75 plots compared to 298 species in 159 plots included in the upland forest and woodland data set. There are nearly as many riparian community types classified in the park (15) as upland forest and woodland community types (16), although the mapped area of upland forests is nearly 39 times greater than the mapped area of riparian communities. Probable reasons for high diversity of species (alpha diversity) and communities (beta diversity) in riparian zones include abundant seed sources, abundant moisture and nutrients, and strong environmental gradients created by variation in flooding intensity and periodicity as affected by relative elevation.

Small areas of headwater wetlands also contribute significantly to species and landscape diversity of the park. The headwater wetland plot data set includes 214 species in 24 plots. Plots from the five headwater wetland community types consistently perform as outliers in multivariate analyses to both the upland and riparian groups due to presence of many obligate wetland plant species.

The vegetation map of NERI presents a snapshot in time, but relationships between community types can also be viewed in terms of succession. Long-term successional patterns are most apparent in the upland forest and woodlands. The entire area of the park was heavily impacted by logging, mining, and other human development in late 1800s through the 1900s. Extensive canopy disturbance resulted in an increase in cover by early successional and shade-intolerant tree species. Following the recovery of forest canopy cover, succession continues by the replacement of shade-intolerant species with shade-tolerant species. Forest soil moisture, organic matter, and fertility increases as time passes since the occurrence of fires or other human-caused disturbances. Seed dispersal acts as a slow agent to reintroduce shade-tolerant understory plant species which were displaced by canopy removal. These processes occur at the stand level and at the landscape level. In the absence of fire or other human-caused canopy and ground disturbances, the aerial cover of upland forest and woodland associations are likely to change in generally predictable ways. Areas of forest and woodland associations adapted to more xeric conditions (Cliff Top Virginia Pine Forest, Cliff Top Pitch Pine Woodland, Oak / Ericad Forest, Oak - Hickory Forest) are likely to decrease over time. Areas of forest and woodland associations adapted to more mesic conditions (Sugar Maple - Yellow Buckeye - American Basswood Forest, Oak - Hickory - Sugar Maple Forest, Deciduous Tree / Great Laurel Forest) are likely to increase. Boundaries between these associations are likely to move upslope. Areas of Eastern Hemlock - Sweet Birch - Tuliptree forest / Great Laurel Forest would be expected to increase, but *Tsuga canadensis* (eastern hemlock) is currently threatened by *Adelges tsugae* (hemlock wooly adelgid), an exotic insect pest. Permanent vegetation plots have been established to monitor changes in eastern hemlock-dominated communities in the park (Wood 1999).

Successional dynamics of riparian and headwater wetland communities in the park are quite different from those of upland communities. Riparian communities are maintained by a disturbance regime of periodic floods. Flooding can maintain open canopies by removing individual trees, or large events can remove entire patches of vegetation. Especially ephemeral riparian vegetation community types include Riverscour Prairie, Riverbank Annuals, and Lizard's-tail Backwater Slough. Catastrophic tributary floods in 2001 during the course of this project resulted in the destruction of mature floodplain forests and deposition of fresh cobble bars and alluvial fans. It has been hypothesized that the Eastern Red-cedar - Virginia Pine Flatrock Woodland at Camp Brookside became established following catastrophic flooding in the late 1800s (McDonald and Trianosky 1995). Successional dynamics and extent of many headwater wetlands are controlled by beaver.

A number of USNVC associations occurring in NERI are likely to be globally and/or state rare. Although formal global and state conservation status ranks (defined in Appendix K) have not been established for many associations, a list of those associations which are likely to be rare is provided in Table 8. A high proportion of these potentially rare associations are associated with riparian zones or cliffs. These are areas of the park where recreational activities (boating,

Table 8. Associations of the U.S. National Vegetation Classification (USNVC) occurring in New River Gorge National River (NERI) which are likely to be globally and/or WV state rare.

NERI community name	USNVC association	Global rank[a]	WV rank[a]
Upland Forests and Woodlands			
Chinquapin Oak – Black Maple Forest	*Quercus muehlenbergii - Quercus (alba, rubra) - Carya cordiformis / Viburnum prunifolium* Forest [CEGL004793]	G4?	SNR
Cliff Top Pitch Pine Woodland	*Pinus rigida – Quercus coccinea / Vaccinium angustifolium* Woodland [CEGL006557]	GNR	SNR
Cliff Top Virginia Pine Forest	*Pinus virginiana – Pinus (rigida, echinata) – (Quercus prinus) / Vaccinium pallidum* Forest [CEGL007119]	G4?	SNR
Eastern Hemlock – Chestnut Oak / Catawba Rhododendron Forest	*Quercus prinus / Rhododendron catawbiense – Kalmia latifolia Forest* [CEGL008524]	G3?	SNR
Yellow Birch Cold Cove Forest	*Betula alleghaniensis – (Tsuga canadensis) / Rhododendron maximum / Leucothoe* fontanesiana Forest [CEGL007861]	G3G4Q	SNR
Lichen and Sparse Vegetation			
Dry Sandstone Cliff	Appalachian – Alleghenian Sandstone Dry Cliff Sparse Vegetation [CEGL006435]	GNR	SNR
Riparian Communities			
Black Willow Slackwater Woodland	*Salix nigra – Betula nigra / Schoenoplectus (pungens, tabernaemontani)* Wooded Herbaceous Vegetation [CEGL006463]	GNA	SNR
Eastern Red-cedar – Virginia Pine Flatrock Woodland	*Juniperus virginiana* var. *virginiana – Pinus virginiana – Quercus stellata / Amelanchier stolonifera / Danthonia spicata – Melica mutica* Woodland [CEGL008449]	G2?	S1
Lizard's-tail Backwater Slough	*Peltandra virginica – Saururus cernuus – Carex crinita / Climacium americanum* Herbaceous Vegetation [CEGL007696]	G2?	SNR
Oak – Tuliptree / Mountain Silverbell Floodplain Forest	*Quercus (alba, rubra, velutina) / Halesia tetraptera* Forest [CEGL006462]	GNR	SNR
Riverscour Prairie	*Andropogon gerardii – Panicum virgatum – Baptisia australis* Herbaceous Vegetation [CEGL006283]	G2G3	SNR
Sycamore – Ash Floodplain Forest	*Platanus occidentalis – Fraxinus pennsylvanica / Carpinus caroliniana / Verbesina alternifolia Forest* [CEGL006458]	GNR	SNR
Sycamore – River Birch Riverscour Woodland	*Platanus occidentalis – (Betula nigra, Salix* spp.) Temporarily Flooded Woodland [CEGL003725]	GNR	SNR
Headwater Wetlands			
Forest Seep	*Acer rubrum – Nyssa sylvatica / Ilex verticillata – Vaccinium fuscatum / Osmunda cinnamomea* Forest [CEGL007853]	G3G4	SNR

[a] Definitions for global and state ranks are provided in Appendix K.

fishing, rock climbing, and sight-seeing) are concentrated and this use may threaten occurrences of these communities and their component plant and animal species. Riparian communities may also be threatened by changes to natural flooding regimes, invasions of exotic invasive species, and water pollution. Occurrences of all of the potentially rare riparian associations may be mapped as pure stands (i.e. the NERI community name is the same as the map class name) and they may also occur within the Steep Riparian Edge map class. Polygons of Steep Riparian Edge should not necessarily be considered inferior conservation units; although many of these polygons are narrow disturbed zones between the river and railroad, others occurring along undisturbed reaches of river shore include high quality natural communities.

Conclusions and Management Recommendations

Although the accuracy of the vegetation map presented here is apparently quite high, errors will inevitably be found and interpretation errors are also likely to occur. Mapping errors may include obvious misattributions of map classes or less-obvious misinterpretations of aerial signatures. These errors could be fixed by updating the geodatabase. Boundaries between similar types, especially the predominant deciduous forest map classes, are represented as lines on the map, but in reality these boundaries will rarely be so definite. Inclusions less than the minimum mapping unit are also likely, especially within more extensive map classes. Although the map may be very useful for office evaluations and planning, field verification of community types using the key to vegetation (Appendix H) is recommended when positive identification is critical.

Spatial distribution and composition of vegetation will change over time, sometimes suddenly, sometimes gradually. Areas of the Cobble Bar map class exposed by floods in 2001 may become revegetated relatively quickly, and would be interesting to revisit in the next few years. Vegetation of the Backwater Slough map class may also be highly dynamic and revisits to sampled plot locations of the Lizard's-tail Backwater Slough community type might help elucidate this. Changes in upland forests are likely to be more gradual and, although it might be tempting to use the vegetation map as a tool to monitor these changes, most boundaries are probably too indefinite to serve this purpose. Revisits to plots with GPS coordinates may be more reliable for detecting long-term changes in these types. However, because cover estimates are subjective and values can vary across short distances, these data are not ideal as a baseline for monitoring.

Photointerpretation may have greater value for detecting changes in conifer signatures. Infestation of *Tsuga canadensis* (eastern hemlock) by *Adelges tsugae* (hemlock wooly adelgid) is now considered to be widespread in the park (NPS, John Perez, Biologist, personal communication, 2007). Many stands of eastern hemlock are likely to die and survival of individual trees or small stands may depend on human intervention. Decline of eastern hemlock may represent the single greatest change to vegetation in the park in the near future. Because canopies with eastern hemlock can usually be distinguished remotely, the vegetation map and aerial imagery developed for this project may be used as a baseline to monitor these changes and to identify stands which have not yet been assessed for adelgid infestation.

Some imminent threats to natural vegetation in the park can be identified and some of these present opportunities for intervention. Priorities can be set based on the occurrence of rare community types and species and likelihood of success. Although eradication of invasive exotic plant species throughout the park is an unrealistic goal, some high priority areas can be identified where eradication may be practical and have high benefits. The two stands of the globally rare Eastern Red-cedar - Virginia Pine Flatrock Woodland at Camp Brookside and Sandstone Falls host a number of rare plant species and should be a high priority for exotic plant removal. Exotic plant species, especially *Rubus phoenicolasius* (wine raspberry) and *Lonicera japonica* (Japanese honeysuckle), have become more abundant in the stand at Camp Brookside since it was treated by prescribed burning in 2001. Exposures of flatrock with Riverscour Prairies at Camp Brookside and Keeney's Creek also host rare plant species and should be targeted for removal of

the exotic plant species *Sedum sarmentosum* (stringy stonecrop) and *Lespedeza cuneata* (sericea lespedeza) which are becoming well established and are rapidly changing successional dynamics of these communities by trapping sediments. Exotic plants are nearly ubiquitous in stands of Sycamore - Ash Floodplain Forests and Tributary Floodplain Forests of the park and are likely to become more abundant; for these community types it may be desirable to choose a small number of polygons as trial areas where populations of exotic plant species such as *Polygonum cuspidatum* (Japanese knotweed) and *Alliaria petiolata* (garlic mustard) are actively controlled. Best management practices for control of exotic invasive plants throughout the park should include avoiding construction of new roads and trails, avoiding use of nonnative plant and fill materials, and controlling populations along existing roads and trails.

Cliff community types should also be given high priority for close monitoring and management. Vegetation of cliff tops with easy access are often heavily trampled by sightseers and climbers, and this visitation may also disturb animals (e.g. common ravens [*Corvus corax*], peregrine falcons [*Falco peregrinus*]) which use cliff habitat. Little is known about the lichen communities of cliff faces or the effects of climbing on these communities. Pedestrian traffic and climbing should be managed to insure that selected areas of high-quality cliff systems remain difficult to access and seldom visited.

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Appendix A. Vegetation plot field form.

Form 3: Quantitative Community Characterization Draft: Spring, 1993

A. Identifiers (general EOR information)

Sci. name: 1.SNAME: Pinus virginiana / Vaccinium palidum 2.GNAME: NERI.204
3.Site name: New River Gorge
4.Survey site name: Endless Wall
5.Quad name(s): Fayetteville 6.Quad code(s):
7.County name(s): FAYETTE 8.County code(s):
9.Town (LOCALJURIS):
10.Lat: __ __ __ __ __ __ N 11.Long: 0 __ __ __ __ __ __ W 12.Directions:
Endless Wall ~ near first spit south of Fern Creek

GPS file C0904I5A UTM: 4211645.644 N 494622.882 E
13.Sourcecode: 2001NERI.004 14.Survey date: Sept. 4. 2001
15.Last obs: . . 16.First obs: . . 17.State: WV
18.Surveyors: Jim Vanderhorst, Leah Ceperley

B. Environmental Description photos 12, 13

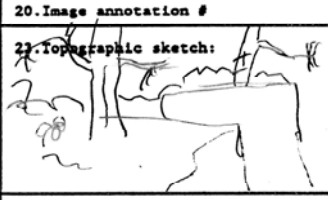
19.Transect / Observation point #

20.Image annotation #

21.Elevation: 1850 ft.

22.Topographic position:
__Interfluve __Backslope
__High slope __Step in slope
X High level __Lowslope
__Midslope __Toeslope
__Low level __Channel wall
__Channel bed __Basin floor
__Other

23.Topographic sketch:



24.Slope degrees: 8°
25.Slope aspect: 220 (SW)
26.Parent material: Sandstone

27.Soil profile description: note depth, texture, and color of each horizon. Note significant changes such as depth to mottling, depth to water table, root penetration depth (SOILCOM)

28.Organic horizon depth: 7cm
29.Organic horizon type:
30.Average pH of mineral soil: 5

in walk of plot away from edge

litter 2cm
O 7cm
A 2.5Y 4/1 sandy clay loam 10cm
B 2.5Y 7/6 loamy sand w/ many roots 15+ cm

31.Soil moisture regime:
__Extremely dry __Somewhat wet
X Very dry __Wet
__Dry __Very wet
__Somewhat moist __Permanently inundated
__Moist __Periodically inundated

32.Stoniness:
__Stone free <0.1%
__Moderately stony 0.1-1%
__Stony 3-15%
__Very stony 15-50%
X Exceedingly stony 50-90%
__Stone piles >90%

33.Soil drainage:
X Rapidly drained __Somewhat poorly drained
__Well drained __Poorly drained
__Moderately well drained __Very poorly drained

34.Average texture:
__ sand __ clay loam
X sandy loam __ clay
__ loam __ peat
__ silt loam __ muck
__ other

35.Unvegetated surface:
2.0 % Bedrock
___ % Large rocks (cobbles, boulders > 10 cm)
___ % Small rocks (gravel, 0.2-10 cm)
___ % Sand (0.1-2 mm)
10 % Bare soil
50 % Litter, duff
5 % Wood (> 1 cm)
___ % Water
___ % Other:

36.Environmental Comments: Note homogeneity of vegetation, erosion / sedimentation, inundation, etc. Sandstone rimrock with Pinus virginiana community. Very shallow soils on level bedrock strata. Dense shrub understory of heath and greenbrier. Very low herbaceous diversity. Community is dissected by many adventitous trails

37.Plot representativeness:
narrow zone (ca. 10 m wide) along edge of cliff band

C. Vegetation 38.System: X Terrestrial ___ Palustrine ___ Estuarine 39.Plot number: 204 40.Plot dimensions: 10 x 40 m

41.Leaf type:
__Broad-leaf
__Semi-b.oad-leaf
__Semi-needle-leaf
X Needle-leaf
__Graminoid
__Broad-leaf herbaceous
__Pteridophyte

42.Leaf phenology:
__Deciduous
__Semi-deciduous
__Semi-Evergreen
X Evergreen
__Perennial
__Annual

43.Physiognomic type:
X Forest
__Sparse woodland
__Shrubland
__Dwarf shrubland
__Sparse dwarf shrubland
__Non-vascular
__Woodland
__Scrub thicket
__Sparse shrubland
__Dwarf scrub thicket
__Herbaceous
__Sparsely vegetated

44.	height	% cover
T1 Emergent tree		
T2 Tree canopy	15m	60
T3 Tree sub-canopy	8m	40
S1 Tall shrub	3m	40
S2 Short shrub	.5m	40
H Herbaceous	.1m	20
N Non-vascular		3
E Epiphyte		
V Vine / liana		

45.Species / percent cover: starting with uppermost stratum, list all species and % cover for each in the stratum. For forests and woodlands, list on a separate line below each tree species the DBH of all trees above 10 cm diameter. Separate the measurements with a comma and note whether in cm or inches.

(T2) Pinus virginiana	40	(S1) Pinus virginiana	10	(H) Smilax glauca	1
13,19,8,14,23,20,15,14,20,16,21		10,10,10,7,7,8,10,8,8,9		Gaultheria procumbens	1.0
15,28,22,15,23,34,17,17,22,15,20		Ilex opaca	T	Acer rubrum	T
13,17,18,18,16,		Nyssa sylvatica	1	Andropogon virginicus	T
Populus grandentata 17,	1	snag 10,7.5,7.5,40,10,15	0	Danthonia spicata	1
Quercus prinus 49,12,22,22	10	Amelanchiar "arborea"	3	Dicanthelium	T
Pinus rigida	3	7.5,		Vaccinium pallidum	T
37		Smilax rotundifolia	20	Amelanchiar 'arborea'	T
Quercus velutina 36,17,	5	Rhododendron maximum	5	Pinus virginiana	T
snag 13,14	T	Oxydendron arborea 10,8	5		
(T3) Pinus virginiana	20	Acer rubrum	T		
16,7,16,16,19,10,13,15,21		Kalmia latifolia	1		
13,13,13,9,11,12,13,16,13,8,14,13		(S2) Vaccinium palidum	10		
13,11,12,17,14,15,		Smilax glauca	3		
		Acer rubrum	1		
		Sasafras albidum	5		
Pinus rigida	3	Oxydendron arborea	5	(N) Leucobryum ✓	1
14,13,		Betula lenta	T	Dicranum	T
Quercus rubra 10,	1	Gaylussacia baccata	3	Polytrichum	1
Oxydendron arborea	5	Rhus copallinum	T	Umbilicaria	T
10,11,8,10,10		Amelanchiar arborea	T		
Acer rubrum	3	Ilex opaca	1		
7.5,14,10,		Smilax rotundifolia	5		
Snag 10,8,10	0	Quercus	T		

Appendix B. Physiognomic type definitions.

FOREST: Trees usually over 5 m tall with crowns interlocking (generally forming 60–100% cover). Shrubs, herbs, and nonvascular plants may be present at any cover value.

WOODLAND: Open stands of trees usually over 5 m tall with crowns not usually touching (generally forming 25–60% cover). Shrubs, herbs, and nonvascular plants may be present at any cover value.

SHRUBLAND: Shrubs and/or small trees usually 0.5–5.0 m tall with individuals or clumps not touching to interlocking (generally forming >25% canopy cover). Trees may be present, but with cover of 10% or less. Herbs and nonvascular plants may be present at any cover value.

HERBACEOUS: Graminoids and/or forbs (including ferns) generally forming >10% cover. Trees, shrubs, and dwarf shrubs may be present, but with cover 10 percent or less. Nonvascular plants may be present at any cover value.

NON-VASCULAR: Non-vascular vegetation (bryophytes, lichen, or other non-vascular plants) with cover greater than 25%. Trees, shrubs, and herbns may be present, but with cover of 25% or less.

SPARSELY VEGETATED: Substrate is predominantly not vegetated, cover of trees, shrubs, herbs, and non-vascular vegetation combined is 25% or less.

Appendix C. Standard accuracy assessment form for USGS-NPS Vegetation Mapping Program.

Plot Number: _____ Park: _____ Date: _____ Observers: _____

Easting: _ _ _ _ _ _ E Northing _ _ _ _ _ _ _ N EPE/APE: _____ DOP: _____ Map datum: _____ Zone: _____

Topographic Description: _____ Elevation: _____ Aspect: _____ Canopy Closure: _____

Vegetation Association at Point: _____

Veg Assoc 1 w/in 50 m of point: _____

Veg Assoc 2 w/in 50 m of point: _____

Major Species by Strata:

_____

_____

Rationale for Classification:

_____

_____

_____

Comments:

_____

_____

A table containing the fields that appear on this standard accuracy assessment form was created in ArcGIS and converted to a Trimble data dictionary file for use in the field. All field data were entered directly into the electronic data dictionary.

Descriptions of fields:

Plot Number: randomly generated in ArcGIS
Park: NERI - New River Gorge National River
Date: automatically generated in the field
Observers: name of observer
Easting / Northing: UTM coordinates automatically generated in field if GPS satellites were available, otherwise edited in ArcGIS after field data were collected
EPE / APE: estimated from GPS differential correction software if collected, otherwise estimated by observer
DOP: estimated from GPS software
Map Datum: NAD 83
Zone: 17N
Topographic Description: descriptors of slope steepness, shape of slope and position on slope
Elevation: calculated by the GPS software, otherwise taken from a topographic map
Aspect: measured to the nearest 1º Azimuth using a Silva ranger handcompass
Canopy Closure: ocular estimate in percent
Vegetation Association at Point: based on the vegetation key
Vegetation Association 1 and 2 within 50 m of point: based on vegetation key and distance to these are also recorded
Major species by strata: common names of major canopy trees seen at point
Rationale for Classification: indicate if it was a strong match to the vegetation key; if it was not, record reasons why the match was not so good
Comments: any other comments

The following fields that are not on the standard form were added to the data dictionary:
Canopy height: measured to the nearest 5 feet
Minor species: herbaceous, shrub, or minor tree species worth noting