Riparian Conditions of the Gauley and Meadow Rivers in Gauley River National Recreation Area, West Virginia

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EXECUTIVE SUMMARY

The West Virginia Division of Natural Resources (DNR) was contracted by the National Park Service (NPS) to map the riparian zone of the Gauley and Meadow Rivers in Gauley River National Recreation Area, evaluate the condition of this zone, and offer recommendations for management of the zone. To accomplish this task the DNR utilized Color Infrared Orthorectified aerial photography (CIOAP) provided by the NPS and protocols developed by the U.S. Bureau of Land Management to assess riparian condition. Of the 85 sites surveyed 71 (83.5 percent) of were considered functioning at or near their potential, 8 (9.4 percent) were considered functioning, but at risk of reduced function and 2 (2.3 percent) were rated as non-functional. The data clearly show that riparian areas of the Gauley and Meadow Rivers within Gauley River National Recreation Area are functioning to their capability and potential.

TASK

The West Virginia Division of Natural Resources was contracted by the National Park Service to map the riparian zone of the Gauley and Meadow Rivers in Gauley River National Recreation Area (GARI), evaluate the condition of this zone and offer recommendations for management of the zone.

Mapping the riparian zone would be accomplished using the best available resources. Primary data sources considered for mapping were: Gauley River National Recreation Area Color Orthorectified 1:4,800 Aerial Photography (CIOAP), West Virginia Statewide Addressing and Mapping Board (SAMB) 1:4,800 aerial photography, Light Detection and Ranging (LiDAR), and multi-spectral imagery (MSI). LiDAR technology is capable of producing high resolution elevation models that could be used to delineate floodplain benches. MSI has the potential to remotely delineate riparian plant communities. DNR investigated the feasibility of sub-contracting Canaan Valley Institute which recently acquired the means to provide the LiDAR and/or MSI, but both were expensive and beyond the funding ability of the project. The State of West Virginia, as part of their 911 mapping effort, contracted a private consultant for 1:4,800 photography, however, this did not become available to the DNR until too late in the project to be used in the mapping efforts. Therefore, DNR used the CIOAP to initially delineate and map the riparian zone of the Gauley and Meadow Rivers in the GARI.

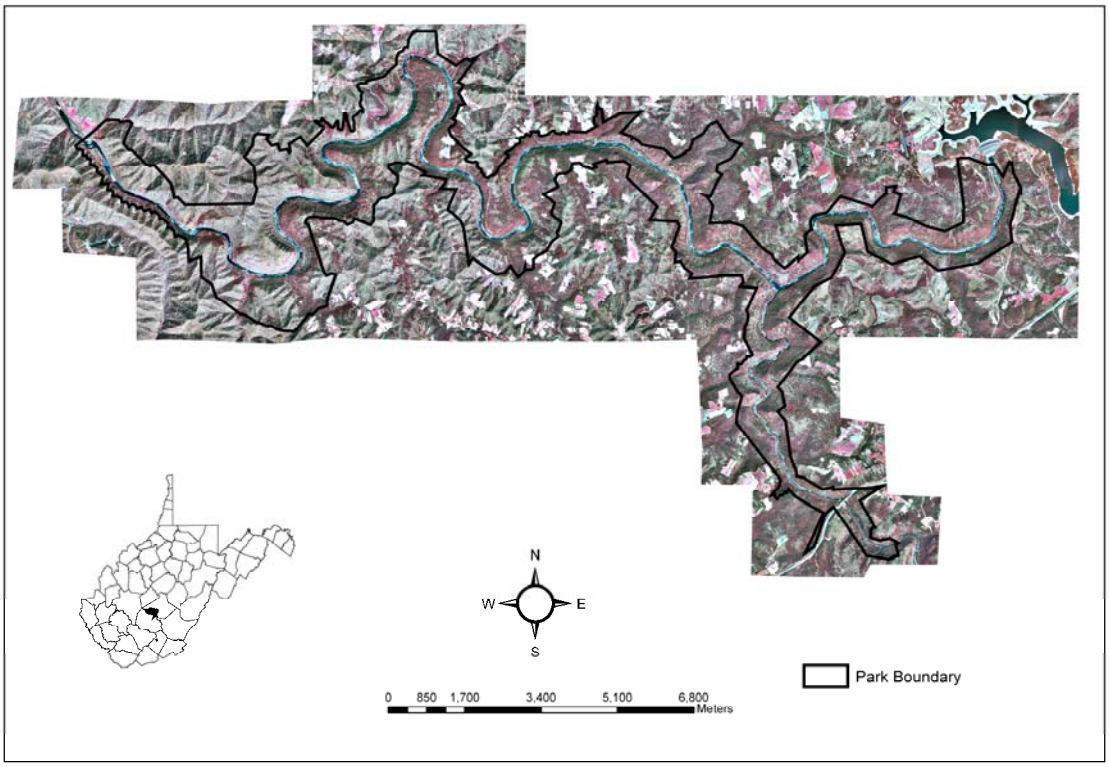
Accuracy of the riparian zone mapping from CIOAP would be evaluated by visiting and visually field inspecting a random sample of the mapped sites. Given the rugged nature of the study area, evaluation sites were largely determined by rail trail accessibility. Mapping of the riparian zone from CIOAP would be deemed acceptable if the mapped areas accurately represented conditions observed during field inspections. The agreement between the NPS and DNR stated that the riparian zone mapping should be accurate within 10 meters.

Riparian zone condition would be evaluated using protocols developed by the U. S. Bureau of Land Management (Prichard 1998), hereafter referred to as the BLM protocol.

STUDY AREA

The assessment area included the riparian zones along the 25.5 miles of the Gauley River and 5.5 miles of the Meadow River within the Gauley River National Recreation Area (Map 1). Riparian zones within the study area consisted of a relatively flat landform (riparian bench) adjacent to the stream that was subject to frequent inundation. Inundation of the riparian bench at least once every 1.5 years is considered frequent. Bankfull discharge is considered the point at which water starts to flow onto the floodplain. This discharge is essentially the same as the effective or dominant discharge. Over time the bankfull discharge transports the majority of sediment load and therefore is responsible for formation and maintenance of the channel. Any flow that exceeds the bankfull discharge will flow onto the floodplain. The bankfull discharge on the average has a return interval of 1.5 years. Abandoned floodplains or terraces are flooded less frequently and are referred to as 5, 10 or 100 years floodplains depending upon their

elevation upon the landscape. For the purposes of this study the authors considered the riparian bench as the primary floodplain.



Map 1. Gauley River National Recreation Area.

The Gauley and Meadow Rivers flow in Type II valleys (Rosgen 1996). Type II valleys generally have moderate relief, are relatively stable, and have valley slopes less than four percent. The Gauley and Meadow Rivers are B2/1c streams (Rosgen 1996). "B" stream types are the most common stream type in Type II valleys, and are generally stable and have low sediment supplies. B2/1c stream types have less than two percent slope, have moderate width/depth ratios, are moderately entrenched, are dominated by boulders with bedrock controls and have bed features that often produce extensive rapids. As anyone who has rafted down the Gauley River can testify, it definitely has extensive and intense rapids.

The Gauley River was regulated by the Summersville Dam in 1966 for the main purpose of flood control. Summersville Dam, located at the upstream boundary of the Gauley River National Recreation Area, has dramatically altered peak discharges in the Gauley River below Summersville Dam.

The United States Geological Survey Water Watch website for West Virginia (http://water.usgs.gov/cgi-bin/waterwatch?map_type=real&state=wv) allows the user to

access current and historical discharge data. Peak discharge of the Gauley River below Summersville Dam (USGS gage 03189600, 806 mi^2 drainage area, river mile 35.3) has not exceeded 18,200 cubic feet per second (cfs) since the dam has been in operation. In contrast, upstream of Summersville Dam, the Gauley River near Craigsville (USGS gage 03189100, 529 mi^2 drainage area, river mile 61.5) has exceeded 18,200 cfs 22 times since 1970.

The highest recorded (period of record 1932-present) discharge at the Craigsville gage (65,000 cfs) occurred on July 4, 1932 (pre-dam). This same event produced a discharge of 105,000 cfs on July 5, 1932 at the Gauley River above Belva (USGS gage 03192000, 1,317 mi^2 drainage, river mile 6.3) located about 10 miles downstream of the lower end of the Gauley River National Recreation Area.

In contrast, on November 4, 1985 (post-dam), the Craigsville gage recorded 61,800 cfs, the second highest reported discharge for that gage. However, this event was not even the yearly peak discharge event for the Belva gage (May 25th, 1985 23,800 cfs). The Summersville Dam gage was not in operation between October 1982 and September 1986, so discharge data is unavailable for the November 4, 1985 event at that site.

The unregulated Meadow River has a watershed of 365 square miles and its confluence with the Gauley River is approximately five miles below Summersville Dam. The extensive wetlands in the Meadow River watershed moderate flood flows. The Meadow River gage located near the mouth at Mount Lookout (USGS 03190400) has consistently reported lower peak flows than the Gauley River Camden gage (03187000), which has a smaller contributing watershed (236 square miles) for the same storm event. For example, a February 1994 flood event produced a discharge of 12,300 cfs for the Meadow River gage and 17,800 cfs for the Camden gage. The Meadow River gage at Mount Lookout consistently reports higher mean monthly flows than the Camden gage thereby adding support to the argument that peak flows are moderated by the Meadow River wetland complex. While the Meadow River adds significant flows, its influence on the Gauley River is overshadowed by the presence of the Summersville Dam.

Even though “B” channels in Type II valleys generally do not carry high sediment loads, Summersville Dam further reduces transport by effectively trapping most sediment originating in the upper Gauley River watershed. Moving water has the capability to transport sediment. In a stable, natural stream system, sediment is transported at the same rate it is removed so that the channel neither aggrades nor degrades (Rosgen 1996). Dams disrupt this natural ability of moving water to transport sediment. Dams effectively remove all of the bedload and significant amounts of suspended sediments from the water. The clear water released from the dam has the capacity to move sediment, but it has none. This condition must be resolved for the stream system to maintain equilibrium. In many cases it is resolved by eroding bed and banks. This phenomenon has been referred to as “hungry water” because it “eats” away at the bed and banks of the river (Kondolf 1997).

The Meadow River is not regulated by a dam and therefore transports sediments from its watershed to the Gauley River. Extensive wetlands that help moderate flood discharge also reduce sediment loads. However, as can be seen in aerial photography (Figure 1), the Meadow River during periods of high discharge does transport suspended sediments to the clear sediment-free Gauley River. The Meadow River has, over time, naturally adjusted its dimension, pattern and profile to efficiently transport its sediment load.

Figure 1. Confluence of Meadow and Gauley Rivers. The SAMB aerial photograph clearly shows suspended sediments of the Meadow River (entering from bottom) being discharged into the sediment free Gauley River (entering from right).

METHODS

Mapping

Aerial photography (CIOAP) was obtained for the project area from the NPS (Figure 2). Heads up digitizing was employed by DNR technical support staff to delineate the riparian zone. The process was complicated by the steep valley type and narrow riparian zone. Also, without first-hand knowledge of the river it was often difficult to distinguish between point bars and large flat boulders.

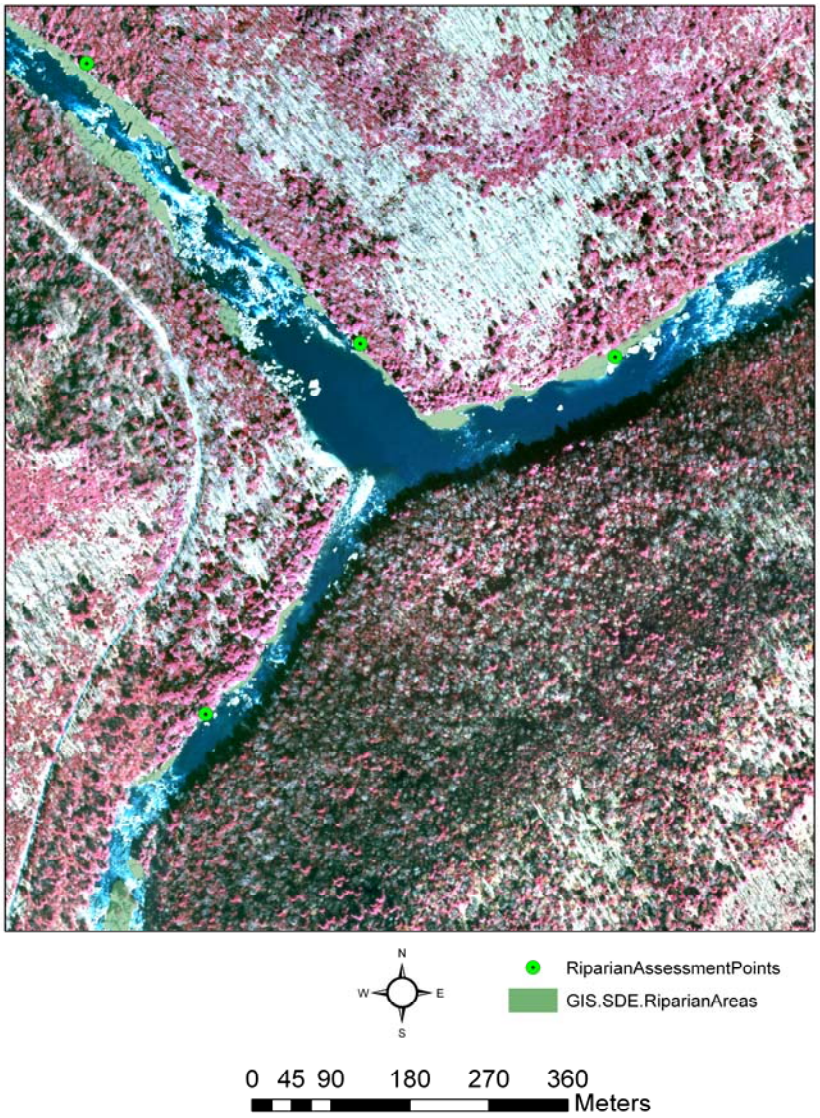


Figure 2. Example of heads-up delineation of riparian areas (green shading) on a CIOAP image of a portion of the Gauley and Meadow Rivers. Large riparian zone on the left descending bank at the confluence of the Meadow and Gauley Rivers was not mapped accurately. In addition, some of the areas shown in green as riparian zones are in fact large flat boulders.

After the riparian corridor was delineated in the office from aerial photography, it was downloaded into a Trimble Geo-XT Global Positing Unit (GPS) for on-the-ground verification. A DNR interdisciplinary team led by Danny Bennett, a fisheries biologist with extensive training in fluvial geomorphology, was assisted by Keith Krantz, Brian McDonald, Joel Harrison and Ben Gilmer. The team visited sites accessible from the rail trail and/or with a moderate amount of cross-country hiking. It was determined that some riparian zones had been misinterpreted and not delineated consistently. For example, areas that had been delineated as riparian habitat were in fact large boulders and a large riparian area at the mouth of the Meadow River was not delineated as riparian habitat. Therefore, it was decided that the entire study area would need to be visually examined to accurately establish extent and determine the condition of the riparian zones. Due to the nature of the study area, the only practical method of accessing the Gauley River riparian corridor was by raft. The Meadow River section of the study area was accessed from the rail trail that parallels that river. Riparian zone delineation and condition assessment were performed simultaneously.

The Cooperative Agreement (CA 4000-8-9011) between the DNR and NPS states that DNR will conduct several iterative sessions that alternate office GIS boundary settings with ground truthing until 90 percent correctness in setting riparian zones boundaries within 10 meters is established. As stated previously, delineating riparian zones from CIOAP did not achieve the desired level of accuracy. During field visits to the Meadow and Gauley rivers it was determined that there was a fairly consistent narrow riparian bench that extended approximately 10 meters (33 feet) from the edge of the ordinary high water mark (OHW) throughout the GARI. Given this fairly consistent feature it was decided that mapping the riparian zone would best be accomplished by digitally establishing a 10-meter riparian buffer strip (adjacent to water's edge) along the entire reach of both rivers (Figure 3). With this 10 meter buffer delineated as the approximate riparian zone of the Gauley and Meadow Rivers, greater than 90 percent of the actual riparian zone was included in the 10 meter margin of error (0-20 meters from edge of the OHW). The few true point bars were not considered to be "riparian zones," but in-channel features that may contain some riparian plants. Point bars are inundated at a significantly greater frequency than riparian floodplain benches and therefore generally do not contain the same vegetative characteristics as floodplain benches.

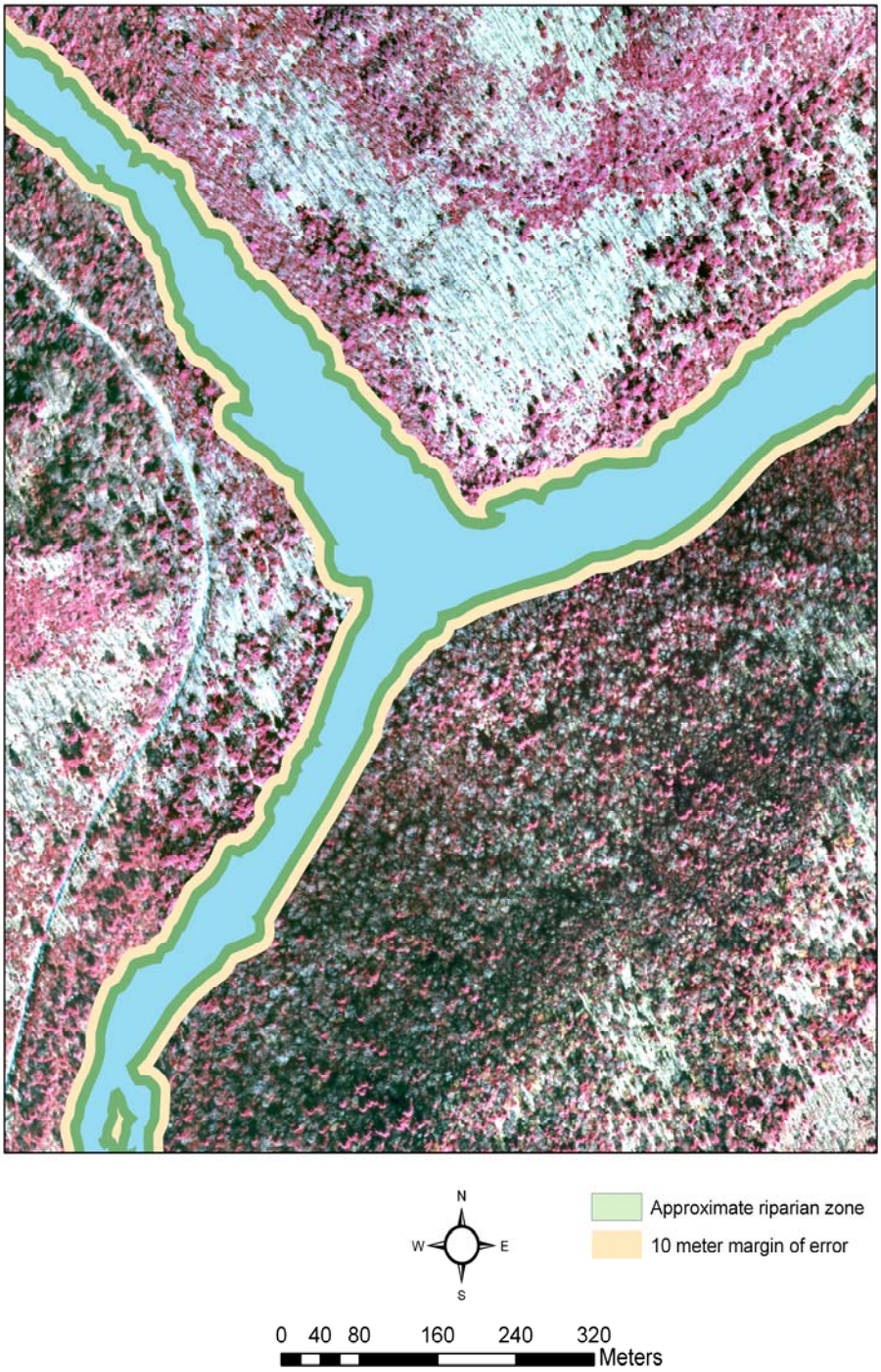


Figure 3. Example of riparian zone delineation based on field observations (see text). A ten meter buffer strip from the visible edge of water was digitally placed on the map and is shown in green. The beige band represents the 10 meter margin of error agreed to in the cooperative agreement. Greater than 90 percent of the actual riparian zone of the GARI will be included in this 20 meter zone. Image shows confluence of the Meadow River (entering from bottom) into the Gauley River (entering from right).

Condition Assessment

GIS technicians placed circles on CIOAP such that the circle circumference would overlay the outside bend of the river. River bends in the Gauley and Meadow Rivers within the GARI were visually broadly classified as straight, tight bends, broad bends, and stream confluences in order to determine the relative proportion of each classification. A biologist trained in river morphology reviewed the data set and selected arcs that were distributed throughout the study area and represented the broad classifications proportional to the classification types (Figure 4). This exercise yielded seventeen arcs. It was believed that the chosen arcs adequately represented the study site. On tight arcs the entire area could be evaluated, however on broad arcs evaluating the entire arc would be time prohibitive. Therefore, it was arbitrarily decided that five evenly spaced sites would be surveyed on each broad arc. Five sample points were placed on each arc; each point represented an individual riparian survey assessment site. A total of 85 riparian assessment survey sites were thereby defined. To aid in field navigation, point coordinates were downloaded into the GPS receiver. Exact locations of individual sites were adjusted in the field because it was not possible, due to river conditions, to reach some of the predetermined locations. Access to Gauley River sites was accomplished by raft, while Meadow River sites were accessed by hiking to the locations from the rail trail that parallels the river.

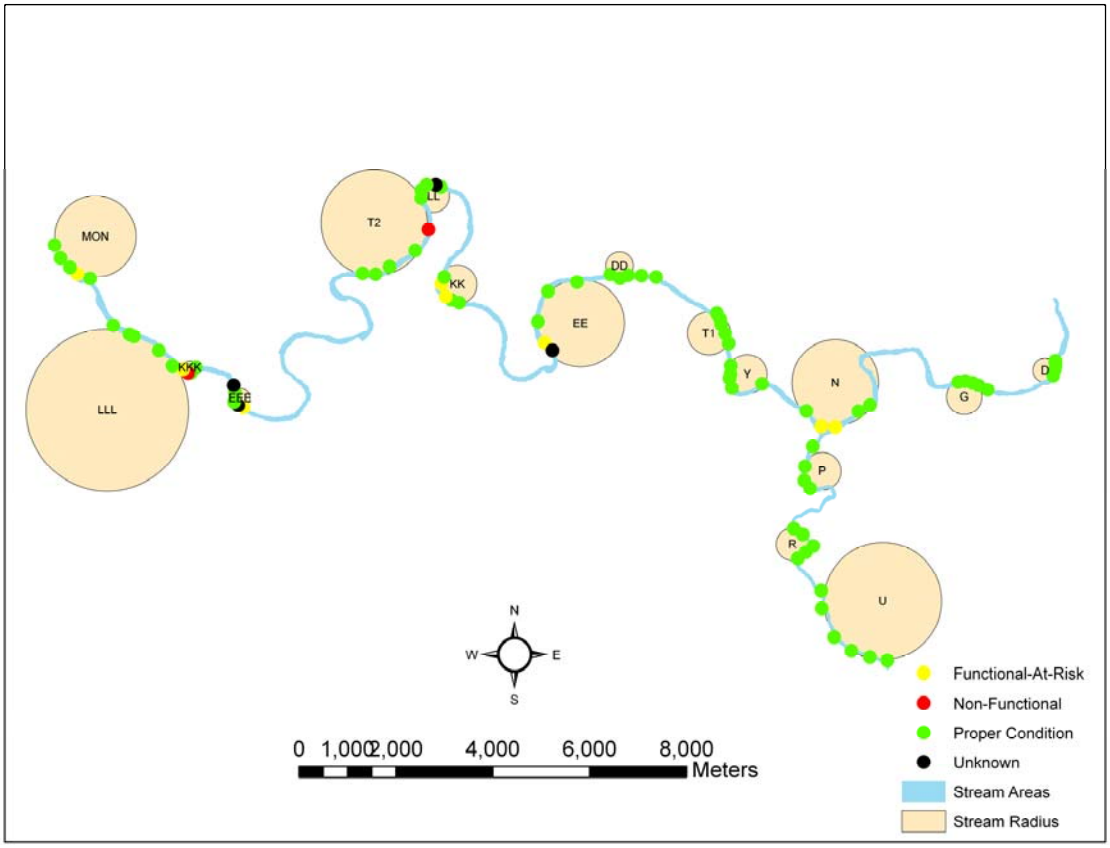


Figure 4. Arcs. The figure shows the inside and outside bends selected for the study. Sites T1 and T2 were stream confluences. Exact locations of individual sample points taken in the field are shown and functional condition of the points are graphically displayed.

The BLM protocols were developed in the western United States to quickly and qualitatively evaluate riparian condition in a relatively consistent manner with minimal data collection. The developers of the protocols established a series of questions in a checklist to guide the evaluator in determining the condition of a particular riparian corridor (Appendix 1). The seventeen questions in the checklist allow for a consistent approach for considering the roles that hydrology, vegetation and erosion/deposition potential play in the condition of a riparian zone. This approach should be considered a valuable first step in prioritizing the type and location for more detailed quantitative studies of sensitive areas. To maintain consistency, the checklist was completed by the same evaluator for all sites in the study. After completing the checklist the evaluator made a determination of the condition of the riparian zone at the individual site. Four separate trips were made to the GARI to evaluate riparian condition. Sites on the Meadow River were completed in two days and two separate float trips were required to complete the sites on the Gauley River.

The BLM protocols do not compare a study area to some idealized pristine reference condition, but evaluate each site on its individual potential and capability. Potential is defined as the highest ecological status a riparian area can attain given no political, social or economic constraints. Capability is defined as the highest ecological status an area can attain given political, social or economical constraints. Capability does not apply to uses, such as grazing, farming, recreation, and timbering, which can be changed. However, Summersville Dam is a constraint on the Gauley River that cannot be changed due to political, social and economic reasons. Therefore, our assessment of the Gauley and Meadow River riparian zones were made considering the very limited potential of extensive floodplains due to valley type and the influence of Summersville Dam.

Some of the questions in the checklist were not applicable to this study because there was no potential for that action to occur. For example, Question 2 asks, “Where beaver dams are present, are they active and stable?” There were no beaver dams present in the study area and, due to very high energy nature of the mainstem Gauley and Meadow Rivers, there is no potential for beavers to build a dam within the Gauley River National Recreation Area.

In other cases, a positive response was recorded although the site was not at full potential. For example, Question 12 asks whether plant communities provide adequate large woody material to the system. The plant community may not be at full potential but, in the evaluator’s opinion, it still provides adequate large woody material.

After completing the checklist for each individual site, a rating of Proper Functioning Condition (PFC), Functional at-risk (FAR), Non-Functional (NF) or Unknown was assigned. Sites rated as PFC were sites that, for their capability, were functioning at or near their potential. Sites with a FAR rating were sites still functioning at or near potential, but were being negatively influenced by disturbance. Sites rated NF had compromised riparian functions and were no longer functioning close to their potential. Sites were rated Unknown when it was difficult for the evaluator to determine the status of the riparian zone, or the riparian zone was non-existent due to the presence of physical

feature such as a vertical rock cliff. Exact GPS points were obtained from each sample point using an Advantage Laser Offset unit (Laser Atlantic Optics), Trimble Geo XT GPS unit, and a TDS Ranger (Tripod Data Systems) data logger. Digital photos were taken of each sample site using a Cannon PowerShot S60 (Appendix 2). Due to technical difficulties no photographs were taken at sites KKK 2-5, LLL 2-5, MON 2-5.

RESULTS

Of the 85 sites surveyed, 71 (83.5 percent) were rated PFC, 8 (9.4 percent) were rated FAR, 2 (2.3 percent) were rated NF. We were unable to determine condition at 4 (4.7 percent) of the sites. The data clearly show that riparian areas of the Gauley and Meadow Rivers within the Gauley River National Recreation Area are functioning at capability and potential. The responses to each question for all 85 samples sites are provided in Appendix 3.

Each question on the checklist was analyzed using Microsoft Excel Pivot Tables to compute basic statistics and determine if there were any significant trends in the responses to individual questions and/or the assignment of the PFC scores (Appendix 4). After consultation with the DNR statistician it was determined that detailed statistical analysis was impractical and unnecessary due to the extremely skewed nature of the data.

The checklist has three separate but interrelated sections. Questions 1-5 deal with hydrology, questions 6-12 deal with the influence of vegetation, and questions 13-17 address erosion and deposition. Hydrology will influence the species composition of the riparian zone and can significantly influence the potential for erosion. The type and amount of riparian vegetation will affect erosion rates.

Question 1: Is the floodplain inundated relatively frequently? This question had a 91.76 percent positive response (78 out of 85). The presence of debris lines was an obvious indication that river water inundated the relatively narrow floodplain. We visited the Meadow River during a high discharge event on September 29, 2004. The edge of the water was in the lower reaches of the floodplain. Discharge on the sample date was about 2000 cfs. Annual peak discharges for the Meadow River (USGS gage 03190400, Meadow River near Mount Lookout, WV) exceeded 5000 cfs in every year except one between 1967 and 2002. This is further evidence that the floodplain is inundated relatively frequently. The Gauley River riparian assessment was competed during typical whitewater releases of about 2000-2400 cfs. At this discharge, water's edge was near the edge of the floodplain. Annual peak discharges of the Gauley River below Summersville Dam (USGS gage 03189600) reach 15,000 cfs, indicating that the river frequently inundates the narrow riparian corridor. Seven (8.2 percent) responses to this question were answered other than in the affirmative. These were areas where there were no field indicators such as a debris line or vertical bluffs. This study provides no evidence of any apparent correlations between the frequency or extent of floodplain inundation and a determination that the riparian zone is not functioning properly (NF rating).

Question 2 deals with the presence of beaver dams. The topography of the Gauley and Meadow Rivers does not lend itself to the building of beaver dams. The lack of beaver

dams does not impact the assessment of the riparian zone because this area does not have the potential to have beaver dams. This question was answered "not applicable" for all sites.

Question 3 relates fluvial geomorphic features of channel sinuosity, width/depth ratios, and channel slope to the riparian zone. The Gauley and Meadow Rivers appear to be very stable systems. The large boulders in the channel and on the banks provide an armoring effect on the channel. Field indicators such as the lack of actively eroding banks, minimal exposed root masses, absence of mid-channel bars, etc. indicate that the river systems are in balance with the landscape. Eighty-four of the 85 (98.8 percent) sites had a positive response to this question.

Question 4 asks whether the riparian zone is widening or has achieved its potential extent. This question had an 89.4 percent (76 out of 85) positive response indicating that the riparian zone has achieved its potential extent. Given the physical characteristics of the valleys it is not possible for the riparian area to be widening. For the most part there is a narrow (~10m) riparian bench on both rivers, with a dramatic change in ground slope from the floodplain bench to the upland vegetation. The beginning of the upland vegetation generally is well defined by the presence of rhododendron (*Rhododendron maximum)*. At the vast majority of sites, the riparian vegetation extends the full width of the floodplain bench. Six of the ten sites (60 percent) rated as NF or FAR had riparian zones that had not achieved their potential extent. For these sites there was evidence that upland vegetation was encroaching on the floodplain, and/or human disturbance had significantly reduced riparian vegetation.

Question 5 is similar to Question 4 but asked about upland vegetation encroaching onto the floodplain. For 80 (94 percent) of the surveyed sites there were no obvious signs indicating that upland vegetation was encroaching onto the floodplain. At the five sites where upland vegetation was encroaching onto the floodplain, the upland species were not dominant with only a few individual upland plants, generally rhododendron, on the upper edge of the riparian zone.

Question 6 asks about the age-class distribution of riparian vegetation. The BLM protocol considers two age classes with emphasis on young (recruitment) and middle-aged classes (replacement) to be an adequate age-class distribution of riparian vegetation to maintain riparian function. There is a slight emphasis on woody vegetation, but understory coverage was also considered. Large storm events in unstable riparian zones could produce an even-age community where the stand age could be traced back to a single storm event. Uneven aged stands are generally considered more ecologically valuable. Young trees provide evidence of ongoing recruitment and mature vegetation has well established root systems better able to withstand high flow events. Uneven aged stands tend to be less susceptible to catastrophic events such floods or disease and can quickly recover after such events. Since the Gauley River is regulated by Summersville Dam, extremely high discharges are no longer part of the hydrologic regime. Therefore, it is unlikely that high discharge events will produce sufficient energy to dramatically remove large sections of riparian vegetation leading to an even-aged community. The

Meadow River is not regulated by a dam, so there is potential for extreme storm discharges to scour away riparian vegetation and lead to development of an even-aged riparian community. Our data indicate that there generally appears to be a diverse age-class distribution of riparian vegetation in 71 (84 percent) of the sample sites. Eleven (13 percent) of the sites were determined not to have a diverse age-class distribution of riparian vegetation. Three of the 71 sites (4 percent) that were classified as PFC did not have a diverse age class distribution of vegetation. These sites were associated with very high energy areas with minimal rooting substrate available. Five of the eight sites (62.5 percent) classified as FAR did not have a diverse age class distribution of riparian vegetation. Both sites classified as NF lacked a diverse age class distribution of riparian vegetation which was associated with human induced impacts.

Question 7 focused on the composition of riparian vegetation. Previous studies documented high species diversity in the Gauley River riparian zone (McDonald 2003, Walton and Anderson 1997). A query of the DNR Plots database (Plots is a database maintained by DNR that includes plant and animal location data) returned 242 records of riparian plants in the GARI. This is not a complete species list of plants living in the Gauley River riparian corridor due to the fact that some records are only to the genus level. Detailed taxonomic identification of vegetation in the study sites was impractical and not necessary to successfully complete the BLM protocols. If there were species present from each tier (overstory, understory, and herbaceous) then we considered the area as having a diverse composition of vegetation. Seventy-seven of the 85 sites (90.6 percent) were determined to have a diverse species composition. This is consistent with earlier vegetative surveys (Walton and Anderson 1997) that concluded, based on species richness of the riparian vegetation, that overall site quality throughout the study area was good. Both sites considered NF and two of the eight (25 percent) FAR sites did not have a diverse species composition. These sites generally lacked diversity in the herbaceous layer due to human disturbance (Figure 5).

Figure 5. Site T2(1). The photograph of this site on the Gauley River shows impacts from a "camp site." The herbaceous layer has been removed by continual human disturbance. The lower end of the sand bar is well vegetated indicating that the site could recover if disturbance was removed.

Question 8 asks if the plant species present indicate that the site is maintaining moist soil conditions. A positive response indicates the species present were considered typical of moist soils. All sites with a defined riparian zone contained plants that indicated moist

soil conditions. The dominate riparian plants, in terms of biomass, were river birch (*Betula nigra* L.) and American sycamore (*Platanus occidentalis* L.*)* which are both listed as Facultative Wetland (FACW) plants indicating that the species usually occurs in wetlands (Reed 1998).

Question 9 addresses the ability of the riparian plants to withstand high discharge events. Type II valleys and "Bc" streams are generally vertically and laterally very stable with low erosion rates (Rosgen 1996). Birch and sycamore are strongly rooted trees capable of withstanding high discharge events and protecting stream banks. Of the sites with a riparian zone, all but one had plants with root masses capable of withstanding high discharge events. Except for one site on the Meadow River (U5) that had recently experienced a minor slip there was no visual evidence of recent uprooting of riparian trees.

Question 10 evaluates health and vigor of riparian zone plants. The Gauley and Meadow rivers are very high-energy systems. Because of the gorge topography and its high-energy characteristics, vegetation should exhibit signs of very swift currents. Vegetation, and particularly trees, located in the floodplain show obvious physical signs of this harsh, high-energy setting, but otherwise appear healthy. Leaning, contorted, and scarred trunks were common physical expressions of life in this high energy environment (Figure 6). Dead or dying plants were not abundant. Only one site (KK3) had a riparian area in which we considered the plant community to be in poor health. This site was located on a cobble/boulder flat and most likely had very shallow rooting soil depths.

Figure 6. Site D(2). Tree trunks showing physical signs of life in the high energy Gauley River, note the deformed trunks and scaring.

Question 11 asked if vegetation was sufficient to adequately protect stream banks. Channel roughness and the "step/pool" profile of the river system dissipate stream energy efficiently. Streambank vegetation plays an important role in bank stability in this system, but a less critical role than in other stream types that are more prone to lateral instability. Although statistical correlation analysis was not performed on the data set,

vegetative bank cover appears to be negatively correlated to riparian condition. All ten sites rated NF or FAR had inadequate vegetation to protect their banks, while only ten of the 71 (14.1 percent) sites rated PFC lacked sufficient vegetative bank protection. These sites were still rated PFC because the lack of bank protection did not result in significant bank erosion.

Question 12 addressed a fish and aquatic habitat concern by asking if the plant communities are an adequate source of large woody debris (LWD). This is difficult to answer in this system because of its high energy nature. Almost all LWD introduced into the rivers from the floodplain is quickly transported downstream. We observed no LWD in the Gauley River above the confluence of the Meadow River, and very little LWD on the Meadow River and the Gauley River below the confluence. This question was answered in the affirmative if medium to large trees were present in the floodplain. Sixty of the 85 sites (70.6 percent) had adequate plant communities to provide LWD to the stream. In retrospect, perhaps a not applicable (N/A) rating would have been a more appropriate response to this question given that the Gauley and Meadow Rivers segments within the Gauley River National Recreation Area do not have the potential to maintain LWD within the stream channel due the high energy nature of this system.

Question 13 asks whether floodplain and channel characteristics are adequate to dissipate energy. While the floodplain is adequately vegetated, it is very narrow, and does not have the width to dissipate the energy of the water. However, channel roughness and the stream's step/pool morphology dissipate energy very efficiently. All sites received a "yes" response to this question.

Question 14 asks if point bars are revegetating with riparian-wetland plants. There were very few "typical" point bars in the study area. Point bars are generally found on the inside bends of streams and consist of sand, gravel and small cobble deposits. Due to the low sediment, high-energy nature of the study area, the few point bars present are generally formed from large cobble (Figure 7). Even using a relatively liberal interpretation of a point bar, only 30 (35.3 percent) of the sites had any feature that could be considered a bar. Of those 30 sites, 27 (90.0 percent) were considered to be revegetating with riparian vegetation.

Figure 7. Site T2(4). The photograph shows a "typical" point bar of the Gauley River in the GARI. The bar is formed with a predominantly cobble/boulder substrate. The bar is revegetating with riparian species.

Questions 15 and 16 ask if the stream channels are laterally and vertically stable. Type B (Rosgen 1996) channels are usually very stable. The only reliable method of determining stream channel stability is to establish permanent cross sections and monitor them over several high flow events. However, field indicators can provide fairly reliable evidence of stream channel stability/instability. Indicators of channel instability include exposed roots, severely undercut banks, vertical raw banks, mid-channel bars, lateral bars, riffles located in outside bends and others. We did not observe any indication that the system was in the process of active adjustment or instability. One Meadow River site (U5) did have evidence of a recent slope failure (Figure 8). This site received a negative response to the lateral stability question. This slope failure was isolated and there is no evidence that this is a common occurrence.

Figure 8. Site U(5). The photograph shows a small isolated slip on the Meadow River.

The last question asks if the system is in balance with the sediment being supplied to it by its watershed. If the river is not in balance with its sediment inputs, adjustments to the channel's dimension, pattern and profile will arise in an attempt to reach equilibrium. Since there is no evidence that the channel is actively adjusting, we assumed that the stream is in balance with the water and sediment being supplied by its watershed.

GENERAL DISCUSSION

The BLM protocols primarily focus on macrohabitat features related to riparian zone function. The main functions addressed are stream bank and channel stability. There were no obvious differences between the Meadow and Gauley Rivers in the functional assessment of their respective riparian zones. The data indicate that the riparian zones are functioning at or near potential. In general, the Meadow River appeared to have a slightly narrower riparian bench and contained more large woody debris on the benches. The Meadow River did have some vegetated islands with small backchannels that were not typical of the Gauley River. Although mid-channel bars can be indications that the channel is not effectively transporting sediments, permanent vegetated islands containing mature woody vegetation are not generally considered indicative of poor sediment transport.

Although the BLM protocols focus on the macrohabitat and broad concepts scale, there are some microhabitat features that should be considered in analyzing function of the riparian zones in the study area. The distribution of plant species in the channel/riparian zones is dependent on which plants are adapted to survive in each habitat type. While some plants are widely distributed throughout the riparian area, others are restricted to certain areas of particular substrate and the hydrodynamic regime that maintains that substrate type. While plant communities of the Gauley and Meadow River gorges' riparian areas have only been partly categorized, several general habitat types are endemic to high-energy rocky rivers in West Virginia and are important to maintaining plant diversity in the study area.

These are sandy beaches, bedrock with crevices that hold soil, relatively stable large boulder areas with sandy interstices, upper reaches of cobble bars that likely move only with the highest flows, and rocky areas with sandy soil that are elevated above the river so as to be disturbed only during major flood events. These habitat types are formed and maintained by the hydrology of the river and may overlap and interlace making delineation and description somewhat problematic. The habitats have been quantitatively described to a limited extent by Walton and Anderson (1997).

Several plants found in the GARI riparian zone are quite rare on a global basis and are briefly discussed below. Thoughts on hypotheses relating to the regulation of the habitat types in which they are found follow the plant reviews.

Virginia Spiraea (*Spiraea virginiana)*

Fifty-nine subpopulations of this Federally Threatened species were delineated in a recent survey of the GARI (McDonald 2003). These varied from one multi-stemmed clump to 168 clumps over a distance of 650 feet. Habitat for this species is characterized as the

upper reaches of sandy beaches or pockets of sandy soil among large rocks or boulders. This plant appears to require a somewhat stable substrate as opposed to a dynamic and rapidly changing gravel bar situation.

Barbara's Buttons (*Marshallia grandiflora)*
Eighty-two subpopulations of this globally rare plant were found in a recent survey (McDonald 2003). These ranged from a single clump of plants to 163 clumps over a distance of 210 feet. Habitat was generally described as cobble bars and crevices in bedrock within the flood zone. While portions of many cobble bars are very dynamic and subject to frequent flooding and possible movement, Barbara's buttons seems to be found more often in the upper (farther from the river) portions of these bars and in sandy soils among more stable rocky portions of the riparian zone, but still subjected to periodic flooding. In some areas of the river there are horizontal layered bedrock outcrops and the crevices in these formations can support this species.

Sand Cherry *(Prunus pumila)*
Fourteen subpopulations were located in a recent survey (McDonald 2003). This species occurs most often on the upper reaches of sandy beaches or among cobbles on large bars along the river.

The habitats for these three species are similar and differ in as yet undescribed ways. Loose community associations were made by Walton and Anderson (1997), but their determination is inadequate to truly assess habitat associations along both rivers. It is hypothesized that all of these species require a flooding regime to maintain the habitat required for their survival. In evaluating the proper functioning condition of the riparian areas, an assessment of the hydrologic regime is needed to determine if the post-dam flood flows of the Gauley River are sufficient to maintain the requisite amount of open riparian area and to provide sufficient deposition of sandy substrates. Since sediment from the Gauley River watershed above Summersville Dam is captured behind the dam and not discharged downstream, the Meadow River is the primary source of sandy sediments and habitat-conditioning scouring flows for the Gauley River below the confluence of the Meadow River.

The important question then becomes: Is the contribution of the Meadow River sufficient to maintain channel and riparian conditions required by the riparian vegetation (in general) and the rare plants (in particular) of the Gauley River within the Gauley River National Recreation Area? Anecdotal evidence, from those with a long association with the Gauley River, suggests that the decrease in the magnitude of large flood events may be allowing the upland forest to encroach into the upper riparian zone, thereby decreasing suitable habitat for species of limited distribution. Decreased maximum flood heights could allow trees to grow out over, and possibly on to, parts of the riparian zone thus altering microhabitats for these rare plant species. All three species of rare plants are only found in relatively open habitat, not in the adjacent forest. The data do not indicate that upland species are significantly encroaching upon the floodplain, but riparian tree species may be encroaching on open habitat. There is little knowledge of the distribution of the plant life of the gorge before 1991 when the DNR did a rare plant survey of the riparian

area (Norris 1992). Recent (2003) surveys were completed using slightly different methodologies so comparisons of rare plant populations or occurrences are not possible even over the last 20 years, adding to the difficulty of establishing any evidence of possible habitat change or loss.

A habitat analysis was not part of either the 1991 or the 2003 surveys (Norris 1992, McDonald 2003). A 1997 study on communities of the Gauley River riparian zone (Walton and Anderson 1997) outlined several community types and associated Barbara's buttons and Virginia Spiraea with specific delineated community types. An expanded analysis of the community types represented and associated rare plants would be valuable for identifying areas along the river that may have appropriate habitat for these rare species but not currently supporting them. The time required for new populations to establish themselves is not known. Because evaluations of microhabitat maintenance by major flood events (50-100 year or longer recurrence interval flood events) may entail periods that are likely to be greater than the average human life span, it is easy to dismiss the issue and conclude that because the plants are present, all is well with the system. Considerable additional inventory, survey and habitat analysis work will be required to make that determination. Walton and Anderson (1997) developed a matrix of communities and perceived threats which indicated that diminished flows could have a high impact in cobble/grassland communities favored by at least two of the rare plants, Barbara's buttons and sand cherry. How they determined this is unknown, but it is suspected to be based on perceived changes related to basic hydrogeomorphological concepts relating to deposition models. Direct concern over the flooding regime is based on the decreased peak discharge following construction of the dam in 1966. In 1932, a major flood event exhibited a peak flow of 65,000 cfs in the Gauley River above the current reservoir site (Craigsville 03189100). Since construction, flows below the dam have not exceeded approximately 18,000 CFS despite 22 events of higher peak flows above the reservoir. As mentioned previously, the Meadow River does not have sufficient peak flow discharge to offset the effects of the dam. Therefore, the Gauley River below the confluence with the Meadow River, despite the injection of flood flows from the unregulated Meadow River, has significantly lower peak discharge after major storm events then during pre-dam conditions.

The BLM protocols were developed and extensively tested in the western United States. There is no doubt that there are significant differences in riparian vegetation communities and hydrologic regimes between the GARI and the western states. However, a Type II valley with narrow floodplain benches and a "B" type stream has the same morphological characteristics regardless of where it is located. The checklist deals with broad concepts, not specific details. The checklist basically gives the user a framework and guidance in their application of best professional judgment of riparian function. We believe that the BLM protocols are appropriate for use in the eastern United States, and a valuable tool in assessing the need for more detailed evaluations of priority riparian areas.

Management Recommendations

A brief outline of the Gauley Development Concept Plan can be obtained from the NPS website (http://www.nps.gov/gari/gauleydcp.htm). The plan outlines several activities

that the NPS would like to consider for the Gauley River National Recreation Area. Activities include the development of scenic overlooks, trails, undeveloped river lunch stops and signage. The data are fairly clear that, on a macro scale, the limited riparian area of the Gauley and Meadow Rivers within the GARI are functioning at or close to their potential and capability. The only areas that were considered nonfunctional were associated with human disturbance. The question then becomes: "What practical management strategies are available to resolve needs in these impacted areas and can additional areas be developed that will minimize impacts to the riparian zone?"

Some areas, particularly at the mouth of the Meadow River, are privately held and the NPS cannot directly manage these areas. Of course, if the NPS acquires these lands then direct management is possible. There are several river access points and riverbank camp sites that show varying degrees of disturbance. In these disturbed areas the primary impact is to the herbaceous layer (Figure 5). In these highly disturbed areas the NPS should relocate the high impact activity out of the riparian zone of the GARI. If use of these disturbed riparian areas was eliminated, the herbaceous layers should eventually regenerate and the riparian area would begin to function at a higher level. However, if the degrading activity is simply relocated to another part of the riparian zone, then the negative impact is merely transferred to this new location, resulting in no net gain of riparian zone function. At a minimum, it is recommended that the NPS closely monitor access sites and if they dramatically increase in size (and/or magnitude of disturbance) the NPS should consider denying access until such time as they recover. Alternative access and camping sites would need to be developed in a manner that would minimize disturbance of riparian function.

The length of time it would take an area to recover is an extremely difficult question to answer. Without detailed data on the condition of the riparian zone before the construction of Summersville Dam it is impossible to determine the "natural" condition of the impacted areas. Any guess to the recovery time of an impacted area would be speculative. The BLM protocols do not involve the level of detailed data collection necessary to "monitor" a specific site. Detailed mapping and comprehensive vegetative surveys would be required to monitor impact sites over time.

The location of undeveloped "river lunch stops" should be based on the potential for disturbance. Riparian areas on flat, sand benches are more susceptible to significant negative impact from increased human activity than areas dominated by large flat rocks. One of the primary considerations in selecting sites for new access areas and/or the expansion/maintenance of existing areas should be the location of rare, threatened and endangered species (RTE). Riparian areas that contain RTE species should be protected from unnecessary human disturbance. If there are active access areas that have RTE species in close proximity, the area could be environmentally altered to discourage disturbance of the RTE plant communities. Such activities could include the placement of large natural boulders and/or planting of native thorny shrubs that "define" the access site and discourage entry into sensitive habitats. Alternatively, a more direct approach would be signage that clearly defines borders of designated "lunch stops." It should be

made very clear to river users that use of these areas is a privilege and abuse of this privilege could result in the closing of the area.

The development of designated primitive riverside camping areas along the Gauley and Meadow Rivers will be difficult due to the narrow riparian corridor and steep upland slopes. Sites that have suitable upland flats close to the river, such as at the mouth of the Meadow River, are currently privately owned. If suitable locations are acquired, primitive camping areas could be developed. The development of these areas should be based on the same criteria as other designated use sites. Limiting direct and indirect impacts is a concern. A direct impact is the actual footprint of the camping area. Indirect impacts would include informal side trails to the river and removal of wood for campfires. Creating formal trails may help reduce the impact of off-trail activity. Carefully locating the camping area to minimize the distance that users would have to travel to reach fishing holes or prime rafting observation points is critical. Camping areas could also be developed and advertised that emphasize one use over another. A hypothetical Camp X is located next to a large pool which offers nice swimming and fishing opportunities and Camp XX is located near Lost Paddle Rapids where you can sit and enjoy rafters attempt this challenging rapid. Signs stating that campers should not venture off-trail, that the area is monitored closely and the campsite will be closed if environmental impacts become unacceptable, may also be useful. The development of upland campsites would reduce direct impacts to the riparian zone. The same guidelines for trails would need to be followed to minimize secondary impacts.

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LITERATURE CITED

Kondolf, G.M. 1997 Hungry Water: Effects of Dams and Gravel Mining on River Channels. Environmental Management; Vol. 21, No.4, pp. 533-551.

McDonald, B. 2003. Rare, Threatened and Endangered Plants of the Gauley and Meadow Rivers. Report: Diversity Program, Wildlife Resources Section, West Virginia Division of Natural Resources, Elkins, WV

Norris, S. 1992. Rare Species Survey of the Gauley River National Recreation Area. Unpublished Report CA 4000-0-9020

Prichard, D. 1998. Riparian Area Management and User Guide to Assessing Proper Functioning Condition and Supporting Science for Lentic Areas. Tech. Ref. 1737-16.

USDI Bureau of Land Management, National Applied Science Resources Science Center, Denver.

Reed, P.B., Jr. 1988. National List of Plant Species that Occur in Wetlands--1988 National Summary: U.S. Fish and Wildlife Service Biological Report 88(24), 244 p.

Rosgen, D.L. 1996. Applied River Morphology. Printed Media Companies, Minneapolis, Minnesota.

Walton, D. and **M. Anderson.** 1997. Critical Habitats and Associated Communities in the Riparian Zone of the Gauley River. Report: Nongame Wildlife and Natural Heritage Program, Wildlife Resources Section, West Virginia Division of Natural Resources, Elkins, WV