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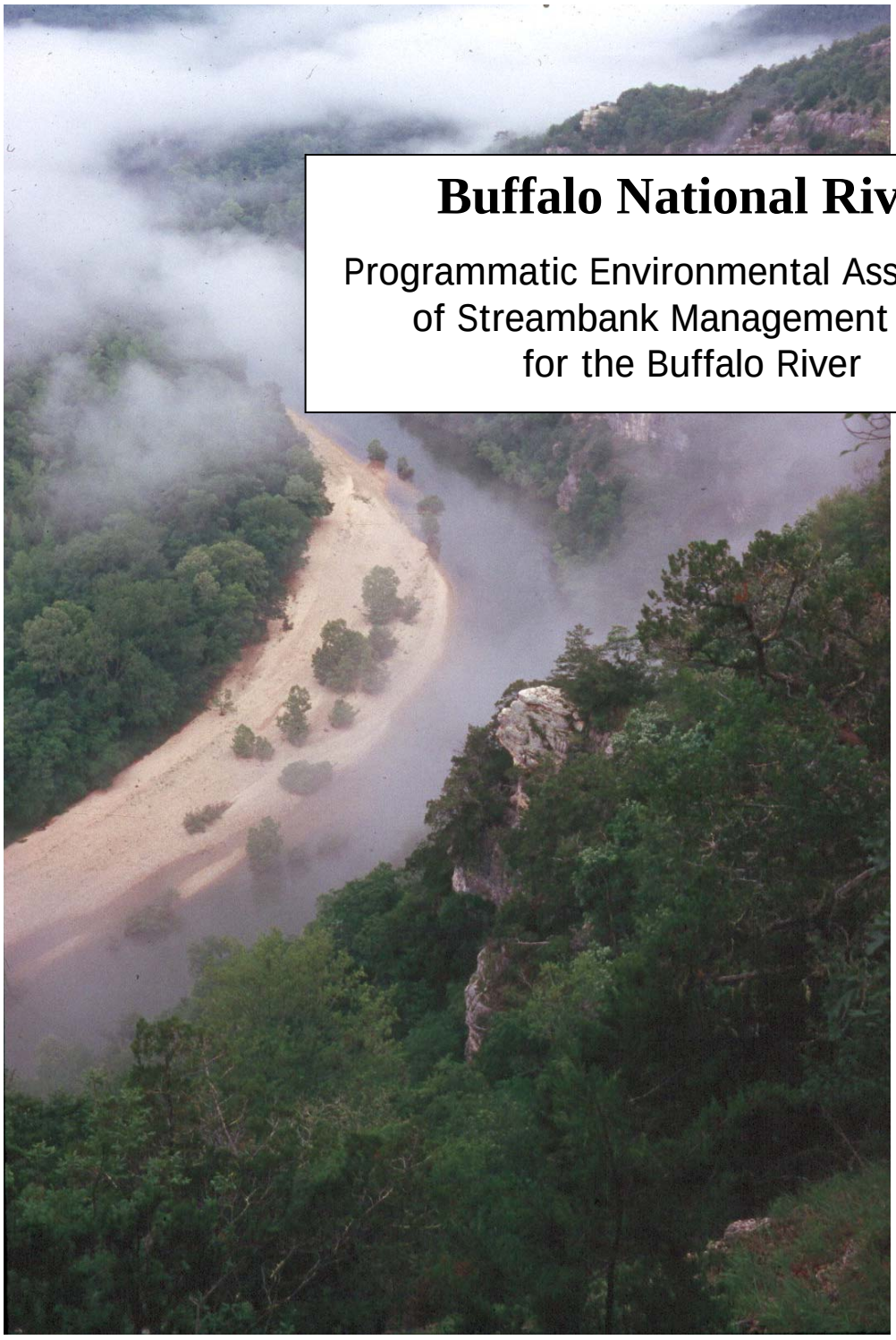

Buffalo National River

Programmatic Environmental Assessment of Streambank Management Plan for the Buffalo River

"*The Buffalo River is recognized as the central element of the whole array of natural and historical features in its setting. It is a symbol of the Nation –a free river preserved to flow through open space for all time as a remnant of our original homeland.*"

–Master Plan, Buffalo National River, 1977.

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SUMMARY

This Environmental Assessment documents potential environmental impacts of a National Park Service proposal to restore riparian corridors and stabilize streambanks of the Buffalo River and its tributaries in areas adversely impacted by historic and ongoing agriculture. Chronically eroding streambanks and resultant channel instability on the Buffalo are generally a result of agricultural clearing and trampling by cattle, which frequently leaves stretches of bank completely denuded of riparian vegetation. Even with cessation of farming activities, many erosion sites on the Buffalo are experiencing soil loss at such rapid rates as to preclude natural revegetation processes from stabilizing the bank. Accelerated erosion compromises in-stream habitats, degrades water quality, and leads to the loss of archeological and natural resources including the riparian forest habitat relied upon by the federally endangered Gray, Indiana, and Ozark big-eared bats.

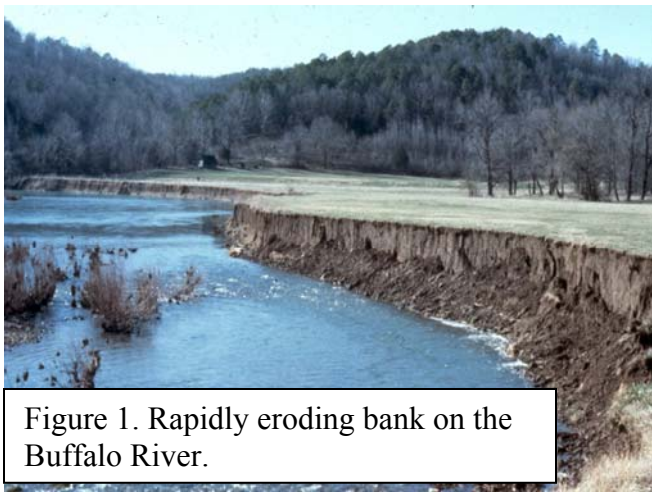

Figure 1. Rapidly eroding bank on the Buffalo River.

Managers at Buffalo National River seek to restore natural erosional rates, encourage the regeneration of streamside riparian zones, and re-establish natural hydraulic energy and sediment flow to the Buffalo River system through the implementation of a Streambank Management Plan. The proposed *Streambank Management Alternative* will incorporate, but not require, a suite of long-term and environmentally sensitive approaches to bank rehabilitation including reforestation of native hardwoods, in-stream transplanting of willows, cane plantings, and the construction of cedar revetments at compromised bank sites along the Buffalo River and its tributaries. This alternative incorporates a holistic view of streams and employs natural materials and processes to restore the dynamic equilibrium between the river channel and its banks. It also allows for restoration efforts to be tailored to each impacted site. This is the environmentally preferred alternative.

The second alternative addressed in this environmental assessment is a "no action" alternative. Under this alternative, active restoration and bank management efforts would not be implemented. Impacted sites would be allowed to continue to erode at currently accelerated rates. This alternative would lead to channel widening, degradation of aquatic habitats, reduced water quality, and additional riparian loss.

Potential environmental consequences of either alternative to a suite of possible impact topics are considered in Chapter Three: Environmental Analysis. Natural and cultural resources are considered, in addition to human environments. Finally, the cumulative effects analysis takes into account the additive effects of past, present, and future actions such as historic agriculture or future population pressure on the resources in question.

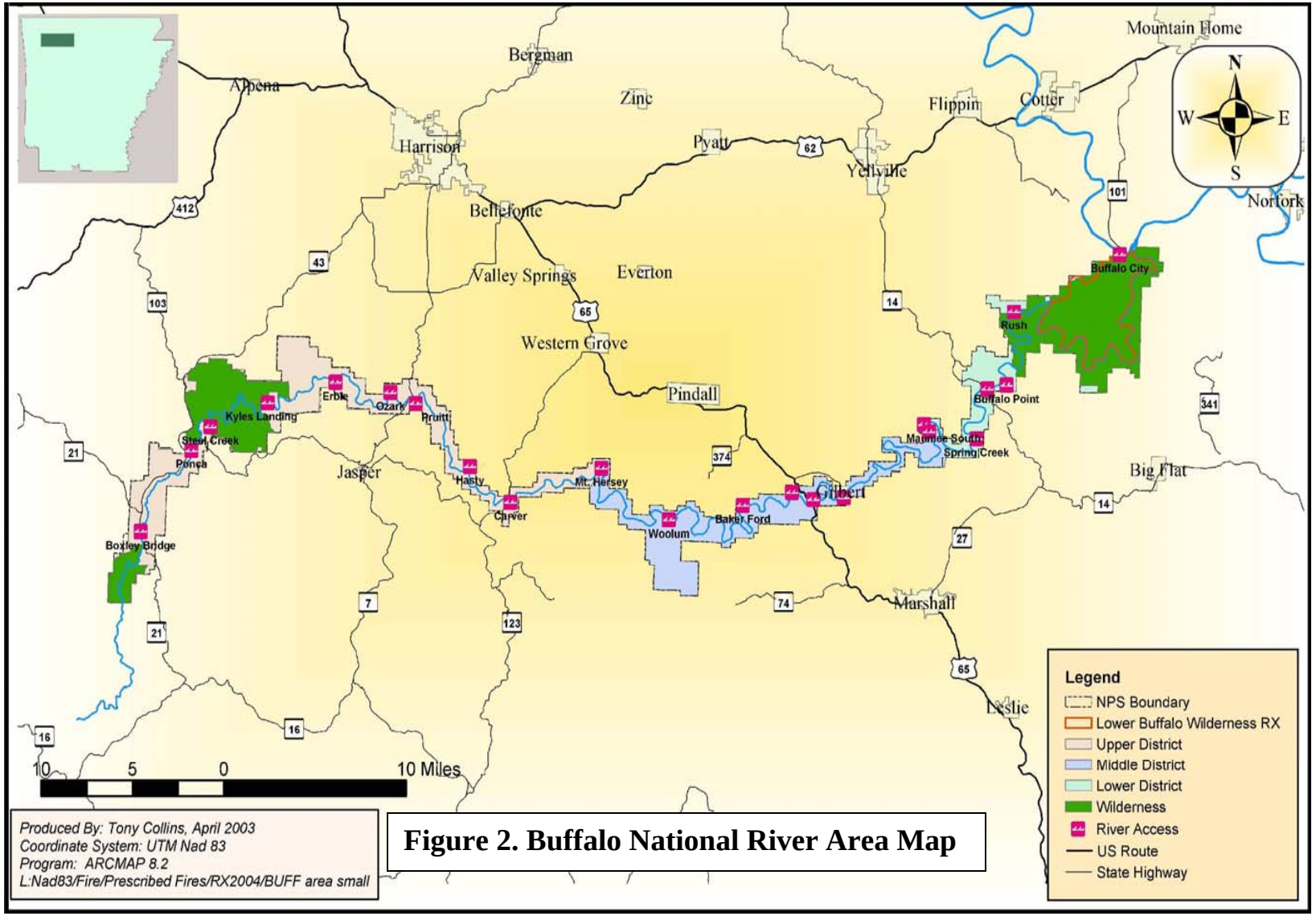

Figure 2. Buffalo National River Area Map

CHAPTER 1 – PURPOSE AND NEED

1.1 Introduction

This Environmental Assessment (EA) documents the potential environmental impacts of a National Park Service proposal to restore riparian corridors and stabilize streambanks in areas adversely impacted by historic and ongoing agriculture.
This EA has been prepared in compliance with:

- The National Environmental Policy Act (NEPA) of 1969 (42 United States Code (USC) 4321 et seq.) which requires an environmental analysis for major federal actions having the potential to impact the quality of the environment;

- Council of Environmental Quality Regulations at 40 Code of Federal Regulations (CFR) 1500-1508, which implement the requirements of NEPA; and

- National Park Service Conservation Planning, Environmental Impact Analysis, and Decision Making: Director's Order (DO) #12 and Handbook.

Key goals of the National Environmental Policy Act are to help federal agency officials make well-informed decisions about agency actions and to provide a role for the general public in the decision-making process. NEPA studies, and the documents recording their results, such as this environmental assessment, focus on providing knowledge of the comparative environmental consequences of possible courses of action to the relevant officials. In this case, the Superintendent of Buffalo National River is faced with a decision regarding restoration and stabilization along stream reaches adversely impacted by agriculture. This decision will be made within the overall management framework already established in Buffalo National River's Final Master Plan (NPS, 1977) and Resource Management Plan (NPS, 1998).

In making decisions about NPS-administered resources, the National Park Service is guided by the requirements of laws such as the 1916 Organic Act, the Clean Air Act, the Clean Water Act, the Wilderness Act, the National Historic Preservation Act, and the Endangered Species Act (summarized in Appendix B). The authority and purpose for conservation and management by the National Park Service is clearly stated in the Organic Act as:

> *"...to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."*

The requirements placed on the National Park Service by statutes such as the Organic Act mandate that resources are passed on unimpaired to future generations. This environmental assessment addresses whether the actions of various erosion mitigation alternatives proposed by Buffalo National River impair resources or values that are (1)

necessary to fulfill specific purposes identified in the enabling legislation of the park, (2) key to the natural or cultural integrity of the park or opportunities for its enjoyment or (3) identified as a goal in the park's general management plan or other Park Service planning documents.

More specifically, the enabling legislation for Buffalo National River (Public Law 92-237, March 1972) states that the park was created for the purposes of "conserving and interpreting an area containing unique scenic and scientific features, and preserving as a free-flowing stream an important segment of the Buffalo River" and that it should be managed for perpetuation of the resources, while providing visitor recreation with minimal environmental impact.

Buffalo National River's Resource Management Plan (NPS, 1998) lists water quality as the Buffalo's foremost natural resource priority because water is the park's major resource and water-based recreation is its primary public use. The Park's management plan requires protection of the Buffalo's water quality because any type of contamination has the potential to degrade the water itself, as well as other park resources (i.e. wildlife, fisheries, cave life) and visitor and employee health.

1.2 Background

The Buffalo River is a free-flowing stream in northern Arkansas that has been recognized by the State of Arkansas through Extraordinary National Resource Waters and Natural and Scenic Waterway designations. The Buffalo is famous for canoeing, fishing, and other recreational activities. The National Park Service's jurisdictional boundary includes a 132-mile corridor that extends from near the Buffalo's headwaters in the Boston Mountains, to its confluence with the White River, encompassing approximately 96,000 acres. Buffalo National River manages eleven percent of the Buffalo River's watershed, sharing ownership with Ozark National Forest (26%), Arkansas Game and Fish Commission (3%) and many private land-owners (60%). A myriad of land use activities, mostly related to agriculture, occur in the watershed. These include wilderness, logging, beef, dairy, swine, and poultry operations.

The Buffalo's basin is underlain by sandstone, shale, dolomite, and limestone. In some areas the river and its tributaries are confined by bedrock; in others they meander through alluvial bottoms. It is common for the Buffalo's alluvial floodplains to be farmed up to the channel banks with little or no buffer strips between cleared ground and the stream. This type of farming practice occurs throughout the region and has undoubtedly increased the vulnerability of river and tributary banks to erosion and accelerated channel migration processes within the flood plain (Jacobson and Primm, 1997; McKenney and Jacobson, 1996; Jacobson and Pugh, 1997). It is also probable that past and present land-use practices in the watershed have increased the delivery of sediment to the river and further encouraged the tendency for lateral channel shifts, especially where riparian forests have been removed (Jacobson et. al., 1990; Stephenson and Mott, 1992). Research suggests that some reaches of the Buffalo River experienced more erosion than deposition during a five year monitoring period ending in 1995, indicating an unstable sediment balance

(McKenney and Jacobson, 1996). Common erosional processes that occur within the Buffalo River corridor are explained in Appendix C.

In the case of Buffalo River, chronically eroding streambanks and channel instability are generally associated with areas where riparian vegetation has been cleared for agricultural purposes. The loss of riparian forests changes the physical characteristics of stream channels by decreasing the resistance of bank materials, resulting in accelerated streambank erosion. Sediments become increasingly coarser, stream channels become shallower and wider, the aesthetic attraction of the corridor is compromised, in-stream aquatic habitats are degraded, water temperature is increased, and water quality is reduced by increased sediment loading and turbidity.

Once streambank cutting has begun in a farmed area, the erosive force of the river can undercut well-established riparian forests downstream from the original site. As a result, erosion sites grow larger both perpendicular and parallel to stream flow. This occurs repeatedly along the Buffalo River.

Even with cessation of farming activities, many streambank erosion sites are experiencing soil loss at such rapid rates as to preclude natural re-vegetation processes from stabilizing banks. In such areas, erosion continues unimpeded and many tons of exposed soils are lost, along with associated cultural, archeological and natural resources such as riparian forest habitats relied upon by the endangered Gray, Indiana, and Ozark big-eared bats.

Many of the terraced bottomlands that have been cleared for agricultural purposes on the Buffalo consist of fine alluvial sediments that become highly unstable when bankside riparian vegetation is disturbed or removed. However, if stabilized by tree roots and other riparian vegetation, these disturbed areas can re-establish productive aquatic habitat units characterized by lateral pools with stable undercut banks, over-hanging trees, and extensive mats of exposed roots (Rabenni and Jacobson, 1993).

Revegetated banks create lateral resistance to flow that provides additional environmental benefits, such as restoring natural sediment transport and hydraulic energy adjacent to the riparian corridor. This is accomplished by providing the hydraulic resistance necessary to reduce current velocity and subsequent floodplain scour. Streamside trees also provide opportunities for pools to form where large root wads persist in the channel from year-to-year, creating habitat for an abundance of aquatic species. When riparian trees are removed from stream reaches, fine sediments erode from banks and the channel is left bordered by steep and denuded banks while adjacent pools are filled. Vegetative recovery is much more difficult under such conditions.

Historic streambank stabilization efforts on the Buffalo River have utilized bank-hardening, channelization, and removal of gravel bars and in-stream vegetation in an attempt to re-direct stream flow. These management approaches often altered natural energy and sediment transport in such a way as to encourage further instability. Also, the natural pattern of in-stream habitat was virtually destroyed by willow removal, bank

"armoring" with stream substrate, and channel bulldozing that accompanied channelization. As a result, invertebrate and fish communities were compromised.

In 1994, Buffalo National River initiated a plan for streambank stabilization and riparian restoration that implemented more holistic, environmentally-sensitive, and long-lasting methods, including cedar tree revetments, that were based on natural processes at undisturbed areas. Cedar revetments slow the force of eroding waters and promote the deposition of sediment within the branches of carefully placed and firmly anchored cedar trees, thereby encouraging the restoration of natural physical processes including erosion. Newly deposited sediments act as a fertile seed bed for the growth of new vegetation, which will eventually stabilize the bank. In time, the revetment trees decay, leaving a bank that is naturally stabilized by the roots of living trees. When properly constructed, these revetments appear natural and are aesthetically pleasing.

Revetments also provide immediate benefits to aquatic habitat by providing cover and lateral stability. Native riparian seedlings are generally planted within and behind the revetment to bind the soil. A successful cedar revetment will protect the bank long enough for riparian trees, river cane, willows, and other native vegetation to achieve sufficient size, density, and root structure to restore the natural stability inherent to well functioning riparian areas.

Buffalo National River staff used revetment and reforestation techniques in conjunction with cane planting, willow transplanting, and gravel bar spawning at twelve erosion sites in the Middle and Upper Districts of Buffalo National River beginning in 1994 (explanations of techniques are given in Appendix D). Reforestation without revetments was used at two additional sites in the Upper District. This compilation of mitigation tactics was devised by BUFF employees in consultation with inter-agency stream management specialists and representatives from the National Park Service's Water Resources Division. Revetment efforts were patterned after work by the Missouri Department of Conservation which installed more than 51 revetments over the course of 6 years with a success rate of 90% (Fantz et. al., 1993).

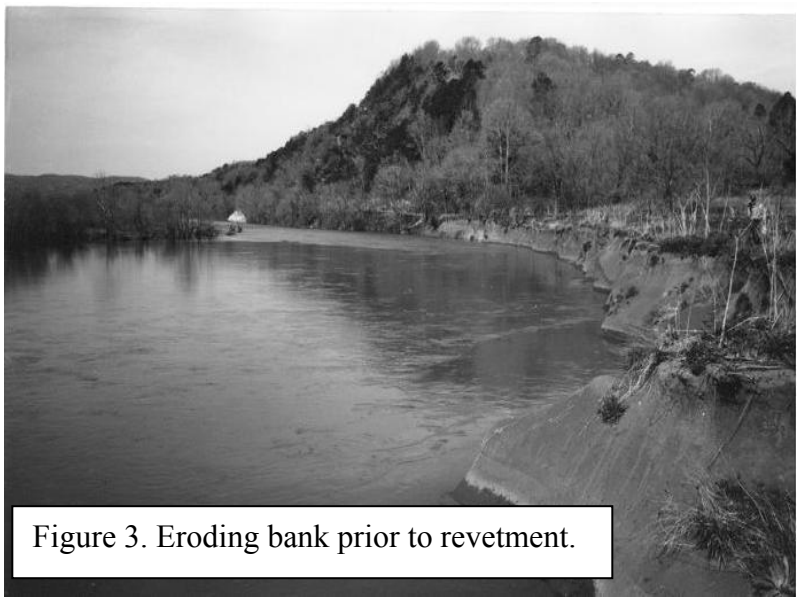

Figure 3. Eroding bank prior to revetment.

Prior to initiating the 1994 restoration effort, 25 erosion sites were identified and monitored over a ten year period (Figure 2). The most rapidly eroding cutbank was 2,200 feet long, 10 feet high, and receding at

an average rate of 14 feet per year. At such a rate, this bank alone may have contributed over 40,000 tons of alluvial sediment annually to the Buffalo River. The remaining banks were categorized according to length, height, erosion rate, and other factors, and had annual erosion rates averaging between one and three feet. Ten of these were identified as potentially successful candidates for cedar tree revetments based on a standardized assessment of site hydrology, existing vegetation, and geomorphic characteristics.

Figure 4. Revetted bank in recovery.

The stabilization and restoration attempts initiated on the Buffalo River in 1994 were largely successful (Figure 3; Appendix E). Seventy-five percent of 5,255 feet of cedar revetments protected streambanks long enough for native vegetation to colonize the bank and resume natural bank stabilization. Failed or partially failed sites were generally host to multiple confounding factors such as on-going disturbance, small radius of curvature, or confluence with a tributary. Of 60 acres of riparian corridor that were protected and reforested, 80% had healthy re-growth of riparian vegetation. Riparian seedling survivorship of six hardwood species averaged 40% (Table 2-1). Based on observation of the Buffalo River's hydrology, and the fact that it is a high-velocity flash flood system, it was concluded that cedar tree revetments are broadly applicable. Also, geomorphic and biological assessments performed following restoration efforts indicated that any efforts at bank stabilization were directly beneficial to the aquatic resources of the Buffalo River and its tributaries (Mott and Usrey, 2002).

Cedar revetments and the associated mitigation alternatives reviewed here are intended to apply cost-effective methods of stream stabilization with the ultimate goal of riparian restoration. Cedar revetments are used extensively in regional alluvial streams when a return to natural conditions is desired. The Missouri Department of Conservation alone has been successfully applying cedar revetments to erosion problems for two decades (MDC, 1986). When correctly implemented, revetments are more environmentally sensitive, holistic, and long-lasting than historic methods of erosion control. Based on efforts at Buffalo National River and in other areas within the physiographic setting of the Ozarks, the techniques reviewed here provide a promising, practical and cost effective method for streambank erosion control and eventual riparian restoration.

It is important to note that the streambank restoration techniques proposed here do not seek to curtail erosion, but rather to restore it to natural rates. Erosion has acted on the

Buffalo River Valley for millennia and, as a member of a suite of natural processes inherent to the Buffalo River, is among the resources that the National Park Service is charged with safeguarding. It is in the spirit of safeguarding this resource that Buffalo National River seeks to encourage the restoration of natural erosion rates at reaches that have been adversely impacted by human activities. Naturally eroding streambanks on the Buffalo, although prevalent, are not addressed by this EA.

Implementation of the described suite of restoration techniques is appropriate for free-flowing streams such as the Buffalo and is in keeping with the management objectives for Buffalo National River and the Boxley Valley National Historic District as stated in the Master Plan (1977) and the Boxley Land Use Plan (1985). The fullest possible protection of park resources, paired with the continued use of adjacent lands, is a common goal of many National Rivers and Wild and Scenic Rivers within the National Park System. Although exact methods and materials used in different physiographic regions are dependent on site specific parameters, continued corridor restoration at Buffalo National River would provide a positive model for other areas.

1.3 Purpose and Need

The primary purpose of this project is to stabilize eroding streambanks and restore naturally functioning riparian corridors at human-compromised sites in accordance with resource management objectives of the Buffalo National River Master Plan. These objectives require park managers to *"preserve the natural river scene and maintain a free-flowing, non-polluted river"* and that *"the natural riverbank cover of trees and shrubs be maintained where presently intact and allowed to revegetate where denuded"* (NPS, 1977).

Additional objectives include restoration of natural hydraulic energy distribution and sediment flow through the riparian corridor by providing the hydraulic resistance necessary to reduce the velocity of floodplain currents and prevent floodplain scour. The improvement of downstream water quality and restoration of a contiguous riparian corridor will benefit associated wildlife species.

The need for streambank stabilization is prompted by historic and ongoing agricultural clearing that has denuded riparian zones and caused subsequent bank erosion at a pace not conducive to natural ecological function. In general, accelerated streambank erosion leads to a shallower, wider stream channel, compromised aesthetics, degraded aquatic habitats, and reduced water quality through increased sediment loads and turbidity.

1.4 Impacts

1.4.1 Impact Topics

Not every conceivable impact of a proposed action is substantive enough to warrant analysis. For example, air quality, noise, utilities, land use, socioeconomics,

environmental justice, ecologically critical areas, Indian trust resources, transportation, and waste management were dismissed from consideration as they will not be substantively affected by either of the proposed alternatives. The topics that were determined to merit consideration in this EA are listed below, followed by the methods used to predict impacts on each topic.

Geology and Soils
Buffalo National River contains valuable geologic resources and landforms including bluffs, caves, and natural arches. Both natural erosive processes and human-caused erosion are inextricably linked with the properties of local soils and geology. As a result, impacts of proposed actions to geology and soils warrant careful consideration.

Potential impacts to geology and soils were assessed through monitoring of both mitigated and unmitigated banks along the Buffalo River that are subject to accelerated erosion due to human activities.

Water Resources
National Park Service policies require protection of water resources according to the Federal Clean Water Act. This is particularly important at Buffalo National River, where water has been mandated as the "number one natural resource". Impacts to water resources, even at restricted sites, can have far-ranging and long-lasting effects. These possible impacts need to be carefully considered.

Potential impacts to water resources were qualitatively assessed using results of past restoration efforts on the Buffalo River and related literature reviews.

Floodplains
Presidential Executive Orders mandate floodplain management and protection of wetlands. The floodplain of the Buffalo River runs the entire length of the river.

Potential impacts to floodplains were assessed through consideration of the hydrologic features and processes of the Buffalo River.

Vegetation
The park is largely forested but also contains a number of clearings. Various restoration strategies proposed under this streambank management plan would impact vegetation directly by transplanting willows in streambeds, revegetating denuded banks, and reforesting riparian corridors with native hardwoods. Both alternatives will have indirect impacts on vegetation in the river corridor.

Potential impacts on vegetation were assessed through consultation with foresters and restoration specialists.

Wildlife
Resident populations of various wildlife species, including reptiles, amphibians, birds, mammals, fish, and invertebrates, are directly impacted by the water resource of the

Buffalo River, and subsequently are affected by erosion events on its banks. Therefore, these populations may be impacted by any action to manage erosion sites on the river. Furthermore, the Federal Endangered Species Act of 1973 prohibits harm to any species that is listed as threatened or endangered, including disruption of habitat. Special consideration should be taken regarding proposed actions that may impact environments harboring species that are listed on the Endangered Species Act.

Impacts to wildlife and fisheries were qualitatively assessed through literature reviews, consultation with biologists, and professional judgment.

Cultural Resources

Section 106 of the National Historic Preservation Act of 1966 provides the framework for federal review and protection of cultural resources and ensures that they are considered during federal project planning and execution. Buffalo National River contains nearly 500 identified archeological sites, over 250 historic structures, four National Register historic districts, and a fifth district that is eligible as such. Some of these cultural resources may be subject to impacts of proposed management actions that would effect erosion events and alter features of the streambank and adjacent corridor.

Impacts to cultural resources were assessed qualitatively by discussions with archeologists and cultural resource specialists.

Visitor Use and Experience

The 1916 National Park Service Organic Act directs the Park Service to provide for public enjoyment of the scenery, wildlife, and natural and historic resources of national parks "in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations." Since the primary natural resource utilized by visitors at Buffalo National River is the river itself, it follows that erosion sites and proposed actions to manage them may have direct and indirect impacts on visitor experience.

Recreation impacts were qualitatively assessed in light of intensity and duration of erosion processes and restoration activities as they relate to visitor use and experience. Visual resource impacts were assessed in terms of aesthetic value and natural appearance.

Human Health and Safety

Because staff and visitor health and safety are a critical priority, the potential impact of *any* proposed action at Buffalo National River should be considered with respect to health and safety.

Impacts on human health and safety were qualitatively assessed through determination of activities, equipment, and conditions that could result in injury, and in light of mitigation measures and best management practices

1.4.2 Regulations and Policies

A myriad of governing regulations and policies must be considered when formulating management decisions regarding federal lands such as the Buffalo National River. These policies are listed opposite the impact topics they pertain to in Table 1-1, shown below.

Table 1-1: Impact Topics and their Governing Regulations and Policies

Impact Topic	Governing Regulations and Policies
Geology & Soils	NPS Management Policies
Water Resources	Clean Water Act; Executive Order 12088; NPS Management Policies
Floodplains	Executive Orders 11988 & 11990; Rivers and Harbors Act; Regulation #2, ADEQ; NPS Management Policies
Vegetation	NPS Management Policies
Wildlife	NPS Management Policies; Endangered Species Act
Cultural Resources	Section 106; National Historic Preservation Act; 36 CFR 800; NEPA; Executive Order 13007; Director's Order #28; NPS Management Policies
Visitor Use & Experience	NPS Management Policies
Human Health & Safety	NPS Management Policies

1.4.3 Impact Thresholds

Impact thresholds for various resources were determined in light of compliance with state and federal laws, and with existing Buffalo National River planning documents. Table 1-2 depicts the impact definitions used in this Environmental Assessment.

Table 1-2: Impact Thresholds

Impact Topic	Negligible Impact	Minor Impact	Moderate Impact	Major Impact	Impairment
Geology & Soils	Geology and soils would not be affected, or effects would be below or at lower levels of detection. Any effects to soil productivity would be slight and short-term.	The effects to geology and soils would be detectable but slight. If mitigation were needed to offset adverse impacts, it would be simple and successful.	Effects to geology and soils would be readily apparent, likely long-term, and would cause change over a wide area. Mitigation would probably be necessary and would likely be successful.	Effects to geology and soils would be readily apparent, likely long-term, and would cause substantial change over a large area. Mitigation would be necessary but extensive and with uncertain success.	Disruption of geological or soils related features or processes that result in irreversible changes.
Water Resources	Neither water quality nor hydrology would be affected, or changes would be either non-detectable or if detected, would have effects that would be considered slight, local, and short-term.	Changes in water quality or hydrology would be measurable, but small, short-term, and localized. No mitigation would be necessary.	Changes in water quality or hydrology would be measurable and long-term, but relatively local. Mitigation would be necessary and would likely succeed.	Changes in water quality or hydrology would be readily measurable, have substantial consequences, and be noticeable on a regional scale. Mitigation would be necessary but success uncertain.	Widespread impairment of water quality that results in significantly increased stream temperatures, turbidity, or nutrient levels and substantially compromises stream habitats. Buffalo River no longer meets primary contact water parameters.
Floodplains	Floodplains would not be affected, or changes would be either non-detectable or have slight, local, and short-term effects.	Changes in floodplains would be measurable but small (< 0.1% of a sub-watershed) and short-term with localized effects. No mitigation would be necessary.	Changes in floodplains would be measurable (0.1 – 0.5% of a sub-watershed) and long-term, but relatively local. Mitigation would be necessary but likely successful.	Changes in floodplains would be readily measurable (0.5 – 5% of a sub-watershed), have substantial consequences, and be noticeable on a regional scale. Mitigation would be necessary but success uncertain.	Erosion and/or deposition would be altered on more than 5% of a sub-watershed.
Vegetation	No native vegetation would be affected or some individual native plants could be affected, but with no effect on native populations. The effects would be short-term, localized, and no species of concern would be affected.	The alternative would affect some individual native plants and would also affect a relatively minor portion of that species' population. Mitigation may be required and would be effective at offsetting adverse effects.	The alternative would affect some individual native plants and would also affect a sizeable segment of the species' population in the long-term and over a large area. Mitigation to offset adverse effects may be extensive but would likely succeed. Some species of special concern may be affected.	The alternative would have a considerable and wide-ranging long-term effect on native plant populations, including species of special concern. Mitigation measures would be required, but with uncertain success.	Native plant populations, including species of special concern would be eliminated through the spread of exotic species. The effects would be irreversible.

Impact Topic	Negligible Impact	Minor Impact	Moderate Impact	Major Impact	Impairment
Wildlife	Wildlife would not be affected or the effects would be at or below the level of detection, slight, and short-term. There would be no perceptible consequences to wildlife.	Effects to wildlife would be detectable, although the effects would be localized and of little consequence to wildlife populations. Mitigation, if needed, would successfully offset adverse effects and be simple.	Effects to wildlife would be readily detectable, long-term, and localized with consequences at the population level. Mitigation measures, if needed, would be extensive but likely successful.	Effects to wildlife would be obvious, long-term, and with substantial consequences to regional wildlife populations. Extensive mitigation would be needed but success uncertain.	Long term or widespread displacement of wildlife groups. Direct mortality of greater than 5% of any native species population.
Cultural Resources	Effects to cultural resources would be at the lowest levels of detection, barely perceptible and not measurable.	Effects to cultural resources would be measurable or perceptible, but slight and localized. Effects would not affect the character defining features of the resource.	Effects to cultural resources would be measurable and perceptible and would change one or more character defining features of the resource, but not diminish its integrity to the extent that National Register eligibility is jeopardized.	Effects to cultural resources would be substantial, noticeable, and permanent. For National Register eligible or listed sites, the impact changes one or more character defining features(s) of the resource, thereby jeopardizing its eligibility.	Permanent adverse impacts to properties listed on the National Register, or to ethnographic resources or objects.
Human Health & Safety	The impact to health and safety would not be measurable or perceptible.	The impact to health and safety would be measurable or perceptible, but limited to a small number of people at a localized area.	The impact would result in readily apparent and long-term effects to health and safety that are substantial and noticeable. Mitigation may be necessary and would likely be successful.	The impact would result in readily apparent and long-term effects to health and safety that are substantial and noticeable on a regional scale. Extensive mitigation would be needed, and its success would not be certain.	Direct or indirect mortality of any visitor or staff person.
Visitor Use & Experience	Visitors would not be affected or changes in visitor use and experience would be below or at the level of detection. Any effects would be short-term. The visitor would not likely be aware of the associated effects.	Changes in visitor use and experience would be detectable, although the changes would be slight and likely short-term. The visitor would be aware of the effects associated with the alternative, but the effects would be slight.	Changes in visitor use and experience would be readily apparent and likely long-term. The visitor would be aware of the effects associated with the alternative and would likely be able to express an opinion about the changes.	Changes in visitor use and experience would be readily apparent and have important long-term consequences. The visitor would be aware of the effects associated with the alternative and would likely express a strong opinion about the changes.	Long term closure of portions of the Buffalo River.

CHAPTER 2 – ALTERNATIVES, INCLUDING THE PREFERRED ACTION

2.1 Alternative One: No Action

Under the No Action Alternative, active bank stabilization and restoration efforts would not be undertaken. This alternative allows a continuation of bank monitoring and previously established setbacks to protect existing buffer zones along the Buffalo River from clearing and trampling, but provides no mitigation for the fact that existing setbacks frequently erode away in the absence of restoration. Additional setbacks and direct restorative measures are necessary to successfully counteract accelerated bank erosion and subsequent channel widening, habitat degradation, and water quality reduction at human-disturbed sites. Under Alternative One, impacted sites would be allowed to continue to erode at current or future rates.

2.2 Alternative Two (Preferred): Streambank Management

Alternative Two, the Streambank Management Alternative, incorporates a pro-active, long-term, and environmentally sensitive approach to the management of human-disturbed banks subject to accelerated erosion. This programmatic approach includes, but does not require, techniques such as reforestation of native hardwoods, transplanting of willows for flow deflection or gravel bar spawning, cane plantings, back-sloping, and the construction of cedar revetments (see Appendix D for explanations of techniques). This alternative would allow any combination of these restoration measures as determined by the resource manager on a site-specific basis.

The Streambank Management Alternative incorporates a holistic view of streams and employs natural materials and processes to restore the dynamic equilibrium between the river channel and its banks. It also allows restoration efforts to be tailored on a site-by-site basis. A flexible approach is imperative because the wide range of hydrologic, geomorphic, vegetative, and disturbance variables present at each site precludes the use of a "cookie-cutter" approach to restoration in which affected sites receive identical treatment. The Streambank Management Alternative is also the environmentally preferred alternative.

Furthermore, in keeping with Section 4 of Buffalo National River's enabling legislation (Public Law 92_237), the Superintendent of Buffalo National River has qualified the Streambank Management Alternative as not constituting any unreasonable actions. That is, the proposed actions do not have any direct or adverse effects on the values for which Buffalo National River was established, nor do they invade the area or unreasonably diminish the scenic, recreational, and fish and wildlife values present in the area.

2.2.1 Differentiating between Human-Disturbed Sites and Naturally Eroding Banks

Human-disturbed banks are readily differentiated from naturally eroding banks by the presence of cleared field up to or nearly to the edge of the eroding bank. Human-disturbed sites also lack a buffer of riparian vegetation that is adequate to stabilize the bank. Generally, park managers consider a 100 ft buffer as a minimum desirable riparian zone. Not all human-disturbed banks require restoration. Those that are successfully self-repairing will be left to their natural course. Likewise, eroding banks with no signs of human disturbance will not be mitigated. These sites generally have an intact riparian zone. Only banks that have obviously been subject to human disturbance and are eroding at an unnatural rate will be recommended for restorative actions.

2.2.2 Appropriateness of Cedar Revetments

Sites recommended for bank stabilization with cedar revetments must first be assessed for predictive revetment success. Natural resource specialists at Buffalo National River developed a Revetment Assessment Questionnaire for appropriateness of cedar revetments (Appendix F) following the construction of revetments at twelve impacted sites in 1994-96. The questionnaire is composed of 22 site-specific yes/no questions regarding remediation objectives, feasibility of revetment installation, site hydrology, geomorphology, and existing vegetation. The Revetment Assessment Questionnaire is followed by a summary of each assessment question and its role in the success or failure of a cedar revetment. This assessment will be performed by trained field staff that has experience with erosion processes.

Responses to the Revetment Assessment Questionnaire that indicate challenges to the effectiveness of a cedar revetment are shaded. Each potential revetment site is scored based on the number of responses that fall in shaded boxes. In the past, cedar revetments were largely successful at impacted sites that received an assessment score of two or less prior to construction. Revetments either partially or totally failed at sites that received scores greater than five. This method of site selection allows managers to focus time and resources on stabilization of sites that have a high probability of success.

2.2.3 Selection of Native Hardwood Species for Reforestation

In 2001, Buffalo National River staff studied the comparative survival of over 113,000 native riparian hardwood seedlings that were planted in buffer zones adjacent to 23 stabilized banks beginning in 1994. The seedlings were nursery-grown by the Arkansas Forestry Commission and consisted of Green ash, Sweet gum, Black walnut, Northern red oak, Pin oak, Shumard oak, and White oak. All planted species had comparable survival rates, which averaged 40% (Table 2-1). Volunteer species such as Box elder, Persimmon, Sumac, Maple, Red cedar, Black locust, Sycamore, and Elm also contributed to the re-vegetation effort. Twenty of 23 sites exceeded the minimum target of 500 seedlings per acre. Sub-standard survival at the remaining three sites was attributed to poor soil moisture retention, mowing within the buffer zone, and damage by elk and deer.

Since the nursery raised species performed comparably during this reforestation effort, these same species will be selected for future plantings, if available.

Table 2-1: Survivorship of Hardwood Seedlings.

Common Name	Scientific Name	# Planted	% Survivorship
Black walnut	*Juglans nigra*	23,500	40
Pin/Shumard oak	*Quercus palustris/shumardii*	27,500	27
Northern red oak	*Quercus rubra*	24,500	34
White oak	*Quercus alba*	21,000	36
Sweet gum	*Liquidamber styraciflua*	7,500	31
Green ash	*Fraxinus pennsylvanica*	9,000	76[1]

[1] May be inaccurate due to misidentification.

2.2.4 Site Specific Management Action

The Streambank Management Alternative requires stabilization and restoration strategies to be tailored to each targeted site, depending on existing hydraulic, geomorphic, and vegetation variables. Table 2-2 identifies five possible bank conditions and recommends management strategies for each under the Streambank Management Alternative (Alternative Two). These examples were patterned after human-disturbed erosion sites on the Buffalo River and the corresponding restoration techniques that were used to mitigate them in 1994. The conditions are listed in order of increasing severity.

Table 2-2: Scenarios for Streambank Conditions and Recommended Actions

Condition	Streambank Assessment	Recommended Action
A	Toe is stable and bank is revegetating naturally. Riparian buffer is thin or lacking.	1. Replant riparian buffer with native seedlings and monitor growth. 2. No direct intervention at bank.
B	Toe is stable. Bank is undercut with scour below root zone. Riparian buffer is lacking downstream.	1. Back-slope bank & transplant cane. 2. Replant riparian buffer with native seedlings. 3. Revetment not necessary since toe is stable, but bank should be monitored.
C	Eroding cutbank with evidence of cattle trampling. Fence in need of repair.	1. Repair fence and monitor as needed. 2. Back-slope and stabilize bank with revetments. 3. Replant bank & riparian buffer with native plants.

Table 2-2: Scenarios for Streambank Conditions and Recommended Actions Cont'd

Condition	Streambank Assessment	Recommended Action
D	Instability at confluence with a tributary. Cutbank erosion is accelerated by thalweg pressure, sandy bank sediment, and riparian clearing.	1. Back-slope and stabilize bank with revetments. 2. Replant bank & riparian buffer with native plants. 3. Transplant willows in bed to divert thalweg and continue to monitor.
E	High vertical bank is subject to massive slumping. Watershed disturbance above site is ongoing. Unique circumstances may inhibit recovery.	1. Site is outside scope of proposal. 2. Revetment would most likely fail. 3. Monitor for potential risk to staff, visitors, or other resources.

2.3 Alternatives Considered, But Rejected

2.3.1 Use of Hard Structures for Bank Stabilization

Additional restoration strategies that were rejected include "hard" structures such as rock vanes, composite revetments, armoring, rip rap, and other aggressive actions. Although many of these techniques have been practiced historically on the Buffalo River and some are currently implemented on its tributaries, they were rejected due to their frequent tendency to ultimately destabilize the river system and their failure to satisfy the project's primary purpose of streambank stabilization and corridor restoration by holistic means. Furthermore, hard structures are generally not in accordance with the park's mandate to preserve a natural river scene and maintain the Buffalo in a free-flowing and unpolluted condition and do little to restore naturally functioning physical processes to the river. Therefore, alternatives involving the use of hard structures were rejected from consideration.

2.3.2 Minimum Management: Revegetation

Also considered was a minimum management alternative that included restoration and re-vegetation of banks and riparian zones at impacted sites, but did not allow direct bank stabilization actions such as back-sloping or revetment construction. This alternative was deemed unreasonable as it did not address the immediate issue of accelerated erosion at human-impacted sites. It is generally of little use to revegetate a rapidly eroding bank without stabilizing the bank itself. Otherwise, the revegetated surface may erode before the plantings are allowed to mature, thereby further compromising bank integrity. Revegetation without stabilization may be appropriate at disturbed sites where the bank toe has stabilized naturally and erosion is slowing.

2.4 Summary of Alternatives

Two alternatives are proposed. Alternative One, the No Action Alternative, would allow for continuation of existing riparian set-backs to protect corridors from trampling and clearing and to allow natural revegetation of the buffer zone. This alternative does not allow for pro-active restoration actions including bank stabilization, re-vegetation, and reforestation.

Alternative Two, the Streambank Management Alternative, is a programmatic management plan that would allow the use of a variety of holistic, long-lasting, and environmentally sensitive bank stabilization and restoration practices as needed to promote the resumption of natural hydrologic, vegetative, and erosion processes at human-disturbed sites along the river's corridor. Alternative Two requires an assessment of impacted sites to identify factors contributing to accelerated erosion rates and to determine the appropriateness of cedar tree revetments for bank stabilization. This alternative also allows management strategies to be tailored on a site-specific basis.

Alternative Two best satisfies the project goals of stabilizing and restoring eroding banks using natural materials and natural processes, thereby re-establishing naturally functioning stream corridors at human-impacted sites. The actions of this alternative are in accordance with resource management objectives requiring managers at Buffalo National River to preserve the natural river scene, safeguard a free-flowing, unpolluted river, and maintain or revegetate the natural riverbank. For this reason, Alternative Two is the Preferred Action. Although reaches of the Buffalo River that are compromised as a result of human actions may eventually resume natural function given sufficient time, the time required to achieve such is beyond the foreseeable future of management objectives for Buffalo National River and the resulting resource losses to the watershed, recreating public, and future generations would be unacceptable.

2.5 Environmentally Preferred Alternative

The environmentally preferred alternative is that which causes the least damage to the biological and physical environment and best protects, preserves, and enhances historic, cultural, and natural resources. Economic, recreational, and technical issues are not considered when identifying the environmentally preferred alternative. This alternative is the one that best meets the mandates of NEPA to:

- fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
- ensure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;
- attain the widest range of beneficial uses of the environment without degradation, risk of health or safety, or other undesirable and unintended

consequences;

- preserve important historic, cultural, and natural aspects of our national heritage and maintain, wherever possible, an environment that supports diversity and variety of individual choice;

- achieve a balance between population and resource use that will permit high standards of living and a wide sharing of life's amenities; and

- enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

In all cases, the Streambank Management Alternative (Alternative Two) best achieves the mandates. This alternative fulfills Buffalo National River's responsibilities as environmental trustee by actively seeking to alleviate environmental degradation caused by past human practices. The No Action Alternative allows the continuation of said degradation up to some unspecified point when, assuming the cessation of active disturbance, the river may accomplish self-repair.

Successful implementation of Alternative Two will ensure safer, healthier, and more natural-appearing river environments by reducing massive slumping and other accelerated erosive processes, improving water quality through the restoration of natural erosion rates, stable banks and riparian corridors. Active restoration of the system will ensure a wide range of continued use such as canoeing, hiking, horse-back riding, and farming of leased and private lands beyond the riparian buffer while safe-guarding the natural balance of the Buffalo River. Under the No Action Alternative, human use has the potential to compound existing environmental problems at previously impacted sites.

Alternative Two helps to preserve cultural and natural aspects of American heritage that may otherwise be lost by seeking to restore natural erosion rates at impacted sites along the Buffalo River. Current erosion rates pose an unnatural threat to in-bank artifacts and adjacent archeological sites. Assessment of cultural resource issues at each site will be coordinated through historic preservation offices at Buffalo National River, the State of Arkansas, and the Midwest Region. Field assessments and compliance reporting will also be performed.

Active bank stabilization and corridor reforestation will ensure that buffer zones between the Buffalo River's principal corridor and practicing agriculturalists will remain intact and of adequate width. This action will maintain a balance between population and resource use. Under the No Action Alternative, current erosion rates at unstable banks will continue to reduce existing riparian buffers, making them increasingly less effective. Repeatedly, Buffalo National River will be faced with the need to re-establish adequate buffer zones when possible, at the cost of further infringing on existing floodplain activities.

Finally, the Streambank Management Alternative endeavors to permanently and decisively improve the quality and protection of both renewable and depletable resources of the Buffalo River. The No Action Alternative maintains set-backs for riparian buffer zones, but without bank stabilization, these set-backs will have little impact on the quality and protection of the Buffalo's resources where actively eroding sites are present.

2.6 Summary of Comparative Impacts

The following table, Table 2-3, provides a summary of the comparative impacts of Alternative One: No Action, and Alternative Two, the Streambank Management Alternative.

Table 2-3: Comparative Impacts Summary

Impact Topic	Possible Impacts of Alternative One: No Action	Possible Impacts of Alternative Two: Streambank Management
Geology & Soils	• Loss of soils • Net annual sediment loss • Coarsening of sediments • Addition of clastics to riverbed • Covering of bedrock by deposition	• Reduction in soil loss • Balanced annual sediment budget • Retention of stream channel clastic composition and arrangement
Water Resources	• Increased turbidity • Increased water temperature • Increased width/depth ratio • Decreased current velocity diversity • Decreased pool depth & volume	• Improved water quality • Improved current velocity diversity • Increased pool volume & depth • Improved width to depth ratios • Decreased water temperature
Floodplains & Wetlands	• Increased floodplain erosion rates • Accelerated rate of channel migration	• Increased floodplain deposition rates • More natural rate of channel migration
Vegetation	• Loss of streamside vegetation • Poor colonization at compromised banks	• Conservation of streamside riparian plants • Re-colonization of compromised banks
Wildlife	• Aquatic & terrestrial habitat loss • Aquatic & terrestrial population declines	• Improved aquatic & terrestrial habitat • Stabilized aquatic & terrestrial populations
Human Health & Safety	• Possible risks associated with water quality	• Mitigation needed for potentially hazardous construction work environment
Visitor Use & Experience	• Decreased aesthetic value • Decreased wildlife hunting & viewing	• Improved aesthetic value • Improved wildlife hunting & viewing
Cultural Resources	• Loss of bankside cultural sites to erosion • Advancement of bank edge on adjacent sites	• Preservation of bankside cultural sites

CHAPTER 3 – ENVIRONMENTAL ANALYSIS

This chapter summarizes existing environmental conditions, the extent of the impact area for each topic, and the probable consequences of implementing the No-Action and Preferred Action Alternatives. When possible, environmental effects are quantified; otherwise, qualitative descriptions are provided.

3.1 Geology and Soils

3.1.1 Affected Environment

The Buffalo River lies within the Interior Highlands Division of the Ozark Plateaus Province, with its headwaters in the Boston Mountains. The remainder of the river lies within the Springfield and Salem Plateaus. The Buffalo begins at 2,400 feet above sea level and flows downward to elevations of less than 400 feet before joining the White River. The river's geologic features include layered rocks and fossils, prominent escarpments, caves, arches, sinks, canyons, faults, and valleys. The Buffalo's channel is generally composed of alluvial silt, sand, gravel, cobble, and boulder deposits overlying a bedrock floor. All formations are of sedimentary origin and generally consist of limestone, dolomite, shale, sandstone, and chert.

Karst features are abundant at Buffalo National River due to underlying limestone and dolomite. Over 300 caves and numerous springs and sinkholes have been identified. Soils are comprised of sandy and silt loams in the more fertile floodplains of the valleys and of less productive cherty loams and clays on the steeper slopes and ridges. Thin soils that occur in most areas are easily eroded. Most soils are well drained.

3.1.2 Environmental Consequences

No Action: Moderate Impact
Under the No Action Alternative, Buffalo River's streambanks and associated resources are likely to continue to degrade at current rates which, in worst case scenarios, can be classified as moderate. Buffalo River streambanks that have been compromised as a result of human activity are generally eroding at rates of one to three feet per year. In one instance, a 2,200 ft bank was found to be eroding at a rate of 14 feet per year and was estimated to contribute 40,834 tons of alluvial sediment annually to the river. When accelerated erosional rates such as these are not balanced by comparable deposition rates, a river system suffers a significant net annual loss of soil. This scenario was documented on the Buffalo River over a five year period by McKenney and Jacobson (1996), and will likely continue if banks are not mitigated.

Also, bed and bank sediments are likely to significantly coarsen as a result of increased stream velocity and rapid erosion. The coarsening of channel sediment will make it increasingly difficult for riparian plants to successfully colonize compromised streambanks. It will also decrease the range of instream habitat substrate types.

Streambank Management: Moderate Impact
Alternative Two, the Streambank Management Alternative, will contribute to the conservation and integrity of the Buffalo River's geology and soils by seeking to restore naturally functioning erosive processes. Impacts will be beneficial and effects will be detectable and, in many cases, long term and widespread. Fully successful restoration efforts will have moderate beneficial impacts. This alternative will balance the park's annual sedimentation budget which tends towards sediment loss, at least in part due to accelerated erosion.

3.2 Water Resources

3.2.1 Affected Environment

The Buffalo River drains an elongated basin of 1,338 square miles. Between the Boston Mountains to the west and the White River to the east, the Buffalo follows a winding 153-mile course, with tributaries entering at intervals. The geology and hydrology of the Buffalo River watershed are unique due to karst geomorphology, steep topography, shallow soils and highly integrated ground/surface water. High-water flows from the Buffalo have the potential to impact the White River as far away as Norfork and, in unusual situations, nearly to Batesville.

The Arkansas Department of Pollution Control and Ecology has designated the Buffalo River and Richland Creek (a tributary) as "Extraordinary National Resource Waters," providing the highest water quality standards and protection through a policy of non-degradation. The water of the Buffalo River has remained relatively unpolluted due to the large quantity of adjacent forest, paucity of point source pollution, and sparse watershed population. Water quality problems are related to high fecal coliform bacteria levels, sediment loading, and nutrient enrichment from a variety of animal operations, sewage treatment operations, inadequate rural septic systems, and runoff from bare ground. The National Park Service initiated a regular monitoring program in 1985 following several short-term water quality studies in the 1970's.

Within the steep terrain of the Ozarks, storm runoff from unpaved roads and cleared land carries both fine and coarse sediments to streams, potentially resulting in unstable stream channels, eroding streambanks, and degraded aquatic habitat. While rigid stability is not natural to a free-flowing river, some of the channel instability occurring on the Buffalo River is the result of both current and historic land use practices within the watershed. Determining the precise origin of changes at each site is difficult and sometimes impossible.

A proposal for water impoundments was the key issue leading to the establishment of Buffalo National River. Buffalo National River's enabling legislation prohibits the federal licensing of water-related projects on or directly affecting the Buffalo National River. The potential development of impoundments or diversion projects on major tributaries outside of Buffalo National River boundaries remains a local issue and obtaining in-stream flow data to address this issue is a critical need.

3.2.2 Environmental Consequences

No Action: Moderate Impact
The No Action Alternative will allow the continuation of adverse impacts to the Buffalo River's water resources. The principal impact to water resources is compromised water quality due to erosion-induced turbidity and sedimentation. Increases in water temperature are expected as shading by streamside vegetation is reduced throughout bank undercutting. Healthy width to depth ratios will become increasingly uncommon as the channel straightens and widens. Also, current velocity diversity and pool depth and volume will be reduced, with direct impacts on aquatic wildlife. Each of these is a far-reaching impact.

Streambank Management: Moderate Impact
Water resources will be positively impacted by Alternative Two through improved water quality due to reduced erosion, cooler water temperatures due to improved colonization of banks, improved width to depth ratios, and increased current velocity diversity and pool depth and volume. Bank mitigation work will be conducted during low water stage so as to minimize potential impacts to water resources during revetment construction, back-sloping, etc. The proposed suite of bank management techniques are designed to re-establish naturally occurring processes and qualities. The impacts felt by water resources as a result of Alternative Two will be positive and long-lasting.

3.3 Floodplains

3.3.1 Affected Environment

In December 1982, rainfall in the Buffalo River watershed led to a discharge along the river that peaked at 158,000 cubic feet per second near the mid-point of the river at the Highway 65 gauge (Neely, 1985). This discharge had an estimated recurrence interval of 65 years and caused widespread flooding along the River's corridor. Floods of even greater magnitude, with recurrence intervals from 100 to 500 years, have greater velocities, rise higher, and spread further across the floodplain. The relatively steep slopes and narrow widths of the Buffalo River make it susceptible to flash flooding.

During floods, the Buffalo River carries large amounts of debris. Generally, this does not pose a threat to bridges as most are either low-water bridges or high-water bridges that span the channel with little contraction. However, debris buildup on houses, barns, and other structures within the floodplain does increase the likelihood of these structures failing.

Buffalo National River includes a number of facilities, such as campgrounds and river access points that are located beside the river and thus exposed to flooding. However, while floods may on occasion lead to temporary closure of such facilities, they do not generally badly damage or destroy them.

3.3.2 Environmental Consequences

No Action: Minor Impact
Alternative One will allow current levels of floodplain scour, which is probably accelerated at some sites due to increased hydraulic force and stream current velocity. This alternative also promotes accelerated channel migration rates. This could result in continued incremental loss of floodplain.

Streambank Management: Minor Impact
The successful implementation of Alternative Two will result in improved floodplain stability as riparian zones are re-established and stream-side vegetation is allowed to develop to the point at which it can contribute to the integrity of the bank and surrounding floodplain. Vegetation encourages the deposition of fine sediment upon the floodplain by slowing over-bank water flow. Also, stabilized banks will result in decreased current velocities, thereby reducing the effects of flood events on floodplain erosion and destabilization, and promoting natural rates of channel migration.

3.4 Vegetation

3.4.1 Affected Environment

Plant communities at Buffalo National River are rich and diverse. The ridges, bluffs, hillsides and valleys provide a variety of habitats, supporting over 1,500 species of plants. The major forest types are Floodplain, Mixed-Hardwood, Oak-Hickory, Oak-Pine, Cedar Glade and Beech. Forests, cultivated fields, or abandoned fields at different stages of ecological succession are present throughout the area.

Buffalo National River is located within the Oak-Hickory Forest Association (USDOI, 1978). The Buffalo River's watershed is dominated by six oak species: White, Black, Blackjack, Chinquapin, Post, and Northern red oaks. Three species of hickory are also prevalent: Mockernut, Black, and Shagbark hickories. Also present are Winged elm, Red maple, Sassafras, Walnut, Hackberry, Black gum, Shortleaf pine, Red cedar, Sweet gum, Persimmon, and more than 40 other tree species. Azalea, redbud, serviceberry, and dogwood dominate the under-story and shrub layers. The herbaceous layer contains components of both tallgrass and forest biomes.

Invasive Species
Eastern red cedar is one of three invasive species and/or noxious weeds that are of management concern at Buffalo National River. Eastern red cedar is a widely distributed, native conifer growing in all states east of the Great Plains. It is a prolific invader of thin-soiled glades, dry woodlands, abandoned fields, prairies, and disturbed forests. If left to itself, it forms stable communities. This condition exists in many areas of Buffalo National River. Eastern red cedar is especially effective in shading out the desirable native grasses that are managed for under Buffalo National River's Open Fields Management Program.

Also of concern is Sericea lespedeza (*Lespedeza cuneata*) which was first brought to the United States from Japan in the 1890s. Although Sericea is a legume, it furnishes very little nitrogen to adjacent plants. As an aggressive colonizer of disturbed sites, it will often reduce or eliminate competing vegetation, including the native plant species that are promoted at Buffalo National River.

Finally, Tall fescue (*Festuca arundinacea)* is an exotic, cool-season forage grass that was introduced to North America from northern Europe. Although fescue's palatability and nutritional value for wildlife varies, studies have suggested that, due to the density of its root mats and because of chemical substances it produces, tall fescue is not desirable on sites that are managed for wildlife and plant diversity. Tall fescue can be invasive and is treated through prescribed burning and herbicide application in order to promote native warm season grasses as part of Buffalo National River's Open Fields Management Program.

Threatened and Endangered Species
No Federally-listed vascular plants are known to occur at Buffalo National River. The Arkansas Natural Heritage Commission reports a number of sensitive plant species occurring in the vicinity of Buffalo National River (Appendix G). Pro-active management may keep these species off the Federal Endangered Species list.

3.4.2 Environmental Consequences

No Action: Negligible Impact
Adverse impacts to streamside vegetation will continue unmitigated under Alternative One. These impacts include the undercutting and loss of riparian vegetation on eroding banks, threats to near-bank vegetation by encroaching erosion, and increased difficulty of channel and bank colonization due to vertical banks and coarsening of channel sediments.

Streambank Management: Negligible Impact
Riparian vegetation will be positively impacted by Alternative Two as rapidly eroding banks are stabilized, allowing for improved vegetative development. Also, the widening of existing riparian corridors and establishment of new corridors where they are lacking will lead to the development of new and more advanced buffer communities.

3.5 Wildlife

3.5.1 Affected Environment

The National Park Service and the State of Arkansas have agreed to cooperatively manage Buffalo National River as a wildlife management area regulated by Arkansas Game and Fish hunting and fishing guidelines.

Mammals
White-tailed deer, Raccoon, Opossum, Bobcat, Mink, Black bear and Beaver are common on the Buffalo National River. Elk populations have slowly increased since their re-introduction to this area in 1981, and sightings are common on the upper river. The eradication of primary ungulate predators such as the Red wolf and Mountain lion have left hunters and natural disease events to regulate most ungulate populations, and many fluctuate at or near ecological carrying capacity.

Black bear are native to the Ozarks and are monitored to a limited extent by the Arkansas Game & Fish Commission. While few nuisance animal complaints occur at Buffalo National River, the potential for bear-visitor interactions is always present and cooperation with the Arkansas Game & Fish Commission in bear management is essential for visitor safety and species protection. Beaver and feral pigs are also present.

Bats inhabiting the park include the state-listed Eastern small-footed bat and three federally endangered bats.

Birds
During 2002, a survey of breeding birds was conducted at Buffalo National River, during which 83 species were detected (Kellner, 2002). Nine additional species were seen, although not during the survey interval, and another 14 are known to occur at Buffalo National River, but were not observed. Abundant species represented a mixture of birds that require forested ecosystems (ex. Red-eyed vireo), species restricted to riparian zones (ex. Northern parula, Louisiana waterthrush) and generalists (ex. American crow, Carolina wren). Red-eyed vireos and Indigo buntings were the two most common species detected; both were located at over 80 % of census points. The Swainson's warbler (*Limnothlypis swainsonii*), a state-listed species, was also detected.

Fisheries
Sixty-six species of fish, including ten endemics, were documented in the Buffalo River during a recent survey (Petersen and Justus, 2005). Twelve additional species may be present. Stone-rollers, Dusky-stripe shiners, Long-ear sunfish, and Rainbow darters were among the more abundant fish species. Other common species include the Banded sculpin, Southern red-belly dace, Orange-throat darter, and Ozark minnow. Three state-listed species, the Ozark shiner (*Notropis ozarcanus*), Least brook lamprey (*Lampetra aepyptera*), and American brook lamprey (*Lampetra appendix*), are known to occur at Buffalo National River (Appendix G). Because of the proximity and inter-relatedness of the Buffalo and White Rivers, hydrologic events on each of these streams have the potential to impact the other. For example, high-water flows from the Buffalo may affect the White River's trout fishery.

Amphibians and Reptiles
Current distribution maps (Conant and Collins, 1991) indicate the presence of at least 71 species of amphibians and reptiles within Buffalo National River. During a recent inventory effort, 60 species were documented within the park, and nine others were reasonably expected, but not observed (Wiggs and Angelo, 2004). Three different amphibians were

considered abundant: Blanchard's cricket frog, Northern spring peeper, and Bullfrog. Several of the detected species of reptiles were considered abundant, including the Fence lizard, Black rat snake, Map turtle, River cooter, and Three-toed box turtle. The observers concluded that the undeveloped portions of the watershed retain a rich diversity and abundance of amphibians and reptiles. Although no federally protected amphibians or reptiles are known to occur within the Park, the state-listed Wood frog (*Rana sylvatica*) and Alligator snapping turtle (*Macroclemys temmincki*) are present (Appendix G).

Shellfish

In recent years, freshwater mussel populations have declined throughout the United States (Master, 1990). Declines in mussel distribution, abundance, and diversity are largely due to habitat and water quality degradation associated with human activities (Williams et. al., 1993). Buffalo National River is no exception. At least two species of once-common freshwater mussels are believed to have been extirpated from the Buffalo River. Although Buffalo National River has mussel population data that, at some reaches, spans more than 85 years, shellfish inventory information is outdated and incomplete. The current condition of mussel populations is largely unknown but is currently being assessed. Tentative results indicate that streambank erosion may be a limiting factor for the Buffalo's mussel populations. Mussels may be susceptible to clastic composition changes and other problems associated with erosion and instability. Fifteen state-listed freshwater mussel species occur in or adjacent to Buffalo National River (Appendix G).

Insects

Studies done in 1994 of the Cecil Creek area documented 93 species of *Lepidoptera* in 19 families and 71 genera of terrestrial insects including one new species and several state records. Usrey (2001) collected macroinvertebrates belonging to 48 different families within the mid-reaches of the Buffalo. The Neartic paduniellan caddisfly (*Paduniella neartica*), which is a candidate species and an Ozark endemic, has been found in small numbers at two sites on the upper reaches of the Buffalo. Three state-listed insect species occur at or near Buffalo National River: the Ozark Pseudactium (*Pseudactium ursum*), a ground beetle (*Scaphinotus influectus*), and a third beetle that has been reported only from a ridge top several hundred feet above the river (*Derops divalis*; Appendix G). Also, a new species of predaceous diving beetle (*Heterosternuta phoebeae*) was recently described from the Bear Creek region of the Buffalo River Watershed (Wolfe and Harp, 2003)

Threatened and Endangered Species

The Bald eagle, a federally threatened species, occurs as a winter resident at Buffalo National River. Annual eagle surveys have indicated widespread winter use of the river by eagles, with higher concentrations of wintering birds downstream of Buffalo Point. Summering eagles have also been documented on the Buffalo.

Three species of federally endangered bats (Ozark big-eared bat, Gray bat, and Indiana bat) have been found at fourteen caves and three mines at Buffalo National River. The endangered Ozark big-eared bat (*Corynorhinus townsendii ingens*) was first listed in 1978 and was historically known in Missouri, Oklahoma, and Arkansas. Its population

has been extirpated from Missouri and the Arkansas population was estimated at 200 individuals in 1992 (USFWS, 1991). The species is primarily known in Marion and Washington counties. The present endangerment of this species is largely due to disturbance and vandalism of cave sites, which they utilize year-round (USFWS, 1991).

Figure 5. Gray bat

The Gray bat (*Myotis grisescens*) was first listed as endangered in 1976 after a census of 22 important roosting sites documented population declines of 50%. This bat is found mainly in Alabama, northern Arkansas, Kentucky, Missouri, and Tennessee. Population declines may be due, in part, to reductions in insect prey over streams due to stream pollution or siltation (USFWS, 1982).

The Indiana bat (*Myotis sodalis*) was listed as endangered throughout its range in 1967. Although it is extinct throughout most of its historic northeastern range, 500,000 individuals are currently believed to exist. This bat depends largely on limestone caves and declines are attributed to commercialization of caves, vandalism, disturbance by spelunkers and bat-banding programs, use of bats as laboratory animals and, possibly, poisoning of their insect prey (USFWS, 1991). Recovery efforts are focused on protection of hibernacula.

In 2001, the USFWS listed the Scaleshell mussel (*Leptodea leptodon*) as a federally endangered species. Occurrence of Scaleshell within the Buffalo River has not been documented.

3.5.2 Environmental Consequences

No Action: Moderate Impact
Wildlife within the riparian corridor will be impacted by the No Action Alternative through the continuation of habitat degradation and loss. Aquatic species, including fish and invertebrates, will be affected by erosion and associated habitat loss as in-stream habitats are homogenized, current velocity diversity lost, water quality degraded, and water temperatures increased (water temperature is important because cooler water carries more oxygen). These impacts may carry downstream into the White River.

Bryant (1997) found that some portions of the Buffalo River had experienced "significant changes in community structure" and that these changes were probably a result of human-induced disturbance. He also documented the presence of an exotic clam, *Corbicula fulminea*, which is only able to invade communities in which native species have already been disturbed.

Usrey (2001) expanded on these findings by suggesting that declining water quality and increasing densities of Corbicula were the two disturbances responsible for shifting macroinvertebrate community composition in middle reaches of the Buffalo River. More

recently, Mott and Usrey (2002) showed decreased habitat quality and taxa richness of pollution intolerant macroinvertebrates downstream of a destabilized bank. Aquatic populations are the first to be impacted by degraded habitat and water quality issues associated with human-disturbed banks and associated areas. Terrestrial species that rely on riparian forest cover, such as the endangered Gray, Indiana, and Ozark big-eared bats, will also be impacted by implementation of the No Action Alternative as riparian corridors are slowly reduced in some areas.

Streambank Management: Moderate Impact
Wildlife will benefit directly from the implementation of Alternative Two through improved in-stream habitat diversity and quality as well as from the advancement of terrestrial riparian habitat in adjacent corridors. The implementation of Alternative Two will promote enhanced current velocity diversity and pool depth, decreased water temperatures, improved habitat diversity, and improved water quality, even downstream on the White River. Managers at Buffalo National River found habitat condition and taxa richness downstream from a successfully stabilized bank to be comparable to or improved over the reach upstream of the rehabilitated bank (Mott and Usrey, 2002).

3.6 Cultural Resources

Section 106 of the National Historic Preservation Act requires federal agencies to consider the effects of their proposals on historic properties, and to provide state historic preservation officers, tribal historic preservation officers, and, as necessary, the Advisory Council on Historic Preservation a reasonable opportunity to review and comment on these actions.

Buffalo National River contains numerous archeological sites, both prehistoric and historic, that span nearly 12,000 years of human history. It is common within the park for a historic structure to overlay a historic archeological site, which in turn may overlay a prehistoric archeological site. Documented archeological resources are found at more than 600 sites at Buffalo National River.

3.6.1 Affected Environment

National Register Properties
Buffalo National River properties listed on the National Register of Historic Places include Cold Springs School, Rush Historic District, Buffalo River State Park Historic District, Parker-Hickman Farm Historic District, and Boxley Valley Historic District. In addition, the 1,500 acre Erbie Historic Zone is treated as a National Register property. The Collier Homestead and the Williams House may also be eligible. These resources total about 12,000 acres or more than 10 percent of the jurisdiction of Buffalo National River.

Archeological Resources
Historic archeological sites cover a period beginning in the early 1800s. Native American groups have been documented in the area during this time. There are also numerous sites associated with 19th and 20th century Euro-American settlement. These vary from vegetation-covered areas with no above ground resources, to the ruins of farms and larger communities and industries.

The prehistoric archeological resources of Buffalo River include cave and bluff shelters, open sites, structures, and objects. Open sites range from villages to flint-knapping workshops. Features include below-surface remains of prehistoric house structures, hearths, and pits. Objects include finished and unfinished stone tools, ceramics, fiber remnants, rock art, and plant and animal remain. Vandalism and erosion continue to be the greatest threats to archeological resources.

Historic Structures and Objects
Historic structures at the National River vary from ruins associated with logging or mining to farmsteads still under occupancy, and can be dated to the 1830s through the 1950s. There are 257 structures on Buffalo National River's List of Classified Structures, including 19 of Buffalo National River's 37 recorded cemeteries, and various mine facilities and houses. Isolated structures in the backcountry or wilderness still need to be evaluated. The majority of the park's historic structures are within Buffalo National River's four historic districts and one eligible district.

Cultural Landscapes
Buffalo National River is awaiting a park-wide Cultural Landscape Inventory. The only landscape within the park that has had formal evaluation and listing as a cultural landscape is the Boxley rural historic landscape, although Rush, Buffalo River State Park, Parker-Hickman, Boxley, and Collier are managed as such. Inventory and evaluation are still ongoing for historic resources at Buffalo National River, and eligible resources are protected until a final determination is made.

Ethnographic Resources
Ethnography is concerned with contemporary peoples, their cultural systems or ways of life, and related technology, sites, structures, and natural resources. Ethnographic resources may include subsistence and ceremonial locales, structures, objects, and rural landscapes assigned cultural significance by traditional users. Ethnographic studies are not currently available for Buffalo National River. All of the alternatives described under this EA have the potential to affect previously unknown ethnographic resources.

3.6.2 Environmental Consequences

No Action: Minor Impact
Buffalo River's archeological and historic resources are limited and nonrenewable. Many are also fragile. When disturbed or removed, the scientific information they contain can be lost forever. The No Action Alternative would allow existing erosion threats to the Park's cultural resources to continue unmitigated. That is, current erosion

rates threaten the preservation of documented and unknown archeological sites both within the eroding bank itself, and at adjacent sites that are encroached upon by the shifting river channel.

Streambank Management: Minor Impact
The Streambank Management Alternative will contribute to the preservation of both documented and unknown archeological and historic resources by reducing erosion and channel migration. Cultural resource personnel will be consulted in advance of any bank remediation action to assess the presence or absence of cultural resources and the potential risk due to management actions. Cultural resource compliance processes will be adhered to in every case. Heavy equipment will be carefully monitored during all stages of bank restoration in order to minimize potential impacts. Minor and temporary impacts caused by restoration action will be greatly compensated for by the resultant long-term benefits of stabilized banks and reduced erosion.

3.7 Human Health and Safety

3.7.1 Affected Environment

Actions initiated by Buffalo National River must minimize risks to human health and safety. Actions with the potential for health and safety risks include, but are not limited to, the construction and maintenance of roads, trails, and other park facilities, including restoration structures such as cedar revetments.

3.7.2 Environmental Consequences

No Action: Negligible Impact
Impacts on human health and safety are not perceptible and are limited to risks associated with water quality, particularly following flood events.

Streambank Management: Minor Impact
Minor threats to staff safety may be present during bank stabilization work, particularly back-sloping and cedar revetment construction as both incorporate the use of heavy equipment. As expected, safety will be a priority during all stabilization work. Past efforts have shown that this type of work can be completed safely with the use of previously developed accident prevention techniques.

Minor improvements to human health may be incurred under this alternative through improved water quality.

3.8 Visitor Use and Experience

3.8.1 Affected Environment

The clean, free-flowing waters of the Buffalo River, set off by the surrounding bluffs, cliffs, woods and pastoral lands, constitutes a visual resource that is enjoyed by more than one million visitors annually. Buffalo National River has two major highway crossings, a number of smaller crossings, and 47 access points which provide for dispersed entry into this linear park.

Popular outdoor activities at Buffalo National River include hunting, fishing, camping, hiking, interpretive programs, and floating the Buffalo by raft, canoe, or kayak.

There is a visitor center at Tyler Bend. Ranger and visitor contact stations are located at Buffalo Point, Tyler Bend and Pruitt. The Buffalo National River's headquarters are located outside of park boundaries in Harrison, Arkansas.

In addition, the White River's popular trout fishery lies at the mouth of the Buffalo River. Water quality changes within the Buffalo as a result of streambank and riparian actions will directly impact the White River's fishery and associated aquatic habitat.

3.8.2 Environmental Consequences

No Action: Negligible Impact
Impacts to visitor use and experience due to Alternative One include diminished aesthetic value of eroding cutbanks, and decreased wildlife viewing, hunting and fishing opportunities as wildlife and their associated habitats are compromised by continued erosion and absence of adequate riparian corridors at impacted sites. Water quality and associated fisheries of the White River will also be impacted.

Streambank Management: Negligible Impact
Impacts to visitor use from bank stabilization efforts will be temporary and negligible. Stabilization work will be conducted when flow in the Buffalo River is low enough so as to preclude most recreational use of the river. Proposed bank improvements are mostly natural-appearing and will not attract unwarranted attention. In time, these temporary structures are covered with vegetation and sediment, and decompose, leaving a naturally stable and aesthetically appealing streambank. Water quality downstream at the White River will benefit from decreased turbidity and sediment loading.

3.9 Cumulative Impacts

The cumulative effects analysis for this Environmental Assessment considers past, present, and future actions that could intensify or offset impacts due to the proposed alternatives. Cumulative effects vary by resource. In general, the geographic areas considered include Buffalo National River and adjacent areas. In some instances, activities may result in both immediate and long-term, and negative and positive impacts. Actions that may have cumulative effects include clearing, trampling, gravel mining, "hard structure" management, and natural erosive forces such as flood events and disturbance by wildlife.

3.9.1 Geology and Soils

Buffalo National River's geology and soils are subject to cumulative impacts such as erosion and loss due to past and present timber practices, road building, agriculture, and mineral extraction both on the park and in adjacent areas. The proposed bank stabilization and restoration activities may have temporary and negligible effects on soils such as minor erosion and compaction. These will be compensated for by long-term beneficial effects. Future actions in adjacent areas, such as logging, road building, agriculture, mineral extraction, and residential development, will continue to impact geology and soils within the park. Overall, the Preferred Alternative will not have negative cumulative impacts on the park's geology and soils. Rather, Buffalo National River's soils will be improved over time through bank stabilization and reduced erosion and floodplain sedimentation if this alternative is implemented. The implementation of the No Action Alternative will allow the continued erosion of currently disturbed banks and floodplains and subsequent impacts to geology and soils. Areas of bedrock within the river may become blanketed with clastics.

3.9.2 Water Resources

The Buffalo River's water quantity and quality have been impacted by past and present human activities such as logging, agriculture, and road-building within and adjacent to the park. Bank stabilization and restoration, as proposed by Alternative Two, will have long-term and beneficial impacts on these resources. In the future, on-going logging and road building on adjacent lands will continue to impact water resources. However, the mitigation of bank erosion will offset a large part of the impacts caused by off-site activities. Whereas the No Action Alternative will allow existing cumulative impacts to build, the Streambank Management Alternative will result in substantial positive impacts to water resources of both the Buffalo and White Rivers.

3.9.3 Floodplains

The floodplain of the Buffalo River is potentially subject to greater flooding as a result of upstream human activities, past and present. This increase in flooding, combined with development within the floodplain, results in increased exposure of people and structures to risks associated with damaging floods. Bank stabilization and restoration, as proposed by the Streambank Management Alternative, will stabilize the floodplain and reduce damage due to natural flood events. Under the No Action Alternative, the Buffalo River will continue to be subject to increased flood effects due to upstream human activities. Under the Preferred Alternative, this effect will be countered by stabilizing eroding banks and adjacent floodplain areas.

3.9.4 Vegetation

As a result of past and present human use, vegetative communities have been altered, native plant diversity and habitats have declined, and noxious weed infestations have increased. In the future, these effects are likely to continue because humans will continue

to use adjacent areas. The Preferred Alternative will help to counter these cumulative impacts to vegetation by promoting the natural development of native plant communities in riparian areas.

3.9.5 Wildlife

Timbering activities and agricultural practices on adjacent National Forest and private lands have generally degraded wildlife habitat and diversity at Buffalo National River, with some exceptions. These impacts are likely to continue into the future, particularly under the No Action Alternative. The Streambank Management Alternative will partially offset these impacts by improving wildlife habitat quality and diversity at in-stream and riparian sites. Fisheries on the White River will also benefit.

3.9.6 Cultural Resources

Although past human disturbance impacted numerous cultural sites along the Buffalo River, establishment of the park helped to protect these resources. The Preferred Alternative will further the protection and preservation of the park's cultural resources through stabilization of eroding banks and reduction of flood events in the vicinity of cultural sites.

3.9.7 Human Health and Safety

Past and present human use of the Buffalo River area have compromised water quality and elevated flood effects along the river and its tributaries. Under the No Action Alternative, there will be no change in these effects. The Streambank Management Alternative will work to mitigate these effects by improving water quality and stabilizing flood-prone areas, thereby causing minor improvements to human health and safety.

3.9.8 Visitor Use and Experience

The establishment of Buffalo National River has greatly increased opportunities for recreational use by the visiting public. Improved roads and trails provide better access to the river and its resources. In addition, increasing population growth and heightened national interest in outdoor recreation has led to increased visitation of national parks such as Buffalo National River. Increased visitation may lead to the development of further tourist destination resources in the future. Whereas the No Action Alternative will not contribute to cumulative effects on visitor use, the Streambank Management Alternative will enhance long-term recreational resources and opportunities through benefits to the resources described above.

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APPENDIX A
Glossary

Alluvium: Sediment deposited by flowing water, as in a riverbed, flood plain, or delta.

Channel Migration: The movement of a river channel across its floodplain.

Channelization: The deepening of a river's bed. Also refers to the use of heavy equipment to straighten a stream channel.

Chert: A member of a group of sedimentary rocks that consist primarily of microscopic silica crystals.

Clastic: Being or pertaining to a sedimentary rock that is composed primarily of fragments of pre-existing rocks or fossils.

Community Succession: The gradual and orderly process of ecosystem development brought about by changes in plant community composition.

Cultural Landscape: A geographic area associated with an historic event, person, or activity, or exhibiting other cultural or aesthetic values.

Cultural Resources: Any building, site, district, structure, object, data, or other material that is significant in history, architecture, archeology, or culture.

Cutbank: A vertical or concave bank subject to erosion and often unvegetated.

Dolomite: A mineral composed of calcium magnesium carbonate.

Dynamic Equilibrium: A state of balance achieved by two forces in motion.

Enabling Legislation: The act of congress that created Buffalo National River.

Erosion: The process by which particles of rock and soil are loosened, as by weathering, and then transported elsewhere, as by wind, water, ice, or gravity.

Ethnographic Resources: Resources associated with the cultural systems of contemporary peoples.

Floodplain: The flat land that surrounds a stream and becomes submerged when the stream overflows its banks.

Floodplain Scour: Occurs when overbank flow scours sediment from a floodplain that is unstable due to lack of riparian vegetation (APPENDIX C).

Geomorphic: Pertaining to the figure of the earth or the forms of its surface.

Hydraulic Resistance: Opposition to the passage of a current of water.

Invasive Species: Generally undesirable species that tend to spread rapidly, invading natural communities.

Karst: A topography characterized by caves, sinkholes, disappearing streams, and underground drainage.

Large Root Wad: A sizeable ball of tree roots that, when lodged in a streambed, creates essential aquatic habitat.

Limestone: A sedimentary rock composed primarily of calcium carbonate.

Loam: Soil composed of a mixture of sand, clay, silt, and organic matter.

Programmatic: Following an overall plan or schedule.

Reforestation: The replanting of a forest that has been reduced by fire or clearing.

Restoration: The act of returning an area to a normal or healthy condition.

Revetment: A structure composed of trees, rocks, or plantings that is placed at the base of a bank with the intent of slowing the current and providing support.

Rip Rap: A loose assemblage of rocks pushed up against the bank to "harden" it, with the intent of stabilizing it.

Riparian Corridor: A strip of specialized habitat that occurs on streambanks and in stream valleys.

Rock Vane (Vein): A linear structure composed of large rocks that is placed in a stream at an angle to the bank to dampen the impact of hydraulic flow, reposition the thalweg away from the bank, and create eddies to facilitate deposition.

Radius of Curvature: The extent to which a channel is curved; often used to evaluate channel resistance to erosion.

Sandstone: A sedimentary rock composed of clastic particles that range in diameter from 1/16 millimeter to 2 millimeters.

Sediment: A collection of transported fragments or precipitated materials that accumulate, typically in loose layers, as of sand or mud.

Sedimentation: The deposition or dropping of sediment.

Shale: A sedimentary rock composed primarily of clay particles less than 0.004 millimeters in diameter.

Slumping: The collapse of a bank (APPENDIX C).

Thalweg: An imaginary line joining the deepest points of a stream channel.

Turbidity: Muddiness caused by stirred up sediment or suspended foreign particles.

Toe (of Bank): The lowest part of an embankment.

Volunteer Species: Plants that grow from self-sown or accidentally dropped seed.

Watershed: The region draining into a river or river system.

Width to Depth Ratio: A useful indicator of stability within a stream system.

APPENDIX B
Pertinent Federal Laws and Regulations

Relevant Laws and Regulations	Summary	Affected Resource(s)
National Environmental Policy Act (NEPA) (42 USC 4321-4370)	Requires Federal agencies to evaluate the environmental impacts of their actions and to integrate such evaluations into their decision-making processes.	All
Council on Environmental Quality (CEQ) Regulations	These regulations (40 CFR 1500-1508) implement NEPA and establish two different levels of environmental analysis: the environmental assessment (EA) and the environmental impact statement (EIS). An EA determines whether significant impacts may result from a proposed action. If significant impacts are identified, an EIS is required to provide the public with a detailed analysis of alternative actions, their impacts, and mitigation measures.	All
Antiquities Act (AA) (16 USC 431 et seq.)	Authorizes the President to designate as national monuments any historic landmarks and historic and prehistoric sites, structures, and objects situated on Federal land. Establishes the requirement of a permit for the examination or excavation of such nationally important sites and establishes penalties for their destruction.	Cultural Resources
Archaeological Resources Protection Act (ARPA) (16 USC 470a et seq.)	Ensures the protection and preservation of archeological resources on Federal lands.	Cultural Resources
National Historic Preservation Act (NHPA) of 1966, as amended	Ensures the preservation of historic properties throughout the nation.	Cultural Resources
Clean Water Act (CWA) (33 USC 1251 et seq.)	Section 401, the state water quality certification process, gives states the authority to grant, deny, or condition the issuance of Federal permits that may result in a discharge to the waters of the United States based on compliance with water quality standards	Water Resources, Biological Resources

Endangered Species Act (ESA) (16 USC 1531-1544)	Prohibits the harming of any species listed by the U. S. Fish and Wildlife Service (USFWS) as being either Threatened or Endangered. Harming such species includes not only directly injuring or killing them, but also disrupting the habitat on which they depend.	Biological Resources
Federal Land Policy and Management Act (43 USC et seq.)	Declares that all public lands will be retained in federal ownership unless it is determined that a use other than public will better serve the interests of the nation. Public land must be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, and environmental aspects of the land.	All
Historic Sites Act (HSA) (16 USC 461 et seq.)	Authorizes the establishment of national historic sites, the preservation of areas of national interest, and the designation and preservation of national historic landmarks. Provides procedures for such.	All
Migratory Bird Treaty Act (16 USC 703 et seq.)	Restricts the taking, possession, transportation, sale, purchase, importation, and exportation of migratory birds through permits issued by the USFWS.	Biological Resources
National Emissions Standards for Hazardous Air Pollutants (NESHAP)	Places standards on all hazardous air pollutants and governs such areas as organic liquids, asbestos, polyurethane foam, and wastewater.	Air Quality, Waste Management
National Park Service Organic Act of 1916 (16 USC et seq.)	Established the National Park Service to manage national parks for the purposes of conserving the scenery, natural resources, historic objects, and wildlife within the parks, and providing for the enjoyment of these resources in such manner that will leave them unimpaired for the enjoyment of future generations.	All
Native American Graves Protection and Repatriation Act (NAGPRA) (25 USC 3001 et seq.)	Protects Native American human remains, burials, and associated burial goods.	Cultural Resources

Wilderness Act of 1964 (16 USC 1121 (note), 1131-1136)	Establishes the National Wilderness Preservation System. Defines wilderness as "an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain…"	Wilderness
Executive Order 11514: Protection and Enhancement of Environmental Quality	Provides leadership for protecting and enhancing the quality of the Nation's environment to sustain and enrich human life.	All
Executive Order 11593: Protection and Enhancement of the Cultural Environment	Provides leadership for protecting, enhancing, and maintaining the quality of the Nation's historic and cultural environment.	Cultural Resources
Executive Order 12372: Intergovernmental Review of Federal Programs	Directs Federal agencies to consult with and solicit comments from state and local government officials whose jurisdictions would be affected by Federal actions.	All
Executive Order 12898: Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations	Requires Federal actions to achieve Environmental Justice by identifying and addressing disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority and low-income populations.	All
Executive Order 13007: Protection and Accommodation of Access To "Indian Sacred Sites"	Directs Federal agencies to consider Indian sacred sites in planning agency activities.	Cultural Resources
Executive Order 13045: Protection of Children from Environmental Health Risks and Safety Risks	Requires Federal actions and policies to identify and address disproportionately adverse risks to the health and safety of children.	All

Executive Order 11990: Protection of Wetlands	An overall wetlands policy for all agencies managing Federal lands, sponsoring Federal projects, or providing Federal funds to State or local projects; requires Federal agencies to follow avoidance/mitigation/ preservation procedures with public input before proposing new construction projects.	Water Resources, Biological Resources
Executive Order 11988: Floodplain Management	Requires all Federal agencies to take action to reduce the risk of flood loss, to restore and preserve the natural and beneficial values served by floodplains, and to minimize the impact of floods on human safety, health, and welfare.	Water Resources, Biological Resources
Executive Order 12856: Federal Compliance With Right-to-Know Laws and Pollution Prevention Requirements	Requires that the head of each federal agency be responsible for ensuring that all necessary actions are taken for the prevention of pollution with respect to the agency's activities and facilities, and for ensuring that the agency complies with pollution prevention, emergency planning, and community right-to-know provisions.	Hazardous Materials

APPENDIX C
Common Erosional Processes that Occur on the Buffalo River

This appendix provides explanations of common erosional processes observed on the Buffalo River and its tributaries. The alternative streambank management methods implemented on the Buffalo River beginning in 1994 were designed with these erosional processes in mind.

1. Slope Failure

The most common bank erosion process acting on the Buffalo River is slope failure. Slope failure can be classified into two different types: rotational failure (slumping) and block failure. Rotational failure can be described as a portion of the bank succumbing to stress and literally "slumping" off into the stream. Block failure on the other hand, occurs when the bank toe is scoured away, leaving the bank material above unsupported. A vertical fault can then occur in the bank so that an entire "block" of bank material can slide down into the channel.

Although slumping is the dominant type of slope failure active on the Buffalo, both types are active to some degree at all impacted sites. Slumping typically occurs when flood waters saturate the bank near to or beyond the bank-full depth. When the flood waters recede, the weight of the water trapped in the near bank floodplain combined with bank weakening resulting from saturation and scour can produce stress forces that exceed the cohesive forces within the bank. This causes the bank to slump. Many tons of soil can be moved from the bank into the channel by this erosional process.

Rotational failure is greatly influenced by the alluvial sediments that compose banks. It occurs most commonly in banks with differing layers of sediment. Banks with an impervious layer of well-consolidated silt or clay within the lower portion of the bank seem to be most susceptible. These impervious layers prevent water drainage from bank sediments and may act as lubricating layers for the slipping slump.

Block failure is commonly seen on clay and silt rich streambanks. Scour and removal of vegetation at the toe of the bank is instrumental in initiating and perpetuating this type of failure. Generally, banks that are susceptible to block failure do not have coarse armoring materials such as cobbles at their toes, leaving them vulnerable to undercutting.

Slope failure on streambanks is greatly influenced by the density, width, and integrity of the riparian forest on *and* adjacent to the bank. The slump line or "scarp" typically extends some distance beyond the edge of the streambank and into the floodplain, depending on bank slope and height. When the riparian corridor has been cleared, the slump line can extend beyond the zone where the binding structure of roots within the bank itself can have any effect in preventing slumping. The interlocking roots of an intact corridor forest help to prevent the scarp line from developing by providing lateral binding *across* the potential scarp line. If slumping does occur, the interlocked roots tend to prevent the failure from becoming catastrophic. The corridor forest also prevents a domino effect of slump scarps migrating up and down a disturbed reach, a reaction that is

often observed in areas lacking a floodplain forest. Thus it is very important to maintain a well-vegetated riparian corridor on *and* behind streambanks.

2. Scour

Scour is a form of erosion caused by sediment being removed from streambanks particle by particle by the force of flowing water. Scour is more significant on stream reaches where the radius of curvature is small, but it affects all banks that lack stream-side vegetation. Scour often increases bank slope and can thus promote slumping. Again, stream side vegetation is the most effective way to prevent scour in alluvial stream channels. Not only do interlocking roots strengthen bank materials, but vegetative structure above ground greatly dissipates the erosive force of flowing water by increasing hydraulic roughness and decreasing stream-side velocity.

Scour is also noted where over-bank flow occurs in areas lacking riparian cover. In these cases, acres of floodplain soil can be scoured away or "blown out" from pasture areas along the stream corridor when high velocity flood waters move into agricultural areas that lack the hydraulic roughness and soil binding provided by buffer trees. Riparian and flood plain trees slow the erosive forces of flood waters and add stability to the flood plain.

3. Sheet and Rill

Sheet and rill erosion is the removal of layers of soil from the land surface by the action of rainfall and runoff. When a floodplain slopes down toward a stream channel, overland flow can transport water and eroded sediment to the edge of an agricultural field, from which it can pour off and further erode the naked bank. This type of erosion is generally thought of in association with upland erosion, but is also active in the erosion of streambanks, particularly when they are tall, sandy and subject to rotational failure.

APPENDIX D
Supplemental Explanations of Alternative Restoration Techniques Implemented at Buffalo National River

Technique 1: Cedar Tree Revetments

A tree revetment is made by anchoring large trees in an overlapping chain at the base of an eroding bank. Eastern red cedar is preferred for revetments because it has numerous limbs and fine branches for slowing current and trapping sediment, in addition to having good resistance to decay. Cedar trees for Buffalo River revetments can be obtained from adjacent successional fields, where they grow in abundance. Additional information on the implementation of cedar tree revetments can be obtained from The Missouri Department of Conservation's "Tree Revetments for Streambank Stabilization" (Gough, 2004), or directly from the MDC.

Except in the presence of archeological sites, revetment sites on the Buffalo River are generally back-sloped to a 45-degree angle prior to revetment installation for purposes of stabilization and to encourage natural revegetation. Seedlings of riparian hardwood trees such as walnut, oak, ash, and sweet gum are planted on the bank and within a 100-foot wide riparian buffer strip behind it. Pumps may be used under dry conditions for watering newly planted riparian areas to insure survival and growth of seedlings and volunteer species.

Technique 2: River Cane Transplanting

River cane can be transplanted behind revetments to contribute to bank stabilization through soil binding. Cane rhizomes are dug up from floodplain areas away from the river and are transplanted into trenches that run at an angle up the back-sloped bank. This technique, along with willow transplanting methods, employs natural materials and processes to restore the dynamic equilibrium between the river channel and its banks. River cane transplanting has been proven successful on the Buffalo River.

Technique 3: Whole Willow Transplanting

Bio-remediation techniques for streambank stabilization and/or restoration often employ some form of willow (S*alix spp.*) transplanting. Willow staking and fascines are used most frequently. Willow staking refers to the sinking of cut segments of willow trunks or branches into a back-sloped bank. Willow fascines are bundles of willow branches that are staked into horizontal trenches dug along a back-sloped bank. BUFF has experimented with both techniques, particularly willow staking, but with little success. Field observations suggest that the high frequency of spring floods in the Ozarks, followed by extreme low water stages and hot, dry summers, may be more than non-rooted willows can withstand.

Whole willow transplanting on the Buffalo River only proved successful when conducted during a window of low-flow conditions in the dormant season. Success also appeared to depend on the willow plants being transferred in their *entirety* (i.e. roots included, not just cut stems). When these conditions were satisfied and the willows were replanted in a trench excavated to a depth below the level of the lowest summer flows, the willows displayed vigorous growth upon the arrival of spring and contributed to hydraulic roughness within the channel, thus promoting increased deposition and bank stabilization.

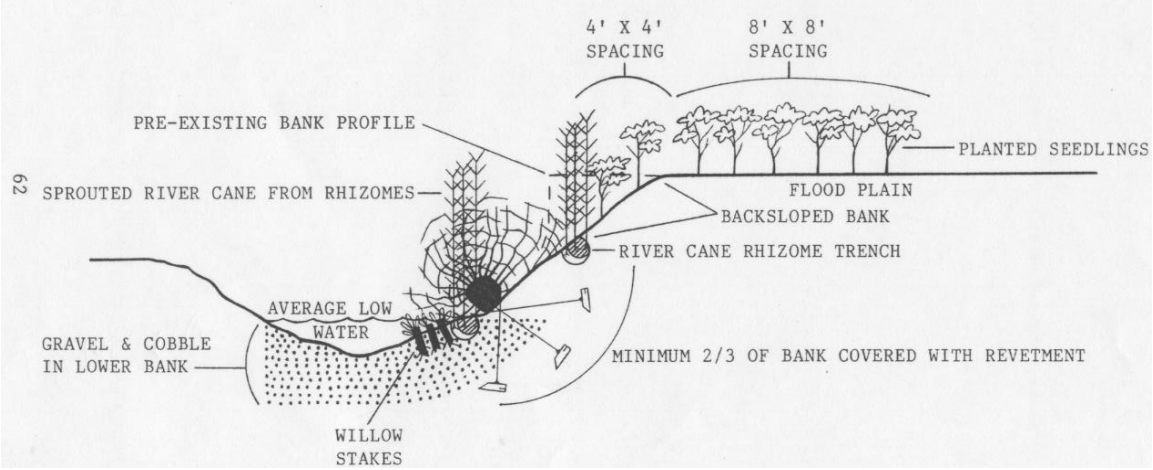

Figure 6. Diagram of cedar revetment showing back-sloping, transplanted river cane rhizomes, willow staking, and reforestation with native seedlings.

Technique 4: Gravel Bar Spawning through Whole Willow Transplanting

The use of willows to spawn gravel bars can augment stream restoration with minimal impact to natural processes. Gravel bar spawning is also relatively easy to accomplish, very cost effective, and can be implemented in small increments over time. This technique also has the advantage of a rapid response time. In fact, problem areas can be anticipated and reacted to before streambank erosion becomes severe. Finally, there is little if any chance of disturbing archeological sites within the active channel and minimal potential for other than short-term impacts to aquatic communities and habitats.

Gravel bar spawning by whole willow transplanting works by mimicking the natural tendency of willow incursion to promote meander processes. In-stream flow can be manipulated through strategic placement of willow plants in specific hydrologic environments. This technique is used to encourage gravel bar formation above eroding streambanks, thus deflecting hydrologic pressure away from the impacted area. Even accomplished fluvial geomorphologists are generally unable to recognize that human intervention has occurred at sites where this method is implemented.

APPENDIX E
Summary of Past Streambank Management Efforts at Buffalo National River

Site Name	Site Type	Techniques Used	Results
Wilderness Boundary	Channel disturbance	1. Willow transplanting 2. Corridor reforestation	***Successful***: slowly stabilizing
Luallen	Channel disturbance	1. Cedar revetment 2. Corridor reforestation	Partially ***failed***[1]
Beech Creek	Channel disturbance, Riparian loss	1. Back-sloping 2. Corridor reforestation	***Successful***: complete rehabilitation
Ferguson	Channel disturbance, Riparian loss	1. Willow transplanting 2. Back-sloping 3. Cedar revetment	***Successful***: bank has stabilized
Cecil Creek	Confluence, Riparian loss	1. Cedar revetment 2. Corridor reforestation	***Successful***: bank has stabilized
Angle Field	Valley crossover	1. Back-sloping 2. Cedar revetment 3. Bank revegetation 4. Corridor reforestation	***Partially Successful***[2]: revegetation slow
Lower Rock Creek	Confluence	1. Back-sloping 2. Cedar revetment 3. Bank revegetation 4. Corridor reforestation	***Successful***: erosion slowed, revegetation progressing
Upper Rock Creek	Confluence, Riparian loss	1. Back-sloping 2. Cedar revetment 3. Bank revegetation 4. Corridor reforestation	***Successful***: erosion slowed on most of bank
Sheldon Br.	Overbank scour, Valley crossover	1. Back-sloping 2. Cedar revetment 3. Bank revegetation 4. Corridor reforestation	***Successful***: complete rehabilitation
Jamison Creek	Disturbance zone	1. Back-sloping 2. Cedar tree revetment 3. Corridor reforestation	***Successful***: bank stabilized and revegetating
Baker Ford	Massive slumping	1. Buffer established 2. Cedar revetment	***Successful***: bank stabilized and revegetating
Calf Creek	Confluence	1. Back-sloping 2. Cedar revetment 3. Bank revegetation 4. Corridor reforestation	***Failed***: erosion has not slowed

Summary of Past Streambank Management Efforts Continued

Site Name	Site Type	Techniques Used	Results
Grinders Ferry	Valley crossover, Massive slumping	1. Back-sloping 2. Cedar revetment 3. Bank revegetation 4. Corridor reforestation	***Partially Successful***: lower 2/3 continues to erode[3]
South Maumee	Overbank scour Massive slumping	1. Cedar revetment 2. Corridor reforestation	***Partially Successful***: upper bank has stabilized[4]

[1] Restoration of this site was complicated by lasting effects of historic excavation of the channel.
[2] Heavy elk use and sandy soil conditions have slowed recovery efforts.
[3] Sycamore trees rooted in bedrock forced turbulent water into the revetment.
[4] Experimental use of a cedar revetment on a bank over 30 feet tall.

APPENDIX F
Revetment Assessment Questionnaire

Assessment Questions	Y	N
1. The primary objective is to "stop" erosion?		
2. The primary objective is to restore natural processes?		
3. Can the impacts to bank or channel that caused the original or ongoing disturbance be stopped or alleviated?		
4. Is the thalweg against the eroding bank?		
5. Is any vegetation trying to colonize bank?		
6. Is any vegetation trying to colonize channel in front of bank?		
7. Can the bank be back-sloped?		
8. Can a natural buffer be established above the bank?		
9. Are appropriate type and size of trees available, and can they be practically transported to the bank?		
10. Are bank materials dominated by sand, or are there other factors such as aspect that would cause the bank to experience extreme drought?		
11. Will resources be available for inspection and maintenance?		
12. Is it possible to drive duckbill or other anchors into the toe of the bank?		
13. Is channel bottom on bedrock?		
14. Is bank rapidly eroding or is the radius of curvature small?		
15. Are there unique circumstances that might interfere with recovery?		
16. Is the channel down-cutting?		
17. Is the channel extensively over-widened?		
18. Is significant willow encroachment occurring within the channel opposite the bank?		
19. Is the water deeper in front of the bank than your equipment and personnel can operate in?		
20. Can the structure be tied into stable streambanks above and below the revetment.		
21. Is this a confluence site or is it otherwise subjected to backwater		
22. Is there significant disturbance in the watershed above site		
Total number of gray blocks checked		

Comments:

Summary of Revetment Assessment Questions

1. If ***yes***, then a cedar revetment is probably not appropriate. A properly constructed cedar revetment will temporarily curtail erosion on almost any bank. Eventually, the bank will be subjected to erosion once again, although hopefully at a natural rate. An eroding bank that must be permanently protected because of a significant structure or artifact is not a good candidate for a natural cedar revetment, since cedar revetments are not intended to permanently end erosion, but rather to restore natural erosion rates, benefits, and processes.

2. If ***yes***, then seek the least expensive and most practical bioremediation technique that has proven successful for the region, stream type, and bank condition in question. A cedar revetment may fit these criteria as it provides temporary structural protection of the bank while transplanted and/or volunteer vegetation is becoming established. Cedar revetments are strongly encouraged, even where there are other risks and probable future maintenance involved in eventually reaching the goal of a naturally functioning channel.

3. If ***no***, then a cedar revetment is probably not appropriate since the primary purpose of bioremediation is to restore natural processes. Natural processes will probably not be restored if anthropogenic disturbances are ongoing.

4. If ***yes***, the odds of long-term revetment success are decreased and the odds of future maintenance on the structure are increased due to scour erosion caused by a high velocity thalweg. A cedar revetment should not necessarily be ruled out, but careful consideration is required.

5. If ***yes***, this is a good sign, particularly if the colonizing vegetation predates the previous flood season. Bank vegetation may be indicative of a streambank that is attempting self-restoration, but may benefit from holistic intervention. Will the bank stabilize naturally upon removal of the disturbance? Or is intervention necessary to assist the restoration.

6. If ***yes***, see #5 above.

7. If ***no***, revegetation will be difficult, if not impossible, on the steep or vertical portions of the bank. Restoration efforts will be jeopardized.

8. If ***no***, the benefit of restoring a natural riparian buffer, including long-term stability, will be lost.

9. If ***no***, then a tree revetment is not practical. Much of the effort involved in revetment construction is in transporting trees to the site. Bushy cedar trees are difficult to handle.

10. If ***yes***, revegetation may be difficult. Recurrent watering and soil remediation may improve success, but will add substantial cost to the project.

11. If ***no***, the chances of long-term success at a given bank are reduced as a function of other negative aspects associated with the site. If the bank needs only minor assistance to initiate restoration naturally, then maintenance may not be needed. If the revetment will be subjected to obvious stress, then inspection and maintenance are necessary.

12. If ***no***, construction of a cedar revetment will be difficult, if not impossible. Cobble in the lower portion of the bank, which is common in high-energy streams, is the most frequent impediment to the installation of revetment anchors. Pre-drilling with a pneumatic hammer or drill may alleviate the problem to some degree, but is labor intensive and expensive.

13. If ***yes***, the bank will likely be subjected to substantial erosional stress since the channel cannot adjust in the vertical dimension without aggrading. Erosional forces are, instead, expended in the lateral dimension.

14. If ***yes*** to either, and particularly if ***yes*** to both, then the odds of restoring natural bank stability are greatly reduced. Bioremediation seeks to assist the bank with native revegetation and stabilization over time. If the bank is rapidly eroding (five feet per year or greater) or the radius of curvature is small (i.e. less than the radius of curvature of other stable reaches), then erosional forces acting on the bank will likely damage the revetment. The revetment can be repaired and maintained after major flood events to reduce erosion. But if maintenance ceases, then accelerated erosion will probably be restored.

15. If ***yes***, then remediation efforts may be compromised. Unique circumstances may include a bridge or dam near the reach, heavy wildlife use, lone trees in the channel or near the bank that could catch debris and deflect currents into the bank, or other factors unique to the area.

16. If ***yes***, the revetment may be undermined.

17. If ***yes***, then sediment bars may form within the channel, as has been observed at gravel mining sites. These bars may become stabilized by vegetation and can deflect flow toward the bank, thus destabilizing the revetment. Inclusion of natural channel design principles may be applicable to restoration at such sites.

18. If ***yes***, then hydraulic roughness and willow durability should not be underestimated. Willows can be a tremendous asset to bioremediation efforts of eroding banks. However, when encroaching on the channel from the opposite side of the stream, they can redirect flow toward the compromised bank. On the Buffalo River, this has only been observed at an over-widened gravel mining site.

19. If ***yes***, revetment construction is probably not practical. The bank can be worked from above, but with much greater difficulty. Coffer dam systems can be used but the associated expense and labor generally exceeds budgetary constraints.

20. If ***no***, erosion above or below the revetment may jeopardize restoration.

21. If ***yes***, revetment success may be compromised since confluence sites often have higher rates of natural erosion and can be difficult to stabilize due to the chaotic nature of sediment transport in environments subjected to backwater effects.

22. If ***yes***, carefully consider the stream at a number of reaches to determine the presence of chronic or widespread erosion, down-cutting, or aggradation. Streams sometimes undergo widespread adjustment to watershed development with associated changes in runoff and sediment production. It may not be possible to treat only the affected reach if watershed-wide changes are ongoing.

APPENDIX G
Protected and Sensitive Species of Counties Containing Buffalo National River

Species	Common Name	Status
Mussels		
Alasmidonta marginata	Elktoe	S3
Alasmidonta viridis	Slippershell	S1
Cyprogenia aberti	Western Fanshell	G2, S2, INV
Cyclonaias tuberculata	Purple Wartyback	INV, G5, S3
Fusconaia ozarkensis	Ozark Pigtoe	S3
Lampsilis reeviana	Arkansas Broken-Ray	S3
Lasmigona costata	Fluted-Shell	S3
Pleurobema sintozia	Round Pigtoe	S3
Ptychobranchus occidentalis	Ouachita Kidneyshell	S3
Quadrula cylindrica	Rabbitsfoot	S?, G3, INV
Strophitus undulatus	Squawfoot	S3
Toxolasma lividus	Texas Liliput	S2
Venustachoncha pleasii	Bleedingtooth	S3
Villosa iris	Rainbow	S2, S3
Villosa lienosa	Little Spectaclecase	S3
Fishes		
Lampetra aepyptera	Least Brook Lamprey	S2, G5, INV
Lampetra appendix	American Brook Lamprey	S2, G4, INV
Notropis ozarcanus	Ozark Shiner	G3, S2, INV
Amphibians and Reptiles		
Rana sylvatica	Wood Frog	S4, G5, INV
Macrochelys temminckii	Alligator Snapping turtle	G3, G4, S4, INV
Bats		
Myotis grisescens	Gray bat	G3, S2, LE, INV
Myotis sodalis	Indiana bat	G2, S2, LE, INV
Myotis leibii	Eastern Small-footed	INV, G3, S1
Corynorhinus townsendii ingens	Ozark big-ear bat	G4, S1, LE, INV
Birds		
Limnothlypis swainsonii	Swainson' Warbler	INV, G4, S3B
Thryomanes bewickii	Bewick's wren	INV, G5, S2B, S3N
Falco Peregrinus	Peregrine Falcon	INV, G4, S1N
Haliaeatus leucocephalus	Bald Eagle	G4, S2, LT-PD, INV
Vascular Plants		
Abutilon incanum	Pelotazo Abutilon	INV, G5, S1, S2
Allium stellatum	Glade Onion	INV, G5, S3

Arabis shortii	Short's Rock Cress	INV, G5, S1
Aster sericeus	Silky Aster	INV, G5, S2
Brickellia grandiflora	Tassel Flower	INV, G5, S2
Carex careyana	Carey's Sedge	INV, G5, S2
Carex mesochorea	Midland Sedge	INV, G4G5, S1
Carex pellita	Woolly Sedge	INV, G5, S1
Carex radiata	Stellate Sedge	INV, G4, S1
Casenea pumila	Ozark Chinquapin	INV, G5, S3S4
Caulophyllum thalictroides	Blue Cohosh	INV, G4G5, S2
Collinsia verna	Spring Blue-eyed Mary	INV, G5, S1
Delphinium newtonianum	Moore's Larkspure	INV, G3, S3
Delphinium treleasei	Trelease's Larkspur	INV, G3, S3
Desmodium illinoense	Illinois Tick-Treefoil	INV, G5, S2
Heuchera parviflora	Little-Leaved Alumroot	INV, G4, S3
Hieracium scabrum	Rough Hawkweed	INV, G5 S2
Juniperus ashei	Ashe's Juniper	INV, G5, S3
Leavenworthia uniflora	Leavenworthia	INV, G4, S3
Lithospermum incisum	Narrow-Leaved Puccon	INV, G5 S2S3
Mimulus floribundus	Floriferous monkeyflower	INV, G5, S2S3
Muhlenberia bushii	Bush'sMuhly	INV, G5, S2
Neviusia alabamensis	Alabama Snow Wreath	ST, G2, S1S2
Penstemon covaea	Purple Beardtongue	INV, G4, S3
Phacelia gilioides	Brand Pacelia	INV, G5, S2S3
Philadelphus hirsutus	Mock Orange	INV, G5, S2S3
Phlox bifida	Sand Phlox	INV, G5?, S3
Rhynchospora capillacea	Capillar Beak Rush	INV, G5, S2
Ribes cynosbati	Prickly Gooseberry	INV, G5, S2S3
Smilax ecirrata	Carrion-Flower	INV, G5?, S2
Spiranthes lucida	Shining Ladies-tresses	INV, G5 S2
Stylophorum diphyllum	Celandine Poppy	INV, G4, S3
Tradescantia ozarkana	Ozark Spiderwort	INV, G3, S3
Trillium pusillum	Ozark Least Trillium	INV, G3, S3
Valerianella ozarkana	Corn-Salad	INV, G3, S3
Insects		
Pseudactium ursum	Ozark Pseudactium	INV, G?, S1
Rimulincola divalis	Beetle	INV, G1, S1
Scaphinotus inflectus	Ground Beetle	INV, G?, S?
Natural Communities		
	Juniper-Hardwood Woodland	INV, S4
	Post Oak-Blackjack Oak Forest	INV, S2

*information obtained from the Arkansas Natural Heritage Commission, 2002
** federal species of concern information obtained from U.S. Fish and Wildlife Service

Federal Codes

LT - Listed Threatened by USFWS
LE - Listed Endangered by USFWS
PD - Proposed for Delisting-proposed to be removed from list by USFWS

G1 - Critically imperiled globally because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2 - Imperiled globally because of rarity (6-20 occurrences or few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G3 - Either very rare or local throughout its range or found locally in a restricted range or because of other factors making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21-100.
G4 - Apparently secure globally, though it may be quite rare in parts of its range, esp. in the periphery.
G5 - Demonstrably secure globally, though it may be quite rare in parts of its range, esp. at the periphery.

State Codes

INV - Inventory element; the Arkansas Natural Heritage Commission is currently conducting active inventory work on these elements. Available data suggests these elements are of conservation concern.
S1 - Extremely rare, typically 5 or fewer estimated occurrences in the state, or only a few remaining individuals, may be especially vulnerable to extirpation.
S2 - Very rare, typically between 5 and 20 estimated occurrences or with many individuals in fewer occurrences, often susceptible to becoming extirpated.
S3 - Rare to common, typically between 20 and 100 estimated occurrences, may have fewer occurrences but with large number of individuals in some populations, may be susceptible to large-scale disturbances.
S4 - Common, apparently secure under present conditions, typically 100 or more estimated occurrences, but my be fewer with many large populations, may be restricted to only a portion of the state, usually not susceptible to immediate threats.
S5 - Demonstrably widespread, common, and secure in the state and essentially ineradicable under present conditions.

B - Breeding Status
N - Non-breeding status