National Park Service
U.S. Department of the Interior

Buffalo National River
Arkansas

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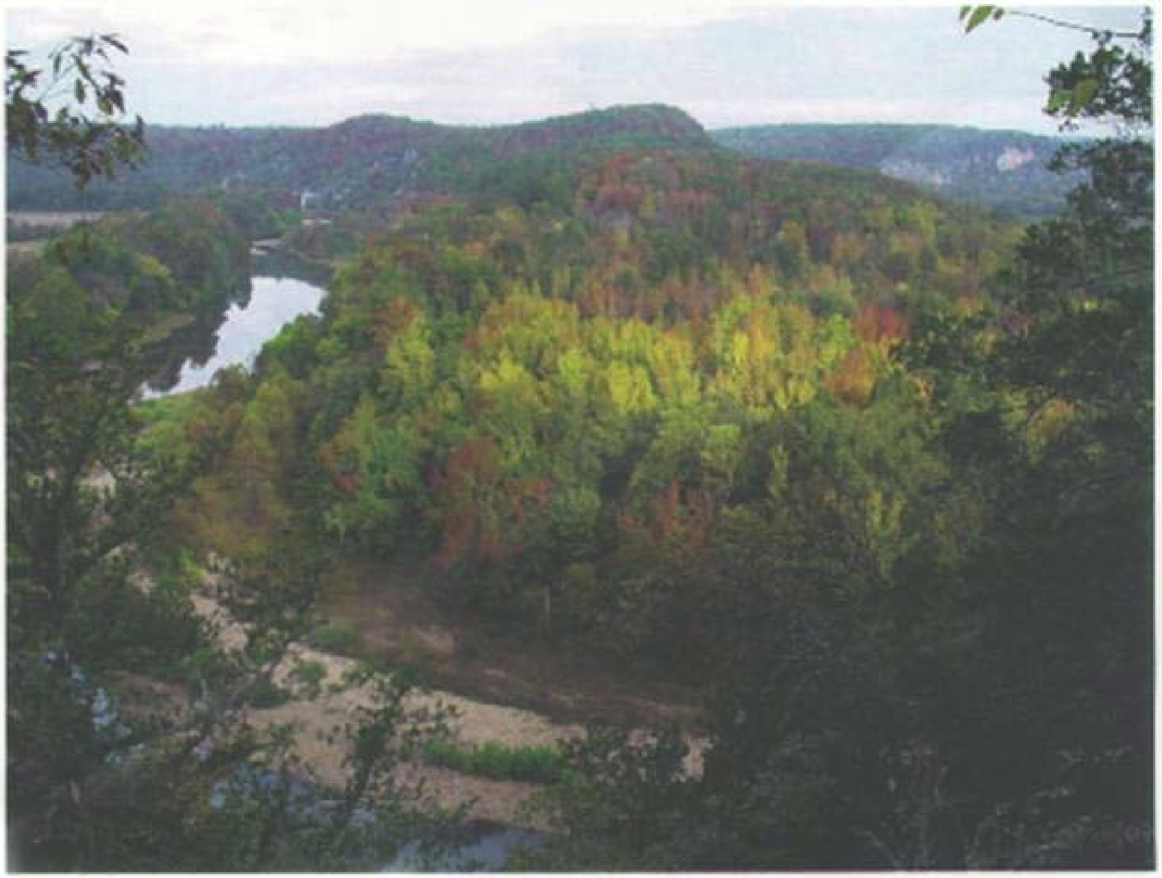
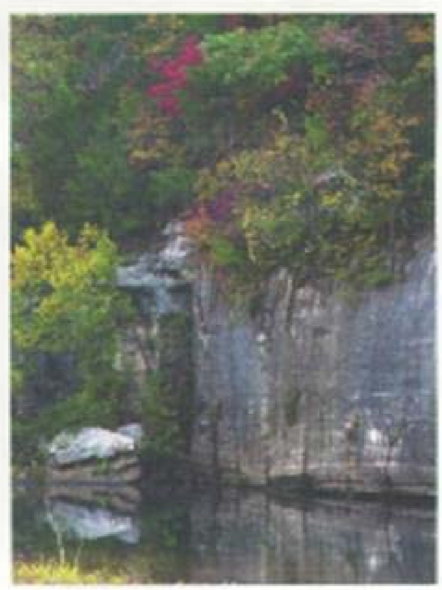
Water Resources Management Plan





WATER RESOURCES MANAGEMENT PLAN

BUFFALO NATIONAL RIVER
ARKANSAS

February 2004

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United States Department of the Interior
National Park Service

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EXECUTIVE SUMMARY

A National Park Service Water Resources Management Plan (WRMP) is designed to summarize the water resources and related issues and make recommendations for future actions. This plan will also serve to identify gaps in information on water resources and issues and provide a basis for future project development.

Buffalo National River, established in 1972, is a water-based park, which encompasses a narrow "shoestring" boundary around the river for 135 miles. Only 11% of the watershed of this free-flowing river is within National Park Service (NPS) ownership; 60% of the watershed is in private ownership, and the remaining 29% is under state or U.S. Forest Service (USFS) protection. Water quality studies on both the river and some of its tributaries indicate degrading water quality, mostly due to the rapid conversion of forested land to agricultural land in the watershed. The resource management problems associated with limited jurisdiction are a common theme addressed throughout this plan, evident in the description of the existing resource conditions and the associated issues and recommendations.

Specific issues and recommendations are summarized below:

1). Planning History of the WRMP-Public relations have been an ongoing issue since Buffalo National River was established, with the main problem relating to poor communication between federal officials and the surrounding communities. These same issues led to an interruption in the development of the original WRMP. The original plan proposed the development of a cooperative, voluntary, community-focused group designed to bring together federal, state, and local officials along with area citizens to protect the water quality of the Buffalo River through a watershed based approach. Miscommunication regarding this proposal led to enough public protest that area counties declined to participate and the program was put on hold. The WRMP still has the same general philosophy and still suggests that in order to protect the water quality of the Buffalo River efforts must be watershed-wide. Thousands of other voluntary, citizen-based watershed groups have formed throughout the country and their efforts have proven successful in protecting water quality and helping area landowners at the same time. This plan emphasizes that private property rights, free economic development, local culture and values, and the county tax base would be protected to the fullest extent possible.

2). Watershed Management - One function of a watershed conservation group would be to work with landowners and assist them with implementation of voluntary Best Management Practices (BMPs) in the watershed. BMPs are simple and economical approaches to conservation and restoration which are put into practice by landowners with financial and/or technical help from an outside source such as local, state, or federal agencies or non profit groups. They are intended to protect sensitive environmental resources and promote land and water conservation. Examples include establishment of riparian buffers, soil conservation practices, riparian bank restoration, and building fence to keep livestock out of streams and rivers.

2a.) ***Degrading Water Quality***-The water quality of the Buffalo is declining, particularly in the middle reach of the river. Land use trends indicate that 94.6% of the annual loss of forested land can be accounted for by an increase in pasture lands in the watershed of the Buffalo (Scott and Hofer, 1995). This rapid conversion rate, in conjunction with improper agricultural practices, has a documented impact upon water quality and aquatic biota.

Recommendation: The staff at Buffalo National River will continue to monitor water quality and document trends. However, this will not solve the problem of degrading water quality; it will only document its demise. In order to address larger issues outside of park jurisdiction but still within the watershed, this plan encourages the development of a citizen based watershed protection group. The staff at Buffalo National River would provide technical assistance and aid in the development of the framework of the group, including recommending ways to obtain financial support.

2b.) *Riparian Zones and Bank Erosion*- Concentrated overgrazing, land clearing along riparian zones, livestock in the streams, and consequent bank destabilization and erosion are common problems in tributaries of the Buffalo and under some circumstances the river itself.

Recommendation: Helping landowners to obtain funds to voluntarily implement Best Management Practices on their land in the Buffalo River watershed is the best way to prevent further erosion and other water quality problems. A locally established and operated, citizen based watershed group would provide the best source of information and financial aid to farmers. Within the park boundaries, continued restoration of destabilized banks along the river are recommended along with monitoring of past bank restoration projects.

3.) Gravel Mining-Gravel mining is a common practice in Ozark streams and it does occur in tributaries of the Buffalo River. Studies have found significant impacts on the fish communities at and below gravel mining sites, including a decrease in game fish species, due to increased turbidity, habitat degradation, and stream channel alteration and channelization.

Recommendation: While gravel mining operations do occur in tributaries of the Buffalo, the impact upon the ecosystems of these streams and the Buffalo River are unknown. Little is known on the potential impacts on higher order streams that have gravel mining activity in their tributaries. This plan recommends the development of a project(s) to investigate what, if any, impacts are occurring on tributaries and the Buffalo due to gravel mining.

4.) Development-Impacts from development are not a major issue because of the low population density in the area but there are some issues of concern. However, the Ozarks area in general is growing and these trends may begin to affect communities in the Buffalo River watershed. An economic and population assessment of the Ozarks Highlands region (southern Missouri, northwestern Arkansas, and eastern Oklahoma), found that the population in the assessment area grew by 48% between 1970 and 1996, compared to a 31% growth rate both for Arkansas and the United States. There is a projected growth of 17% between 1996 and 2010 (USDA-USFS, 1999). There are also four wastewater treatment plants in the Buffalo's watershed, which thus far have not posed any major problems. Septic tanks in many of the small communities around the watershed have impacted water quality when they are not maintained and installed properly.

> **Recommendation**: An extensive dye trace study was conducted involving 29 septic tanks in Gilbert, AR, a small town that adjoins the park boundaries. This successful study isolated the leakage problems and NPS assisted owners of the malfunctioning septic tank with the task of finding money to make the necessary repairs. The lessons and successful results from this study can be applied to other communities with similar problems. Also, along with continuation of the water quality monitoring program, a biomonitoring plan should be implemented to better detect changes in water quality, particularly if a spill from a treatment plant should occur. Grab water quality samples may miss such an event.

5.) Roads-There are 83 miles of active dirt and gravel roads and an unknown number of abandoned and backcountry roads inside the park boundaries, many of these roads are poorly constructed and are contributing large volumes of sediment to river during storm runoff. In the 1,338 square miles of the watershed of the Buffalo there are an estimated 2,000 miles of roads.

> **Recommendation-**Recommendations will come from a current NPS road assessment project which is near completion. This project involves only roads in park boundaries. Projects should also be developed to address roads outside of the boundary, particularly in adjacent wilderness areas.

6.) Recreation-Around 800,000 visit the park annually and that usage is concentrated from late spring to mid-summer, particularly in the upper district of the park. Recreational impacts on the river include overcrowding, bank and trail erosion from overuse, and trash along the river. Boat launch areas are also an issue, causing stream channel alteration and bank destabilization at major access points to the river.

> **Recommendation:** Recreational impact has been minimal when compared to larger watershed issues. Continued water quality monitoring and visitor education on wilderness ethics is necessary to maintain minimal impact. Overcrowding and erosion problems from overuse would be best addressed by revisiting the River Use Plan and Wilderness and Backcountry Management Plan.

7.) Reservoirs and Impoundments-The potential development of impoundments or diversion projects on major tributaries of the Buffalo River remains a possibility as the surrounding communities develop and water supply needs change. The Searcy County Regional Water District (SCRWD) recently proposed a dam on Bear Creek, a major tributary of the Buffalo River. While the permit to build the dam was denied, this situation initiated ongoing research on the potential hydrological and ecological impacts of an altered flow regime.

> **Recommendation**: Work is currently underway to understand the physical and ecological impacts a dam on Bear Creek would have upon the Buffalo. These studies will provide information on the dependence of a river upon its tributaries and the ecological impact of seasonal flooding on a stream. Recommendations for handling future proposals for water resource development projects on tributaries of the Buffalo River are situation specific; it is not practical or useful to make broad recommendations regarding this issue.

8.) Groundwater and karst geology-The extensive karst geology and complicated groundwater system that underlies the Buffalo River makes delineation of the true watershed a difficult task. Studies have found that inter-basin transfer of water from streams outside of the Buffalo's topographic watershed boundary is occurring and this is negatively impacting water quality along the river. The karst geology also makes groundwater pollution a much greater threat. Since water flowing in the Buffalo during its base flow stage is supplied by groundwater recharge, threats to the groundwater supply also mean threats to the water quality of the Buffalo.

> **Recommendation**: In the short term, project work will continue in attempting to understand the karst system and where the water that supplies the base flow of the river comes from. More long term solutions involve implementation of BMPs by landowners in sensitive karst areas and the establishment of a citizen based watershed group to work with these landowners.

9.) Exotic Species-The Buffalo flows into the cold hypolimnetic released waters of the White River, which may help shield from the introduction of some exotic species that may migrate up from the White River. However, this does not exclusively protect the river, specifically from introductions above the White River. One aquatic exotic species found in the Buffalo is Corbicula, a mussel introduced in the U.S. from Europe in the 1930's. Corbicula is associated with degrading water quality along the Buffalo and both of these factors are likely impacting the macroinvertebrate and mussel communities on the river. Another exotic species in the park that may be impacting water quality is the European Wild Hog, or feral pig. Little is known about the population size or impact from this species. There may be other exotic species in Buffalo National River affecting water quality and the river's ecosystem but the information is limited.

> **Recommendation:** Because there is limited information on the impact these species have on the water quality and aquatic ecosystem of the Buffalo, these data must first be obtained before any management recommendation can be made in regard to controlling species populations and mitigation of damage. Ultimately, implementation of consistent biomonitoring of aquatic communities, particularly macroinvertebrates, is the most effective method to prevent invasion of exotic species. Because native freshwater mussels are under a demonstrated risk and

there is little known about the impact of Corbicula on their populations, an immediate assessment of the mussel community should be conducted.

10.) Human Health- During precipitation events, fecal coliform levels in the Buffalo and its tributaries can exceed state standards for primary contact recreation waters. Even though during base flow conditions fecal coliform levels remain safely below state standards, visitors still face bacteria counts that are unsafe many times throughout the course of the year following storm events. This could pose a health threat.

Recommendation: The current water quality monitoring program does not have any standardized storm event sampling protocols incorporated into it and therefore does not incorporate times when most of the nonpoint source pollution occurs, during flooding. Some high flow events are captured during routine water quality monitoring. A regular storm event sampling protocol, along with the development of specific water quality standards for the Buffalo and its tributaries are necessary to address this issue. A more long term solution again returns to watershed management issues and implementation of BMPs.

11.) Environmental Education Programs-Many of the problems associated with preserving the water quality of the Buffalo are linked to problems outside of park boundaries. One important forum to communicate these problems and the necessity of addressing them is through the classroom. Some environmental education programs put on by Water Resources staff from the park, in particular, the Project WET program, have been successful in the past. But, with dwindling funds, these programs are not currently being implemented.

Recommendation: The park needs to redevelop an environmental education program focused on hands on, aquatic related activities which are directed primarily towards high school and junior high school students. The major obstacle is the lack of funding to implement these programs.

12.) Regulatory Designations/Standards-Existing state standards do not provide the proper framework for assessing nonpoint source pollution. Random water quality sampling programs, such as the one the state uses for enforcement purposes, reflects some component of nonpoint source pollution only 15 to 20% of the time. This sampling method misses most major runoff events. Also, the Extraordinary Resource Water designation by the state that requires existing water quality standards be maintained has limited potential because the process to identify impaired water bodies involves only random water quality sampling, not storm sampling.

Recommendation: It would be beneficial to adopt water quality standards applicable specifically to the Buffalo River which are directed at protecting the existing water quality. These standards should be based on the extensive data set that has been established on the Buffalo and its tributaries.

13.) Cumulative Effects/Ecosystem Disruptions-Currently, most of the issues threatening the water resources at Buffalo National River are addressed independently of each other. In reality, these issues are all going on simultaneously and have a cumulative impact upon aquatic communities

> **Recommendation:** Projects and future research endeavors should be accepted around a more interdisciplinary approach in order to address the overall impact of these issues rather than the effects of a single problem. Biological and habitat monitoring are key components of an interdisciplinary approach.

INTRODUCTION

Purpose of the Plan

Buffalo National River is a water-based national park unit. In other words, the river, its riparian zone, adjacent wetlands, and back channels are the primary resources of the park. A Water Resources Management Plan (WRMP) is needed to better understand the water and water-dependent resources of Buffalo National River and provide a means to better protect those resources. The WRMP will supplement the park's Resource Management Plan with much greater detail specific to water related issues.

The WRMP provides an opportunity to synthesize all available information concerning the parks water resources, to identify gaps in information about the river, and to develop project statements setting up a process to eliminate those gaps. The project statements become the vehicle through which funding is secured from special funding sources to address top-priority issues.

The WRMP begins with a summary of existing information on the area, including not only a description of natural resources but also a summary of the political and economic setting of the area. Water resource issues related to the park are then presented with associated recommendations. Issues addressed in this plan include the following:

- watershed management
- riparian zone and bank erosion
- gravel mining
- development
- roads
- recreation
- reservoirs and impoundments
- groundwater and karst geology
- exotic species
- human health
- environmental education programs
- regulatory designations/standards
- cumulative effects/ecosystem disruptions

The WRMP and its products will support the management goals of Buffalo National River by:

1. Identifying and defining programs at the park level to monitor, inventory, research, and mitigate activities required to perpetuate park natural resources and natural processes.

2. Describing changes in water quality and to assess the potential for adverse impacts to aquatic resources, including endangered species and their habitats.

3. Assessing water condition in specific areas relative to sensitive floral and faunal communities, recreation, and other water-dependent activities.

4. Providing consistency in the type, frequency, and locations of water quality data collection

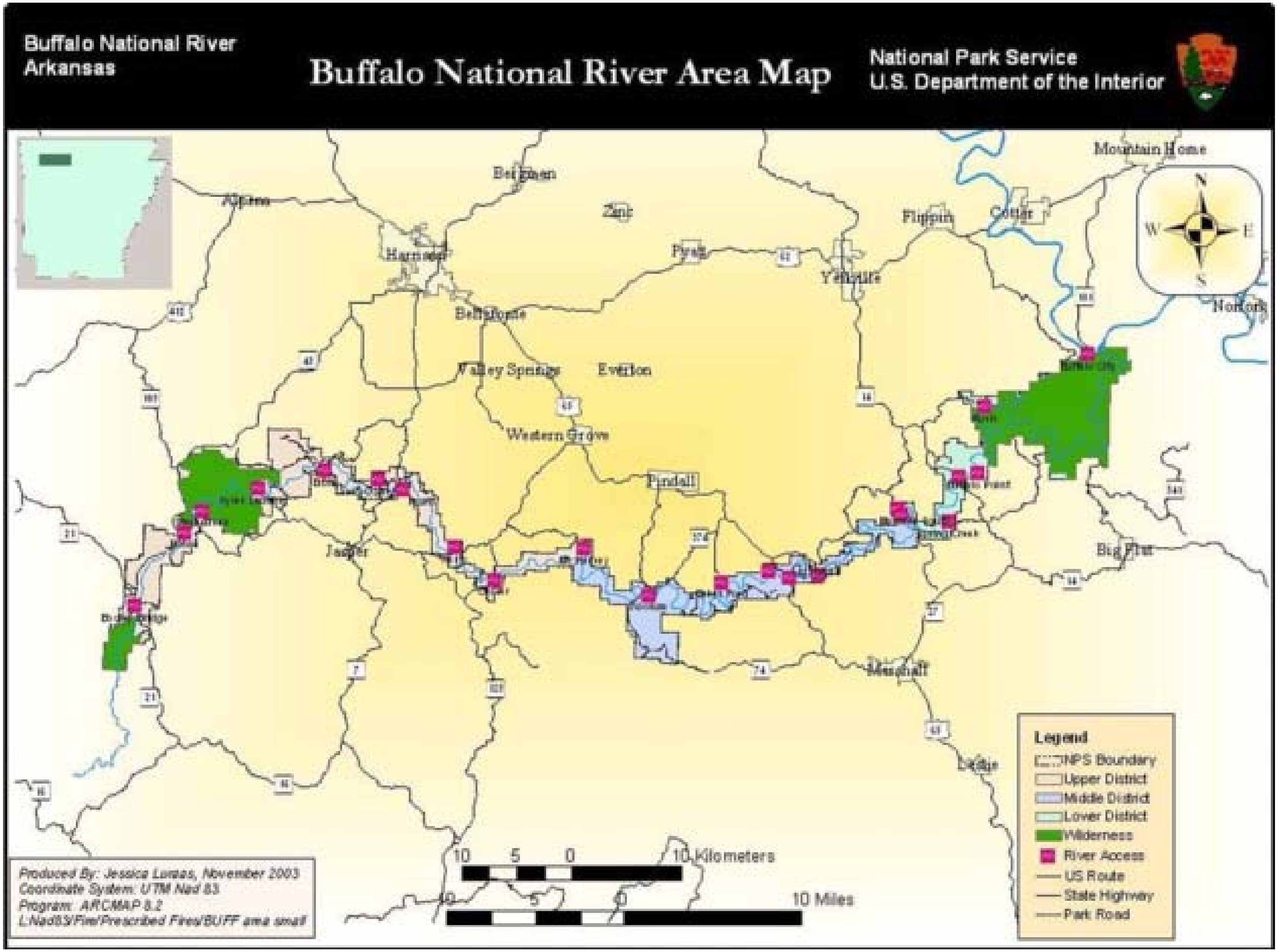


Figure 1. Buffalo National River Area Map

EXISTING RESOURCE CONDITION

This section provides the reader with background information on Buffalo National River. It includes information regarding the river's physical, chemical, and biological resources along with summaries of the management policies and legislative background of the park. It also addresses past and ongoing research and restoration projects that have taken place both along the Buffalo River and within its watershed. This summary of resources will provide an important source of information for new staff and managers to familiarize themselves with the area's political setting, physical environment, and water resources. It will update long-term staff on new research and provide an important reference for future projects.

Location and Adjacent Land Ownership

The Buffalo River flows through the heartland of the Ozarks in northwestern Arkansas and is considered one of the region's finest natural rivers (Figure 1). The Buffalo is one of only a few entirely free flowing rivers in the country. According to the Nationwide Rivers Inventory, only 42 high quality free-flowing rivers (no major dams) greater than 200 km remain in the 48 contiguous states (Benke, 1990). The National River encompasses 150 square miles (95,730 acres) and includes 135 miles of the 151-mile-long Buffalo from the Boston Mountains to the White River. The first 16 miles of the headwaters are within the Ozark National Forest and were recently designated as part of the National Wild and Scenic Rivers system. Overall, 11% of the 1,338 square mile watershed lies within National Park Service (NPS) administration and 28% is in other federal or state ownership (Figures 2 and 3). The remaining and majority (61%) of the watershed is in private ownership (NPS, 1998).

Figure 2. Land ownership within the Buffalo River watershed

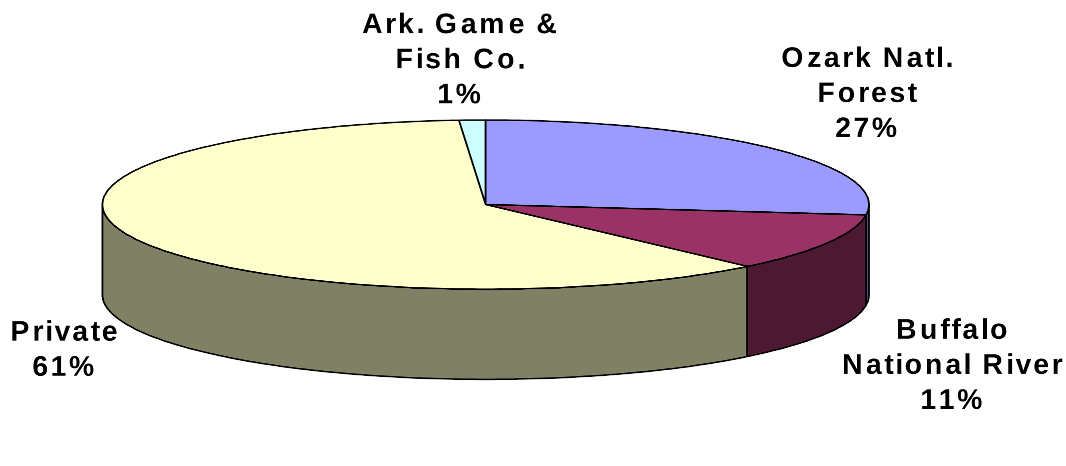
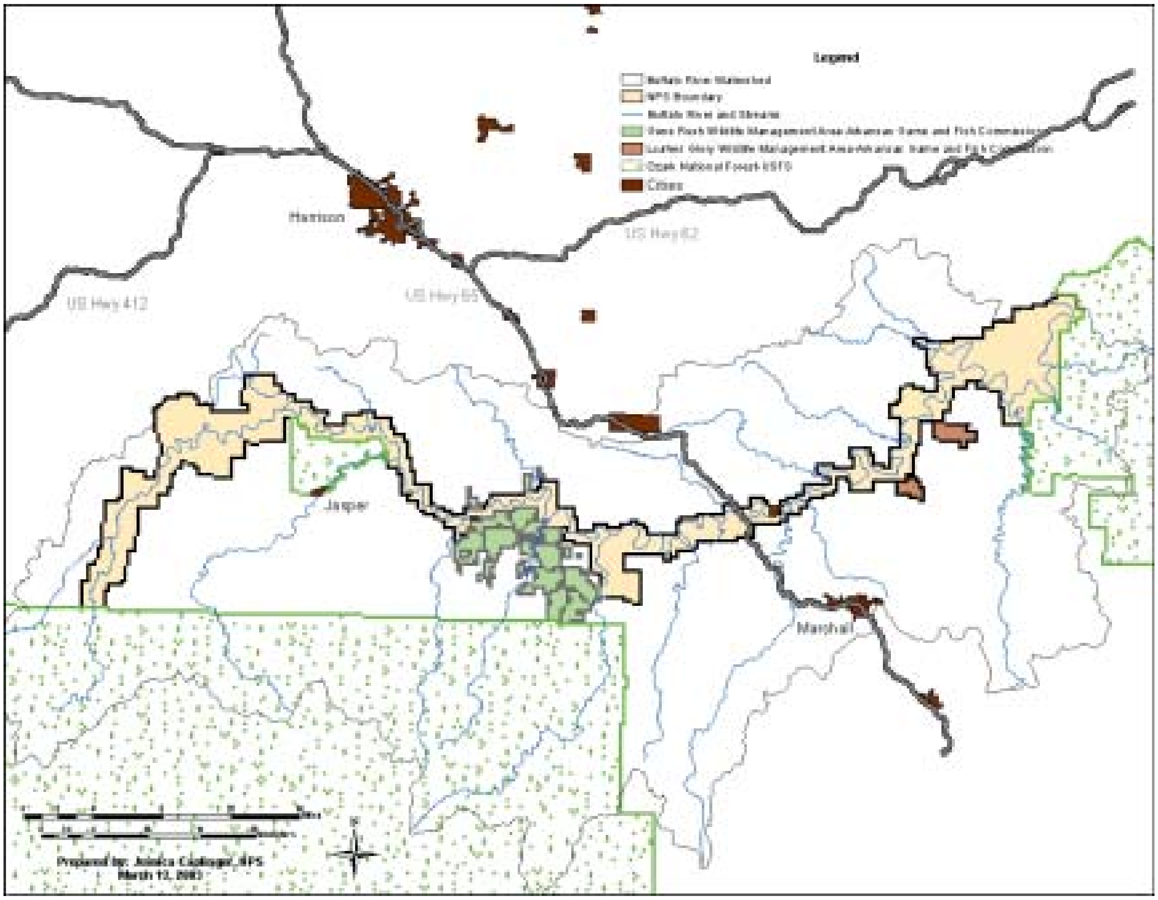


Figure 3. Land ownership in the Buffalo River watershed

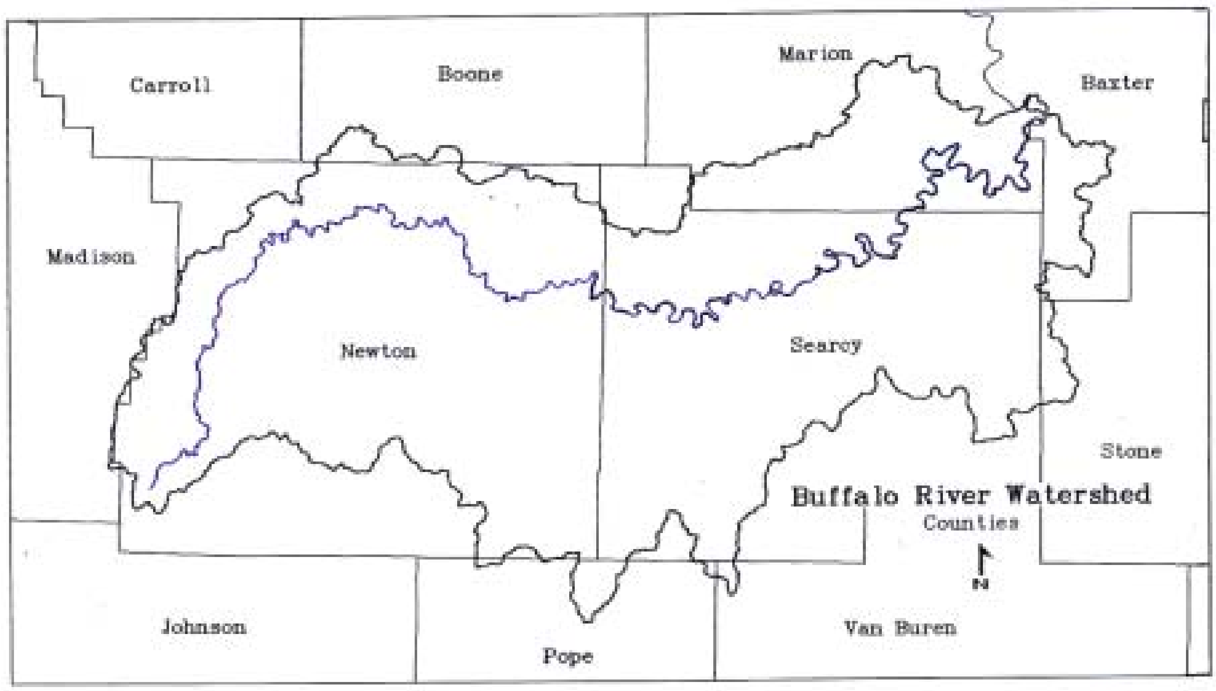


Buffalo River watershed occupies all or portions of forty two 7.5-minute topographic USGS quadrangles and nine counties in northern Arkansas. The majority of Newton and Searcy counties are contained within the watershed. Together, these two counties comprise over 83% of the watershed. The third largest area is in Marion County, which contains 11% of the watershed (Scott and Smith, 1994). Table 1 and Figure 4 indicate the percentages for the remaining counties in the watershed.

Table 1. Proportion of the Buffalo's watershed in each county
(Scott and Hofer, 1995)

County	*Areal Extent (acres)*	*Percent of Total*
Baxter	21,746	2.54
Boone	6,583	0.77
Madison	1,590	0.19
Marion	95,439	11.13
Newton	396,536	46.24
Pope	7,725	0.90
Searcy	319,704	37.28
Stone	6,835	0.80
VanBuren	1,449	0.17

Figure 4. Watershed and county coverage of the Buffalo River Watershed (Scott and Smith, 1994)



Most of the land in the river basin is of low quality agriculture, with cleared acreage being confined to sparse bottomland and upland ridges. These open fields are used primarily for cattle and hay production. The land does not produce sufficient income to sustain a large population, and there is little industry (NPS, 1985). The only town with a population over 1,000 is Marshall, AR in Searcy County.

Boxley Valley is an area of special designation that includes roughly 8,000 acres in the upper portion of Buffalo National River. The valley is approximately seven miles long. It has been designated as a historic district with archeological and cultural resources but is to remain in private use, thereby retaining the rural agricultural setting (NPS, 1985). Park managers have worked and will continue to cooperate with landowners and farmers in the valley to control streambank erosion and runoff associated with private agricultural practices.

Legislation and Management Strategy

Formal recognition of the Buffalo River's outstanding scenic and recreational qualities began with the establishment of Buffalo River State Park in 1935 and culminated in the creation of Buffalo National River 37 years later. Public Law 92-237 of March 1, 1972 (86 Stat. 44) established Buffalo National River as a part of the National Park System

"*...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 BuffaloRiver in Arkansas for the benefit and enjoyment of present and future generations...*"

The U.S. House of Representatives Committee Report (1972) explained the basis for establishing Buffalo National River.

> "*Because it is a pure, free-flowing stream which has not been significantly altered by industry or man, it is considered to be one of the country's last significant natural rivers. It is not one single quality, but the combination of its size, its completeness, its wild qualities, and its associated natural, scenic, and historic resources that makes the Buffalo River worthy of national recognition*". (Public Law 92-237)

In addition, the Buffalo National River enabling act, states that "*The Secretary shall administer, protect and develop the Buffalo River in accordance with the provisions of the Act of August 25, 1916..*". The central provision of that Act mandates the National Park Service to *"…conserve the scenery and the natural and historic objects and the wildlife therein…"* for the enjoyment of present and future generations.

The park's Master Plan (1977) emphasizes the importance of the river as the unifying feature of the park.

> "*The Buffalo River is recognized as the central element of the whole array of natural and historical features in its setting. It has clean, clear water uniting all elements in philosophical coherence.*"

The Master Plan describes a land classification system, a visitor plan, and a general development plan. It also defines specific resource management objectives. The potential for various internal and external threats to this preservation effort is recognized and discussed in relation to increased recreational use, development of facilities, and landuse practices within the watershed.

> *"It is essential that increased recreational use of the watershed does not contaminate the river."*

> *"The river's natural setting must be maintained. Recreation facilities and support structures must be situated where they will blend with their surroundings...the natural riverbank cover of trees and shrubs will be maintained where presently intact and allowed to re-vegetate where denuded"*

> *"...continuation of the river in its pure and attractive state depends upon the entire watershed; activities and industries upslope affect the water quality..."*

The Master Plan also recognized the importance of open fields as an element of the river's pastoral landscape and scenic quality. The Master Plan provides for a "Natural Environment Zone" with natural and pastoral sub-zones. Areas within the pastoral sub-zone are to be perpetuated as open fields through agricultural use or other methods (i.e. prescribed burning). The Master Plan does not specify which areas within the "Natural Environment Zone" are in the natural or pastoral sub-zones. Interpretation of the Master Plan's intentions regarding pastoral landscapes has varied. For two of the three areas zoned as a "Private Use Zone," Boxley and Richland valleys are predominately agricultural lands in private ownership (subject to restriction and covenant requirements) and the mandate to preserve the cultural landscape is clear (NPS, 1977).

Agricultural activities within the national park system include private lands with restrictions and covenants and Use and Occupancy lands. Additional fields along the river, owned in fee by NPS, are maintained using special use permits or historic leases to permit hay cutting or grazing. Scenic easement lands will remain in private ownership, while Use and Occupancy reservations will be expiring over the next few years. Agricultural special use permits are issued for 5 years and historic leases extend for 20-year terms. Farming in these areas consists of cattle grazing and hay cutting on improved pastures (NPS, 1977).

Overlaid on the National River's designation within the National Park system are several additional legal and administrative designations. Over one-third of the National River was included in the National Wilderness Preservation System in 1978 and is administered in accordance with the Wilderness Act of 1964. Four historic districts and one building are on the National Historic Register. A fifth district is considered eligible. One archeological site is individually on the Register and several more are part of the Boxley Historic District.

Boxley Valley is one of the most complex management areas within the National River: a historic district located in the upper reaches with archeological overlay, a cultural landscape, and an agricultural economy. The Boxley Land Use Plan/Cultural Landscape Report refined the private use zone classification, leading to the return of selected fee-title lands to private ownership in a process that is still ongoing. The plan's objective is "…*to perpetuate a harmonious relationship between the private, agricultural community and the historic scene, natural resources, and appropriate visitor use*." The balance of preserving the values for which the National River was established while allowing for continued use of the valley farms remains a challenge for management.

Seven specific management goals can be derived from the goals stated in the Master Plan and the Government Performance and Results Act (GPRA). They are listed below.

1. **Preserve the National River's scenic value and maintain a free-flowing, non-polluted river.**
   This includes the following specific goals and programs:
   - Maintain a base funded water quality-monitoring program, which encompasses physical, chemical and biological characteristics to determine

baseline conditions and natural variability, detect trends, and enable the development of water quality standards specific to the area.
- Document and analyze land use changes within the watershed to enable correlation with water quality trends using both biological and chemical data.
- Manage riparian lands to protect or restore a minimum 100-foot forested riparian corridor on either side of the river.
- Determine groundwater drainage basins feeding springs and surface streams within the National River and conduct a complete spring inventory within the park.
- Utilize all available management opportunities to implement effective agricultural "best management practices" within the National River to minimize impacts on water quality.
- Cooperate with federal and state agencies, local governments, and non-governmental organizations to develop strategies for watershed protection.
- Maintain and seek additional funds to support the Water Education Team program within high schools in the watershed to promote water resource monitoring and awareness of water resource issues.

2. **Manage for the perpetuation of natural and cultural resources, while providing recreation for visitors in such a manner that the impact on the environment will be minimized.**
    - Fully implement the River Use Management Plan and Wilderness and Backcountry Management Plan.

3. **Coordinate, encourage and administer a viable and purposeful research program.**
    - Maintain cooperative agreements to carry out cooperative research projects.
    - Facilitate selected non-NPS funded research projects with project support in the form of housing, transportation, and supplies.
    - Continue efforts to draft proposals for research within the park and seek funding from NPS and other sources for that research

4. **Inventory and monitor park resources.**
    - Develop a long-term inventory and monitoring program for the park and develop strategies for restoration and mitigation of identified problems.

5. **Reintroduce extirpated species where feasible.**
    - Examples include channel catfish, possibly mussels

6. **Provide special protection for rare and endangered flora and fauna.**
    - Implement an effective protection strategy for caves and mines utilized by endangered Gray (*Myotis grisescens*), Indiana (*Myotis sodalis*), and Ozark big-eared bats (*Corynorhinus townsenddii ingens*).
    - Monitor wintering bald eagle populations and potential nesting activity.

- Assess the status of state and federal species of concern such as the alligator snapping turtle on the Buffalo River.
- Cooperate with the Arkansas Natural Heritage Commission to maintain a database on the status of federal and state listed plants and animals.

7. **Open fields will be maintained where scenic qualities and wildlife habitat will be restored.**
   - Identify specific areas to be maintained and appropriate management methods (i.e. agricultural or prescribed fire).
   - Determine pre-settlement species diversity patterns and quantity and quality of open field habitat.
   - Attempt to restore a pre-settlement landscape diversity, associated native plant communities, and a more natural diversity of woodland dependent and open field dependent wildlife species.

Additional legislation and management strategies can be referenced in Appendix A, covering both state and federal regulations affecting Buffalo National River.

Buffalo National River is also regulated and/or influenced by an array of federal agencies (NPS, USFS, NRCS, EPA, USACE), state agencies (AG&F, ADEQ, Extension Service, ASWCC), local agencies (County Chambers of Commerce), county governments, and private organizations (environmental groups).

- **The National Park Service** (NPS) manages the 95,730 acres within the park boundaries of the National River, including portions three Wilderness Areas. Its mission is to ensure "access and enjoyment" of national parks while maintaining "resource stewardship and protection." The NPS operates visitor centers and collects data on recreational use and pollution levels in the Buffalo River. NPS issues a limited number of canoe permits to concessionaires. NPS is part of the US Department of the Interior, and Congress established Buffalo National River in 1972.

- **The United States Forest Service** (USFS) has a mixed mission of providing a site for recreational activities as well as providing for a steady flow of timber. Its traditional mission has been strictly the commercial component -- the recreational component was added only in 1985, under the rubric of "multiple-use sustainable-yield administration" (MUSYA). It builds roads into the forests, decides which acreage should be cut and how to cut it, and conducts timber sales. The USFS is part of the federal Department of Agriculture. Ozark National Forest, which borders Buffalo National River, was established by Congress in 1908.

- **The Natural Resources Conservation Service** (NRCS) provides information to agribusiness and landowners regarding land use and Best Management Practices (BMPs) in the Buffalo River watershed and in all agricultural regions. Its role is primarily advisory; it advises landowners without any enforcement or regulatory power. The NRCS has funds to provide assistance to institute BMPs where they deem appropriate. It has periodically conducted "soil surveys" of the region, where types of soils and land use are identified. It is currently conducting new surveys as part of a proposal for federal funding for water quality improvements. The NRCS is part of the federal Department of Agriculture.

- **The Arkansas Game and Fish Commission** (AG&FC) manages 24,000 acres in two wildlife areas along the Buffalo River, Gene Rush and Loafer's Glory Wildlife Management Areas. AG&FC sets hunting seasons and promulgates and enforces regulations regarding management of Arkansas' wildlife resources. Its mission includes "control, management, restoration, conservation, and regulation of bird, fish, game, and wildlife resources." The entire Buffalo River is designated as a wildlife management area under AG&FC legislation. AG&FC is funded by the state of Arkansas, and has been in the region since the State Legislature made the agency independent in 1944.

- **The Arkansas Department of Environmental Quality** (ADEQ) enforces Clean Water Act regulations regarding agricultural practices, soil runoff, and any activities which potentially cause pollution damage within the Buffalo River watershed and across the state. Its mission is to minimize pollution and its ecological impact, but they are sensitive to Arkansas' political and economic needs. Its role is primarily regulatory; which includes licensing livestock operations, monitoring fertilizer practices, and other related activities. The resource management staff at BUFF works closely with ADEQ in conjunction with the water quality monitoring program. ADEQ is funded by the state of Arkansas.

- **The Agricultural Extension Service** provides information to farmers and ranchers about agricultural practices. Like the NRCS, it is strictly an advisory agency, with no regulatory or enforcement power. Its mission is to assist agribusiness to improve their agricultural practices and business profitability. It is cognizant of good stewardship practices although environmental stewardship is not part of their mission. The Extension Service is associated with the State University System.

- **The County Chambers of Commerce** (COC) promote economic development in the county. There is a Chamber of Commerce in each relevant county, to advise business owners and investors about opportunities in the region. The Searcy COC is especially active in economic development. The Newton COC has a working group discussing the promotion of "ecotourism." The Chambers of Commerce are funded by local businesses.

- **Arkansas Soil and Water Conservation Commission (ASWCC) and County Conservation Districts** are designed to keep management of soil and water resources at a local level. There are 75 local Conservation Districts in the state of Arkansas, administered by the ASWCC. The ASWCC is responsible for state level planning and management of groundwater and surface water resources, including monitoring, implementation of BMPs, conservation enforcement, and education. The Commission coordinates grant programs for Conservation Districts, cost share programs for water and wastewater treatment plants, and administers a wetlands mitigation and restoration program. ASWCC also addresses water rights issues, dam safety, beaver control, and water compliance certification for projects involving flood control, water use and treatment, and water diversion.

Climate

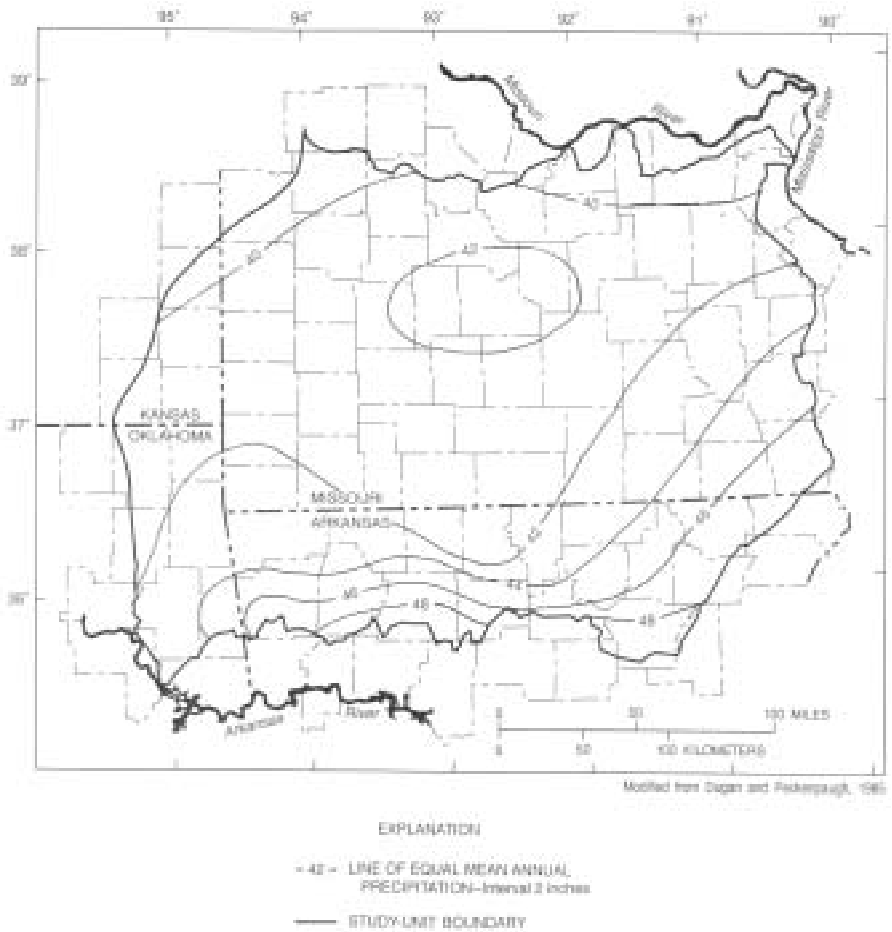
The climate of the Buffalo River basin is characterized by long, hot summers and relatively short, mild winters**.** Temperature records at Harrison run from -13 F to 107 F (NPS, 2003). Rainfall varies between 30 to 80 inches and averages 46 inches annually in Harrison, AR (NPS, 2003 and Figure 5). The greatest amounts of precipitation occur in winter and spring, usually around 4 to 5 inches per month. Average winter snowfall is 12 inches (NPS, 2003)**.** Dryer months in terms of precipitation are July through October, when monthly precipitation is around 3 inches, as shown in Table 2. In spite of the fairly uniform precipitation, runoff varies widely by season and dry river sections are common in late summer and fall, except in the lower reaches where it usually maintains floatable conditions year round. Both moderately intense local storms and storms with heavier rainfall can last several days. Larger storms are more likely to occur in spring; however, they can occur any time during the year (NRCS, 1995).

Relative humidity ranges from moderate to quite high; tornadoes often occur during spring and summer months. The growing season is 200 days annually, indicating that vegetative recovery from impacts of construction or overuse would be fairly rapid on good soils (NRCS, 1995).

Table 2. Average monthly precipitation in the Buffalo River area (inches)
Data from (NRCS, 1995)

January	4.4	**May**	5.0	**September**	3.0
February	4.1	**June**	4.0	**October**	3.2
March	4.7	**July**	3.0	**November**	4.2
April	4.8	**August**	2.9	**December**	4.2

Figure 5. Mean annual precipitation in the Ozark Plateaus **(Adamski et al., 1995)**

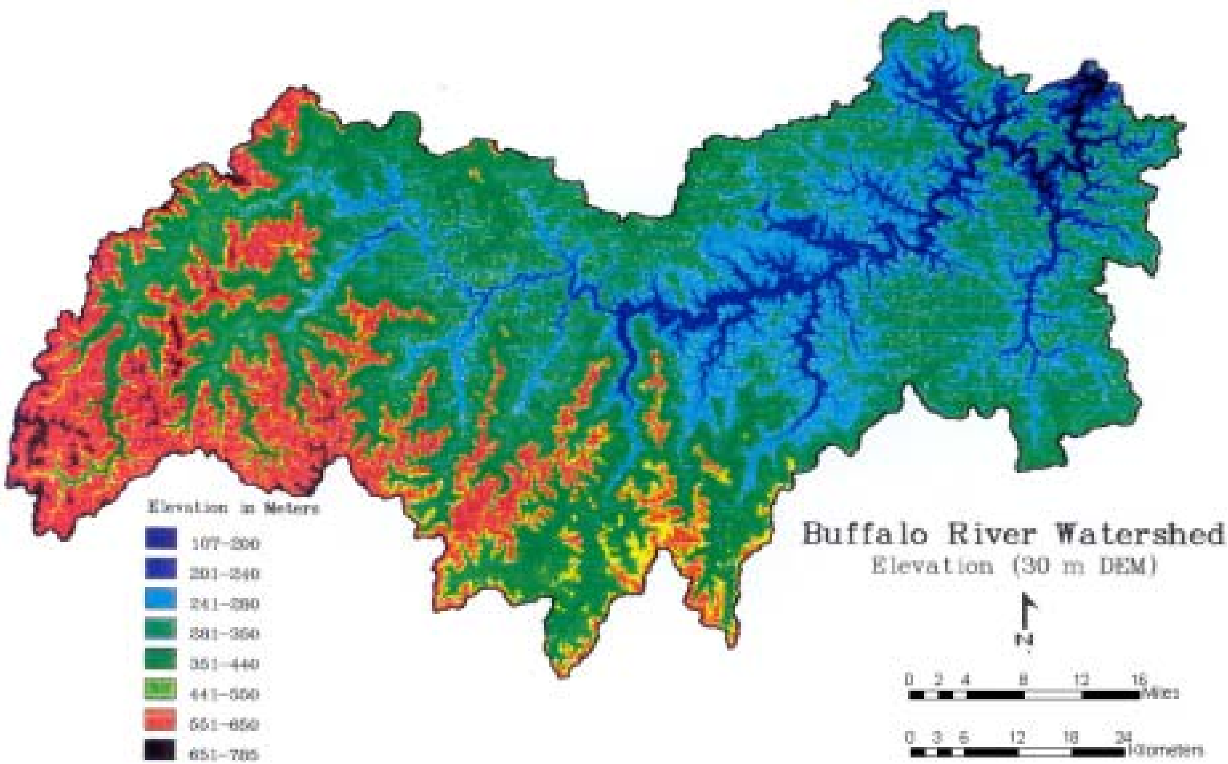


Physiography

The Buffalo River has cut deeply into the bedrock, leaving tall, vertical bluffs standing at river bends (Figure 6). In some areas the river is confined by bedrock; in others it meanders through alluvial bottoms. The channel is vertically stable as the bedrock is either exposed or covered with a thin layer of gravel and sand (Adamski et al., 1995). The river is characterized by quiet pools separated by short riffles. From Ponca to Pruitt the river falls an average of 13 feet per mile. From Pruitt to Highway 65 the average gradient is 5 feet per mile, and from there to the mouth it is about 3 feet per mile (NPS, 1977). The elevations within the Buffalo River watershed range from 2,576 feet above sea level in the Boston Mountains to 351 feet above sea level where the Buffalo River empties into the White River (Figure 7). The hills or ridge tops surrounding the river are usually narrow and winding, the sides alternate in steep slopes and vertical escarpments (Scott and Smith, 1994).

Figure 6. Outcrop of St. Joe limestone near Pruitt, Buffalo National River

Figure 7. Elevations in the Buffalo River watershed (Scott and Smith, 1994)



The watershed is characterized by three physiographic regions, the Springfield Plateau, the Boston Mountains, and the Salem Plateau (Adamski et al., 1995). The Springfield Plateau occupies about 47% of the Buffalo's watershed and is underlain by limestone and cherty limestone of Mississippian age. Land surface altitudes range from 1,000 to 1,700 ft but locally topographic relief rarely exceeds 200 to 300 ft (Adamski et al., 1995). Sinkholes and springs are common in this region. The Boston Mountains occupies 34% of the watershed. They are underlain by sandstone, shale, and limestone of late Mississippian to Pennsylvanian age. Land surface altitude ranges from 1,200 to more than 2,300 ft above sea level and topographic relief is as much as 1,000 ft in some places (Adamski et al., 1995). The topography is rugged with narrow divides separating steep-sided valleys. Finally, the Salem Plateau occupies 19% and is underlain by rocks of the Cambrian and Ordovician age although the Cambrian rocks are not surficially exposed with the watershed. The upland is characterized by gently rolling hills and local relief is 50 to 100 ft in the upland area (Adamski et al., 1995).

Geology

The rocks of Buffalo National River are entirely sedimentary, laid down in an ancient marine basin. Over its 300-million year history it was variously uplifted and eroded and then again submerged below the sea to receive more deposits. Deposition of the strata was discontinuous, and unconformities have been left in the sequence. Most of the rocks contain invertebrate fossils - trilobites, brachiopods, crinoids, cephalopods. Today the rocks are again uplifted and superimposed on them are high bluffs, waterfalls, springs and hundreds of solution pits and caves. Two features are especially noteworthy; one, the 200-foot waterfall in Hemmed-in-Hollow, which is the one of the highest in the entire region between the Appalachians and the Rocky Mountains; the other, the gypsum formations of Beauty Cave (NPS, 1977).

The basin is underlain by gently folded sandstone, shale, cherty dolomite, and limestone of Pennsylvanian to Ordovician age (Figure 8 and 9). Unlike most Ozark streams, the Buffalo River's watershed contains a substantial amount of sandstone and shale (Table 3). The Pennsylvanian sandstone and shales occupy a large part of the upland, particularly in the upper basin. Most of the river itself is underlain by the St. Peter sandstone and Everton Formations. The prevalence of sandstone and shale, as well as the relatively small amount of chert in the upper strata, substantially affects the size and availability of transportable sediment (McKenny, 1997).

Typical of the Ozarks region, approximately 64% of the basin is underlain by limestone and dolomite formations (Scott and Smith, 1994). The Boone formation, a karstic cherty limestone formation, occupies the largest part of the basin (31.8%) and underlies many tributaries and a substantial part of the mainstem of Buffalo River (Scott and Smith, 1994).

Figure 8. Surficial geology of the Buffalo River watershed **(Scott and Smith, 1994)**

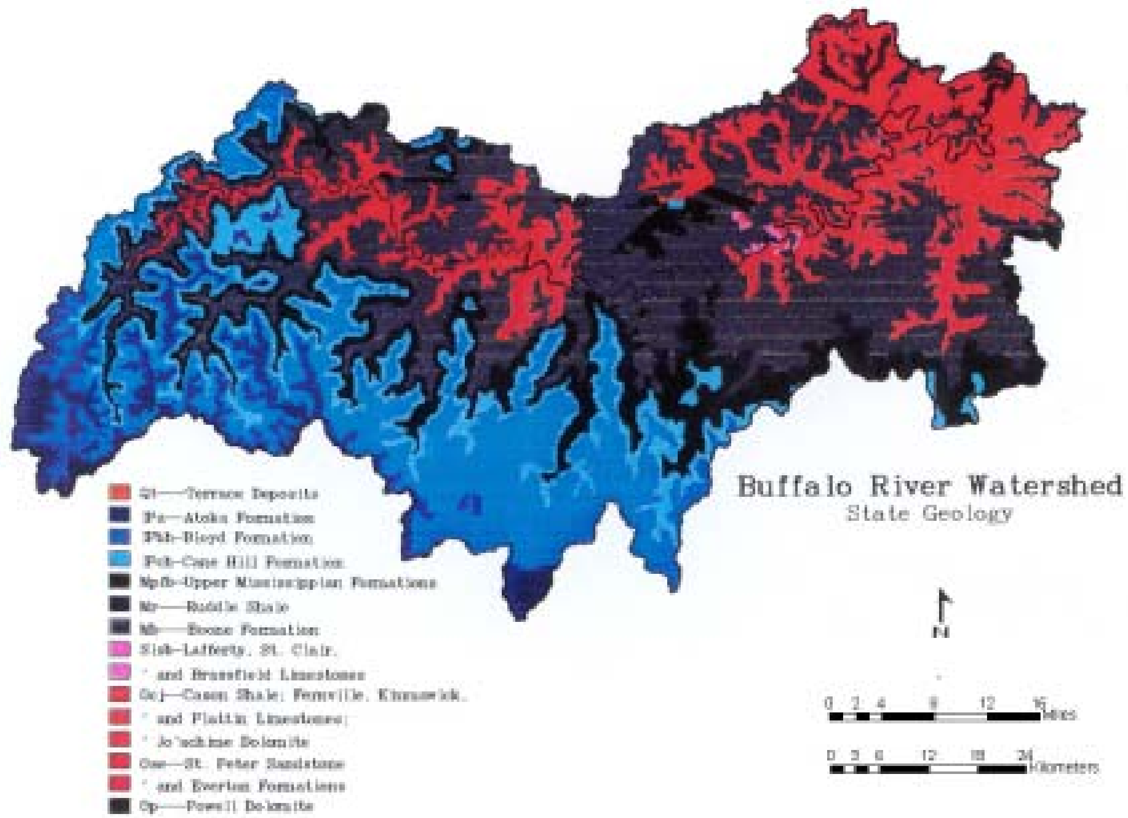
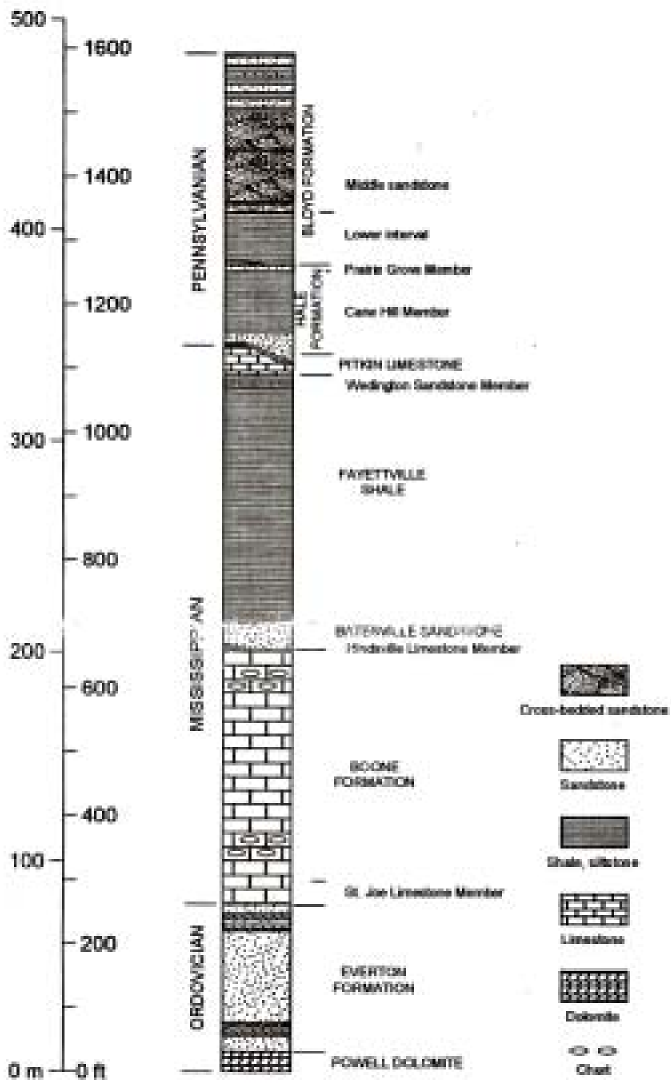


Table 3. Areal extent of surficial geology in the Buffalo River watershed
(Scott and Smith, 1994)

Formation	Acres	% of watershed
Terrace deposits	300	<0.01
Atoka Formation	52,009	6.1
Bloyd shale, Praire Grove member of the Hale Formation	160,170	18.7
Cane Hill member of the Hale Formation	80,886	9.4
Pitkin limestone	111,213	13.0
Ruddell shale	15,880	1.9
Boone Formation	272,910	31.8
Lafferty, St. Claire and Brassfield limestone	2,083	0.2
Cason shale, Fernvale, Kimmswick, and Plattin limestone, and Joachim dolomite	50,698	5.9
St. Peter sandstone and Everton Formation	105,519	12.3
Powell dolomite	5,939	0.7

Figure 9. Stratigraphic column for Paleozoic rocks of the upper Buffalo River
(Hudson, 1998)



Soils and Erosion

The two most extensive soils in the watershed are the Enders-Nella-Mountainburg-Steprock association, which occurs in the Boston Mountains, and the Clarksville-Nixa-Noark association, which occurs in the Springfield Plateau. Together, these two soil associations cover about 76 percent of the land area in the Buffalo River watershed. There are 64 dominant taxonomic soil units mapped and a total of 167 mapping units in the watershed. This shows that the area within the watershed is highly complex and variable with regard to soil characteristics (Scott and Smith, 1994). Most soils contain significant amounts of coarse fragments (predominantly chert) on the surface and in the profile (NRCS, 1995).

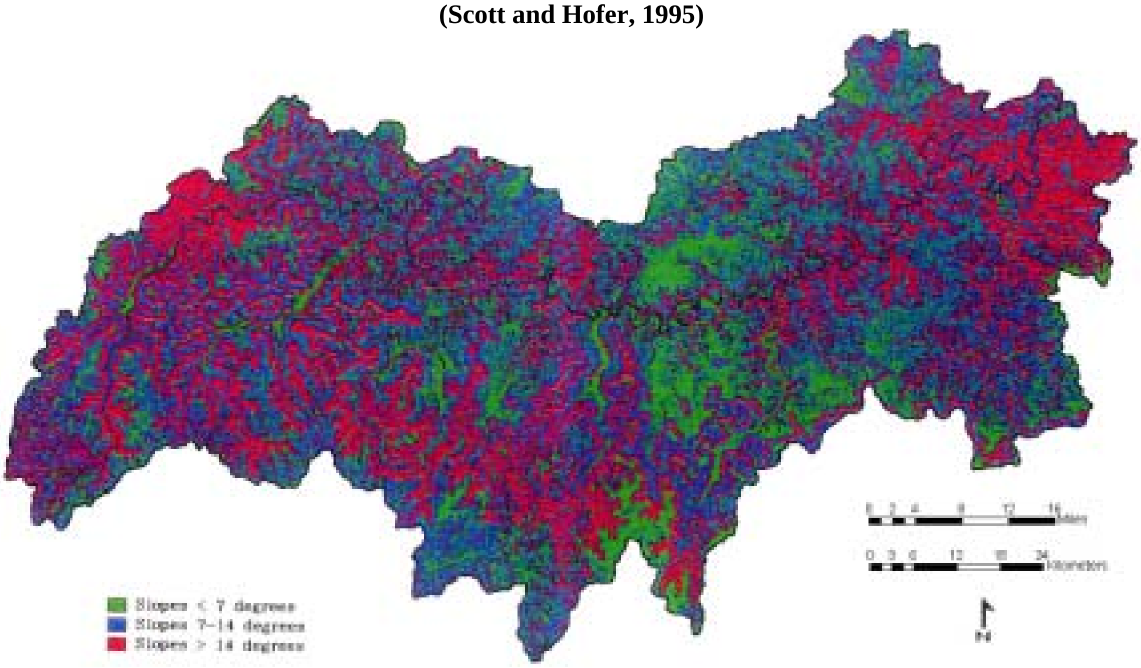
Land slope data show that steep slopes are found on a large portion of the watershed (Table 4). Land slopes range from one percent or less in valley bottoms and upland flats to 60 percent on the sides of mountains. The hazard potential for erosion is moderate to very severe, depending on land cover and slope. Soils in pastures on steeper slopes are difficult to manage, and the use of farm equipment is restricted. Slopes over 15 percent should not be cleared for pasture (NRCS, 1995). Over 45% of the watershed occurs in slope category 7 to 14 degrees and almost 30% is in a slope category of greater than 14, indicating the ruggedness of the terrain (Scott and Hofer, 1995).

Table 4. Slopes of the watershed **(Scott and Hofer, 1995)**

Slope category	Areal extent	Percent of total
Degrees	*Acres*	*%*
<7	225,069	26.24
7-14	393,376	45.87
>14	239,162	27.89

Unfortunately, over the 27-year period, the greatest loss of forest was in the two highest slope categories (Scott and Hofer, 1994). The acreage in pasture increased among all years in all slope categories during the 27-year period and the greatest increase in pasture was in the two highest slope categories where pastureland is not recommended. Figure 10 shows the distribution of the three slope categories throughout the watershed.

Figure 10. Spatial distribution of slope categories in the Buffalo River watershed
(Scott and Hofer, 1995)

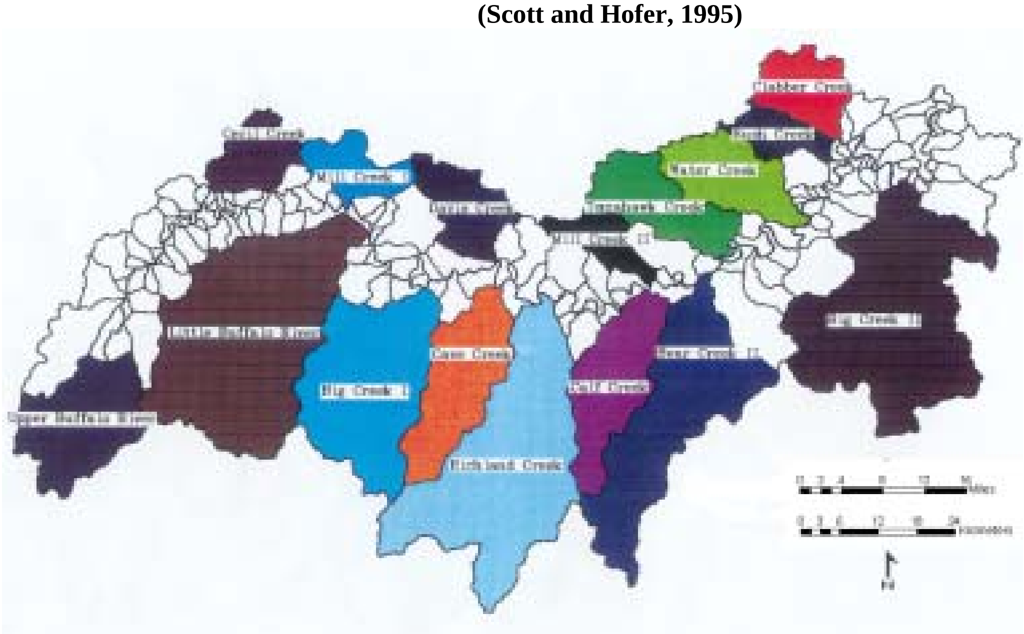


Water Resources

Surface Water

There are 91 sub-basins in the Buffalo River watershed. The largest sub-basin is the Little Buffalo River, which occupies 10.76% of the watershed. This is closely followed by the sub-basins Big Creek (II) (10.06%) and Richland Creek (9.8%) (Scott and Smith, 1994). Locations of the largest sub-basins in the watershed are shown in Figure 11.

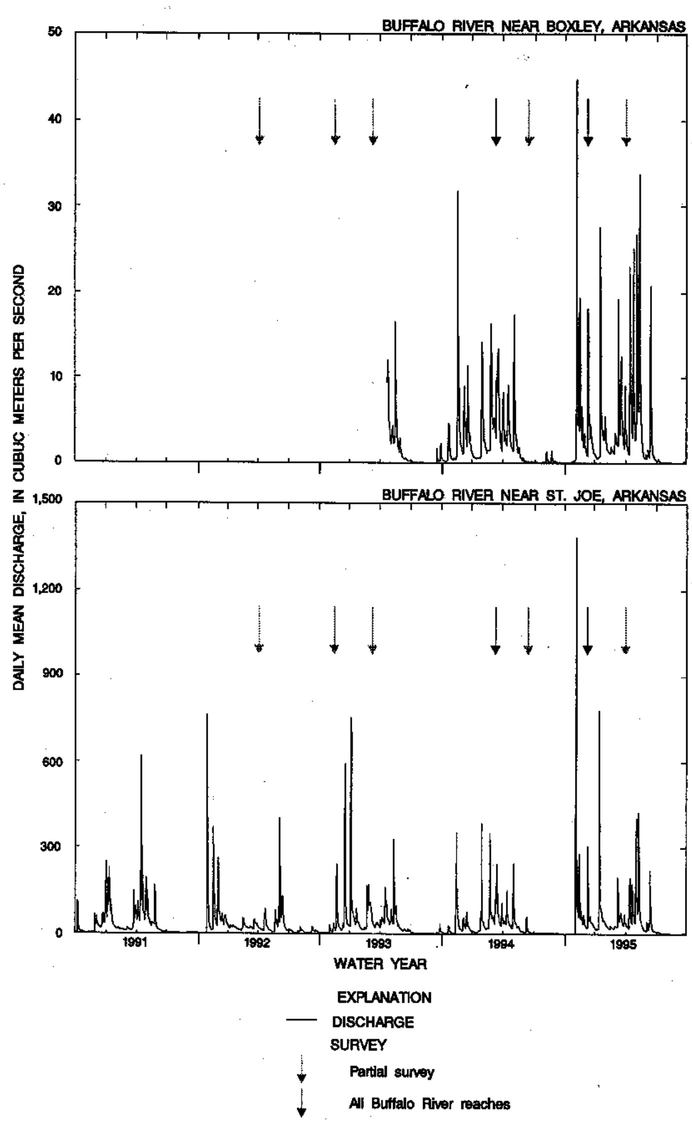
Figure 11. Location of the larger sub-basins in the Buffalo River watershed
(Scott and Hofer, 1995)



There is a network of discharge and staff gauges within the Buffalo River watershed. Discharge data have been collected since 1939 at the gauge near St. Joe on Hwy 65. A USGS gauging station at Highway 14 was recently added and discharge data was previously recorded at Rush. Discharge data are also being collected at a USGS National Water Quality Assessment (NAWQA) Program gauge on the upper Buffalo above Boxley Valley. There are USGS gauges in tributaries of the Buffalo River, measuring water level and discharge at Richland, Bear, and Calf creeks. Additional information is recorded by the flood warning system run by NPS personnel, which has staff gauges located at four locations along the Buffalo and 19 rain gauges located throughout the watershed. River levels are measured at Ponca, Pruitt, Highway 65, and Highway 14 access points.

Water levels in the Buffalo and its tributaries are considered “flashy”, with rapid rises and falls in the hydrograph on daily and monthly scales, as indicated in Figure 12. The Buffalo River basin contains fewer springs than most other Ozark streams, and during dry periods surface flow is discontinuous in some reaches. A dry reach is not uncommon in late summer just below Woolum. A record low-flow of 6 cfs was recorded in 1957 at the Highway 65 gauge. However, during heavy rains, the steeper slopes and shale bedrock result in faster-rising floods on the Buffalo River than in other Ozark streams.

Figure 12. Hydrographs of mean daily discharge from gauges at Boxley and St. Joe
(McKenney, 1997)



The highest discharge on record for the Buffalo River occurred on December 3, 1982. Rainfall of between 8 and 9 inches fell in the basin on December 2nd and 3rd, 1982 causing widespread flooding. The peak discharge at a gauging station near St. Joe, Arkansas was 158,000 ft^3/s on December 3rd. This discharge has a reoccurrence rate of about every 65 years. At Rush, the peak discharge reached the 100-year flood stage, at about 215,000 ft^3/s. According to the hydrographs, Steel Creek had its peak discharge about 12 hours after the water level began to rise. St. Joe's peak discharge occurred about 36 hours after the stage started increasing due to a larger drainage area (Neely, 1985).

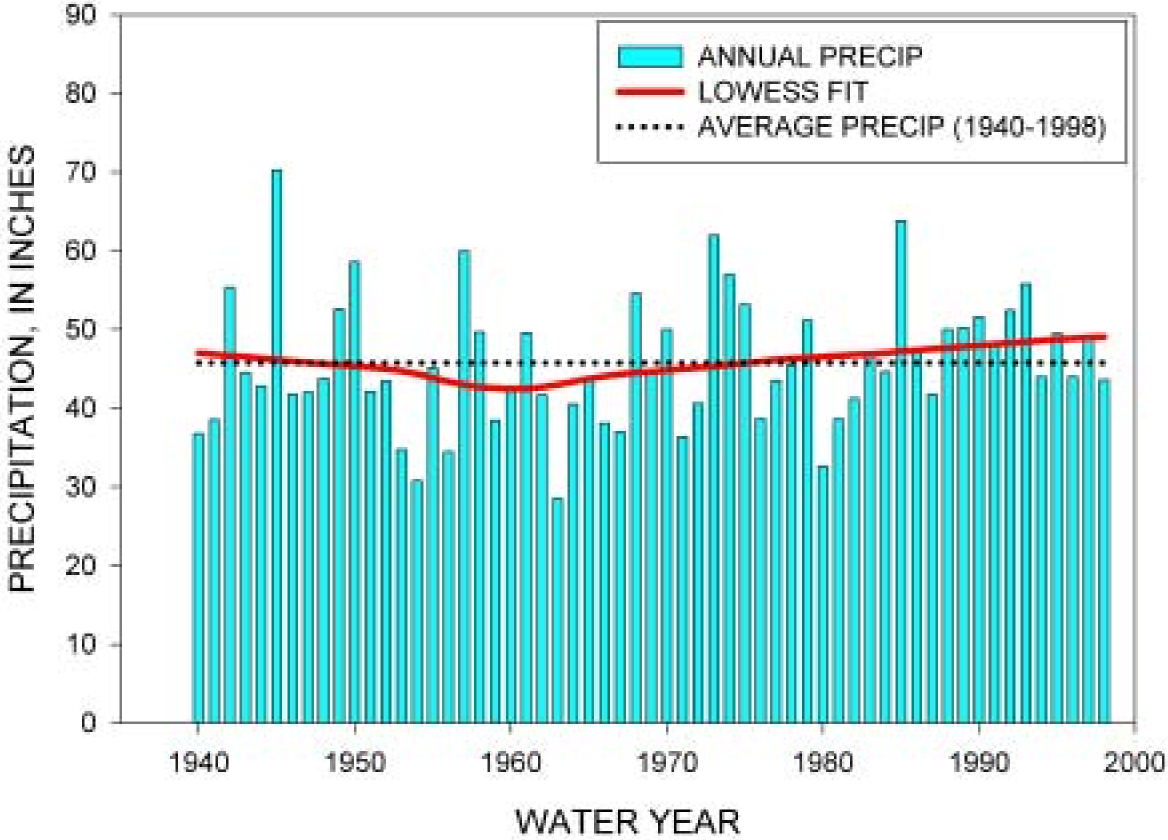
Because spring flows are limited (yet make-up most of the baseflow during the dry summer months) the contribution of large tributaries like the Little Buffalo, Richland, Big Creek, and Bear Creek are important to water levels in the Buffalo River. A recent study on Bear Creek documented this importance. Bear Creek is one of the larger tributaries on the Buffalo and it can have a substantial effect on stream flow and water quality. Bear Creek originates southeast of Witts Springs, Arkansas and flows north, emptying into the Buffalo just north of Marshall, Arkansas. Below its confluence with the Buffalo River, the Bear Creek basin makes up 9.8% of the river's drainage area. On an annual basis, stream flow for the Buffalo is much greater than for Bear Creek (Petersen et al., 2002). During 1999 and 2000 the mean annual flows for Bear Creek were about 7 and 9 percent of the mean annual stream flow for the Buffalo. However, during periods of low flow in late summer and early fall, Bear Creek comprises a much larger percentage of the total flow in the Buffalo River. On 25 percent of the days in August through October of both 1999 and 2000 (the three months with the lowest flows) Bear Creek flow comprised a minimum of 18 percent of the same-day flow of the Buffalo River near St. Joe (Petersen et al., 2002). In September of 2000, for 23 consecutive days the flow of Bear Creek was at least 25 percent of the flow at the Buffalo River site (Petersen et al., 2002).

Flow Analysis

An important aspect to understanding how the surrounding changes in land use and population in the Buffalo's watershed may be impacting the river is the assessment of long-term changes in flow pattern. Changes in water level or flow could have serious consequences to the hydrologic characteristics of the river channel along with impacts on the biological communities, particularly those dependent on consistent stream flow. Shane Barks from the Arkansas District of the U.S. Geological Survey conducted a flow analysis of the Buffalo River near St. Joe, Arkansas. This analysis used data from USGS stream gage station number 07056000, located on the downstream side of the US Highway 65 Bridge, at river mile 58.2. The gauge is located 1.2 miles downstream from the confluence with Mill Creek, 4.0 miles upstream from the confluence with Bear Creek, and 4.5 miles southeast of St. Joe, Arkansas. At this location the Buffalo River drains 829 square miles of primarily forested and agricultural land. The USGS stream gage at this site has been in operation since October 1939. The flow analysis assessed daily mean discharge for the water years (Oct. 01 to Sep. 30) 1940 to 1998 to determine if any changes in flow patterns occurred at this site.

The precipitation data used in the analysis were obtained from the U.S. Historical Climatology Network, Arkansas, Division 01 and Division 02, reported by the U.S. Department of Commerce, NOAA. The annual precipitation ranged from a low value of 28.53 inches in 1963 to a high value of 70.26 inches in 1945. The average annual precipitation is 45.75 inches, precipitation data is shown in Figure 13.

Figure 13. Average annual precipitation for Arkansas (Climate Division 01 and 02, 1940 to 1998)



Changes in flow over time were analyzed using mass curves and double mass curves. Mass curves plot accumulated discharge against time and double mass curves plot accumulated precipitation in the basin against accumulated discharge. Figure 14 shows the mass curve and Figure 15 shows the double mass curve. Neither figure showed significant change in the discharge pattern for water years 1940 to 1998.

Figure 14. Mass curve of daily mean discharge at Buffalo River near St. Joe, Arkansas

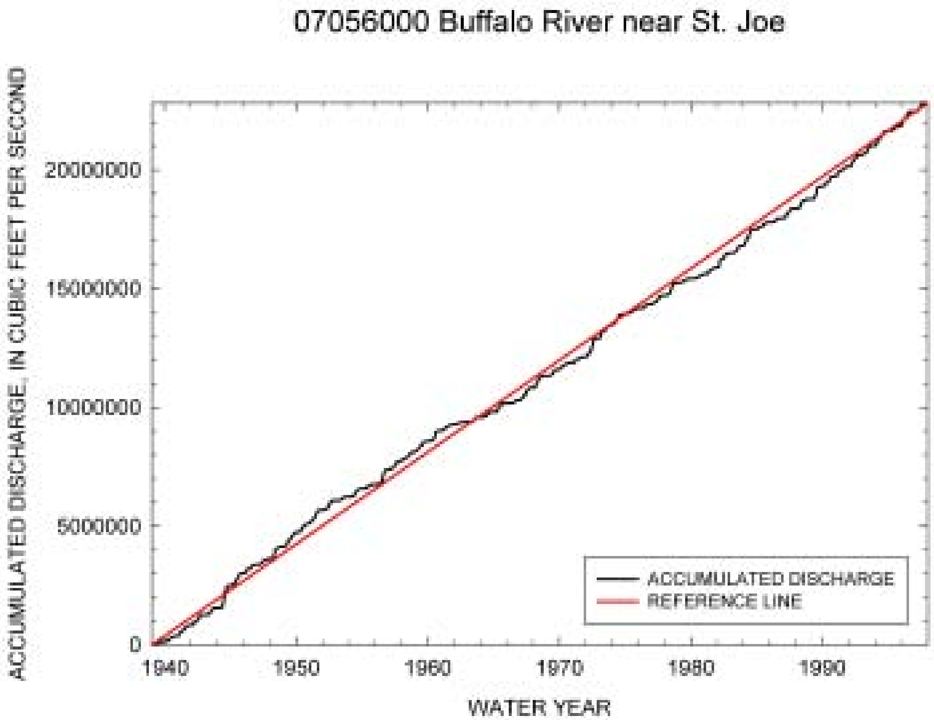
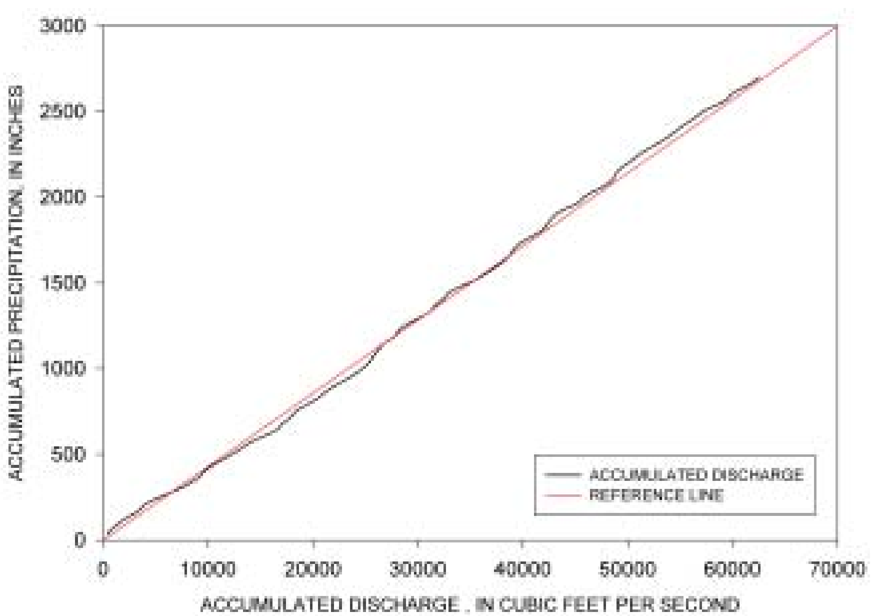
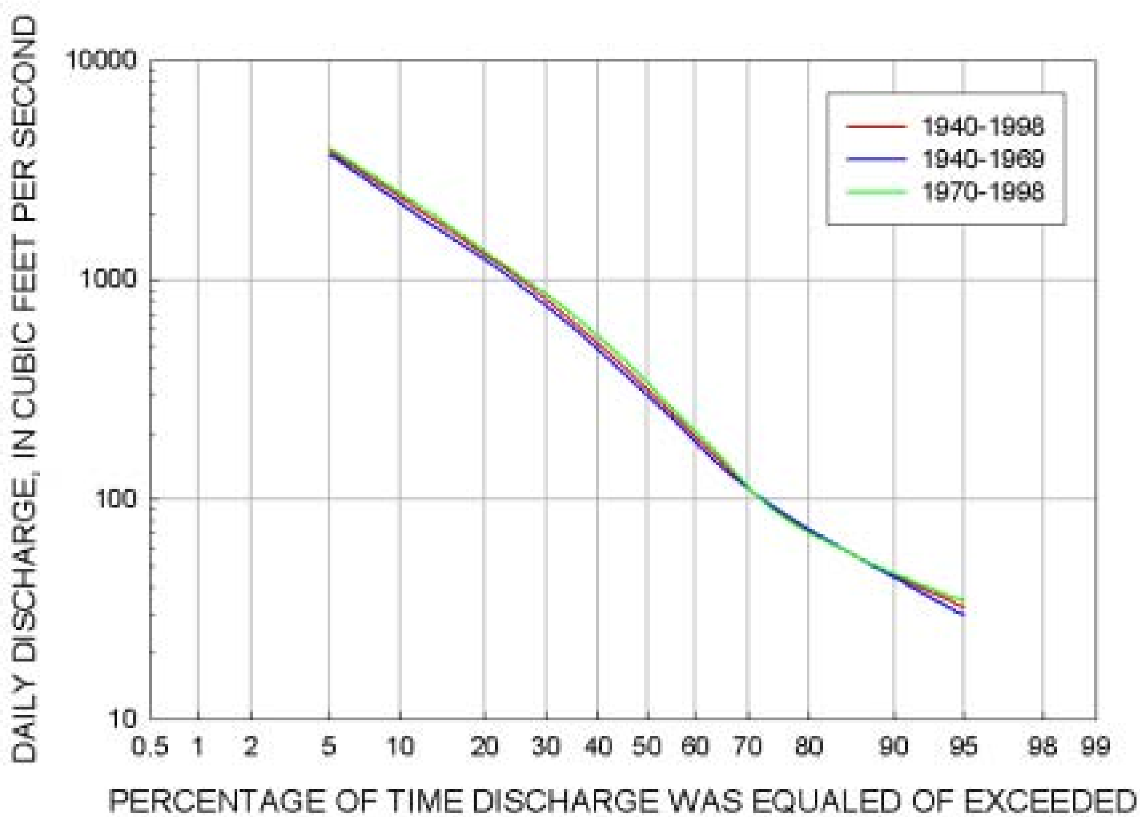


Figure 15. Double mass curve of precipitation and discharge at Buffalo River near St. Joe, Arkansas, water years 1940 to 1998.



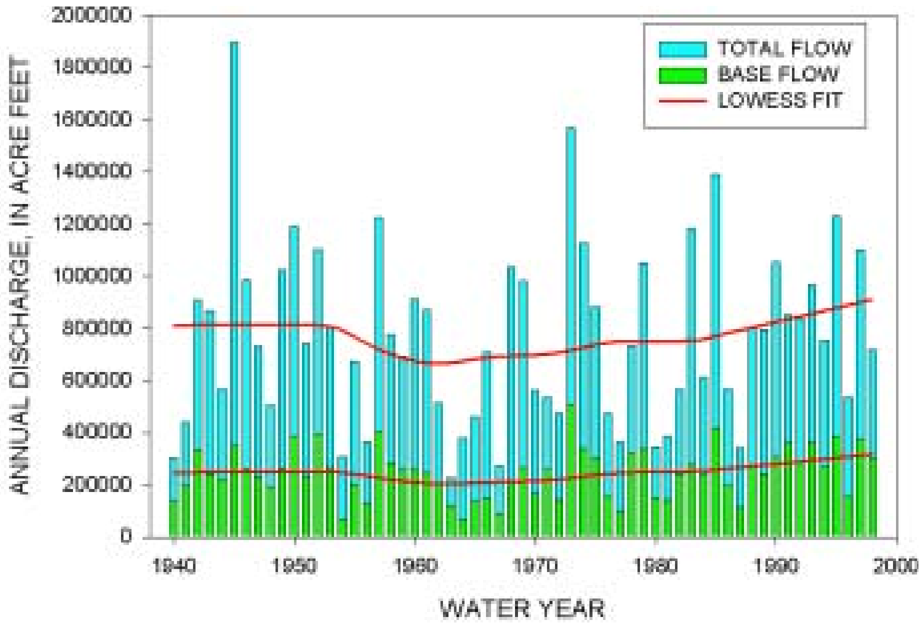
The previous graph indicated to no change in the discharge pattern over the 58 year time period. A lack of change is also evident in flow duration over three different time periods (1940-1969, 1970-1998, and 1940-1998). Figure 16 shows the flow duration curves for each of the time periods. These curves demonstrate little variability in the flow duration between the different time periods.

Figure 16. Flow duration curves for the Buffalo River near St. Joe, Arkansas.



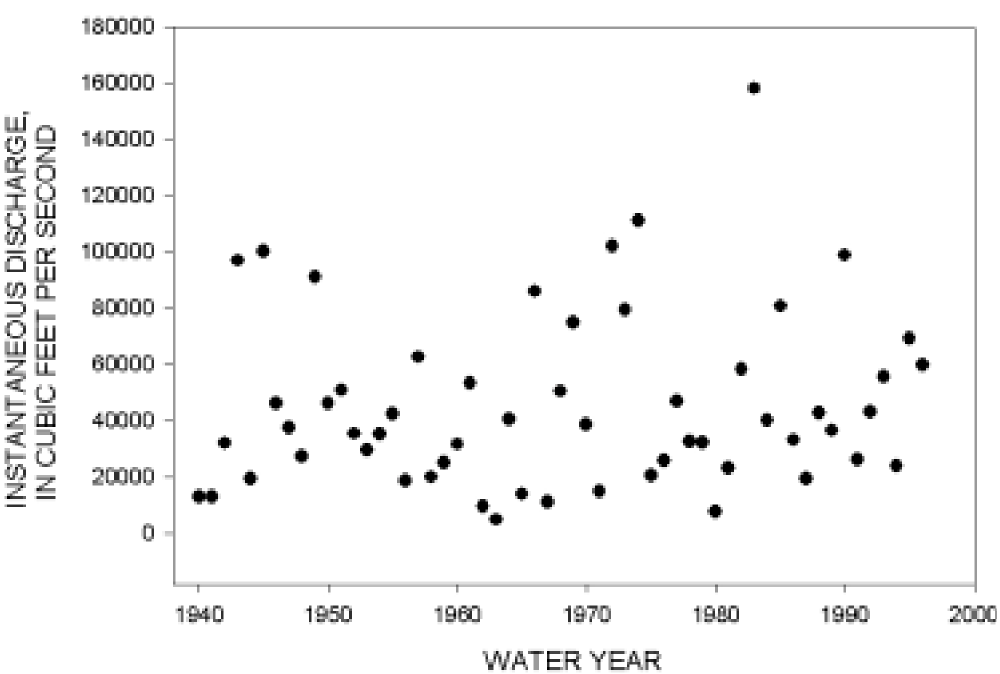
A hydrograph separation method was used on the daily mean discharge values to separate the base flow from the total flow. Bar graphs of the annual total and base flow volumes are displayed in Figure 17. The annual runoff values can be determined by subtracting the base flow from total flow. Lowess lines are plotted on the total and base flow plots. It appears that there is a slight increasing trend in flow beginning around 1961. This coincides with the slight increasing trend in precipitation for the same period shown on Figure 13.

Figure 17. Annual flow volume for the Buffalo River near St. Joe Arkansas.



Finally, the annual peak instantaneous discharges were analyzed from 1940 to 1998. They range from 4,820 cubic feet per second (cfs) in March, 1963 to 158,000 cfs in December, 1982. There appears to be no trend in the peak discharges (Figure 19).

Figure 18. Annual peak instantaneous discharges for Buffalo River near St. Joe, Arkansas.

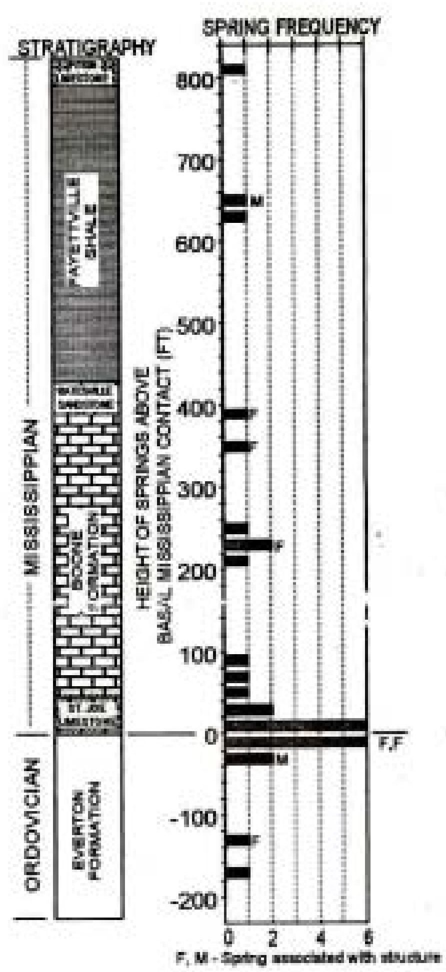


Groundwater

There are two types of groundwater recharge in the Buffalo River area, diffuse recharge and discrete recharge. Diffuse recharge is a slow percolation of water through the soil layers. Diffuse recharge can allow pollutants to be filtered out of the water before it reaches the aquifer. Discrete recharge is a concentrated, rapid movement of water to the subsurface drainage network, most common in areas dominated by karst, which is typical in the Ozarks. Sinkholes and losing streams are examples of discrete recharge. Most sinkholes and losing streams (where a portion of the reach goes dry) are found to be underlain by the Boone formation in northwest Arkansas and most springs emerge in the Boone, as shown in Figure 19 (Aley, 1999). Groundwater pollution is most common in limestone and dolomite areas such as the Boone formation because discrete recharge does not allow for the effective filtration and absorption of pollutants. Faster travel rates provide less time for bacterial and viral die off as well. This is important for water quality management of the Buffalo River since almost 32% of the watershed is underlain by the Boone formation (Aley, 1982).

Figure 19. Histogram of spring frequency versus stratigraphic height above the basal contact of the Boone Formation with the Buffalo River area. (Hudson, 1998)

F and M represent springs spatially associated with faults and monoclines, respectively.



A study involving inter-basin transfer was conducted in response to a potential landfill just outside the Buffalo River's topographic boundary. This study delineated the recharge area for Mitch Hill Spring, the parks largest spring. The recharge area is 20.8 mi^2 and is located northeast of the spring. It includes four topographic stream basins (Clear Creek, Mill Creek, Mill Branch, and Cane Branch). Most of the runoff from the area enters the groundwater as discrete recharge and then discharges from the springs into the river. Groundwater tracing found that approximately 65 percent of the recharge area for this spring lies beyond the perimeter of the surface watershed boundary (Aley and Aley, 1989). Detailed geologic mapping revealed previously undetected faults which provided a continuous pathway for the interbasin transfer of groundwater along these solutionally enlarged lineaments (Aley and Aley, 1989). The proposed landfill within this recharge area was permitted by the state. The permit was rescinded when a judge ruled that the State had been negligent in its assessment of the potential groundwater impacts in this highly karstic groundwater area. This study demonstrates how important delineating recharge areas and obtaining more information on the complex karst system are to protecting the pristine water quality of the Buffalo River. Most of the land use practices that pollute the groundwater system are nonpoint sources within the recharge areas of springs like Mitch Hill (Aley, 1999).

Poultry production has been increasing by 33 million birds per year in Arkansas (Daniel et. al, 1991). Because a large volume of poultry wastes is land applied, concern exists regarding the effect of this on both groundwater and surface water quality. Unconfined aquifers of limestone and dolomite make groundwater very susceptible. Nitrate levels in the groundwater increase in areas of application; however, they have remained below EPA standards for drinking water. During storm events some sites can temporarily go above the 10mg/L standard (Daniel et. al, 1991). A study by Daniel et al. (1991), compared nitrate and bacteria concentrations in groundwater between areas with large amounts of cattle/poultry production to areas mainly forested. Thin soils, fractures, and solutionally enlarged openings in the Boone-St. Joe and Everton limestone aquifers make them susceptible to contamination. There is concern about the quality of groundwater in the region because the area is dependent on these limestone aquifers for domestic water supplies but large amounts of poultry waste is surface applied to pastures as fertilizer. The study found that cattle/poultry areas had significantly higher nitrate concentrations. The study also found that the deeper Everton aquifer showed significantly lower nitrate concentrations than the Boone aquifer; similar results were observed for fecal coliform levels (Daniel et al., 1991).

Another study compared wells in the Everton and Boone formations and also compared control wells in mostly forested areas to experimental wells in pasture areas. Nitrate levels were significantly higher for wells in pasture dominated areas compared to control wells (Steele et. al, 1990). Also, during rain events, springs in pasture dominated areas showed minor increases in nitrate concentrations but large increases in fecal coliform colonies. Nitrate concentrations were about 50% lower for the Everton formation than the Boone-St. Joe aquifer, indicating that the Everton aquifer is less susceptible to contamination (Steele et. al, 1990). The difference in water quality between the two is due to a layer of impermeable Chattanooga shale that separates them (Steele et. al, 1990).

It is presently unknown if the nutrient concentrations in runoff from areas receiving poultry waste are excessive. Since impacts from pollution can occur some distance downstream from the actual application point, further research is required to link the pollution application upstream to the impacts downstream(Daniel et. al, 1991).

Pesticides have also been detected in groundwater samples throughout the Ozarks Plateau region, including areas in and around the Buffalo River watershed. Well and spring samples were taken as part of the National Ambient Water Quality Assessment program (NAWQA) for the Ozarks Plateaus region from April through September of 1993. Pesticides were present in 29 (20 springs, 9 wells) of 100 samples taken. Fourteen different pesticides were detected, with a maximum number of four detected in one sample (Adamski, 1996). Atrazine, prometon, tebuthiuron, and P,P' DDE were the most commonly detected pesticides. P,P'DDE is a metabolite of DDT, which was banned by the EPA in 1973. This indicates how chemically stable DDT is in the environment. Because there is limited row crop agriculture in the Ozarks Plateau, the presence of pesticides is somewhat surprising. It probably is due to the thin soils and fractured carbonate rocks, allowing rapid movement of waters from the surface to the aquifer. Concentrations were near detection limit, probably a result low pesticide usage throughout most of the study area. The occurrence of pesticides appears to be related to land use, with more samples containing pesticides collected in the Springfield Plateau, the most developed and heavily farmed sampling area (Adamski, 1996).

Other problems with groundwater contamination include septic systems, dairy operations, and confined animal operations. In the Fitton Cave area, most people are served by on-site sewage systems, most of which are septic systems. Previous work in the Boone Formation has shown that 60% of onsite systems yield some contaminants to groundwater and 15% are major sources of pollutants (Aley, 1999). The amount of contamination is not a factor of lot size but is related to the characteristics of the site selected for the system. Septic systems in soils derived from very cherty rock units are five times more likely to contaminate the groundwater than systems in soils with very little chert. Density of septic systems appears to be a minor factor in determining the risk of groundwater pollution (Aley, 1999).

Dairy operations are also likely to be significant sources of nitrates and fecal material to groundwater (Aley, 1999). The karst geology of the region makes waste lagoons undesirable because of leakage into the groundwater. Spray irrigation is better but it will run off during periods of rain or in areas of sparse vegetation. The low price of milk makes it difficult for farmers to operate and maintain waste disposal facilities. Currently in the Ozarks, the number of dairies is decreasing but their size is increasing. This is not a positive trend since the Buffalo River area is not conducive to the development of large dairies due to water supply and waste disposal issues.

Confined animal operations are expanding in Northern Arkansas. There are some broiler houses in the Buffalo River area but the density is much less than areas farther west in the state. Most of the waste produced is disposed of by land application, contributing to nitrogen and phosphate inputs into the groundwater.

The Crooked Creek topographic basin is a potential development site for increased land application of confined feeding operation wastes (CFOs). Crooked Creek is not within the topographic watershed of the Buffalo but research has found that land use activities in the Crooked Creek basin are affecting the water quality of the Buffalo River. Any future development of CFOs or increased land application of poultry waste is a concern. Mott et al. (2000) found that water rich in nitrates and phosphates is being transferred from Crooked Creek to the Buffalo through Mill Creek. Mill Creek, a tributary of the Buffalo, has a small drainage that is mostly forested yet a major spring system within the drainage (Dogpatch Springs) showed nitrate and phosphate levels comparable to that of springs in the Crooked Creek drainage. Aley (2000) delineated the recharge areas for Crooked Creek and Mill Creek springs, including upper and lower Dogpatch Springs, and found that groundwater from Crooked Creek drainage is reaching springs in the Buffalo River drainage. While Upper and Lower Dogpatch Springs are located within the Mill Creek topographic basin, 71% of the recharge are for Upper Dogpatch Spring is in the Crooked Creek topographic basin and 80% of Lower Dogpatch Spring's recharge area is in the Crooked Creek topographic basin (Aley, 2000). Water quality measurements determined that Mill Creek contributes as much as 96 percent of the nitrate load in the Buffalo River below their confluence due to the influence of Crooked Creek. Base flow discharge to topographic drainage basin area ratio were calculated for Crooked Creek and Mill Creek, with results indicating that transport of groundwater was occurring from Crooked to Mill Creek was further supported by dye tracing work in the two basins.

In terms of a drinking water source for northern Arkansas, southern Missouri, northeastern Oklahoma, and southeastern Kansas, the Ozark aquifer is the largest and most important aquifer in the region. Water usage from the aquifer is increasing and protection of the groundwater is important not only for maintaining the water quality of the Buffalo but also for more general protection of a major drinking water source in the Ozarks. Potentiometric-surface maps generated from data collected in 2001 were compared to pre-development maps and there was general agreement between the two surfaces. Differences could be attributed to differences in pumping related to changing population from 1990 to 2000 (Schrader, 2001). Water used in the aquifer was estimated to be 35.8 million gallons per day in 1995, 33.3 Mgal/d in 1990, and 32.3 Mgal/d in 1985. Water use has increased about 11 percent from 1985 to 1995 (Schrader, 2001).

Boxley Valley Historical District

Boxley Valley is an area on the Upper Buffalo of special designation for cultural and archeological preservation that remains in private use, mainly agriculture. Boxley Valley is 2.2% (6.1 km^2) of the watershed of the Buffalo River. The sandy and silty loam soils that are present in the valley are characterized by high hydraulic conductivity. The greatest number of cattle grazing in the valley, around 800, are present during the winter. In the spring and summer cattle are moved so that hay and fescue can be harvested, decreasing the herd to about 400 (Mott and Steele, 1991).

A study by Weeks (1987) determined that water quality of the Buffalo and its tributaries in Boxley Valley is affected by the agricultural activities in the area. A major contribution to decreased water quality was the livestock in fields adjacent to the river. The majority of the livestock were located between Moore and Clark creeks during the summer months and these higher livestock numbers correlated with increases in bacteria and nutrient values (Weeks, 1987). Moore Creek and Mill/Whiteley Creek were shown to have the greatest pollution impact on the river corridor. Nutrient values increased in the Buffalo River below the confluence of Mill/Whiteley Creek.

Weeks (1987) conducted a study to evaluate bacteria standards set by the Arkansas Department of Pollution Control and Ecology (ADPCE, currently ADEQ) for waters of extraordinary recreational and aesthetic value and outstanding national resource waters, standards the Buffalo River falls under. The standard for fecal coliform states that fecal counts shall not exceed a geometric mean of 200 colonies per 100 ml based on a minimum of five samples taken over a period not exceeding 30 days (ADEQ, 1995). None of the river corridor sites in Boxley Valley had fecal coliform levels exceeding the geometric mean of 200/100ml. However, 27% of the River corridor stations did have geometric means greater than 100/100ml with a maximum geometric mean of 169/100ml. And, 71% of the tributaries and springs sampled in Boxley valley had fecal coliform levels that exceeded the 200/100ml standard (Weeks, 1987). This indicates a potential for the Buffalo River to exceed ADEQ standards, particularly during and immediately after precipitation and runoff events when visitors are attracted to canoe the river's high flows.

Human fecal coliform may be contributing to high bacteria levels and Weeks (1987) recommends testing for fecal streptococcus, which is used to determine if the bacteria source is human, or cattle**.** He also recommended that nutrient data and bacteria data should be collected during storm events to determine the extent of any elevated concentrations that occur during runoff events. Neither of these recommendations have been implemented but they could provide valuable information.

Mott and Steele (1991) analyzed fecal coliform samples from above and below Boxley Valley after rain events. Higher fecal coliform concentrations were found at sites downstream of Boxley as compared to upstream. The maximum fecal count after a precipitation event was 1500col/100ml at the downstream site. Maximum fecal counts were 500col/100ml for upstream sites. Maximum counts occurred during the winter when vegetation was sparse and the maximum number of cattle were present. The fecal coliform concentrations draining the fields of Boxley were more than 50 times the background concentrations at the upstream site during large precipitation and runoff events (Mott and Steele, 1991). The positive relationship between discharge and fecal coliform suggests that extremely large total transport occurs during a storm. More than 150 days of low flow transport would be required to produce the same amount of fecal coliform that was produced during the largest rain event (Mott and Steele, 1991).

Ten years of water quality monitoring (1985-1995) found that the geometric mean fecal coliform concentration is 3.25 times higher at Ponca (13 col/100ml) than the mean of all other sites sampled on the river (4 col/100ml) (Mott, 1997). This again indicates the impact of direct access by cattle to the tributaries and the river. The higher bacteria concentrations at Ponca, while greater than background concentrations, do not represent a significant health threat during base flow conditions. The state standard for primary contact is 200 col/100ml for a geometric mean of five samples collected over a 30 day period. This standard is based on human waste as the source of the bacteria. The chance of contracting an infectious disease from water born pathogens originating from a human source is much greater than the chance of contacting a disease from an animal source (Mott, 1997). Therefore, geometric mean concentrations of 13 colonies per 100ml at Ponca during base flow conditions likely represents a small increase in the possibility of disease transmission.

In response to these trends of higher and increasing concentrations of fecal bacteria at Ponca, NPS has been actively working with land owners in Boxley Valley to exclude cattle from the Buffalo River within this private use zone of the park. In 1998, an extensive fence building and alternative water source (stock tanks) project was completed, excluding cattle from direct access to the river. Monitoring of water quality and fence stability should continue, particularly since this area is prone to flash flooding.

The Buffalo River is under special protection designated by ADEQ as an Outstanding National Resource Water (ONRW), with extraordinary recreation and aesthetic values, the highest ranking of stream quality by the State (ADPCE, 1988). ADEQ applies specific standards to the Buffalo, under the ONRW designation, which exceed those standards applied to undesignated waters. These steps were necessary to comply with the Extraordinary Resource Waters designation which requires no degradation of existing water quality. The cooperation shown by the Boxley Valley landowners in this project should be commended and it is the hope of Buffalo National River to develop cooperative relationships of a similar nature in other areas of the watershed.

Water Quality

The water quality monitoring program at Buffalo National River is designed for the Buffalo River and its major tributaries to determine compliance with state standards, including the ONRW designation. The program also defines the present water quality of the surface and groundwaters at Buffalo National River, thereby establishing a baseline against which future changes can be compared. This section is intended to provide background information and present water quality conditions in a statistically appropriate manner. This information is critical to park managers making decisions about future demands placed on the Buffalo River and the waters within its drainage basin. As the Buffalo River's watershed becomes increasingly populated and developed, background water quality data will be crucial in understanding the effects of changing land use on the National River's water resources. The goal of the water quality monitoring program is the protection of visitors and the preservation of the Buffalo River's aquatic resources.

A comprehensive analysis of the water quality data collected between January 1991 and December 1998 will be presented. Data have been collected since 1985, but the sampling schedule did not become consistent until 1991. From 1985 to 1990, sampling included all river corridor sites on a monthly basis and tributary and spring sites twice each month from May until September. During the first 5 years of the water quality monitoring program, river corridor samples were analyzed for metals and nutrients once each season. From 1991 to 1995, samples were taken from both river and tributary sites every other month and, beginning in 1996, samples are taken seasonally. Sample locations and names are shown in Table 5 and Figure 21.

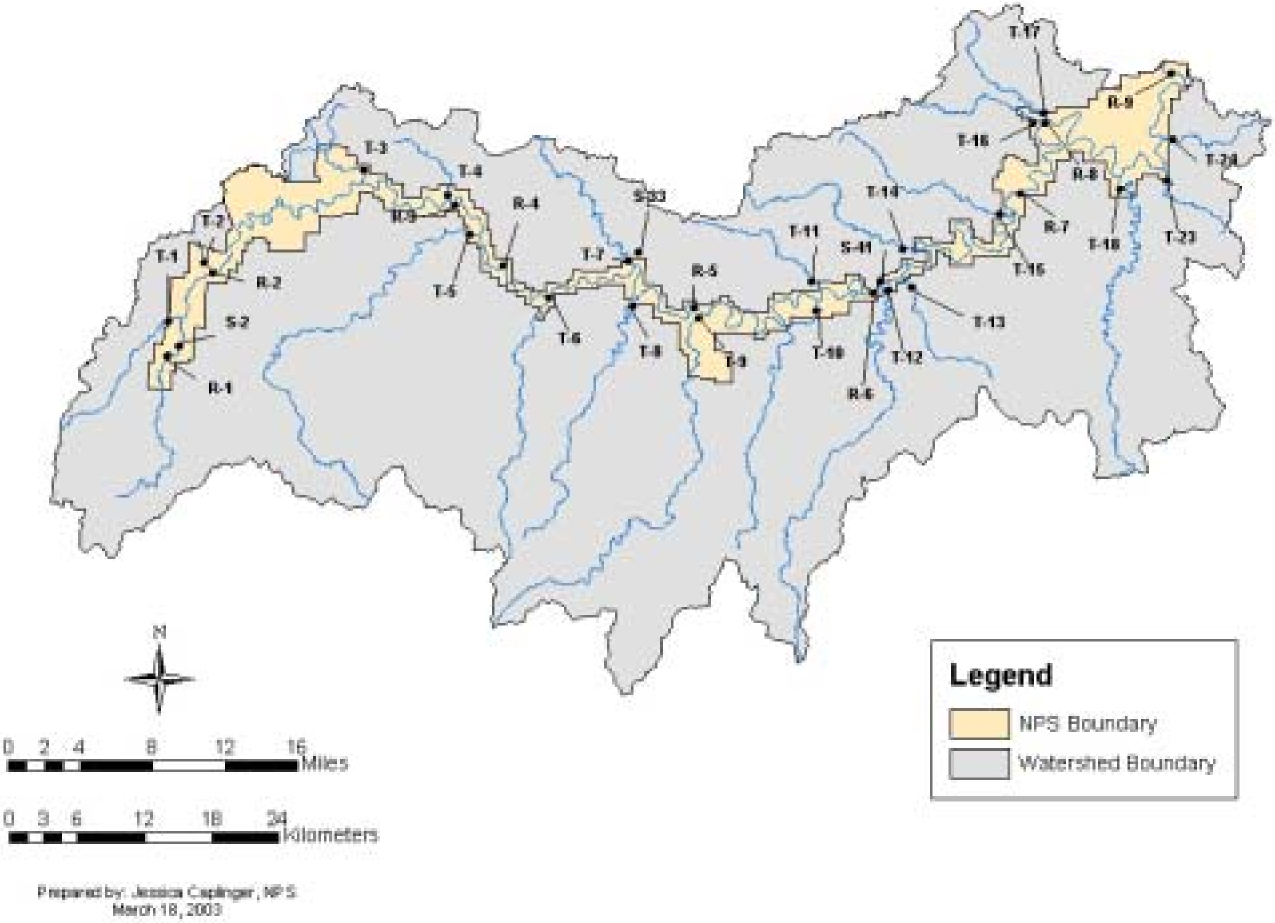
Table 5. Site names and numbers for water quality monitoring sites.

Springs	
S2	Luallen Spring
S33	Mitch Hill Spring
S41	Gilbert Spring

River Sites	
R1	Wilderness Boundary
R2	Ponca
R3	Pruitt
R4	Hasty
R5	Woolum
R6	Gilbert
R7	Hwy 14
R8	Rush
R9	Mouth

Tributaries	
T1	Beech Creek
T2	Ponca Creek
T3	Cecil Creek
T4	Mill Creek
T5	Little Buffalo River
T6	Big Creek/M
T7	Davis Creek
T8	Cave Creek
T9	Richland Creek
T10	Calf Creek
T11	Mill Creek/M
T12	Bear Creek
T13	Brush Creek
T14	Tomahawk Creek
T15	Water Creek
T16	Rush Creek
T17	Clabber Creek
T18	Big Creek/L
T23	Middle Creek
T24	Leatherwood Creek

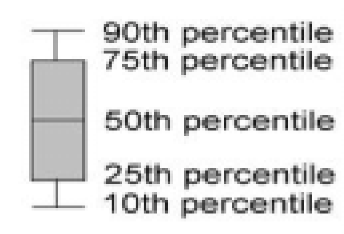
Figure 20. Water quality sites for Buffalo National River's water quality monitoring program



Data collected from river corridor, tributary, and spring sites between January 1991 and December 1998 were analyzed using site comparison methodologies. Statistical analysis was performed by Jim Petersen with the Arkansas District of the U.S. Geological Survey. Trends over time for a given site were analyzed with data from 1984 to 2001. The actual range of dates varies with each parameter depending of the temporal distribution of data. Site comparisons were performed using box plots, Kruskal-Wallis one-way analysis of variance of ranks, and Dunn's multiple comparison test routines in the statistical packages SigmaStat (SPSS Inc., 1997) and SigmaPlot (Jandel Corporation, 1995). The analysis of trends for a particular site was conducted using a software program called S-ESTREND. Water-quality variables analyzed include specific conductance, fecal coliform bacteria, turbidity, nitrate plus nitrite as nitrogen, ammonia as nitrogen, and orthophosphate as phosphorus. Values reported as less than the detection limit were converted to zero for analysis. All samples, including those taken during high flow conditions, were included in statistical analysis and were adjusted to reduce flow-related variability. The LOWESS (Locally Weighted Scatterplot Smoothing) procedure was used to establish a relationship between water quality and flow. Water quality values were then adjusted based on this relationship in order to limit variability.

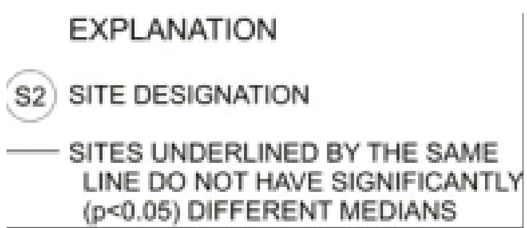
Box plots were used to graphically show the distribution of the central 80 percent of the data for each water-quality variable at each site. Values on the box plot are the 10th, 25th, 50th (median), 75th, and 90th percentile within that central 80 percent (Figure 21).

Figure 21. Explanation of box plots



Kruskal-Wallis analysis of variance and Dunn's multiple comparison tests were used to test for differences in water quality among corridor sites, tributary sites, and springs. Because water-quality data are typically not normally distributed, non-parametric methods were used for these tests. Within a group of sites (river corridor sites for example) values of each water-quality variable were ranked. A Kruskal-Wallis one-way analysis of variance of the ranks was used to test for statistically significant ($p<0.05$) differences among sites. If statistically significant differences were detected, the Dunn's multiple comparison test was used to test for statistically significant ($p<0.05$) differences in the medians between each of the pairs of sites. Figure 22 explains how the multiple comparison tests will be presented. Sites are listed in order from highest median to lowest median and sites that have a line under them do not have significantly different medians. If there is no line under any sites, then they all have significantly different medians.

Figure 22. Explanation of trend analysis graphics

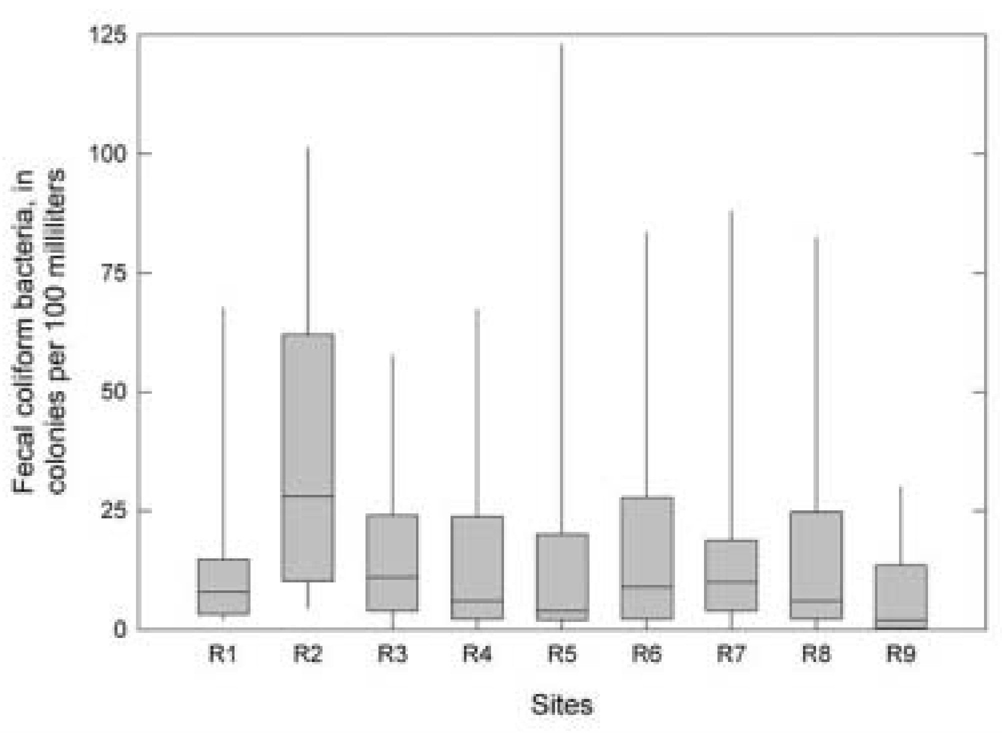


The third aspect of data analysis looked at changes in water quality parameters over time for each river, spring, and tributary site using the Kendall Test for trend analysis, implemented through the software program S-ESTREND. The values for each analysis were compared only with values occurring in the same season but a different year. Data from 1984 to 2001 were included in the analysis. The calendar year was divided into four seasons: January through March, April through June, July through August, and September through December. When more than one value was available for a given season and year, the value that corresponded with the sample collected closest to the midpoint of the season was used for trend analysis. The longest time period that could be used and still include as many stations with a similar temporal distribution of data was used and the time period was held constant for each group of sites (i.e. main stem sites, tributary sites, or spring sites). The time period was not consistent among parameters. All values that were reported as zero or less than the detection limit for the particular parameter were set to one-half of the detection limit. Two important values, the p-value and the slope, are produced from this analysis and help determine if changes over time are occurring and by how much. A calculated p-value determines whether or not a change over time is considered statistically significant. If the p-value is less than 0.05, the change is considered significant. The slope determines a "typical" rate of change during the trend analysis period, but it does not indicate that the rate of change is constant, or even always in the same direction. It is the overall rate of change during the time period being analyzed.

Fecal Coliform Bacteria-River Corridor

As displayed in Figure 23, fecal coliform concentrations attain their highest median values at station R2, the Ponca sampling site located at the downstream end of Boxley Valley. The median concentration at Ponca is 28 colonies/100 ml, four times higher than the average median of all other sites (7 col/100 mL). Other water quality studies (Thornton and Nix, 1985; Weeks, 1987; Mott and Apel, 1988; Fraser, 1988; Mott, 1990; Weeks, 1991) indicate that cattle operations in Boxley Valley are responsible for the higher bacteria concentrations. Direct access by cattle to tributaries and the river within Boxley Valley is the dominant mode of input during base flow conditions.

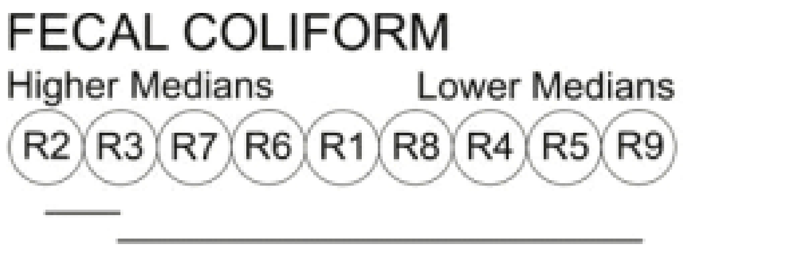
Figure 23. Fecal coliform box plot for Buffalo River corridor sites sampled from 1991 to 1998.



The higher bacteria concentrations at Ponca, while greater than background concentrations, do not represent a significant health threat during base flow conditions. The state standard for fecal coliform concentrations in primary contact recreation waters is 200 col\100 mL for a geometric mean of five samples collected over a 30 day period. The standard is based on human waste as the source of the bacteria. The chance of contracting an infectious disease from water born pathogens originating from a human source is much greater than the chance of contracting a disease from an animal source.

Figure 24 shows the results of the multiple comparison tests between each river corridor site. The sites are listed in order from highest to lowest medians. Only Ponca (R2) and Pruitt (R3) have median values that are greater than the other corridor sites and this difference is statistically significant. Ponca has a median of 28 colonies per 100ml and Pruitt has a median of 11 colonies per 100ml. Median values for the remaining sites are between 10 and 3 colonies per 100ml.

Figure 24. Multiple comparison test and rank for fecal coliform among river corridor sites



Because of the higher fecal coliform concentrations at R2, the National Park Service has actively worked with land owners in Boxley Valley to exclude cattle from the Buffalo River within this private use zone of the park. The cattle in Boxley Valley were fenced out of the Buffalo River by 2000. Continued monitoring will determine the effectiveness of this action on the bacteria concentrations at Ponca. These steps are needed to comply with the Outstanding Natural Resource standards, which require no degradation of existing water quality, and to meet NPS mandates to protect and preserve the Buffalo River as a free-flowing stream for present and future generations. The cooperation of Boxley land-owners in this endeavor is to be commended and the example set by their good stewardship may represent a model which can be expanded to other areas of the watershed.

Finally, trend analysis over a 13 year period (1988-2001) shows a significant ($p< 0.05$) increasing trend in fecal coliform concentrations over time at Pruitt, with a p value of 0.0056 and a median slope of 2 col/100ml. This does not indicate that there is a constant increase in fecal coliform concentrations of 2 col/ml every year but does show that in general, levels are rising over time at this site. Two other stations had p values that were close to showing significant increasing trends over time, Ponca at $p=.058$, and Hwy 14 at $p=0.069$.

Fecal Coliform Bacteria-Tributaries

Tributary median fecal coliform concentrations are shown in Figure 25 for each of the monitored tributary sites. Tomahawk Creek (T14) shows a median fecal coliform concentration of 63 colonies per 100ml . Clabber Creek (T17), Tomahawk Creek (T14), Mill Creek (T4), Calf Creek (T10), and Bear Creek (T12) all showed median concentrations above 20 colonies per 100ml. Figure 26 shows the multiple comparison results among tributary sites. Tomahawk Creek (T14) shows the highest ranked median among all sites and this difference is statistically significant. The next group of sites that is statistically higher than the remaining sites include T17, T4, T10, T12, T9, and T3.

Figure 25. Fecal coliform bacteria box plots for Buffalo River tributaries sampled from 1991 to 1998.

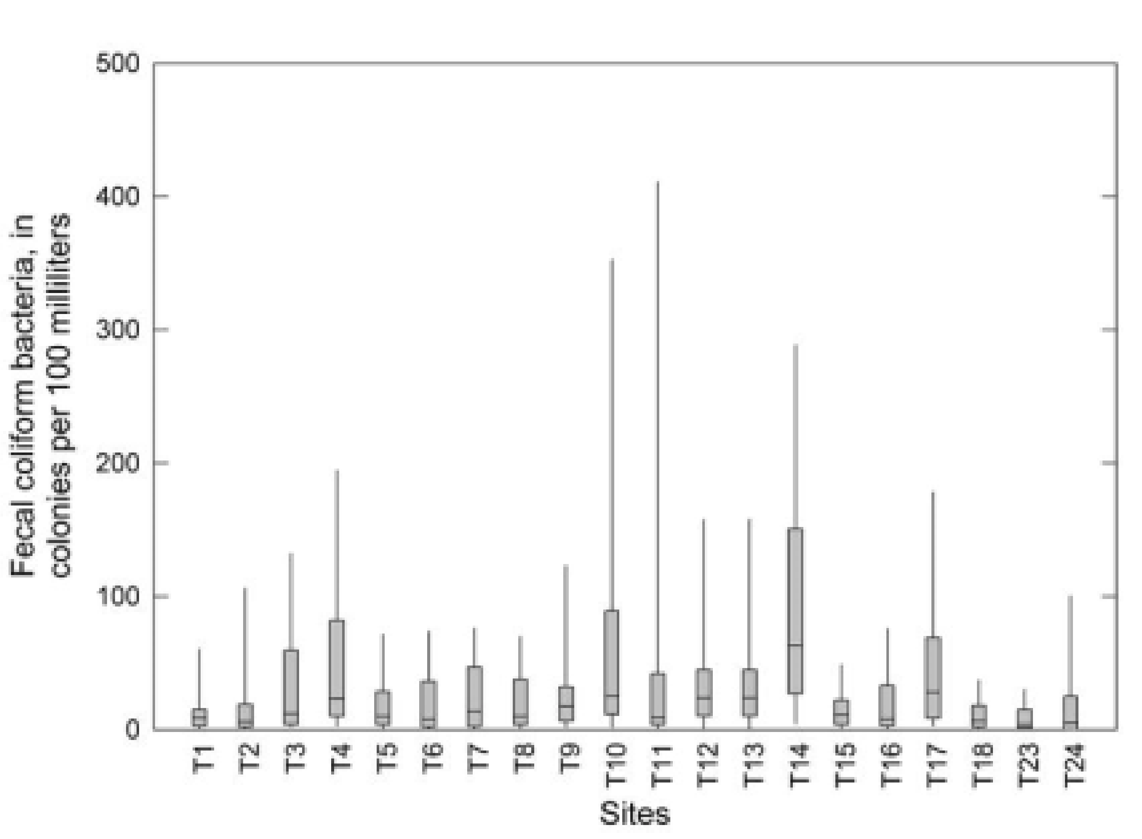
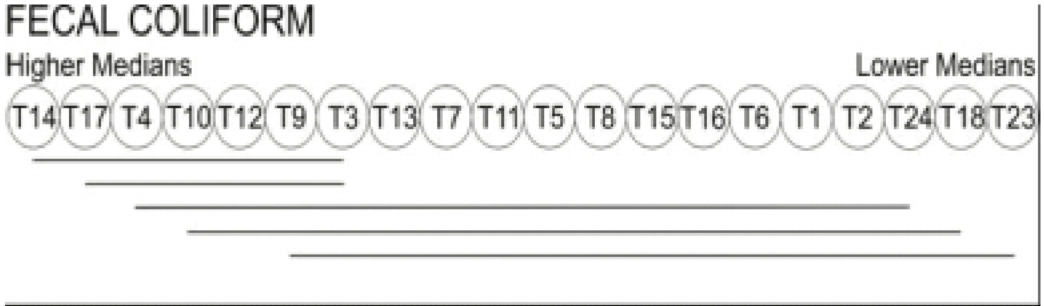


Figure 26. Multiple comparison test/ rank for fecal coliform among tributary sites



At Tomahawk Creek, higher fecal coliform concentrations routinely observed during base-flow conditions can be attributed to direct deposition of cattle waste as little as 200 feet upstream from the sampling site, in addition to general watershed inputs. The short distance does not allow time for die-off and the relatively small discharge of this creek provides little opportunity for dilution. At Calf Creek, Bear Creek, Richland Creek and Clabber Creek, the bacterial sources are dominantly from livestock and confined animal operations within their watersheds. During base-flow conditions, direct deposition of cattle waste, re-suspension of bacteria in stream sediment, and groundwater inputs account for the majority of the bacteria. Land use studies show these four tributaries have some of highest ratios of land area converted to pasture (Scott, 1995). Calf Creek is also experiencing major bank erosion and channel cutting, particularly near its confluence with the Buffalo, just upstream from the water quality monitoring site. For most of its length within park boundaries Calf Creek runs through open hay fields and above NPS boundaries its surrounding watershed and riparian zones are being converted to pasture. Mitigation efforts were attempted in 1994 to stabilize Calf Creek's banks within the park, but this effort was unsuccessful.

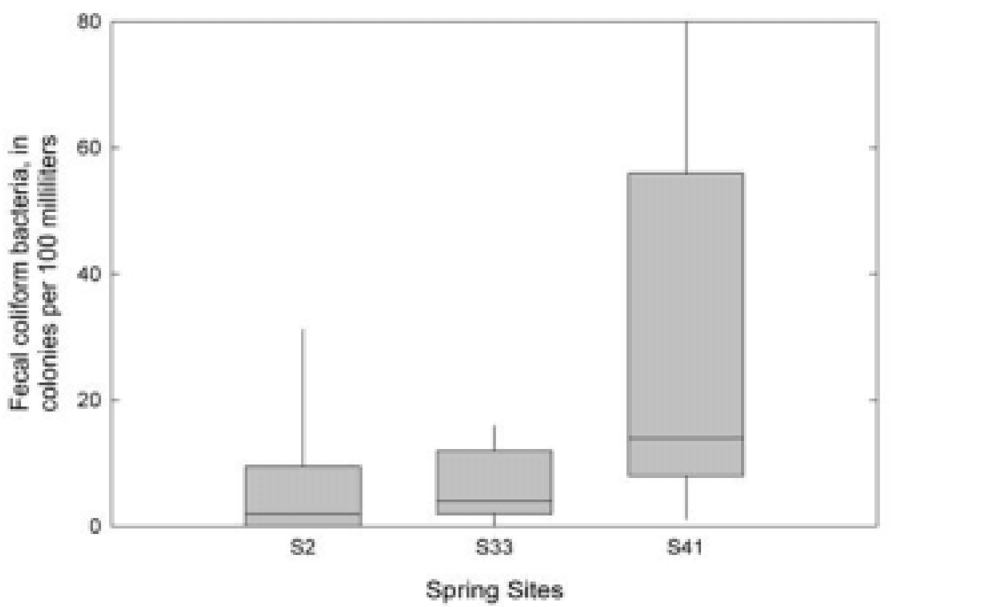
Mill Creek {T4} also has some livestock operations in its watershed, but Maner and Mott (1991) determined that residential and cabin/camping area near the confluence of Harp Creek had the highest bacteria along the length of Mill Creek. Poorly constructed septic systems or systems located within the floodplain and near Mill Creek are the probable source of much of the fecal bacteria. Dye tracing studies in the Mill Creek area have shown that interbasin transfer of groundwater is occurring between the Mill Creek watershed and the Crooked Creek watershed, a watershed which is out of the Buffalo River's topographic basin. Fluorescein dye moved over 2.5 miles in less than five days to emerge from the springs at the head of Mill Creek. More than 70% of the recharge area of Dogpatch Springs is located in the Crooked Creek watershed, contributing to elevated levels of fecal coliform.

Fecal coliform levels showed a significant increase from 1988 to 2001 at Davis Creek (p=0.012, slope=2.14 col/100ml) and Cecil Creek (p=0.026, slope=0.8 col/100ml in Mill Creek (Mott et. al, 2000 and Aley, 2000). These streams do not rank high in the multiple comparison analysis, indicating that negative changes may be occurring in these watersheds causing fecal coliform levels to increase over time.

Fecal Coliform Bacteria-Springs

Figure 27 indicates that the range of fecal coliform concentrations is much greater for Gilbert than the other two sites. Higher fecal coliform concentrations at Gilbert are statistically significant from the other two springs that were sampled. No significant changes in fecal coliform concentration over time were evident for the three spring sites.

Figure 27. Fecal coliform box plots for three springs sampled from 1991 to 1998.



Higher concentrations of fecal coliform at Gilbert Spring were preliminarily attributed to septic leachate from the town migrating into the spring's karstic recharge area. Gilbert is entirely underlain by limestone and several large sinkholes can be observed in the area. Recent dye tracing efforts isolated some problem septic tanks in Gilbert and remediation has taken place (Mott, 2002). Dye tracing studies also found that the major bacteria source actually came from the Dry Creek watershed, with water being pirated through underground conduits into Gilbert Spring. This study is discussed in greater detail in the Development section of this report, under Water Resource Issues and Recommendations. Future monitoring is needed to determine if septic system remediation will reduce the elevated fecal coliform concentrations and if continued development in the Dry Creek watershed will further degrade water quality in Gilbert Spring.

Nutrients-River Corridor

Nitrogen based nutrient median values for the river corridor sampling sites are shown in Figure 28. Nitrate plus nitrite/nitrogen values are higher at Ponca, begin to rise again at Hasty, peak at Woolum and Gilbert, and gradually fall until the Buffalo flows into the White River (Figure 28). Nitrate concentrations tend to increase near the middle river sites. Land use information for the middle portion of the river's watershed indicates that it has the highest percentage of pasture land and other forms of development (Scott and Hofer, 1995). Median values for R5, R6, and R7 rank highest among all the sites but this difference is not statistically significant, with the exception of R1, as shown in Figure 29. Higher nutrient values along middle river sites may become more evident as more long-term monitoring takes place and a larger data set is available to analyze. Only R1, the headwaters site above Boxley Valley is significantly lower than the other sites. R1's watershed is primarily forested and the geology at this site is different from all sites because it is mostly within the Pennsylvanian strata of the Boston Mountains.

Trend analysis indicates that some changes in this pattern may be occurring. Site R1 and R2 were the only sites that showed statistically supported increase in nitrate concentrations over time (data were analyzed from 1985 to 2001) although slope values indicate that these changes may be minimal. The Wilderness Boundary site (R1) had a p-value of 0.017 and a slope of 0.025 mg/l. Ponca (R2) had a p-value of 0.0137 and a slope of 0.0003 mg/l. These sites ranked among the lowest medians in the multiple comparison tests among the river corridor sites. If nitrate levels continue to increase at these sites, it may relate to influences from spring discharge along the upper portions of the Buffalo. Previous dye tracing and water quality work, particularly in the upper Buffalo River, indicate that nitrate contamination may be coming from sources outside the Buffalo Rivers' surface water drainage area.

Figure 28. Box plots of nitrate plus nitrite for the nine Buffalo River corridor sampling sites from 1991 to 1998.

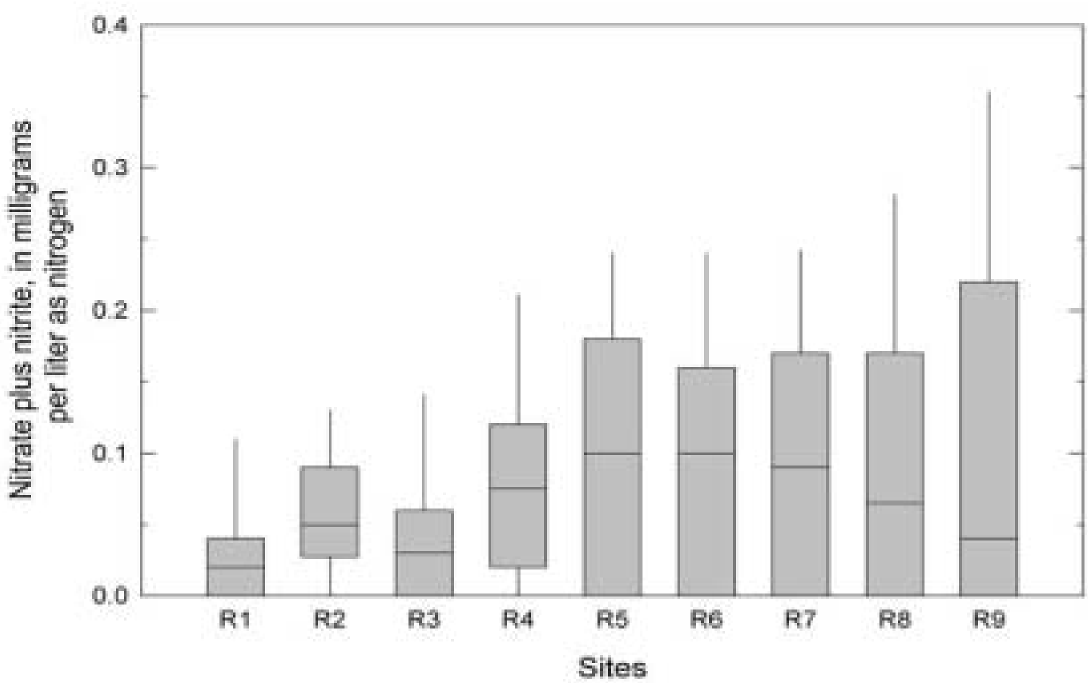
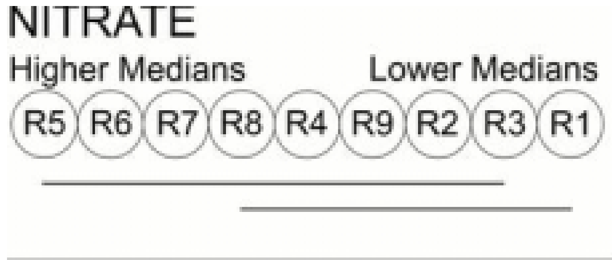


Figure 29. Multiple comparison test/rank for nitrate plus nitrite among river corridor sites.



Ammonia and orthophosphate median values for the nine river corridor sites were minimal. Ammonia concentrations show a decreasing trend in the downstream direction as expected due to increased dilution. While there are slight differences in the medians, none of these proved statistically significant. Orthophosphate medians for all sites except for the Wilderness Boundary site (R1) were below detection limits, R1 showed a value of 0.01mg/l. While this showed up as a significant difference in the multiple comparison tests, the values are so low that this does not indicate any real difference. No significant changes over time were observed for ammonia or orthophosphate concentrations at any of the sites.

Nutrients-Tributaries

Nitrogen based nutrient median values in the twenty tributaries monitored over eight years (1991 to 1998) are shown in Figure 30. Six tributaries exceeded 0.2 mg/l (Mill Creek {T4}, Davis Creek {T7}, Calf Creek {T10}, Mill Creek {T11}, Brush Creek {T13}, and Tomahawk Creek {T14}). Multiple comparison tests showed this difference to be statistically significant; these six sites have a higher median than the remaining sites, as shown in Figure 31.

Mill Creek {T4} was studied intensively by Maner and Mott (1991), and is a spring fed system. The highest concentrations of nitrates in Mill Creek are found in the springs at its headwaters. Nitrate values declined from 1.46 mg/L at the springs to 0.35 mg/L at the mouth. Even with the reduction in nitrates it was determined that 96% of the nitrogen load being carried by the Buffalo River below the confluence was supplied by Mill Creek. Mott and Maner hypothesized that the source of the nitrates was from agricultural operations in the spring's recharge area.

The remaining tributaries with higher nitrate concentrations are also highly spring fed systems, although some tributaries that are highly spring fed are not high in nitrate concentrations. It appears that a combination of a high ratio of spring input combined with a significant portion of the recharge area in agricultural use tends to result in tributaries with higher base-flow nitrate concentrations. Water quality and dye tracing studies are indicating that most of the nitrate contamination, at least in the upper portions of the Buffalo River, is coming from sources outside of the Buffalo’s surface water drainage area.

Ponca Creek was the only tributary that showed statistically significant (p=0.008, slope=0.02) increases in nitrate concentrations over time (1989 to 2001). Mott (1997) showed that Ponca Creek has a high spring influence. Increased nitrate levels in this creek may again relate back to the influence of groundwater inputs into the tributary and the changes in land use that are occurring in spring recharge areas. The town of Ponca also continues to develop and is served exclusively by on-site septic systems.

Figure 30. Nitrate plus nitrite box plots for the twenty tributary stations sampled from 1991 to 1998.

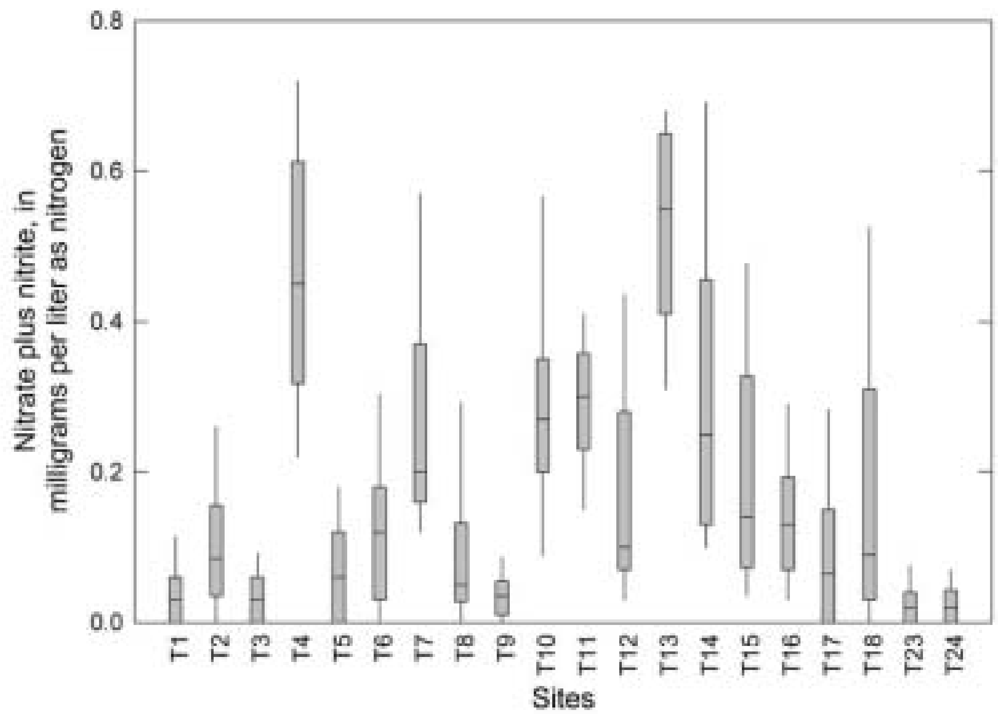
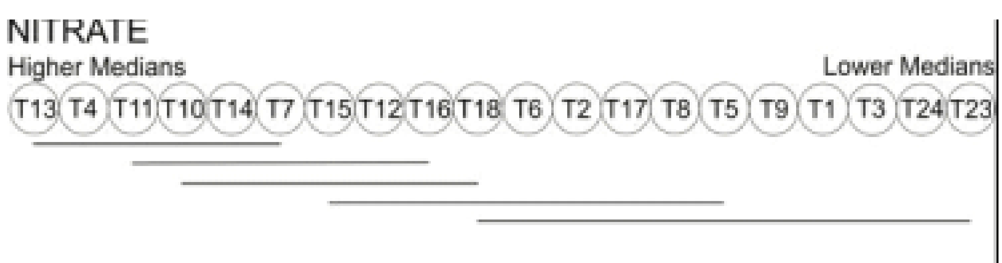


Figure 31. Multiple comparison test results for nitrate plus nitrite among tributary sites.



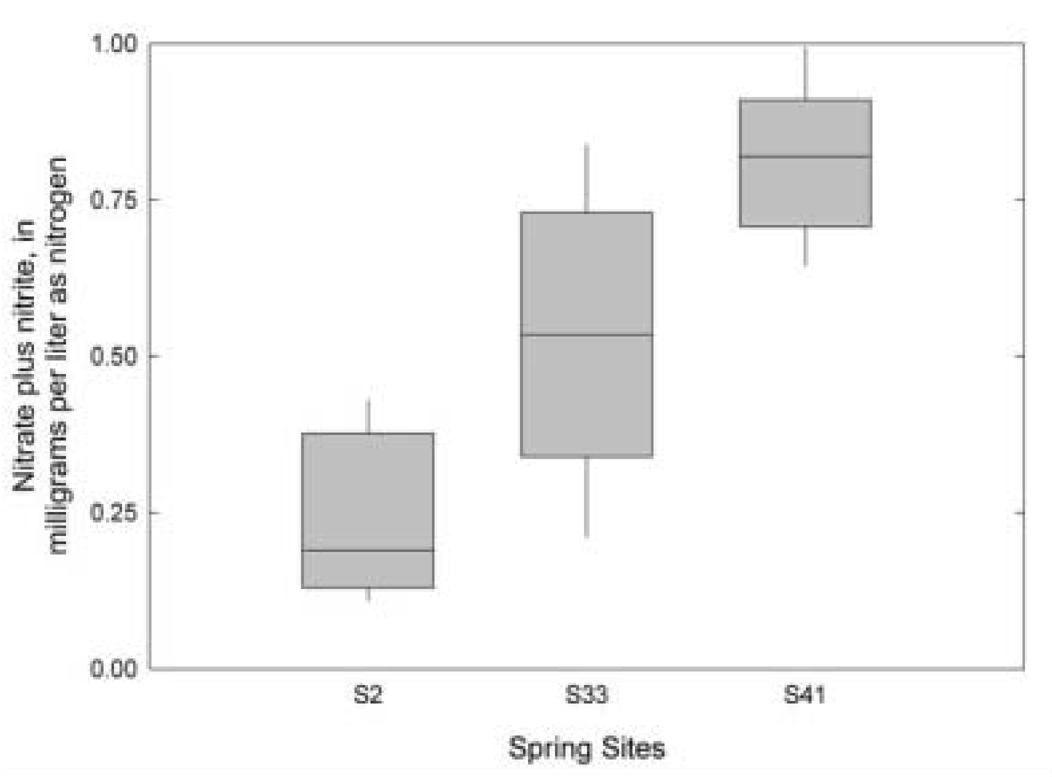
Orthophosphate and ammonia median values are low in tributaries and show no obvious trends or changes over time. No significant difference was shown among sites for ammonia medians and levels remained at or near detection limits. For orthophosphate levels, no medians exceed 0.025 throughout the sampling period and only three sites showed medians greater than detection limits (Cecil Creek {T3}, Calf Creek {T10}, and Big Creek {T18}). The consistently low values for these sites along with the river and spring sites despite differing land use in the surrounding watersheds indicates a steady state process acting to keep orthophosphate concentrations consistently low.

Nutrients-Springs

Ammonia and orthophosphate medians are below detection limits for all three spring sites and show no significant differences. Nitrate values are shown in Figure 32. The highest nitrate median came from Gilbert Spring, at 0.82 mg/l. The second highest average came from Mitch Hill Spring, at 0.54 mg/l. Luallen Spring, which has a relatively undeveloped recharge area, had an average nitrate value of 0.19 mg/l. These values correlate well with land use in the spring's recharge area. Gilbert Spring is impacted from urban land uses (septic leachate from Gilbert, yard fertilizers), beef cattle operations, and dairies. Mitch Hill receives nitrate inputs from rural septic systems and beef cattle operations (Aley, 1990). Multiple comparison analysis showed these differences to be significant among each of the three sites.

In addition, Gilbert and Mitch Hill Springs are in very karstic settings, while Luallen Spring's recharge area contains a mixture of strata with a large component of sandstone and shale. Numerous studies conducted in the area (Austin and Steele, 1990; Adamski, 1987; McCalister, 1990; Edwards and Daniels, 1992) indicate karstic aquifers are very susceptible to nitrate leaching into groundwater. The data collected for the Buffalo River, its tributaries, and springs supports this hypothesis. In general, the highest nitrate concentrations are observed at springs. The next highest concentrations are in tributaries influenced by springs or with springs near the point of sampling. Even lower nitrate concentrations are found in tributaries with little nearby spring water infusion, and the lowest concentrations are in the river. Superimposed over this pattern are land use factors which tend to distort the general pattern in affected areas. A combination of intensive land use and an extensive karst network leads to the highest nitrate concentrations for any of the systems that are sampled. No significant changes over time were found for nitrate, phosphorous, or ammonia concentrations among the three spring sites.

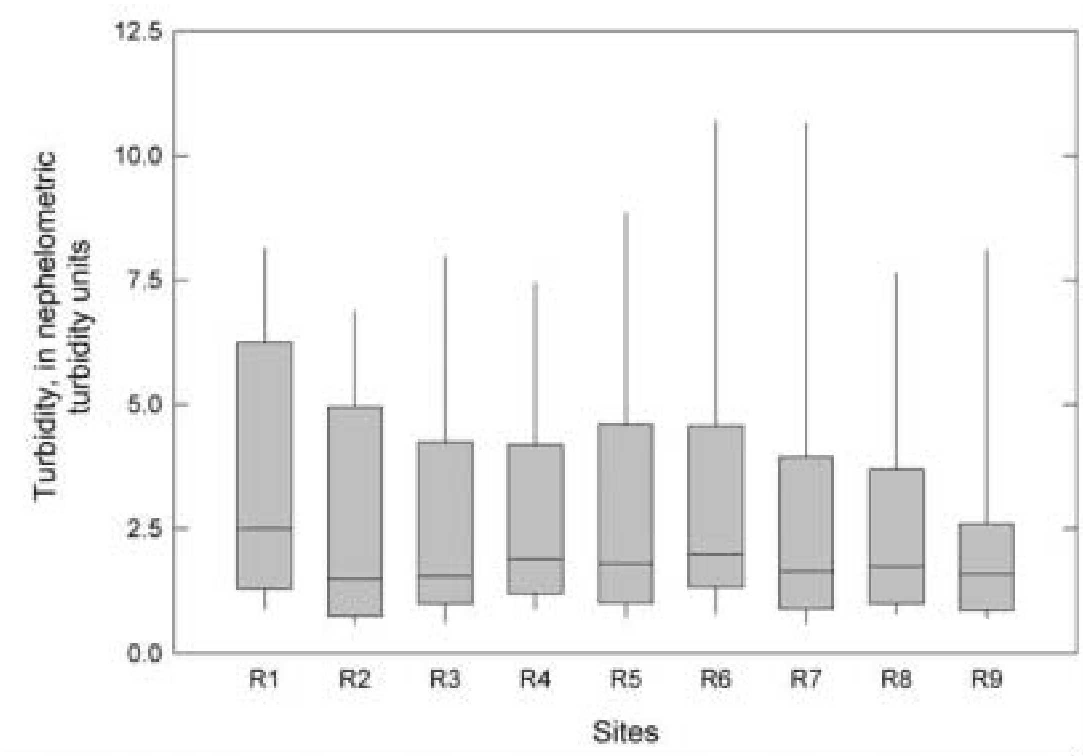
Figure 32. Nitrate plus nitrite box plots for three springs in the Buffalo River watershed sampled between 1991 and 1998.



Turbidity-River Corridor

Figure 33 shows the median turbidity values for each river corridor site. No statistical difference was found between medians among any of the sites. Despite the presence of cattle in the Boxley Valley area and the associated trampled and eroding banks, fecal deposition, and poor soil cover in winter, median turbidity values are less at Ponca (R2) than at the upstream Wilderness Boundary collection site (R1). Lower median turbidity is dominantly the result of the geologic differences between the upper and lower site. The Ponca site has a much greater proportion of limestone in its drainage area than the upstream, Wilderness Boundary site. The Boone Limestone Formation outcrops in Boxley Valley and its abundant springs and seeps bring clear groundwater to the river. The watershed above the wilderness boundary is dominated by interbedded Pennsylvanian aged sandstones and shales which contribute suspended clays.

Figure 33. Turbidity Box Plot for the Buffalo River corridor sites sampled between 1991 and 1998.



Generally, base-flow turbidity of the Buffalo River is between one and three NTU's (Nephelometric Turbidity Units). Turbidities as high as 420 NTU's have been recorded in association with rain events. The dominant source of turbidity during high flow is from erosion of road surfaces and ditches, cattle pastures and other cleared land, and unprotected rapidly eroding cut-banks. Although turbidity and fecal coliform concentrations correlate very well during rainstorms (Mott, 1990), a similar relationship is not observed during base-flows, except to say that both are typically low. Sites R1 and R9 were the only ones to show any significant change over time. Both showed decreases in turbidity over the analysis period. No other sites showed any significant change over time and these results from R1 and R9 do not have any clear explanation. Because most water samples are taken during base flow conditions, it may be difficult to identify any major trends in turbidity levels. Samples taken during storm events would likely reveal better information on any changes over time that may be occurring.

Turbidity-Tributaries

The median turbidity values are shown in Figure 34. Tributaries that drain the Boston Mountain sandstones and shales tend to have a higher proportion of suspended load, and consequently turbidity. Indeed, all the tributaries with average turbidities in excess of 1NTU have a significant portion of Boston Mountain strata in their watershed.

Tributaries with turbidity under 1 NTU typically drain from Springfield and Salem Plateau strata (Figure 35). For example, the tributaries with the three highest turbidities (T1, T9, and T3) all drain from the Boston Mountains. However this is not the only influencing factor on turbidity. Activities in the watershed, such as road construction, deforestation, and bank erosion can create sediment laden streams. However, sediment input from these sources is storm-event driven and sampling must be targeted around storm periods to detect their impacts (Steele and Mott, 1998).

As with the river corridor, the turbidity in the tributaries shows no clear relationship to nutrient concentrations and is probably more a function of geology and sediment transport during rainstorms than from algal growth. For example, Tomahawk Creek (T14) has some of the highest nutrient and fecal coliform concentrations and yet exhibits a very low turbidity. This indicates that a significant amount of groundwater recharge feeds Tomahawk Creek, and that this groundwater may be contaminated by land use practices occurring in Tomahawk Creek's groundwater recharge area. The statistical variations among sites are related to a variety of factors, including storm water runoff, land use activities in the watershed, and surrounding geological influences. Additional storm event sampling would help determine why these differences exist and what factors are influencing them. No significant changes over time were evident for any of the tributary sites.

Figure 34. Turbidity box plot for tributaries of the Buffalo River sampled between 1991 and 1998.

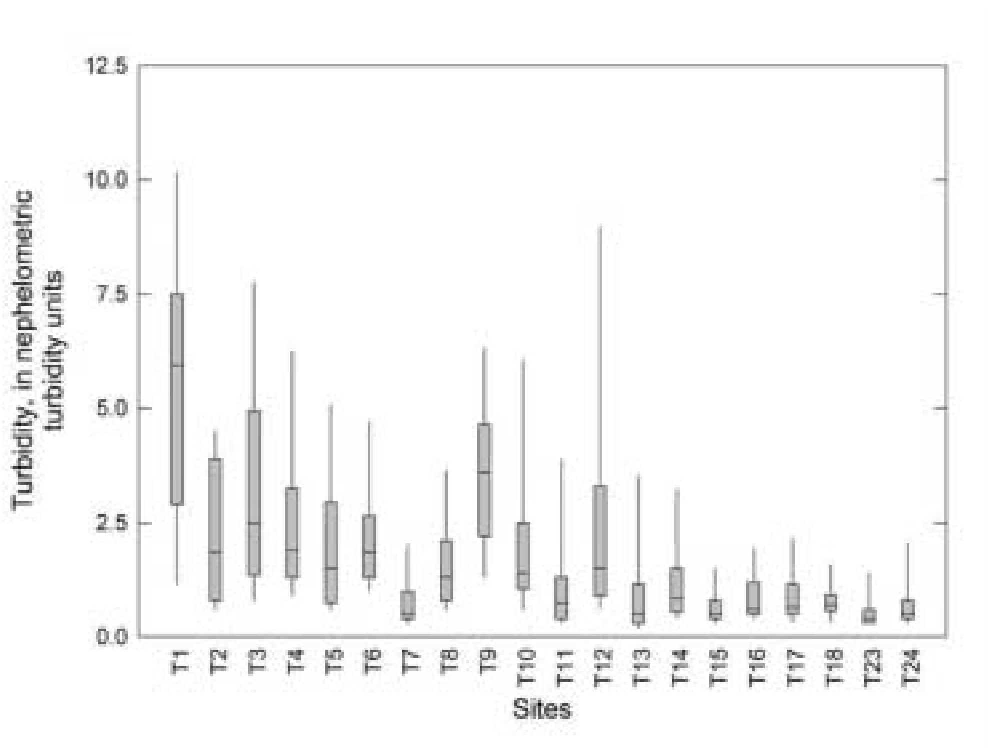
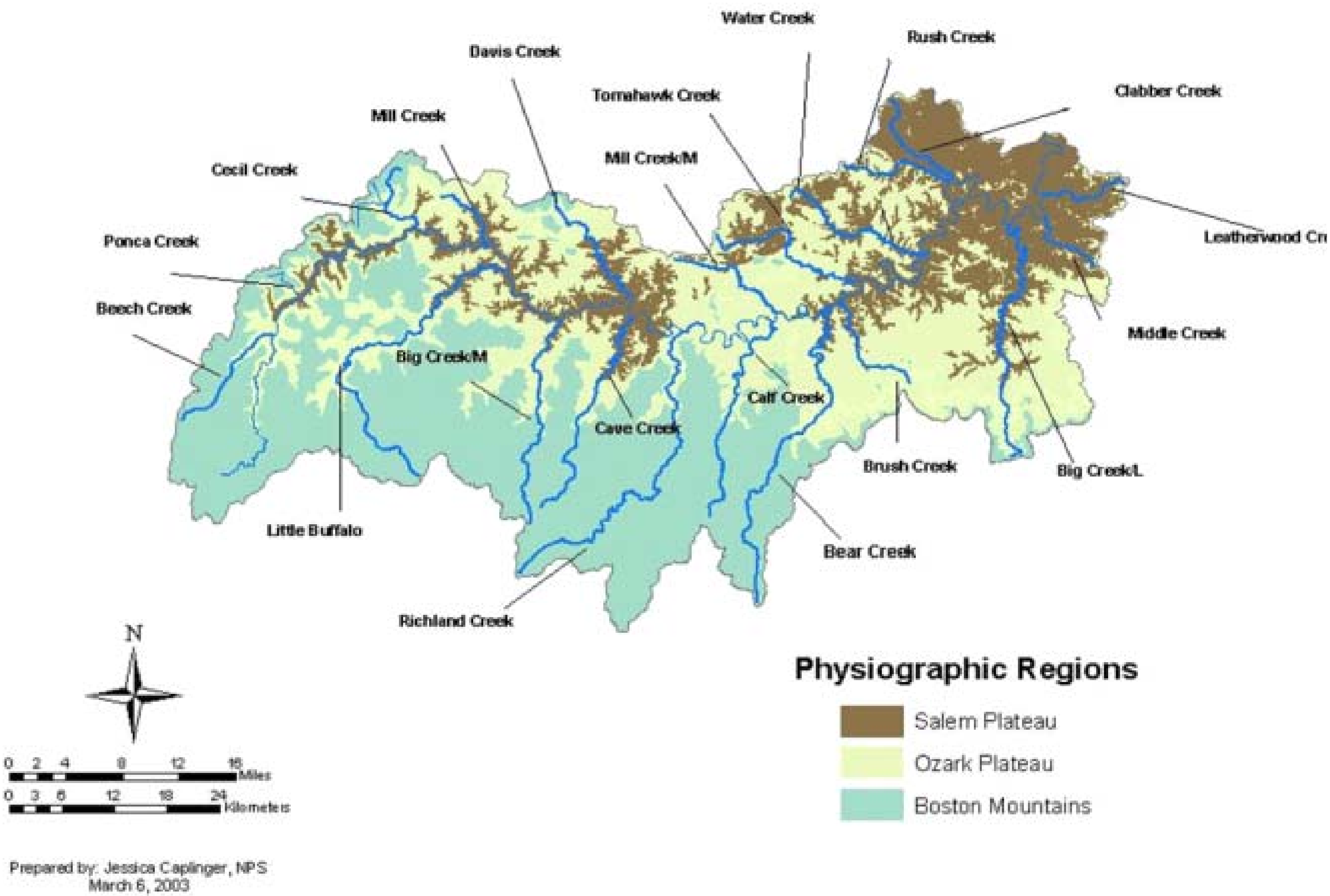


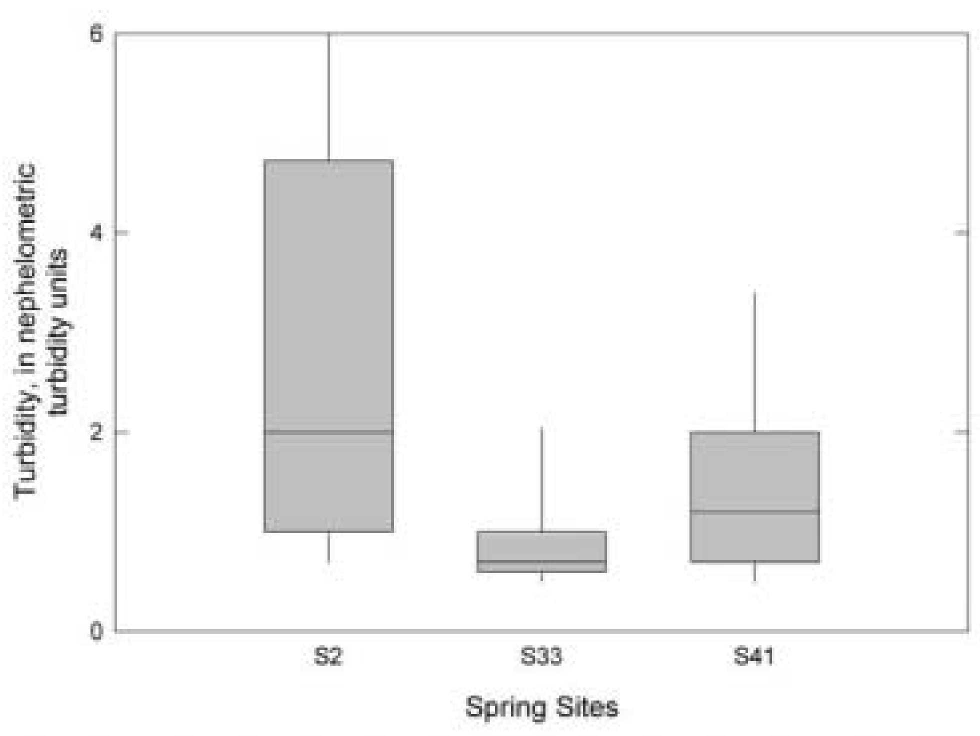
Figure 35. Physiographic regions and major tributaries in the watershed of Buffalo National River



Turbidity-Springs

Turbidity in springs is a function of the relative amount of discrete recharge associated with the spring's drainage basin, and the rock formations contained within the recharge area. Luallen Spring, which drains the Boston Mountain sandstones and shales, had the highest median turbidity of 2.0 NTU's, while Gilbert and Mitch Hill Springs, recharged from Springfield Plateau limestone, both showed average turbidities of 0.9 NTU. Multiple comparison results support this as a significant difference. No significant changes over time in turbidity levels were evident for the spring sites.

Figure 36. Turbidity box plots for springs sampled between 1991 and 1998.



Dissolved Oxygen and Specific Conductance-River Corridor

Dissolved oxygen (DO) and percent saturation are measured on-site with other field parameters. Typically, these measurements are made between 1000 and 1400 hours when photosynthetic activity is relatively high. Because samples are collected during periods of highest photosynthetic activity, DO readings do not reflect potential minimum values which characterize most of the night hours. Some sites are routinely sampled earlier in the morning than others because the same routes are often followed when a sample run is conducted. The sites tend to show lower overall dissolved oxygen levels because they are sampled early in the day when photosynthetic production is not as active.

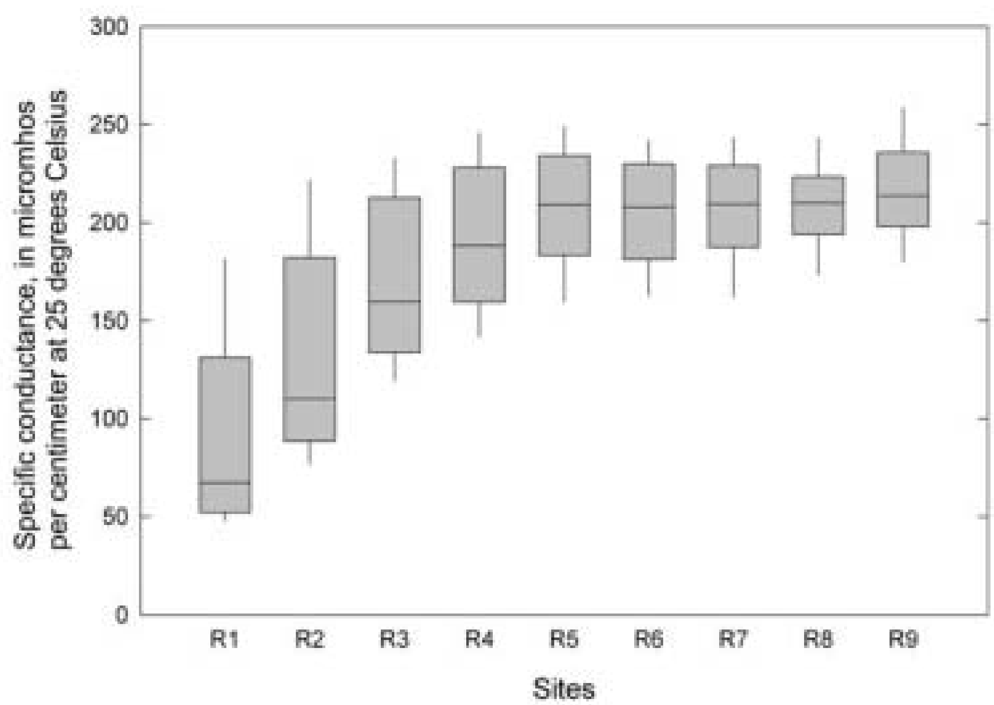
DO is used as a screening tool to determine if other problems may exist. Arkansas state standards for minimum dissolved oxygen concentration is 6 mg/l. River corridor sites have occasionally fallen below the state standard of 6 mg/l, as shown in Table 6. Note that six of the twelve samples that were below standards were also sampled before 10 am, before peak photosynthetic activity. No statistical analysis was conducted on this data due to the large number of variables that influence dissolved oxygen.

Table 6. River Corridor samples which have fallen below state water quality standards for dissolved oxygen (6 mg/l)

Site	Date	Time	Temperature (C)	Dissolved Oxygen (mg/l)
R1	6-23-03	9:20	22.0	5.8
R1	7-22-91	10:09	24.8	4.6
R1	8-16-03	10:50	26.3	5.6
R2	8-16-93	10:00	27.0	5.2
R2	7-22-96	9:40	26.5	5.8
R2	7-06-98	8:55	26.0	5.4
R3	6-24-91	11:00	26.1	5.9
R4	9-30-87	9:45	17.5	5.9
R4	7-30-90	11:30	29.2	5.4
R5	7-30-90	13:30	31	5.4
R9	8-23-90	11:30	29.3	5.9

Temperature and specific conductance tend to increase in the downstream direction along the river (Figure 37). Increased temperatures result from such factors as less shading along wider reaches of the lower river, increased dilution of incoming groundwater, friction, and lower elevations. The increases in conductance results mainly from increased concentrations of bicarbonates of calcium and magnesium from increased spring discharge and seepage into the river channel through limestone. Addition of bicarbonates increases the concentration of dissolved ions and thus the specific conductance. River sites R1, R2, and R3 show a statistically lower conductivity than the remaining river sites as a group. Trend analysis results indicated no significant change over time for any of the sites.

Figure 37. Specific conductance box plots for Buffalo River corridor sites sampled between 1991 and 1998.

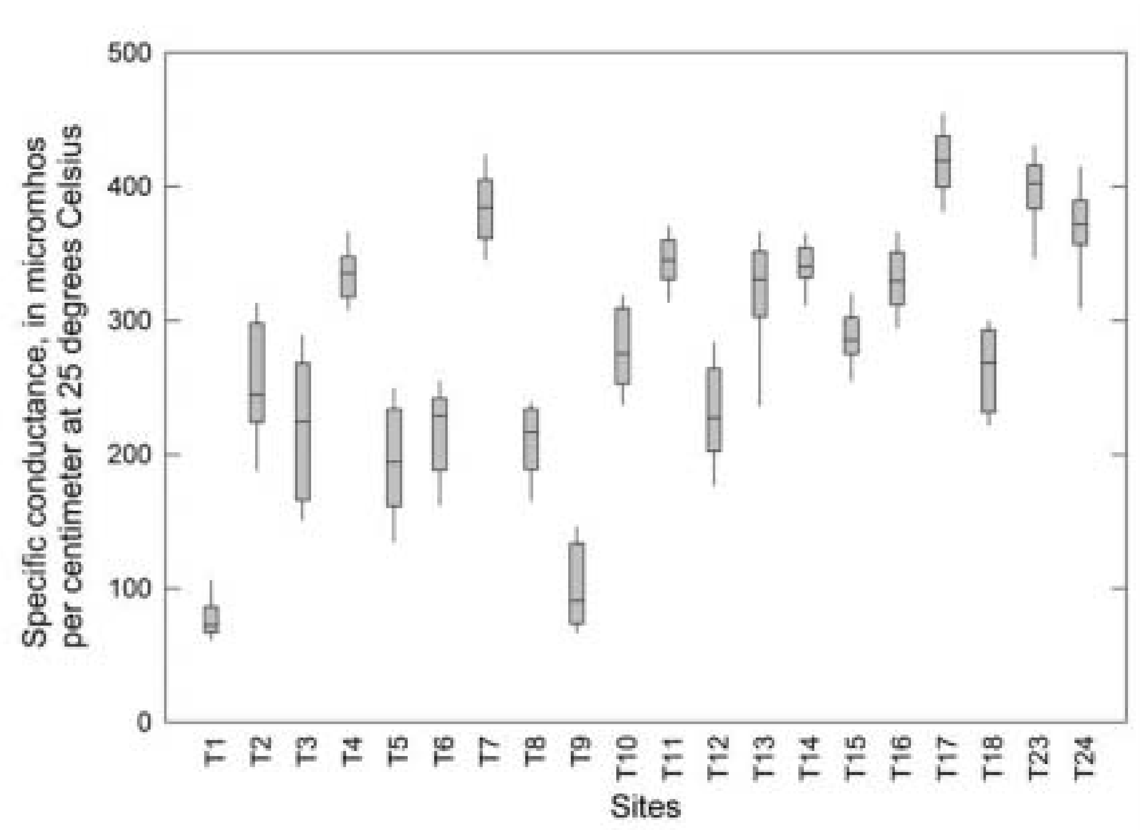


Dissolved Oxygen and Specific Conductance-Tributaries

As discussed in the previous section, dissolved oxygen levels were not statistically analyzed due to the large number of variables that influence their levels. Levels in the tributaries do fall below the state standard of 6 mg/l but there can be a variety of reasons for this. When used as a screening tool, dissolved oxygen can be used in conjunction with other water quality parameters to help isolate a particular problem but it is not as useful when used solely as a diagnostic tool on its own. For example, in 2000 Davis Creek exhibited dissolved oxygen levels below 6 mg/l and elevated fecal coliform levels. After some investigation, it was found that water levels had gotten low enough that anaerobic water began to leach from the floodplain, resulting in low oxygen and high fecal coliform concentrations.

Specific conductance is shown in Figure 38. Values appear highly variable due to the different amounts of groundwater input into individual tributaries. Because conductance is higher in springs than surface water, high conductivities in streams indicate the majority of the water being sampled has been in contact with bedrock for a relatively long period of time. The increase in conductance primarily indicates large contributions of groundwater. Trend analysis showed no significant changes over the analysis period among any of the tributary sites.

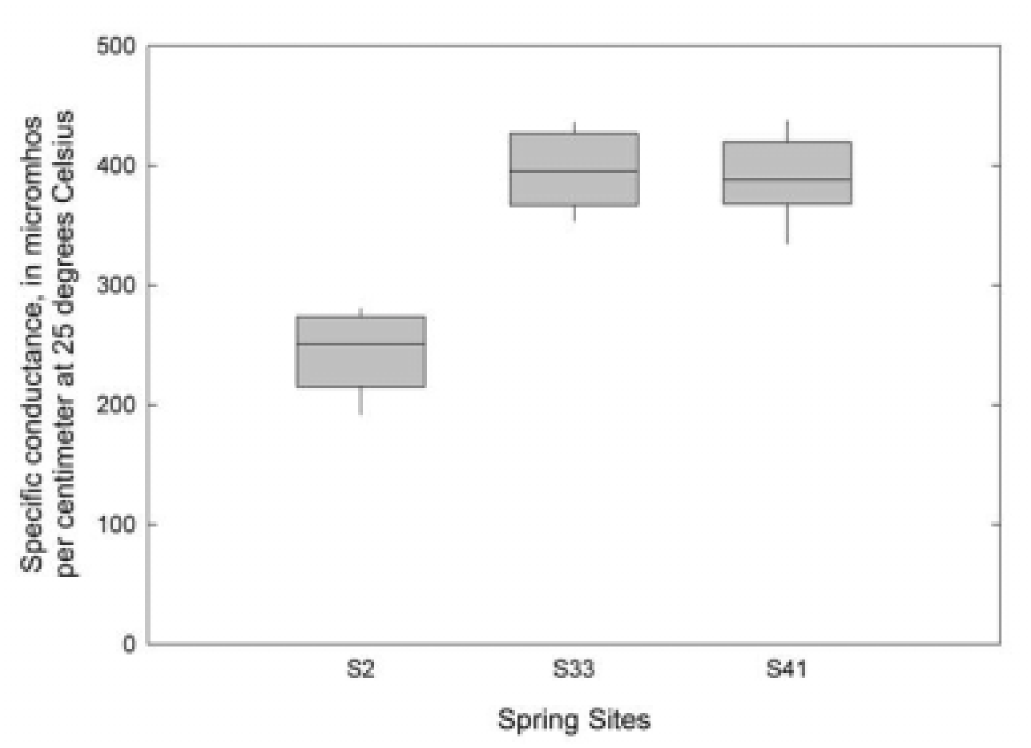
Figure 38. Specific conductance box plots in tributaries sampled between 1991 and 1998.



Dissolved Oxygen and Conductance-Springs

Luallen Spring (S2) and Gilbert Spring (S41) both had higher dissolved oxygen concentrations than Mitch Hill Spring (S33). Luallen Spring had median dissolved oxygen of 9.3 mg/l, Gilbert had a median of 8.7 mg/l and Mitch Hill's median dissolved oxygen was 8.1 mg/l. Reasons for this tendency are unclear. Given the low fecal coliform and nutrients found at Mitch Hill Spring, higher biological or chemical oxygen demand would not be expected. Possibly, this is because Mitch Hill Spring is characterized by "full-conduit" delivery, which limits atmospheric re-aeration. Mitch Hill Spring also has a high conductivity, as shown in Figure 39. This indicates a long residence time for the water in transport to the spring. Gilbert Springs also has a high conductance, but karst windows near the town of Gilbert and the short underground flow-path between Dry Creek and Gilbert Spring, allow for atmospheric re-aeration to occur. Luallen has a significantly lower conductivity because it is located in the Boston Mountains, which is dominated by sandstones and shales.

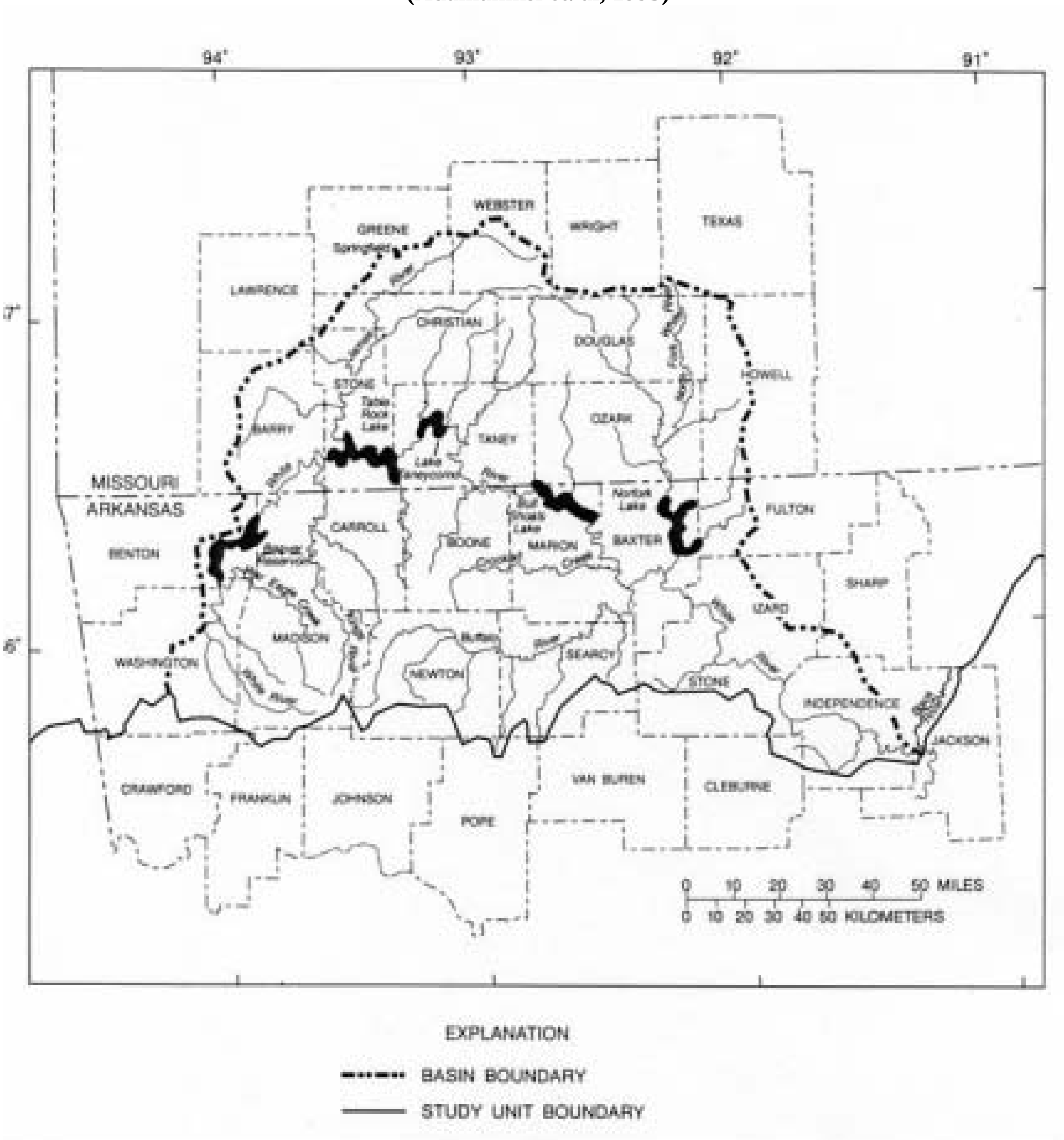
Figure 39. Specific conductivity box plots for three springs sampled between 1991 and 1998.



Reservoirs

Although the Buffalo is preserved as a free flowing river from its headwaters to its mouth, it flows into the White River, a river greatly modified by the presence of several reservoirs along its course. The White River originates in the Boston Mountains of Northwestern Arkansas and flows northward toward the Arkansas-Missouri state line. The reach of the White River near the state line is a series of reservoirs beginning with Beaver Reservoir then Table Rock Lake, Lake Taneycomo, and Bull Shoals Lake (Figure 40). In the 1950's, Bull Shoals Reservoir was constructed about 27 miles above the confluence of the White River and Buffalo River. While this dam is 27 miles from the Buffalo, it has been shown to have a significant effect on the fish communities of the river. Hypolimnetic release of water from Bull Shoals reservoir into the White River has resulted in water temperatures as low as 7°C throughout the year (Cashner and Brown, 1977). Summer temperatures in the Buffalo River are usually around 25 to 28°C. This temperature difference has caused two major impacts on fish communities in the Buffalo, loss of migration of warm water fish species from the White River into the Buffalo and increased migration of cold water species like the rainbow trout from the White River (Cashner and Brown, 1977).

Figure 40. White River Basin with major tributaries and reservoirs
(Adamamksi et. al, 1995)



In a study by Siegwarth and Johnson (1994), catfish populations were compared between three rivers at sites near their confluence with a larger river. The Buffalo River, Mulberry, and Kings Rivers were sampled for catfish migrations from March 29 to April 22 , 1992. The rivers all exhibit similar physical characteristics in terms of water temperature, turbidity, chemistry, and geomorphology. The major difference among the three sites is the influence of the Buffalo emptying into the cold water of the White River. Using hoop nets and sampling throughout most of April, the number of channel catfish migrating up the Buffalo was significantly less (n=33) than the Kings River (n=169) and the Mulberry River (n=263). Water temperature differed significantly between the White River and the Buffalo River but did not differ between the Kings or Mulberry and their respective confluence. According to Siegwarth (1994), the Buffalo showed a significantly lower abundance of young of year (YOY) channel catfish when compared with similar warm water streams and it supported a sparse natural adult population. Despite increasing visitor use and nearly 10,000 anglers fishing the Buffalo each year, there is no evidence of heavy angler pressure or significant exploitation of the catfish population. Siegwarth (1994) found that more than 93% of the total channel catfish population was hatchery reared; of the 33 catfish captured in this study, 25 were hatchery reared. While the cold tailwaters of the White River do not totally inhibit the migration of channel catfish into the warm waters of the Buffalo during the spring, reduced numbers of migratory catfish may partially account for the river's overall low reproductive output and sparse adult population (Siegwarth and Johnson, 1994). Other species that show diminished populations are White Bass (*Morone chrysops*) and Crappie (*Pomoxis sp.*) (personal communication, Oliver, AGFC).

The cold tailwaters of the White River have an impact on the structure of fish communities along the Buffalo as well. There are five species that are present in the White River just above its confluence with the Buffalo and may be present in the Buffalo as well. They include the rainbow and brown trout (*Salmo gairdneri* and *S. trutta*), the threadfin shad (*Dorosoma petenense*), the fathead minnow (*Pimephales promelas*) and the black crappie (*Pomoxi nigromaculatus*) (Cashner and Brown, 1977). The trout are introduced into the cold waters of the White River as they are released from the dam and the shad are stocked in Bull Shoals Reservoir but collections have been made below the dam (Cashner and Brown, 1977). The fathead minnow is a common bait species throughout the Ozarks, with specimens taken in the White River near Cotter, Arkansas (Cashner and Brown, 1977).

Wetlands and the Riparian Zone

The wetlands and riparian zone play an important role in protecting the water quality of the Buffalo River. Listed below are some roles riparian buffer zones play in protecting water quality (Welsch, 1991).

1. Removes sediment and sediment attached phosphorous by filtration. Cropland erosion accounts for 38% of the 1.5 billion tons of sediment that reached the nation's waters each year. Pasture and range erosion account for another 26%. Buffers help sediment to settle out as the speed of flow is reduced, some sediment is also filtered out by porous soil, vegetation, and organic litter. Phosphorous levels are reduced as sediment flux into the streams is reduced because about 85% of the available phosphorous is bounded to the small soil particles in the sediment. With a forest riparian buffer, about 80% of this attached phosphorus is removed.

2. Aids in the transformation of nitrate to nitrogen gas. Under well-oxygenated conditions in the soil, bacteria and fungi convert nitrogen in runoff and decaying organic debris into nitrate, which can then be synthesized by plants and bacteria into proteins. In anaerobic conditions, denitrifying bacteria convert dissolved nitrogen into various nitrogen gasses, returning it to the atmosphere.

3. Acts as a sink by storing nutrients for an extended period of time. Some estimates indicate that 25% of the nitrogen removed by the streamside forest is assimilated in tree growth.

4. Acts as a source by providing energy to streams in the form of dissolved carbon and organic debris particulates. This is a critical food source for the base of the food chain, including benthic invertebrates, bacteria, and fungi that feed on the detritus.

There has been limited research done on these wetland and riparian areas within the park but a few studies and surveys have been done. Sagers (1995) surveyed 11 sites within park boundaries for rare and endangered plants species associated with springs and seeps. The survey was conducted between June and September, focusing on the evaluation of known populations rather than seeking out new populations. Table 7 lists the uncommon species found and their locations.

Table 7. Populations of uncommon plant species found in 1994 (Sagers, 1995)

Date	Site	Species	Observations
June 24	Pruitt glade and seeps	*Draba sprica* (whitoow grass) *Juniperus ashei* (Ashe's juniper)	Locally Abundant
June 24	Pruitt Visitor Center	*Neviusia alabamensis* (Alabama snowwreath)	Locally abundant
June 25	Hwy 7, 2 mi south of Jasper (outside park boundary)	*Delphinum newtonianum* (Moore's delphinium)	New population, locally abundant
June 25	Leatherwood Creek	*Panax quinquefolium* (ginseng) *Trillium pussillum ozarkanum* (Ozark trillium)	Present
July 15	Rush	*Sedum ternatum*	New Population-present
July 16	Gilbert	*Mimulus floribudus*	New population-locally abundant

In another project, Sagers and Lyon (1996) attempted to define the compositional and spatial attributes of the riparian corridor of the Buffalo River. Multivariate analysis and ordination techniques were used to characterize the composition and distribution of woody and herbaceous vegetation. Thirty-six transects were measured along the river between 1994 and 1996, running perpendicular to the river up to the point were the dominate vegetation was oak-hickory forest. The report found that the diversity of the woody vegetation made delineating a distinct boundary for the riparian zone difficult. Woody and herbaceous species were mixed throughout the transects and there were not distinct assemblages of well-defined plant species except along the streamside. Geomorphic features were associated with some well-defined plant species however, so linking specific species with specific landscape features will aid in restoration of disturbed sites (Sagers and Lyon, 1996).

Biological Resources

Fish

Managing and protecting the fisheries resources on the Buffalo River and its tributaries is critical to the maintaining the "unique scenic and scientific features" mandated by the enabling legislation as well as protecting an important recreation activity that draws tourist to the area and boosts the local economy. Figure 41 shows on of the most popular game fish in the Buffalo River.

Data involving diversity and density of fish in the Buffalo is incomplete, consisting of early field data in conjunction with the park's establishment. No data are known to exist prior to the impoundment of the White River. Fish surveys beginning in the late 1960's and into the 1970's reported from 49 to 56 species in the river (NPS, 1995). In a 1998 survey, 62 species were counted (Robinson and Buchanan, 1998). There is currently a project underway assessing the fish community of the Buffalo River and its tributaries. This will provide more comprehensive data on the fish of the Buffalo and how they are influenced by land use activities and other environmental factors. According the Fisheries Management Plan (NPS, 1995), there are 14 families and 66 species present in the Buffalo and its tributaries (Table 8). Between FY 2001 and 2003, a comprehensive fish assessment has been conducted on the Buffalo River and associated tributaries which should provide additional information of the species distribution and impacts of land use upon the fish communitity. Two additional species were recently discovered in the Lower Wilderness of the Buffalo River, the Redear Sunfish *(Leposmis microlophus)* and the Walleye *(Stizostedion vitreum).* There are currently no documented threatened or endangered fish species.

Figure 41. Smallmouth bass (*Micropterus Salmoides*)

A member of the Black Bass family, this is a common game fish in Ozark streams, including the Buffalo River.

http://www.americanfishes.com/thumbnails.htm

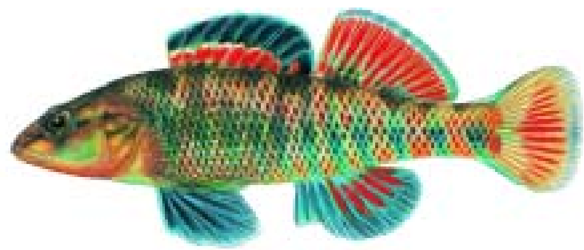
Joseph R. Tomelleri, Artist

Table 8. Family (in bold) and species (in italics) list of fishes in the Buffalo River **(NPS, 1995)**

Petromyzontidae	**Catostomidae**	**Centrarchidae**
Ichthyomyzon castaneus	*Carpiodes velifer*	*Ambloplites constellatus*
Lampetra appendix	*C. carpio*	*Leposmis cyanellus*
Lepisosteidae	*Hypentenlium nigricans*	*L. macrochirus*
Lepisosteus osseus	*Mineytrema melaops*	*L. microlophus*
Anguillidae	*Moxostoma carniatum*	*L. megalotis*
Anguilla rostrata	*M. dugeusnei*	*Micropterus dolomieu*
Clupeidae	*M. erthrurum*	*M. punctulatus*
Dorosoma cepedianum	**Ictaluridae**	*M. salmoides (Figure 41)*
Cyprinidae	*Ameriurus melas*	*Pomoxis nigromaculatus*
Campostoma anomalum	*A. natatis*	**Percidae**
C. oligolpeis	*Ictalurus punctutas*	*Etheostoma blennoides*
Cyprinella galactura	*Noturus albater*	*E. caeruleum (Figure 42)*
C. whipplei	*N. exilis*	*E. euzonum*
Cyprinus carpio	*N. flavater*	*E. juliae*
Erimystax dissimilis	*Pylodictus olivaris*	*E. punctulatum*
Luxilus chrysocephalus	**Salmonidae**	*E. spectabile*
L. pilsbryi	*Oncorhynchus mykiss*	*E. stigmaeum*
Nocomis biguttatus	**Cyprinodontidae**	*E. zonale*
Notemigonus crysoleucas	*Fundululs catenatus*	*Percina caprodes*
Notropis amblops	*F. olivaceus*	*P. evides*
N. Boops	**Athreinidae**	*P. maculata*
N. greenei	*Labidesthes sicculus*	
N. nubilus	**Cottidae**	
N. ozarcanus	*Cottus carolinae*	
N. rubellus	*C. hypselurus*	
N. telescopus	**Percichthyidae**	
Phoxinus erythrogaster	*Morone chyrsops*	
Pimephales notatus		

Semotilus atromaculatus

Figure 42. Rainbow Darter (*Etheostoma caeruleum*)



A common riffle dwelling species in the Buffalo River and throughout its tributaries, characteristic darter of the Ozarks region in general. Habitat requires rocky riffles and runs and clear shallow pools with permanent flow and silt free bottoms.

Picture taken from: www.americanfishes.com/ bigimg/tf1.jpg

The river has been periodically stocked by the AG&FC over the last fifty years. Records indicate more than 1.5 million fish of various species have been stocked in the river and its tributaries since 1942 (NPS, 1995). Stocking of game species occurred as late as 1983 for smallmouth bass and continued for channel catfish until terminated in 1988 at the request of NPS (NPS, 1995).

Managing and protecting the fisheries along the Buffalo is a task with many pressures. In order to protect the fish community of the river, management actions must also be taken to protect the tributaries. These are important habitats for breeding and larval development. Poor land use practices such as land clearing and channel modifications result in increased nutrient levels, greater erosion, and habitat loss. These impacts are felt through the tributaries and the results are eventually manifested in the Buffalo River's fish community. As part of NAWQA, fish communities were assessed in the Ozark Plateaus study region from 22 reaches at 18 stations in 1993, 1994, and 1995 (Petersen, 1998). Several sites were located on the Buffalo River and its tributaries. The study looked at the impact of different land use practices on species composition and diversity. It also analyzed the effects of other factors on fish population structure like stream order, drainage basin size, and disturbances such as channelization (Petersen, 1998).

The study found that in reaches with forest as the predominant land use, the relative abundance of stonerollers and suckers was smaller and the relative abundance of sunfish and darters was larger (Figure 44 a and b) (Petersen, 1998). Stonerollers (Figure 43) showed the greatest (and only statistically significant) difference in relative abundance between forest and agricultural basins, with 14% of the population in forested basins and 35% of the population in the agricultural basins (Petersen, 1998). In forested basins, sunfish made up 11% of the population and darters 14%. In agricultural basins, only 4% of the population was sunfish and 4% was darters (Petersen, 1998). This higher relative abundance of stonerollers and lower abundance of darters and sunfish in agricultural basins was also reported in a study by ADEQ (1995) in the upper White River basin in Arkansas. The relative abundance of stonerollers consistently increased and the relative abundance of darters decreased as more sites were developed into pasture and animal production over the years (Petersen, 1998). Increased nutrients and warmer water from a more open canopy around the stream combine to produce ideal conditions for increased algal growth. This provides a food source for stonerollers, resulting in higher relative abundance in agricultural areas.

Figure 43 . Stoneroller (*Campostoma sp.)*

Stonerollers live in large schools near the bottom and feed primarily by scraping attached algae from submerged objects using a hard shelf-like extension on the lower jaw.

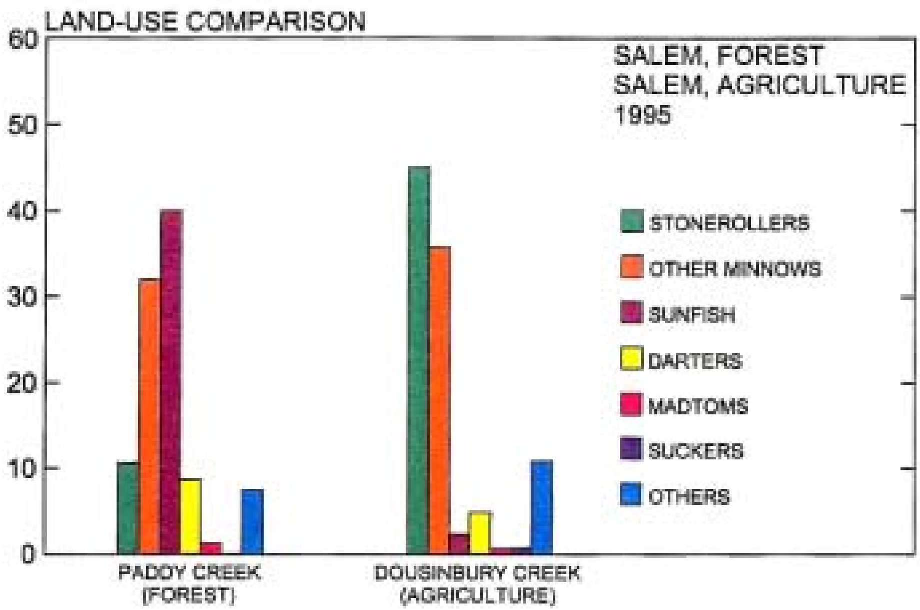
Picture taken from: www.dnr.cornell.edu/Sarep/fish/Cyprinidae/stoneroller.html

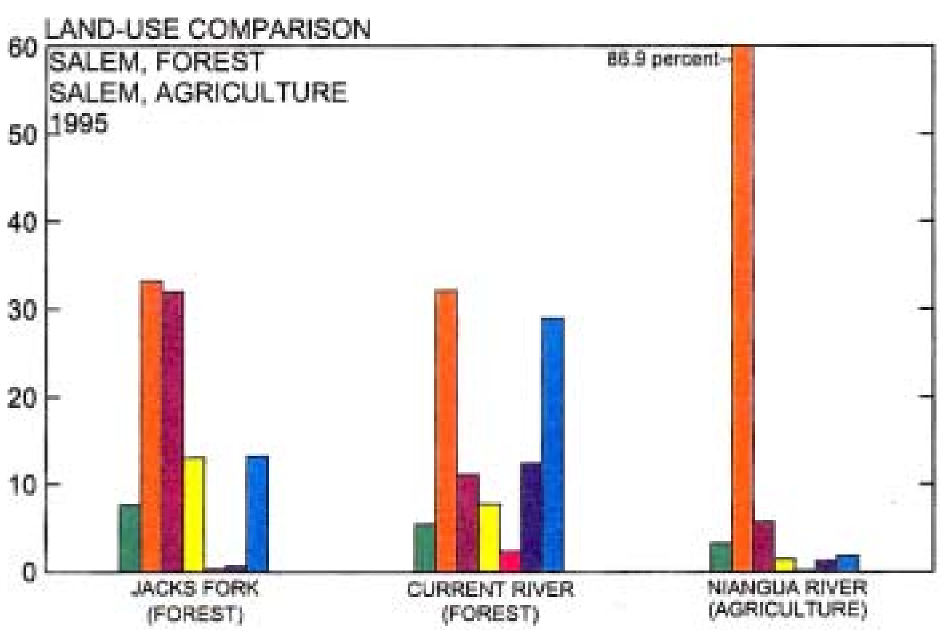
These trends have not always held true however; there were a few sites that showed exceptions, including Big Creek and the Buffalo River near Boxley (Petersen, 1998). Both had a relative abundance of stonerollers between 35% and 40%, indicating that land use and associated higher nutrient concentrations and more open canopy are not the only factors that determine stoneroller abundance (Petersen, 1998). Possible explanations relate to the water chemistry of these streams. For Big Creek, the limited water quality data available suggested that the nutrient concentrations were higher than for most other forest reaches (Petersen, 1998). For the Buffalo at Boxley, stream morphology, lower alkalinity, and location in the Boston Mountains make the reach different from the other forested reaches (Petersen, 1998).

Other disturbance activities besides agriculture have been shown to increase the abundance of stonerollers. Ebert and Filipeck (1998) reported that central stonerollers were more abundant in reaches of a third order Boston Mountain stream altered by channelization when compared to more natural reaches. These channel reaches had less canopy cover and were shallower. Regardless of the form of disturbance, the abundance of stonerollers is related to the availability of periphyton, its main food source (Petersen, 1998). Stonerollers graze on periphyton and are usually the most abundant herbivores in Ozark streams. When nutrient concentrations increase and canopy cover decreases, periphyton densities increase, providing more food for the stonerollers.

Maintaining heterogeneous habitats including a well-developed pool/riffle sequence, is important to both the overall fish community and to single species. A study by Walters, (1993) analyzed the specific habitat needs of an important game fish in the Buffalo River, the smallmouth bass. The study observed smallmouth bass population structure in pools and runs of the Buffalo for young and adult fish to determine microhabitat preferences. The results indicate that adults and young have different habitat preferences both among each other and overall when compared to other smallmouth bass habitat studies in other streams. Young smallmouth preferred mid depths in pools and adults preferred deeper areas in pools with more cover. The most important source of habitat for young smallmouth appeared to be cobbles in runs and shallow pools, refugia too small for adults. Adults favored large boulders and submerged logs. This study reinforces the importance of habitat diversity of even a single species of fish. Channel modifications, bank destabilization from riparian zone clearing, and increased sediment input result in shallow pools, poorly developed riffles and loss of refugia zones, which ultimately leads to changes in fish community structure.

Figure 44 a and b. Relative abundance of selected taxa at selected sties in comparison to forest and agricultural land use **(Petersen, 1998)**





Other pressures on fish populations in the Buffalo River watershed include heavy recreational use by anglers and canoeists. According to the River Use Plan, 33,000 anglers used the river in 1981 and a study in 1977 estimated 27,380 anglers/year (NPS, 1983). The annual number of anglers for 1991/1992 was 8,848, much reduced from the late seventies and early eighties (Johnson, 1993). Recreational pressure has not increased on the river since 1981, indicating the effectiveness of NPS efforts to control boat numbers on the river (Johnson, 1993**).** Between 1991 and 1992, a total of 1,656 boats containing 3,071 recreators were contacted by the creel clerks, 9.2% of those surveyed were anglers (Johnson, 1993). Smallmouth bass was the principle gamefish, harvested at a catch rate of 0.08/hr in 1991 and 0.03/hr in 1992 (Johnson, 1993). This is a small harvest rate when compared to other streams and is not likely impacting the population. Other common angling fish include the Ozark bass (*Ambloplites constellatus*), longear sunfish (*Lepomis megalotis*), flathead catfish (*Pylodictis olivaris*) and channel catfish (*Ictalurus punctutus)* (Cashner and Brown, 1977).

Whisenant and Maughan (1989) conducted a study using old creel survey records to determine whether the increase in recreational use from 1965 (5,500 canoeists) to 1982 (51,000 canoeists) impacted Ozark bass (*Ambloplites constellatus*) and smallmouth bass (*Micropterus dolomieui*) populations. The study also provided baseline data on habitat and food requirements for both species. Lengths for both the Ozark and Smallmouth bass were found to be close to the national average and there appeared to be no change in mortality rate due to increased recreational use and consequent increase in angling pressure.

The guidelines for managing and protecting the high quality fishery of Buffalo National River are discussed in the Fisheries Management Plan (NPS, 1995). The Fisheries Management Plan is watershed based with recreational fishing represented as an important component. Commercial fishing and competitive activities such as fishing tournaments are not permitted within the park. Habitat manipulation is only permitted to mitigate past inappropriate practices. Efforts to increase numbers of fish artificially beyond their natural carrying capacities or to introduce new species to provide for “better” recreational fishing will not be considered. However, efforts to establish or restore natural, self-sustaining populations are encouraged in the plan.

Some specific goals and objectives from the plan are summarized below (NPS, 1995):

1. Fisheries management will seek to preserve and restore natural ecosystem functions and components such as aquatic habitats and to conserve natural abundance and distribution of native aquatic species, including fish, together with associated terrestrial habitats and species.
   Objectives
   - Hire full time fisheries biologist
   - Obtain baseline data on selected aquatic, physical, chemical and biological parameters
   - Design and implement long-term monitoring to establish trends
   - Evaluate potential for restoration of channel catfish

- Develop a plan to assess the potential effects caused by cold water releases from Bull Shoals dam on fish species

2. Provide diverse and quality recreational angling opportunities for native species.
   Objectives:
   - Assess recreational angling baseline opportunities
   - Correlate recreational data with long-term biological monitoring data to recognize potential impacts on fisheries program
   - Maintain adequate fishing access within the confines of NPS policy, regulations, and management goals
   - Design and implement actions in response to fisheries compliance issues

3. Coordinate management of resources with state, federal, and private sector
   Objectives:
   - develop formal agreements with cooperators to promote better communication
   - define common needs
   - provide mechanism to mitigate joint issues
   - develop forum for information exchange
   - develop information/exchange outreach

Aquatic Macroinvertebrates

In the past, most monitoring strategies were based on physical, chemical, and microbiological techniques. More traditional methods measure water quality only at the time samples are collected and may fail to detect pollutants that occur at low concentrations or as periodic fluxes. They also analyze for a limited number of compounds and say nothing about biotic effects of the perturbation. Until recently, biological techniques have been ignored but today we have realized that a more integrated monitoring program produces more accurate results. For example, when Ohio EPA added biological methods to its conventional physiochemical monitoring program, the number of streams and lakes considered degraded doubled. The Buffalo River does not currently have a biomonitoring program. However, there has been extensive research done on macroinvertebrate community structure and how it is influenced by physical and chemical degradation of the river. As the following reports indicate, there is a great need for Buffalo National River to develop a long-term biomonitoring program using indices designed specifically for the Buffalo River system. There has not been a well-supported aquatic macroinvertebrate index with regard to community structure and much of the previous work in the Ozarks and on the Buffalo has differing degrees of taxonomic complexity.

In 1982, Getltz and Kenney conducted one of the first macroinvertebrate studies, a survey of benthic macroinvertebrates along the Buffalo River. They found a dominance of Ephemeroptera and Diptera during all sample seasons, likely associated with the high alkalinity of the water. Tricoptera and Coleoptera were also common, with collector and collector/scraper functional feeding groups dominating (Getltz and Kenney, 1982).

Shredders were not the dominate functional feeding group in the headwaters as predicted by the River Continuum Concept (RCC) (Vannote et. al, 1980) but this may be a result of cattle grazing in Boxley Valley and decreased CPOM input into the river. A lower representation of collectors and scrapers and more shredders may have been found if sampling had been conducted above Boxley Valley. The study also stressed the need for a diversity index that better represents the changes in species composition. The Shannon Weaver diversity index used in this report showed no significant trends for macroinvertebrates in the Buffalo and is considered to be a poor indicator of species diversity for the river (Geltz and Kenney, 1982).

Mathis (1990) conducted a macroinvertebrate community structure assessment on selected sites in the Upper Buffalo using Hilsenhoff's Biotic Index (HBI). This index incorporates species diversity with indicator organisms. It specifically assigns weighted factors to each taxon according to their known pollution tolerances and then uses these adjusted values in a calculation similar to those for species diversity. Six 0.1 m^2 benthic samples were collected at each site on six dates using a modified Hess sampler and specimens were identified to lowest possible taxonomic level. Tolerance values were assigned to each species and the HBI was calculated on pooled data collected from November to March. Sites were selected as pairs, one with higher water quality and one with lower quality. Main channel sites included the relatively pristine reach in the upper Boxley Valley just below the boundary of the Upper Buffalo Wilderness Area and two more disturbed sites at the downstream end of the valley near Ponca. Tributary sites included the pristine site at Cecil Creek near Erbie and a more disturbed Mill Creek near Pruitt. Selection of these sites was done so as to minimize differences between physical attributes.

No distinct seasonal patterns were observed and there were no consistent differences between Upper Boxley and Ponca (Mathis 1990). However, a strong pattern of lower diversity at Mill Creek when compared to Cecil Creek was apparent (with the exception of the June sampling date). Figure 45 shows the Shannon's Index of Diversity (H) for the four sites, one of the diversity indices Mathis used in his analysis. Shannon's Index (H) is a statistically derived value that incorporates both the proportional abundance of species in a sample along with the species richness, or total number of species in the sample. The results in Figure 45 show that Mill Creek has a consistently lower diversity over time when compared to the other three sites.

Mathis (1990) also compared community composition by percentages of pollutant tolerant and intolerant groups. Ephemeroptera, Plecoptera, and Trichoptera are Orders of insects whose larvae are considered intolerant to pollution (Figure 46). The proportion of these three groups in a sample is combined into an EPT index. When comparing sites, sites with higher EPT values generally have better water quality. Diptera is considered a pollution tolerant group and their proportions are incorporated into another proportion EPT:D. Again, lower values indicate poorer water quality. In Figure 46, values for both EPT and EPT:D were higher at the two pristine sites indicating a greater abundance of pollution intolerant taxa at these sites as compared to Mill Creek and the Buffalo at Ponca site (Mathis 1990).

Figure 45. Shannon's Index for the four sites (Mathis, 1990)

"H" represents an index of diversity, higher values mean greater diversity at a given site. Mill Creek shows consistently lower diversity

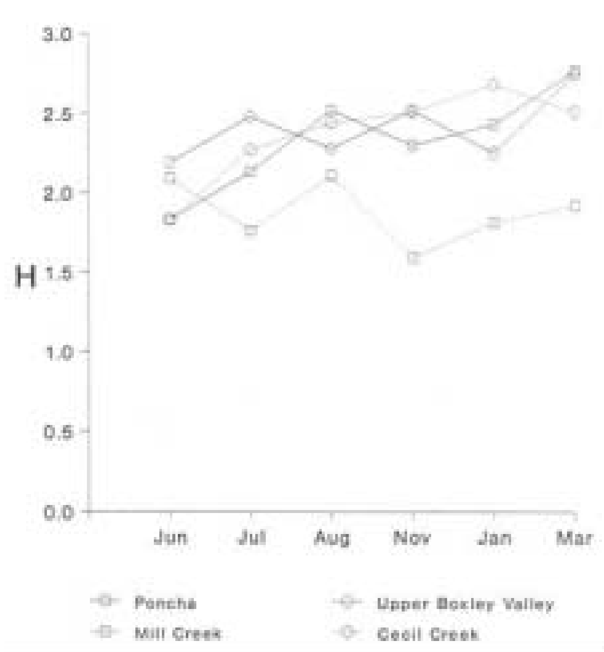
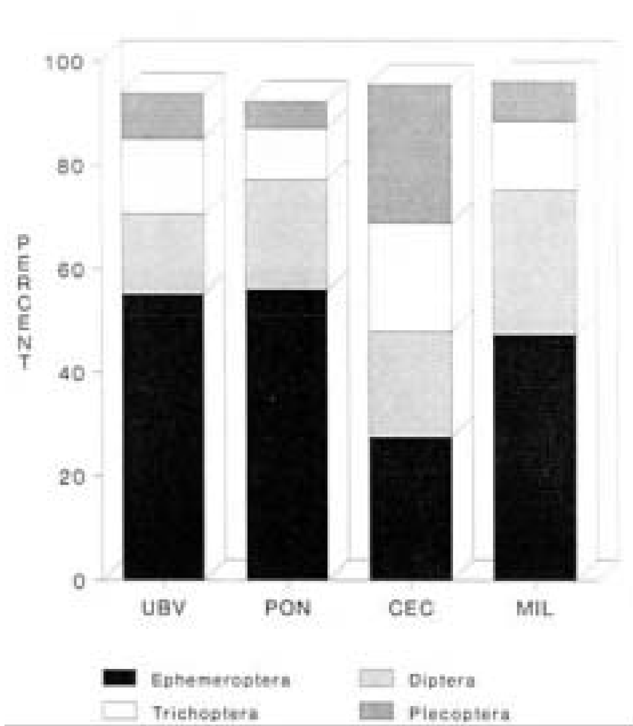


Figure 46. Community Composition by percent Ephemeroptera, Trichoptera, Plecoptera, and Diptera compared by site. (Mathis, 1990)



The presence or absence of indicator species which are either pollution tolerant or intolerant gives an indication of the water quality at a particular site. Taxa considered by Hilsenhoff to be pollution intolerant were collected at only the two pristine sites (Cecil and Upper Boxley) (Mathis 1990). These included the caddisflies *Stactobiella, Wormaidia*, and *Rhycophila* and the stoneflies *Paracapnia* and *Zealeuctra.* Intolerant taxa that were present at all sites but whose relative abundance's differed substantially at pristine versus disturbed sites included the mayfly *Triocorythodes*, the caddisfly *Agapetus*, and the stonefly *Isoperla* (Mathis 1990).

Two major conclusions can be drawn from these results. First, the aquatic assemblages at the Cecil, upper Boxley, and Ponca sites indicate that these stream reaches are relatively "healthy". However, Mill Creek's results suggest that the stream has been impacted substantially. Secondly, although the Buffalo River at Ponca may be classified as relatively healthy, impacts have occurred. According to Mathis, " Results obtained from this site always were below those obtained at Upper Boxley. Numerous published reports and the RCC suggest that natural increases in species richness and diversity should have occurred on the stream between Upper Boxley and Ponca. Because my results demonstrate just the opposite, I suggest that as the stream flows through Boxley Valley, it is being slightly impacted by the disturbances associated with agricultural practices" (Mathis 1990). This report suggests that additional study is needed to determine the impact Mill Creek has on the Buffalo River and to further verify the Boxley Valley findings.

Mathis has also conducted other baseline studies on spring systems and tributaries to assess disturbance impacts and continue the development of a biotic index for the Buffalo River. In one study (Mathis, 1994a), baseline data were established for the fauna inhabiting three springs in the Fitton Cave area. These springs are important ecosystems which provide an isolated habitat for many rare and unusual aquatic organisms; at least 65 species of invertebrate animals are restricted to these crenal habitats in the Ozarks. Many of these species represent relic populations of more northern species that cannot survive the high water temperatures in area streams during the summer. Polluted groundwater poses a significant threat to these species, particularly in the Ozarks with karst geology and poorly developed soils.

Samples were collected from Chestnut, Fitton, and Hutchinson springs at 3-month intervals at the eucreanal zone, the area near the source characterized by stable physical characteristics (Mathis, 1994a). Unlike normal warm water streams where insects dominant the macroinvertebrate fauna, spring ecosystems are often dominated by non-insect forms. In all three springs sampled, the dominant species was *Licerus hoppinae*, an isopod. However, richness was much greater in the insect group (Mathis, 1994a). Richness was much lower in the three springs when compared to larger streams in the Buffalo River watershed (Mathis, 1994a). This is expected due to the specific characteristics and homogeneity of the spring sites (Mathis, 1994a). These sites have high water quality and the results of this investigation reflect that water quality. Although overall diversity and richness is low compared to warm water streams, richness and diversity is much higher in these springs when compared to more impacted springs in

Northwestern Arkansas. These sites would be useful reference sites as the results observed reflect near pristine conditions (Mathis, 1994a).

In another study, the impacts of pesticide applications near two tributaries were assessed using macroinvertebrates (Mathis, 1994b). Baseline data was also obtained for these streams and used in the development of a biotic index. Spraying of the pesticide Dimalin and the biological control agent *Bacillus thuringiensis* were initiated in the summer of 1993 to control a gypsy moth (*Lymantri dispar*) outbreak. These pest control substances are known to have long-term impacts on stream communities and may affect non-target species through direct toxic effects or biomagnification.

The results of this study indicated that both streams were relatively unaffected by any anthropogenic disturbances including the pesticide and other pest control applications, with both locations dominated by pollution intolerant orders Ephemeroptera, Trichoptera, and Plecoptera (Mathis, 1994b). Many of the species present were highly susceptible to pollution. Large numbers of shredders and predators were also present, indicating a healthy community structure. In cases of anthropogenic disturbance, shredder and predator populations typically decrease dramatically. Species richness was extremely high for headwater streams, along with values for Margelef’s Index, Shannon’s Index of Diversity (Mathis, 1994b). These high values indicate good water quality and community health.

In a similar attempt to understand the macroinvertebrate community along the river and its relationship to anthropogenic disturbance, Bryant (1997) tested the River Continuum Concept (RCC) along fourth and fifth order reaches of the Buffalo River. Among other things, the RCC predicts biotic transformations down a stream's gradient (Vannote et. al, 1980). The RCC predicts that species richness and diversity are lower in headwaters reaches, increases in midreaches, and a return to decreased richness and diversity in lower reaches (Vannote et. al, 1980). Bryant found that discharge, conductivity, pH, and temperature increased in the downstream direction while substrate size decreased. In contrast to the RCC, richness, diversity, EPT:D, and EPT taxa were reduced in the middle-river reaches. After extensive review of the RCC and the macroinvertebrate data, and to his own admitted surprise, Bryant concluded that "significant changes in community structure have occurred in some portions of the stream and that these changes most probably result from anthropogenic (human-induced) disturbances." Bryant's work showed that species richness and diversity were negatively correlated with nitrate concentrations at the sampling sites. Thus indicating that "nonpoint source pollution may be changing the natural continuum in lotic community structure in this reach."

Bryant (1997) also found that populations of the exotic mussel Corbicula (*Corbicula fulminea)* were higher in the middle reach, particularly at Woolum, as compared to the other sites. Corbicula (Figure 47) was first introduced in the U.S. in the Columbia River during the early 1930’s as a supplemental food source. Since its introduction, Corbicula has extended its range to include 38 states in the northern climate. Corbicula was first documented in Arkansas by Fox (1970) and he concluded that it was already widespread throughout the state. Corbicula does not produce a parasitic larval form like most indigenous mussels. It has a free swimming larval form which gives it a greater advantage for colonization and dispersal. Once in the adult form, dispersal is limited and occurs primarily by wading birds. Research has shown that Corbicula can only successfully invade communities that have already been disturbed. If the native fauna is not already distressed, Corbicula cannot displace the native species (Bryant 1997).

Usrey (2001) expanded upon Bryant's findings in the middle reach of the Buffalo River by using a large number of sites to determine possible causes for the loss in diversity and richness. Analyzing 10 years of water quality data indicated that elevated levels of nitrogen occur at the mid-reaches of the river and that these increased concentrations are due to nonpoint source loading by several tributaries. Nitrogen levels for four mid-reach tributaries (Mill Creek, Little Buffalo River, Big Creek, and Davis Creek) represent approximately 40% of the total nitrogen loading to the river and average nitrate values are two to four times higher in these tributaries than in the adjacent river (Usrey, 2001). The highest nutrient loads come from Little Buffalo River and upper Big Creek. Usrey suggested that declining water quality and increasing densities of Corbicula were the two disturbances that are most likely responsible for the shifts in macroinvertebrate community species composition in the middle reaches of the river.

Figure 47. Corbicula (*Corbicula fulminea*)

Picture taken from: www.zoo.cam.ac.uk/zoostaff/aldridge/corbicula.html Scale in mm.

To further investigate these mid-reach disturbances and their impact on macroinvertebrate community diversity, Usrey (2001) sampled eight sites seasonally for one year. Physical habitat and water quality were also measured at each site. No seasonal relationship was apparent between increasing nitrate levels and the various parameters that measure diversity and health of the macroinvertebrate community. However, when all seasons were combined, increasing nitrate concentrations correlated with decreasing abundance of EPT (Usrey, 2001). The lack of association at the seasonal level could be due to differences in the collection and analyzing of water quality data. Further evidence of the effect of nutrient enrichment on the community is shown by the correlation of Diptera abundance with increasing orthophosphate concentrations (Usrey, 2001).

In order to assess mid-sized tributaries and determine reference water quality conditions along with continuing the development of a biomonitoring program for the Buffalo River, Bradley (2001) sampled four tributary sites for water quality and macroinvertebrates quarterly for two years. The sites included Bear Creek, Tomahawk Creek, and Calf

Creek, all representing disturbed streams in the mid to lower reaches of the Buffalo's watershed. Water Creek was used as a reference site. Its watershed is primarily forested while the other three streams have a larger percentage of cleared land. Bear Creek and Calf Creek have larger drainage basin areas and a higher average yearly discharge compared to Tomahawk and Water Creek. All four sites are located in the middle portion of the Buffalo River drainage and generally have similar geologic and habitat characteristics if left undisturbed.

Water quality characteristics, including dissolved oxygen, conductivity, temperature, and pH were similar among the four sites and typical for the Ozark Highlands ecoregion (Bradley, 2001). They reflected typical seasonal trends and the geology of the area. Because discharge was significantly higher for Bear Creek and Calf Creek in the spring, fecal coliform and turbidity levels were also higher for these sites (Bradley, 2001). This was expected due to the larger drainage area and more cleared land. Water Creek was low in turbidity during all seasons, likely due to a higher proportion of forested land in its drainage. Tomahawk Creek showed a consistent level of fecal coliform throughout the year while the other three sites fluctuated, indicating a possible point source pollutant like a septic tank or continuos direct access of livestock to the stream (Bradley, 2001).

The four tributaries showed both seasonal and between year variations in macroinvertebrate community structure, density, and richness (Bradley, 2001). Most of the seasonal variations in community composition are explained by differences in life histories of the organisms and not due to anthropogenic disturbances. Between year shifts cannot be explained by life history alone. In the disturbed tributaries, the largest component of the community was Diptera, a pollution tolerant group typically abundant in streams with organic enrichment (Bradley, 2001). Water Creek was dominated by Ephemeroptera (mayflies) and Coleoptera (beetles), much less pollution tolerant groups (Bradley, 2001). Another important finding in Water Creek was the presence of large numbers of riffle beetles in the family Elmidae. These beetles are long lived compared to other aquatic organisms, sometimes up to five years. They also have vestigial wings, making migration from an impacted habitat difficult. This longevity and lack of ability to relocate makes them more susceptible to changes in water quality. It is likely that members of the Elmidae family would be found in the other three tributaries if they had been left undisturbed (Bradley, 2001). These differences in taxonomic composition resulted in significantly lower percent EPT, EPT:D and diversity at the three impacted streams compared to Water Creek, the reference stream (Bradley, 2001).

Dick (1998) conducted similar research, collecting water quality and macroinvertebrate data from four perennial and two intermittent headwater tributaries to the Buffalo River. The objectives were to gather baseline information on macroinvertebrate assemblages in regional headwaters streams, determine significant differences assemblages, and relate variation in community assemblages to environmental variables. As expected, significant differences in community attributes were observed between intermittent and perennial streams, and that seasonal succession was most influential in structuring the communities. Flow regime was also more important than stream order (size) in structuring macroinvertebrate communities. The study found that significant natural differences in benthic macroinvertebrate communities exist among headwater streams in the Ozark physiographic region. Ecological and biological water quality monitoring investigations must standardize by season and for flow regime in order for legitimate comparisons to be made (Dick, 1998).

Finally, Jackson (2001) conducted a study to compare the macroinvertebrate communities among spring ecosystems in the Buffalo River's watershed. Seven spring sites were selected and sampled quarterly for one year. Physical and chemical parameters were measured along with macroinvertebrates. Luallen Spring, Lost Valley Spring, and Leatherwood Spring are all low volume springs that have no flow or greatly reduced flow in the summer and fall. Fitton and Hutchinson Springs have moderate, variable flows throughout the year and Mitch Hill and Gilbert Springs are large volume, perennial springs with relatively high discharges throughout the year.

Correspondence and Principle Component Analysis were used to compare the physical and chemical data with the macroinvertebrate data among the seven spring sites. The analysis resulted in three distinct groups based on macroinvertebrate community structure (Jackson, 2001). Mitch Hill and Gilbert were dominated by amphiopods; Fitton, Hutchinson, and LuAllen springs were dominated by isopods, insects, and oligochaetes; Leatherwood and Lost Valley consisted mostly of insects (primarily dipterans) and oligochaetes (Jackson, 2001).

Water quality data did not show any clear patterns between spring groups; the parameters for each site were in close range with each other (Jackson, 2001). Fecal coliform levels were high at Gilbert and Lost Valley throughout the year. The levels at Gilbert Spring were due to a small town with leaching septic tank lines and at Lost Valley due to an area of concentrated vacation cabins with septic lines. The physical characteristics, including substrate, discharge rate, vegetation and detritus levels, followed the same clustering pattern as the macroinvertebrates (Jackson, 2001). Discharge (permanence of flow), substrate, and emergent vegetation showed the strongest correlation with the macroinvertebrate community, in other words, these are the most important variables that influence the community (Jackson, 2001).

These community assessments and correlations with water quality demonstrate the complexity of the macroinvertebrate community of the Buffalo River and its interdependence on the unique physical, chemical, and biological characteristics along with the impact of anthropogenic disturbances on their community structure. To address this issue, Mathis (2001) produced a multimetric biological monitoring system based specifically on macroinvertebrate communities inhabiting the Buffalo called the Index of Community Integrity (ICI). This would allow resource managers to more reliably identify areas of the river that are experiencing water quality degradation. This information will help formulate best management practices and remediation plans to improve water quality. The program was designed to be cost effective, easy to implement, and to enhance the current physiochemical monitoring program.

The ICI is a multimetric system that integrates the results of several metrics into one score. An important advantage of a multimetric system is that it minimizes the influence any one metric has on the score (Mathis, 2001). By chance alone samples from one site may yield a score not expected under the given water quality conditions forcing resource managers to make decisions about which metrics are more important and informative (Mathis, 2001).

To calculate an ICI, the individual metric scores are summed to produce an overall ICI score for a given site on a given date. Ten metrics are typically used, each with values ranging from 1 to 10, higher values indicating greater community health. If all ten metrics are used, the highest possible score would be 100 and the lowest would be zero. Usually a site with good water quality has most scores in the highest range with a few in the middle and sometimes even the lowest range (Mathis, 2001). Ten metrics were selected for the Buffalo River ICI including Margalef's Index of Taxa Richness, Shannon's Taxa Diversity Index, percent dominant taxa, percent Chironmidae, percent Plecoptera, percent Trichoptera, percent Corbicula, percent intolerant, percent Elmidae, and percent collector-filterer.

Testing of the ICI with correlation analysis found that the index accurately portrays water quality in the main channel of the river during three of the four seasons (Mathis, 2001). During the summer when precipitation is low, little transport into the river occurs and sites may appear to have high water quality when in fact they are greatly impacted by storm flow transported nonpoint source pollution. Some main channel sites that exhibited relatively low concentrations during low flow had values over three times higher during periods of high flow. This is why Mathis chose to use annual means for each metric rather than seasonal means. Incorporation of the ICI into a long-term biological monitoring program will help in the understanding of the impact of anthropogenic disturbances on the Buffalo and provide a more complete set of data for managers to use in decisions and management actions (Mathis, 2001).

Rare, threatened, and endangered species

Buffalo National River is home to only a few federal endangered or threatened species. The alligator snapping turtle (*Macroclemys temmincki)* has been documented within the National River but no systematic reptile studies/surveys have been implemented. The Neartic Paduniellan Caddisfly *(Paduniella nearctica)* is a candidate species and an Ozark endemic which has been found in small numbers at two sites on the upper reaches of the river. Recent surveys have documented the presence of the Ozark shiner *(Notropis nubulis),* a federal candidate fish species. The endangered Gray Bat (*Myotis grisescens*), Indiana Bat (*Myotis sodalis*), and Ozark Big-eared Bat (*Carynorhinuss townsendii ingens*) reside in cave areas along the Buffalo and forage for emergent aquatic insects from the river, its tributaries, and springs. Most of the caves that serve as important habitat units for these species are closed to public access. Moved from endangered to threatened status in 1994, the Bald Eagle (*Haliaeetus leucocephalus*) is common along the Buffalo, particularly in the wintertime on the lower reaches of the river. Fifty to one hundred bald eagles winter along the river.

While there are no mussel species listed as threatened or endangered, several species are extremely rare, as shown in Appendix B. In 30 years the freshwater mussel abundance and diversity have declined throughout the United States, and freshwater mussels are imperiled. Declines in mussel distribution, abundance, and diversity are primarily due to extensive habitat degradation and destruction associated with human activities, many of which have been documented within the Buffalo River. An old survey of mussel resources found that two species, *Ligumia recta* and *Potamilus purpuratus*, once common, are now extirpated from the Buffalo River. In 2001, the USFWS listed the Scaleshell mussel (*Leptodea leptodon*) as an endangered species. Distributions of Scaleshell within the river have not been documented and an imminent need to search for the Scaleshell within the river exists. The background knowledge of historic and current mussel species composition and locations within the Buffalo River is unique among NPS units. BUFF has mussel population data that spans 85 years upon some portions of the river, but the information is outdated and incomplete. The lack of information on the current condition of the mussel resources is problematic. A complete list of state species of concern and their status can be found in Appendix B.

Exotics

Besides the exotic mussel, Corbicula, discussed earlier in the macroinvertebrate section, rainbow and brown trout are other exotic aquatic species in the Buffalo. Small populations of trout can be found in the lower Buffalo, migrating up from the cool, heavily stocked waters of the White River. The limited number of exotic species in the Buffalo may be due in part to the cold waters of the White River which may provide a barrier to warm water exotic species spreading into the Buffalo. However this does not prevent invasion of exotic species and introductions can still occur. There is presently no consistent long term monitoring program so the presence of exotic species may go undetected.

The park does have another exotic species, the feral pig or European Wild Hog that likely has an impact on water quality. The feral pig was introduced into the United States in the early part of the 20^{th} century in North Carolina and has since spread south and west, including Arkansas. Wild hogs are a problem for many National Parks, particularly at Great Smokey Mountains National Park, where much of the feral pig ecology research has been conducted (GSMNP, 1985). Feral pigs are present in many areas in Northwestern Arkansas, including Buffalo National River. A survey of wildlife officers conducted in 1998 found that feral pigs had been observed or reported in two counties with NPS land (Conner, 1998).

Feral pigs have a negative impact on vegetation, which in turn affects water quality nearby. Pigs feed by rooting and digging for plants, roots, and insects. The amount of vegetation taken often depends on the quality of the mast year. High quality mast years (season of vegetation growth and production) typically result in less vegetation destruction (GSMNP, 1985). Rooting and digging activities are the first sign of feral pig presence. Wallowing, or rolling in the mud to control body heat, is also common in the warmer months of the year. The result is usually an increase in early successional plant species or a loss of plant cover all together. Ground cover is reduced, decomposition decreases, and the nitrogen cycle is altered (GSMNP, 1985). Nutrient leaching is accelerated and erosion becomes more apparent in pig feeding areas. Pigs have also been shown to contribute to increased bacteria loads in streams near rootings and wallowings and destabilize soil (GSMNP, 1985).

Algae

There has been limited research on the algae community along the Buffalo River. This is an area that needs more attention; algae are the base of the aquatic food chain and they serve as excellent bioindicators of water quality. Algae blooms are quick to respond to changes in water quality and habitat; these changes are easily observed by looking at species composition and diversity.

Meyer (1976) conducted a baseline study of the spatial and temporal distribution of algae in the Buffalo River. It was done in conjunction with a water quality assessment. The study found that algal distribution seemed to be most clearly determined by water level, flow rate, and flooding. Other factors that affected algal distribution included water chemistry, light, and temperature fluctuations. The principal algal component along the Buffalo is periphyton, or attached algae. There is a usually an extensive bloom of *Spirogyra sp.* (a green algae, hair-like periphyton) during the summer months along the lower Buffalo. However, there is a diverse algal community associated with variations in substrate and flow rate (Meyer, 1976). The structure and distribution of the algal community is also dependent on the continuity of flow and diversity of habitat. In the upper river, the algae are most numerous during periods of higher discharge (May through October). Species that are present during lower flow periods must have modifications to survive drought and desiccation (Meyer, 1976). Diversity increases longitudinally down the river, with species from the upper section of the river also present in the middle portion and species from the middle portion present in the lower section of the river (Meyer, 1976). Diatoms, greens, blue-greens, and even some red algae are present at various habitats along the river. Differences in population structure and density appear to be related to substrate availability rather than nutrient concentrations (Meyer, 1976). Meyer found that orthophosphate concentrations (the soluble source of phosphorous taken up by algae) was very low in the river, indicating it is quickly processed by the algal population, suggesting it could be a limiting nutrient. Meyer hypothesized that increased levels of phosphorous could increase the density of algae and frequency of algal blooms present in the river.

Periphyton in Ozark streams is influenced by many factors, such as light, spatial and temporal temperature variations, nutrients, grazing, and other physical disturbances such as floods and droughts. Many of these relationships are clearly defined such as light or physical disturbances. Algal biomass often decreases as the amount of riparian vegetation and thus shading increases. Physical disturbances like floods, droughts, or instream gravel removal can cause near depletion of periphyton from the stream bottom but the algal community generally recovers within two to four weeks (Lohman and others, 1992). Temperature also has a fairly predictable impact upon periphyton communities. Local groundwater influence, which is a major factor in the karst terrain of the Ozarks, can have substantial impacts on water temperatures. Groundwater influence causes cooler temperatures in the summer and warmer temperatures in the winter along with a more stable streamflow. Other relationships are not as clearly defined but just as important. Petersen and Femmer (2002) attempted to present and define these relationships between periphyton community structure and environmental factors, as related to Ozark area streams. The assessment was conducted through the NAWQA program of the U.S. Geological Survey. Data were collected at 51 stream sites in the Ozark Plateaus ecoregion. Samples were collected from August through September of 1993 to 1995. The study looked at sites in six land use categories, forest, agriculture, mining, urban/mining, urban, and one site with a mix of land uses.

While Petersen and Femmer (2002) found no environmental factors that correlated with total biomass of periphyton, the biomasss of blue green algae and diatoms did significantly correlate with several different factors. It appears that land use, nutrient concentration, and alkalinity are the most important water-quality factors influencing periphyton communities. Biomass of blue green algae and percent agriculture land use were significantly and positively correlated. Biomass of diatoms was significantly and positively correlated with alkalinity and negatively correlated with embeddedness, orthophosphate, total phosphorous, and dissolved organic carbon. In general, results indicate that total biomass increases with increasing alkalinity and decreases as siltation (embeddeness) increases.

Blue green algae composed the largest percentage of the periphyton community in all but two samples within the entire study unit. The relative abundance of blue green algae averaged 60 percent of the periphyton community. In relation to the Buffalo River, historic records indicate a shift in community composition from a historically higher relative abundance of diatoms. NAWQA samples indicate that sites usually exceed 90 percent relative abundance of blue green algae, a great contrast from the mid-1970’s when diatoms were described as the most abundant and diverse algal taxon on the river. Table 9 shows the diversity index, relative abundance, and taxa richness for sites on the Buffalo River and its tributaries.

Table 9. Shannon Wiener Diversity Index, Relative Abundance, and Taxa Richness for periphyton from sites in the Buffalo River watershed (Petersen and Femmer, 2002).

Site Name	Year	Shannon-Wiener Diversity	Relative Abundance			Taxa Richness		
			Blue-Green algae	*Diatoms*	*Green algae*	*Blue-Green algae*	*Diatoms*	*Green algae*
Big Creek near Big Flat	1994	0.96	99.0	0.6	0.0	4	13	0
Buffalo near Boxley	1993	1.50	88.4	11.0	0.6	5	21	1
Buffalo near Boxley	1994	0.71	98.6	1.0	0.0	4	18	3
Buffalo near Boxley	1995	1.11	94.0	5.8	0.1	4	25	1
Buffalo near Eula	1994	1.12	99.2	0.5	0.0	4	34	1
Buffalo near St. Joe-lower	1993	1.01	98.5	0.9	0.2	3	34	4
Buffalo near St. Joe-lower	1994	1.07	98.1	1.4	0.0	4	37	0
Buffalo near St. Joe-lower	1995	0.33	99.4	0.5	0.1	4	43	0
Buffalo near St. Joe-middle	1994	1.11	98.6	1.3	0.0	4	36	0
Buffalo near St. Joe-upper	1994	1.2	96.8	2.8	0.2	4	29	2
Richland creek near Witts Spring	1994	0.97	98.9	0.8	0.0	4	27	0
Water Creek near Evening Star	1994	1.07	94.1	5.4	0.0	3	21	0

Filamentous algae blooms have posed problems on the Buffalo, algal blooms in late summer are extensive enough to warrant complaints by visitors. *Spirogyra sp.* is the most common, occurring in dense, floating masses in pools along the middle and lower river. It was found in 60 percent of the macro algae samples taken from sites along the Buffalo River (Petersen and Femmer, 2002).

Fire

The primary effect of fire on water quality is from soil erosion. Fire removes ground litter and defoliates plants permitting the impact energy of raindrops to move soil particles in suspension. The soil is then carried off with surface water. Frequency and intensity of fire affects the rate of erosion. Frequently burned areas have reduced aerial and ground cover to intercept surface runoff, permitting unnatural rates of erosion.

According to the Buffalo River Fire Management Plan (NPS, 2003), most fires at Buffalo National River are small in size and erosion is minimal. Fires involving large areas and on steep slopes cause the greatest impact to water quality. Turbidity and sedimentation are increased with increased erosion, reducing sunlight, restricting respiration, and increasing water temperature. If misapplied, fire retardants and foams could potentially cause significant temporary to short-term impacts to water quality and aquatic life. However, unless the retardants are put directly into the water, their toxic effects should be minimized as dilution below toxic levels is quickly achieved. Impacts from one or two wildland fires or suppression efforts a year may have a short-term, localized, and minor impact on water quality but long-term effects are likely to be minimal (NPS, 2003).

Fluvial Geomorphology

The long-term consequences of the destruction of riparian vegetation are now becoming evident in Ozark streams, including the Buffalo River. Several studies have found that Ozarks streams have excess gravel loads and an altered geomorphology due to land clearing nearly 100 years ago (Jacobson and Prim, 1997; Panfil and Jacobson, 2001). At the time of European settlement, beginning in the 1830's, streams deposited more gravel and less silt and clay, indicative of less energy dissipation in the valley bottom from decreased riparian vegetation. Lower order streams became depleted of gravel and this gravel was accumulating in the higher order streams. Before European settlement, streams were depositing a mixed sediment load of gravel bedload and silty overbank sediment (Jacobson and Primm, 1997). Observations of early explorers conspicuously lack descriptions of extensive gravel bars; observations of geologists working during the middle to late 1800's include descriptions of large quantities of gravel in stream banks and beds (Jacobson and Primm, 1997). Valley bottom reworking is believed to have occurred faster in the last 100 years than over the previous thousands of years (Albertson et al., 1995).

Probably the most destabilizing effect on Ozark stream channels during this period was caused by livestock grazing in valley bottoms that destroyed riparian vegetation (Jacobson and Primm, 1997). Destruction of riparian vegetation in small valleys continued into the 1900's, encouraging headward migration of channels and resulting in extension of the drainage network and accelerated release of gravel from storage in the small valleys (Jacobson and Primm, 1997). From 1960 to 1993, cultivated fields and croplands decreased, but cattle populations continued to increase. This increase in grazing density is likely maintaining runoff and sediment delivery to streams at rates higher than natural background rates (Jacobson and Primm, 1997).

Panfil and Jacobson (2001) demonstrated that the amount of gravel in Ozark streams is positively correlated with cleared riparian buffer zones and with increased cleared land in the drainage basin. The proportion of cobble and boulders is negatively associated with both increased gravel and cleared buffer zones. A strong positive correlation ($R^2 = 0.85$) was found between the proportion of gravel in the thalweg and the proportion of cleared land in the drainage basin (Panfil and Jacobson, 2001) (Figure 48a and b). These results support the hypothesis that cleared land and pasture increase the supply of gravel in streams. Visual observations also support the relationship between cleared land and gravel flux into streams. In some tributaries, cobbles appear to be embedded in a matrix of chert gravel as though a gravel flux recently inundated the stream (Panfil and Jacobson, 2001).

When riparian vegetation has been excessively cleared, a chain of disturbances begins that results in modified geomorphology which causes habitat loss and negative impacts to stream biota. Increased fine sediment causes substrate to become embedded. Increased embeddedness reduces pore space between gravel and cobble, which is important habitat for macroinvertebrates and small fish. Embeddedness also inhibits flow of oxygenated waters through the bed gravel.

More gravel in the system reduces the average particle size and decreases particle diversity in the streambed (Panfil and Jacobson, 2001). When coarse substrates are lost, the larger pore spaces they provide are also lost, filled in with smaller gravel. Fluxes of gravel into the stream also cause the stream to become shallower, filling in channels and reducing longitudinal roughness (Panfil and Jacobson, 2001). Habitat diversity decreases as more gravel, glide habitats increase and pool habitats disappear. This reduces living space for pool-dependent species. Shallow streams also may have greater daily and seasonal fluctuations in water temperature.

Figure 48a. Relationship between the amount of gravel in the thalweg and percent carbonate bedrock (Panfil and Jacobson, 2001).

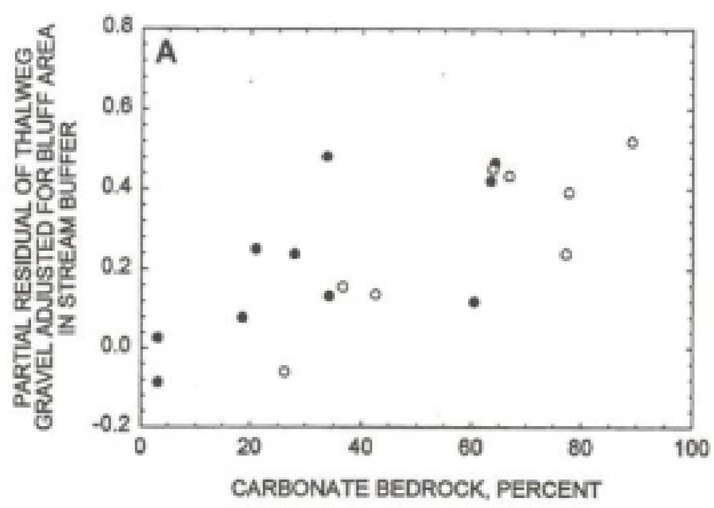
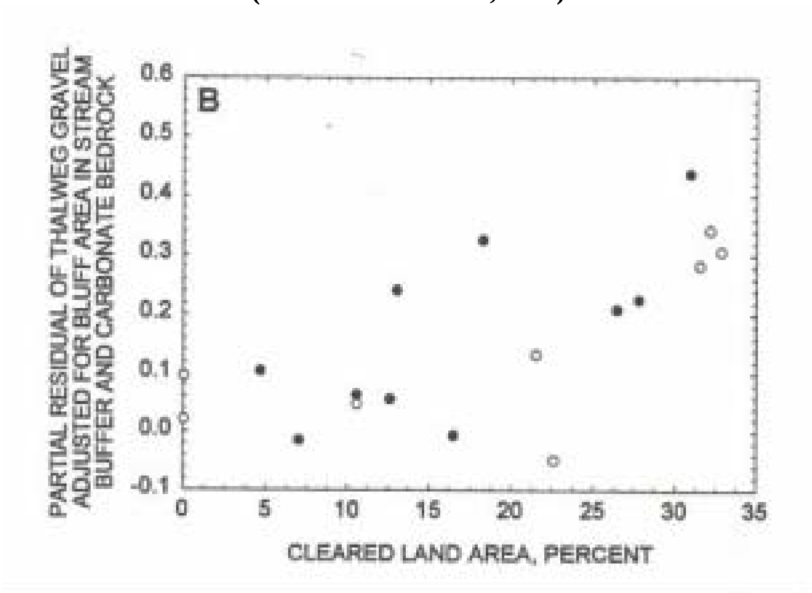


Figure 48a and b. Partial resdiual plots showing relations in the Buffalo River system among gravel in the thalweg, carbonated bedrock, and cleared land after accounting for differences due to bluff area in the stream.

Note that in figure a, as percent carbonate bedrock increases gravel along the thalweg increases and that in figure b, as cleared land area increases, gravel along the thalweg increases with adjustments for percent carbonate bedrock.

Figure 48b. Relationship between the amount of gravel in the thalweg and percent

of cleared land in the drainage basin, modified for percent carbonate bedrock
(Panfil and Jacobson, 2001).



Loss of coarse woody debris inputs into the stream from riparian vegetation means fewer debris jams and snags, which create flow diversity and initiate scour that forms pool habitats. Increased storm flows cause more erosion and bank destabilization, causing stream banks to become a source of fine sediment and gravel into the stream. Stream bank erosion also leads to stream widening, reduction in channel sinuosity, and loss of canopy cover. This creates shallower, warmer habitats and lowers habitat diversity (Panfil and Jacobson, 2001).

Socioeconomic Profile

Gordon and Baker (1995) constructed a socioeconomic profile of the Buffalo River region. Because the boundaries of the watershed do not fall neatly along any political boundaries, the three primary counties in the watershed were used as a proxy for the entire region. The study found that counties adjacent to Buffalo National River are some of the poorest in Arkansas. Unemployment is high, education levels are low, and the population is aging as young people move out. The local residents are predominantly cattle ranchers. The current tax structure and price structure provide an incentive for clearing forests for cattle pasture. In terms of per capita income, Searcy County is the second poorest of Arkansas' 75 counties. Newton County is tenth poorest, and Marion County is also below the median. About 25% of all people in the three-county region are below the poverty level, compared to 18% for all of Arkansas, and 12% for all of the U.S. (Gordon and Baker, 1995).

A USDA-Forest Service report, assessing the social and economic conditions in the Ozark-Ouachita Highlands region, found that median household incomes were $19,208 in the assessment area, compared to $30,056 in the nation. The median household income for Searcy and Newton counties was less than $16,000 in 1990 (USDA-USFS, 1999). In

1995, the per capita income in Newton County was $11,272, while the state average was $18,097 and the national average was $23,196. Newton county citizens on average earn nearly half what the average American earns. Similar statistics apply to the other area counties. However, real income levels have been growing faster than the rest of Arkansas and the rest of the U.S. During the 1980s, the number of people below the poverty line has fallen, while the number of people below the poverty line across the U.S. has risen (Gordon and Baker, 1995). The per capita income gap between the three-county region and the rest of Arkansas is shrinking (Gordon and Baker, 1995).

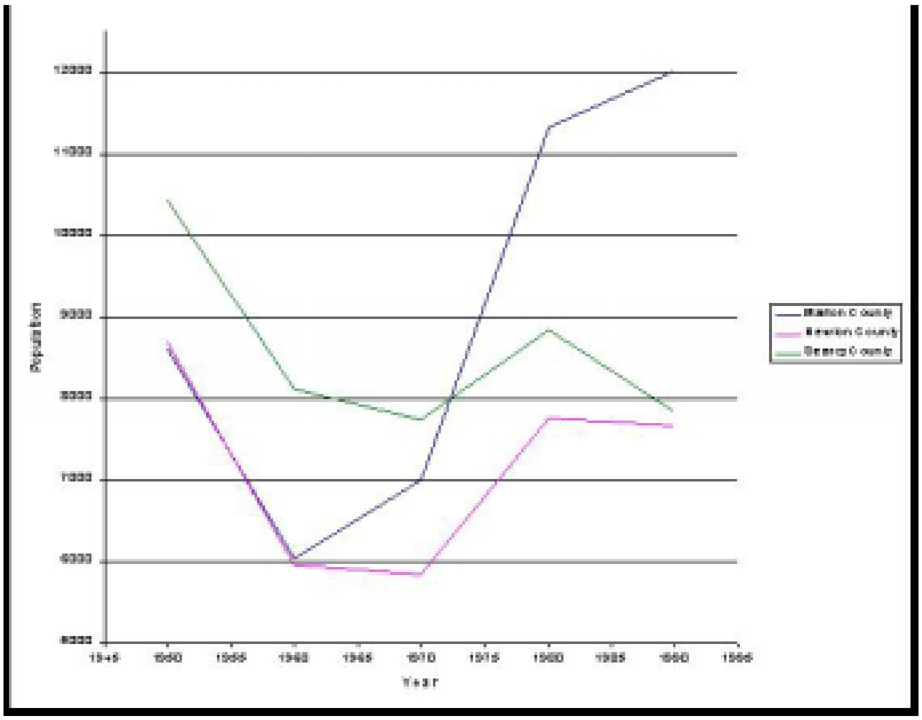
According to the 1990 US. Census, 21% of Newton County residents that are 18 and over have less than a 9th grade education and another 20% have only completed between 9th and 12th grade but have no high school diploma. Twelve percent have some college but no degree and the remaining 20% have some form of college degree. These values are all slightly above the state average.

People have been moving out of the Buffalo River region, especially from Searcy County (Figure 49 and Table 10). Marion County has grown in population, but growth has been slower than the average national rate (Gordon and Baker, 1995). The region remains lightly populated, compared with the rest of Arkansas and the United States. Newton, Searcy, and Marion counties all have current population densities of less than 15 people per square mile (USDA-USFS, 1999). Newton County has less than 10 residents per square mile. Searcy County has shown growth in the 1970's but lost population in the 1980's and 1990's (USDA-USFS, 1999). The three-county region is also older than average, and will continue to age (Gordon and Baker, 1995). There are significantly fewer young people and many more elderly people in the region compared to Arkansas and the U.S. (Gordon and Baker, 1995). The region is less educated than the rest of Arkansas and the rest of the U.S., although that difference may be largely attributable to the age difference (Gordon and Baker, 1995).

Table 10. Population data in the Buffalo River tri-county area from 1950 to 1990
(data from Gordon and Baker, 1995)

	Marion	Newton	Searcy	3-County	State of AR	Whole USA
1950	8,609	8,685	10,424	27,718	1,909,511	151,325,798
1960	6,041	5,963	8,124	20,128	1,803,272	
1970	7,000	5,844	7,731	20,575	1,923,295	208,066,557
1980	11,334	7,756	8,847	27,937	2,286,435	231,106,727
1990	12,001	7,666	7,841	27,508	2,350,725	253,451,585
% change from 1980-1990	5.9%	-1.2%	-11.4%	-1.5%	2.8%	9.7%
Square Miles	587	823	668	2,078	52,082	3,540,315
Persons/Sq.Mile	20.4	9.3	11.7	13.2	45.1	71.6

Figure 49. Population data in the Buffalo River tri-county area from 1950 to 1990.
(data from Gordon and Baker, 1995)



Unemployment rates in the three-county region are comparable to Arkansas as a whole, but unemployment is concentrated in Newton and Searcy Counties (Gordon and Baker, 1995)**.** Newton and Searcy Counties have consistently suffered higher unemployment rates than Arkansas as a whole, which in turn has consistently suffered higher unemployment rates than the US as a whole (Gordon and Baker, 1995). However, as with per capita income, job growth has been much stronger in the three-county region than average, so the unemployment gap is slowly closing. One in five jobs in the region are in farming and livestock, compared to one in eighteen for Arkansas and one in thirty-seven for the United States (Gordon and Baker, 1995). The three-county region is heavily oriented towards agribusiness, but earnings in that sector are significantly lower than elsewhere (Gordon and Baker, 1995). The low per-job productivity in Marion and Newton Counties suggests that farmers there do not rely on farming income as their sole source of income (Gordon and Baker, 1995).

Except for brief economic booms associated with cotton in the 1880's, zinc mining in the early 1900s and the lumbering boom of the 1910s, agriculture in the Ozarks has been dominated by subsistence farming (Wall, 1996). This is a major reason Arkansas has one of the lowest per capita incomes in the U.S. and that counties in the Buffalo River watershed have some of the lowest per capita incomes in the state (Wall, 1996). The boom/bust trend in economic development has resulted in a depletion of natural resources.

Another bust is occurring in Searcy County, only this time the raw material is not lumber or minerals, it is cattle, and the producers are not outside interests but local landowners (Wall, 1996). However, resource depletion is still a common thread. In an 18-year study from 1965 to 1983, 390 hectares of land had been converted from forest to pasture out of the 1710 hectares in Searcy County (Wall, 1996). That represents 28% of the forested land in the county (Wall, 1996). The current rate of deforestation may cause the same economic collapse that resulted from previous economic booms and the associated rapid depletion of natural resources (Wall, 1996).

Cattle production is keeping the economy of Searcy County alive. Between 1980 and 1990, over half of the counties in Arkansas experienced a decline in agriculture's contribution to total income but the proportion of income derived from agriculture in Searcy County increased almost 9% in the same time period (Gordon and Baker, 1995). Several counties in the Buffalo River basin are experiencing similar growth due to cattle production. The sale of livestock for these basin counties is above the median growth rate for livestock sales in the state (Gordon and Baker, 1995). This is of particular note since there has been an increase in overall livestock sales due to the tremendous expansion of Tyson chicken production in the state over the last few years.

Cattle production is dominated by small-scale farmers with ten, fifteen, and twenty cows (Gordon and Baker, 1995). For most farmers, the cattle sales provide an additional income that puts them either just over the poverty line or comfortably in the middle class (Gordon and Baker, 1995). Cattle production is only marginally profitable but there are very few other options and residents see increased cattle production as essential to economic survival. The decline of real wages and women increasingly employed off the farm drives the need for additional income and consequently the conversion of forest to pasture (Gordon and Baker, 1995).

Gordon and Baker (1995) also did an assessment of the gross financial value of recreational use and agribusiness in the watershed. According to the study, tourism and recreational activities bring nearly $39 million per year to the Buffalo River watershed, and provide for 550 jobs. This value represents the gross earnings from all concessionaires, hotels, and travel-related services in the three-county area. About 1,035,000 visitors come annually to the river. Dividing those two figures, the average visitor spends $37 dollars per day. The number of recreational visits to the park is growing by about 45,500 visits per year (Gordon and Baker, 1995). At current growth trends, gross earnings from tourism and recreation can be expected to increase by $1.7 million per year, and employment can be expected to increase by 24 jobs per year (Gordon and Baker, 1995). In terms of agribusiness, the report estimated that logging, livestock, and farming activities bring $69 million per year to the Buffalo River region and provide for 1,800 jobs. The report also estimates if worst case scenario pollution trends estimated by NRCS were to occur, the annual loss to the economy would be $12.6 million (Gordon and Baker, 1995).

One important thing to remember when reading these estimations of value is that they do not capture the true benefits of having a National River within the region. It is virtually impossible to assign economic value to clean water and a healthy ecosystem and so the true economic benefits of the Buffalo River are much greater than what is represented in jobs and tourism.

Staffing and Current Projects

Managing the aquatic resources of Buffalo National River lies within in the hands of Water Resources, a subdivision of the Resource Management Division. The Water Resources staff consists of a full time, permanent aquatic ecologist, one permanent, subject-to-furlough hydrologic technician, and other term or seasonal employees. The aquatic ecologist is responsible for most aspects of water related management actions, is a team leader for the water division, and is responsible for the implementation of water related projects. Hydrologic technicians' responsibilities include the weekly water quality monitoring program and air quality program, maintenance of the flood warning system, assisting other researchers in the park, and other duties as assigned. One important source of funding for these projects comes from the Natural Resource Challenge, a sum of money set aside by Congress for research and restoration in National Parks.

Recent and ongoing water resource projects include:

Road Assessment:
Within the boundaries of the Buffalo River, there are currently more than 100 miles of gravel/dirt roads being maintained. There are also numerous abandoned roads and road traces, which have never been inventoried or assessed. The excess sediment and storm water routed from these road surfaces and ditches across the landscape and receiving watercourses is the greatest impact to water quality from any source within the boundaries of Buffalo National River. Many of the roads were inherited from the county when the park was designated in 1972, and conform to no standards. The problem is exacerbated by steep topography, lack of road drainage structures, ditch line interception of ephemeral drainages, routing of ditches directly into streams, and slope failure. This project, which began in FY 2002, involved an inventory and assessment of roads inside the park boundary, assessment of impacts from the road drainage systems, identification and documentation of specific problem locations, and development of long-term cost effective mitigation strategies. This project is near completion.

Fish Migration:
This project was implemented in FY2001 in order to understand the dependence of the Buffalo River fish community upon fish communities in the perennial and intermittent portions of Bear Creek and assess the potential effects of damming. Little is known regarding fish movement in small, warm water streams and even less is known regarding factors affecting recruitment in these systems. The extent to which Buffalo River fish communities depend upon tributaries as spawning grounds is unknown. This study is designed to document the seasonal fluctuations in fish community species composition, relative abundance, and migration patterns at the macrohabitat, reach and watershed scale and to document larval drift densities and rates as components of fish community recruitment in the upstream, middle, and downstream reaches of Bear Creek. Results will aid in interpreting the extent in which the Buffalo depends upon Bear Creek to provide a

fish species pool and as a potential nursery location. It will also aid in interpreting the effects of stream drying upon the fish communities at a local and regional scale. To date no other research has been conducted on larval drift behavior in these systems.

Fish Communities:
Regional studies have linked land use changes to alterations in the relative abundance of fish species. This project, which began is 2001, was designed to collect and analyze fish communities from a wide variety of river and tributary sites throughout the watershed using multi-agency support. Multiple regression, correlation, and population comparison techniques were employed to relate and compare previously collected and ongoing water quality, macroinvertebrate, aquatic habitat, and watershed scale information to determine the factors influencing native fish communities. Results will provide current information to managers on existing fish communities, their composition, their distribution, and their dependence on natural and anthropogenic factors and disturbance. Additionally, this study will provide a critical base-line data set for future comparison. This project is near completion.

Karst Groundwater:
This project, currently in the final stages of completion, focused on an area of suspected interbasin transfer and integrates groundwater tracer studies, geologic mapping, karst inventories, and water quality analyses to delineate and characterize the groundwater recharge area of Davis Creek (a major tributary to the Buffalo) and John Eddings Cave. The results will allow park managers to more effectively protect contributing karst basins and researchers to better interpret the results of aquatic resource investigations. The objectives of this study included 1.) map the surficial geology, 2.) inventory karst features (such as sinkholes, caves, solution conduits, losing stream reaches and springs), 3.) collect, measure, and analyze water quality in selected springs and streams, 4.) delineate groundwater recharge basins, and 5.) assess the biological community within John Eddings Cave.

Spring Inventory:
A project with funding that began in fiscal year 2003 is focusing on documenting two major sources of water that feed the Buffalo, springs and perennial streams. Along with locating and mapping these features, water quality measurements are being taken for each spring and stream. A database will be established summarizing spring location, description, water quality results, and photographs using ArcGIS technology. The results will allow park managers to isolate problem areas and evaluate springs that may be receiving groundwater from outside basins, and will be shared with agencies and researchers doing work involving springs.

Ground and Surface Water Interactions:
Also beginning in fiscal year 2003, this project will focus on better understanding the surface and groundwater interactions that occur in the complex karst geology surrounding the river. The movement of water between groundwater and surface water in karst terrain provides a major pathway for contaminant transfer between terrestrial and aquatic systems. To better understand the ecological implications of nonpoint source discharges

within the Buffalo River basin, location of stream flow gain and loss and relations between water-quality characteristics and base flow of the stream must be defined. Identification of locations along the Buffalo where groundwater significantly contributes to stream flow is needed so sources of pathogens and fate and transport of contaminants can be better monitored and used to assess human health risks related to recreational activities. This synoptic study will evaluate the ground-water and surface-water interactions and assess base-flow water quality and quantity within the Buffalo River watershed.

Macroinvertebrate Drift:
The goal of this study is to document the benthic component of the macroinvertebrate community within the three most common geomorphic habitats in Bear Creek at the upstream, middle, and downstream reaches. Drift species composition, density, and rate of drift within the three sites will be documented. Also, the study will characterize the disturbance component of macroinvertebrate drift as a result of a single storm event.

WATER RESOURCES ISSUES AND RECOMMENDATIONS

This section will provide the reader with a broad understanding of the issues facing the management of aquatic resources at Buffalo National River. It will present research documenting these problems and recommend solutions. While most of these recommendations address selected issues along the river, they are all part of a more encompassing problem that involves the entire watershed of the Buffalo River. NPS only has managerial control over 11% of the watershed, a narrow boundary along the river's edges. Protecting the water quality and aquatic resources of the Buffalo will only be accomplished by addressing issues within the entire watershed, not just within park boundaries. This requires cooperation with local communities and other state and federal agencies in the area.

The overarching recommendation and goal of this management plan is to open the doors of communication between local, state, and federal agencies and local citizens and landowners, resulting in all parties working together to protect the river. In the process landowners and citizens in the watershed will benefit.

Planning History of the WRMP

Buffalo National River has had public relation problems since it's foundation in 1972, leading to distrust and poor communication between the local community and federal officials. Efforts by Buffalo National River to bring together federal, state and local officials along with area farmers and landowners to work as a cooperative group to protect water quality have been impacted by these same public relation issues. The Water Resources Management Plan attempted to outline the development of this cooperative group but the area counties, in response to public outcry, declined to participate. The program was put on hold. This section will describe what happened the first time the WRMP was attempted and what its true intent was and still is. The general philosophy of the WRMP has not changed. Voluntary water quality programs have proven successful in the past but they are usually implemented after a river has been degraded and water quality standards have been violated. Buffalo National River wants to prevent this from happening and protect water quality. In order for that to happen, efforts must be watershed wide.

The original WRMP proposal

Buffalo National River was awarded a grant from the NPS Water Resource Division (WRD) in 1997 to initiate development of the WRMP. A large portion of the WRMP was to summarize and analyze the enormous volume of data and information on the resources of the Buffalo and then make specific recommendations for aquatic resource protection. ADPCE (currently ADEQ) was to be a partner, providing both personnel and financial contributions. The overall objective, from the beginning stages of development, was to bring land management agencies, local governments, and private groups together to recognize and address water related issues affecting Buffalo National River. A series of preliminary meetings between BUFF and ADPCE decided that a comprehensive watershed planning process is necessary. The USGS was later enlisted to provide technical assistance through statistical analysis of water quality and flow data.

Preliminary planning outlined what the purpose of the WRMP was and what issues it should focus on to protect the water quality of the Buffalo River for the long term. First, the plan was to effectively summarize all issues facing water resource management of the Buffalo and present these in a manner that was available to the general public. The WRMP was also needed to identify nonpoint source pollution issues that may be impacting the river and then identify all potential programs and studies which could address and/or mitigate these issues.

Because so much of the watershed of the Buffalo River is outside of NPS boundaries, it was decided that the only way to prevent degrading water quality was to develop a community partnership to voluntarily work together to maintain good water quality. It was clearly established, from the beginning, that the plan was not an attempt to justify government control of private lands and that any activities outside of the park boundaries would be strictly voluntary. No new regulations would be forced upon area residents, no limitations on economic development would be implemented, and private property values would be respected and protected.

Most importantly, absolutely no private land would be acquired based on WRMP recommendations. A new act of Congress would be required for any new park expansion. There was absolutely no justification, be it water quality or any other issue, that could be brought before Congress in an attempt to expand the park boundary, nor was there any desire by NPS officials to do so. New land acquisition, new regulations, or any infringement of private property rights are not part of the current plan nor have they ever been part of the WRMP. Landowners would not be forced to participate, it is strictly voluntary for those that are interested in improved water quality through Best Management Practices (BMPs) on their own land. BMPs would include actions such as establishment of riparian buffer zones, bank restoration, fencing to keep cattle from walking in streams, creation of alternative water sources other than streams, and other cost effective and simple soil and water conservation practices that benefit both the landowner and the environment.

Most of these ideas were created during preliminary development meetings; nothing was official and nothing was written in an organized form. The only written text for the plan was about 70 pages of literature review with verbiage summarizing background data and information of the river to later be used in various sections of the plan.

<u>What happened to the original WRMP</u>

In June of 1998, the NPS provided a press release to local papers (Harrison, Jasper, Marshall, and Yellville) describing the program and providing phone numbers for anyone who wanted information or wanted to participate. The NPS next held meetings with the County Conservation Districts for Marion, Searcy, and Newton Counties and the Newton County Cattleman's Association to introduce the planning process. The planning process was initially accepted by these groups.

The first interagency meeting was held in Little Rock on August 12, 1998 with 20 people representing 10 agencies. This meeting included cooperative issue scoping and early planning on what the future steps should be. A major outcome of the meeting was the formation of an informal advisory group to assist in developing mutually acceptable conservation strategies and project statements to be included in the plan. The need to include private groups and others in the process was re-emphasized by several attendees. A draft list of issues was developed to focus the planning effort and begin compiling relevant background information and research from the attendees. The public was invited to the next meeting of the advisory group to be held November 9th, 1998 in Marshall. Buffalo National River released numerous press releases stating the intentions of the WRMP and addressing public questions and comments along with calling for local involvement and support.

The November 9th meeting in Marshall was open to the public. The county judges of Newton, Marion, and Searcy Counties were invited to attend the meeting in Marshall but they opted to send representatives instead. Several attendees were there as "concerned citizens", others were there representing various local agencies and the three area counties. The majority of attendees felt that they were not adequately informed of this meeting or the management plan and its process. They also voiced concern over the misdirected attention on farming/agricultural community and lack of discussion about the role of visitor pollution.

At the meeting in Marshall, concerns were also vocalized over the state designation of Extraordinary Resource Waters (ERW) and whether or not the state of Arkansas followed a legal process that included public input. As a state listed ERW, the Buffalo River is covered by Section 3 of the Regulation Establishing Water Quality Standards for Surface Waters of the State of Arkansas, which states:

> *Where high quality waters constitute an outstanding state or national resource, such as those waters designated as extraordinary resource waters, ecologically sensitive or natural and scenic waterways, those uses and water quality for which the outstanding water was designates shall be protected by (1) water quality controls, (2) maintenance of natural flow regime, (3) protection of instream habitat, and (4) pursuit of land management protective of the watershed.*

Essentially, this legislation only disallows two activities in ERW streams in Arkansas, gravel mining and dam construction. Because the Buffalo River is a National River, managed by the National Park Service, gravel mining and stream damming are not possible anyway. The National Park Service has no jurisdiction to enforce any provisions of the ERW or any other state regulations in any areas of the Buffalo River watershed, in fact it is subject to all state and federal water quality regulations just as any private property owner would be. It seems the ERW has been perceived as encroaching on the rights of private property owners.

In the months following the meeting, several local citizens began a campaign to get the ERW designations revoked because they felt that it would give NPS the power to implement the WRMP involuntarily and violate private property rights. Letters were sent to elected officials including Governor Huckabee and local senators and representatives at the state and federal level. Fears became elevated to the point that people feared their land would be acquired or they would be forced through new regulations to comply with the WRMP. Some even went as far as to say they believed that some areas would be made off limits to visitors and other areas would be severely restricted. Negative public sentiment began to build with a very vocal minority spreading rumors and misinformation which enveloped the planning process and eventually paralyzed it.

Quorum courts of the counties of Newton, Searcy, and Marion all passed resolutions of non-participation in the WRMP in one form or another. Marion County stated that the quorum court opposed any expansion of the authority over Marion County roads and lands and the private property of Marion County citizens. It stated that the court will not participate in the plan (Gray, 1999). Newton and Searcy Counties issued similar resolutions based on fears of infraction on private property rights. Searcy and Newton County Quorum courts also passed resolutions asking Governor Mike Huckabee to revoke all ERW designations, citing that they were illegally made because they did not meet the public meeting requirements. They also claimed that ERW designations constituted taking of private land without compensation (Newton County Times, 1999). A copy of Resolution 99-5 and 99-6 from the Newton County Quorum Court is attached in Appendix C.

On September 16, 1999, Governor Huckabee's staff hosted a public forum meeting in Harrison to hear comments regarding the proposed WRMP and issues related to ERW designations. More than 300 people attended to voice opinions and ask questions to representatives from NPS, ADEQ, and the Governors office. The meeting was dominated by declarations that NPS was attempting to take away private property rights and citizens spoke of their distrust for anything NPS wanted to put forth. The discussion became quite heated despite attempts by NPS to explain that the WRMP was suggesting only a voluntary program and that no rights will be violated. The meeting lasted over three hours and it sparked significant press coverage and editorials in the local and statewide newspapers.

The State of Arkansas House of Representatives Committee on Public Health, Welfare, and Labor also responded to public outcry by conducting an investigation on the status of the WRMP (ISP 99-25). The Interim Study Proposal and Summary Report ISP 99-25 are attached in Appendix C. The subcommittee held three meetings and the full house committee heard testimony and opinions regarding the WRMP from NPS, ADEQ, state and local groups and private citizens. The summary report basically concluded that public notification was inadequate regarding planning of the WRMP and that due to the continued distrust of the Park Service's intentions; property owners are worried that park personnel are not releasing all their goals and objectives in regards to future plans. The report stated: "The Subcommittee strongly recommends to Park Service staff, in order to repair and improve relations between Buffalo National River and landowners, the Park Service must be totally forthcoming with all potential plans."

Current Proposal

The goal of establishing a cooperative and voluntary watershed-based conservation program has not changed. However, due to lack of public support and resolutions of non-participation from each county, Buffalo National River will not attempt to further develop such a program until public perception changes. The WRMP still highly recommends a cooperative program that brings together state, federal, county official and private landowners and citizens to work together to protect water quality of the Buffalo River watershed.

Hundreds of citizen-based watershed councils are successfully preserving water resources and assisting land owners with conservation practices throughout the country and also locally. Below are some examples of successful groups.

Watershed Committee of the Ozarks

Located in Springfield, MO, this group was established as a non-profit organization in 1989 with guidance from the Springfield City Utilities. Their mission is to preserve and improve the water supplies of Springfield and Greene County through education and effective management of the region's watersheds. The committee consists of a six member board of local citizens and four full-time, paid staff members. Funding for the committee comes from Springfield City Utilities along with federal and state grants and private donations. For example, the Committee received a grant from the Missouri Department of Natural Resources to implement cost-share projects with area landowners, public education projects, and other restoration efforts along the Little Sac River.

The Niobrara Council

This group, located in Nebraska, is a grassroots-driven organization formed in

1997 to assist the National Park Service in managing and protecting the Niobrara National Scenic River. It was formed based on wishes by the local community and area landowners to have an active role in river management issues and a strong desire to preserve the rural characteristics, scenic qualities, and private ownership of land in the area. The council was originally formed by an inter-local agreement with four area counties but in 2000 it was strengthened when the state of Nebraska passed legislation which reconstituted the Council as a "State-Recognized" organization. This gave the Council authority to develop conservation easements and hold title to land. The Council consists of a 16 member board made up of representatives from local, state, and federal government, local landowners, county commissioners, area industries, and the environmental community.

Lower Columbia River Estuary Partnership

This group works to protect 146 miles of the Lower Columbia River and associated estuaries. The group is a two state, public-private partnership that has brought together diverse interests to reach a consensus on the how to protect the river. They are implementing a Management Plan that was designed based on citizen input, scientific research, and technical advisement from federal, state, and local officials. The management plan has no regulatory authority; it relies entirely upon voluntarily participation. The group's priorities include on the ground improvements for habitat and land use, pollution reduction, public education programs, and mediation between public and private groups regarding watershed associated issues. The Partnership recently received a Watershed Initiative Grant from the EPA.

Every watershed group is unique in the way it is administered, the way it is funded, and the mission it pursues. One common theme among these groups is to improve communication between public officials and the local community while simultaneously working to protect both the watershed and its associated natural resources. While there are many possibilities for the structure and development of a citizen based watershed conservation group in the Buffalo River watershed, the following paragraphs suggest a possible framework. Regardless of the framework of the organization, emphasis should be placed on protection of private property rights, free economic development, preservation of local culture and values, and protection of the county tax base to the fullest extent possible as well as protecting the water quality of the Buffalo River.

NPS and other cooperating state and federal agencies along with a group of local citizens and county quorum courts could form a board to provide guidance for the initial stages of development, focusing mainly on finding a base funding source to start the program. One possible source is the Land and Water Conservation Fund (LWCF), a fund that Congress could tap into to finance the effort. The proceeds from the fund could be used to implement the water quality projects that have been locally proposed and approved by the final approving board.

Once the base funding is located and the program has a solid foundation for development, NPS would serve only as an equally participating board member and a source for technical advisement. The program would be entirely voluntary, with the decision to participate up to the individual landowner. Any project could be funded through the process described below if the landowners felt it benefited their operation and if locally trained staff state that whatever the landowner proposed to do could indeed improve or help maintain water quality. Examples of such projects include cross fencing, warm season grass planting, streambank stabilization, road improvements, buffer strips, alternative water sources, and septic tank improvements.

Locally administered work stations could be set up within the County Conservation District Headquarters in Newton, Marion, and Searcy Counties. One employee in each county (three employees total) could be hired to help landowners turn their needs into funding proposals and assist landowners with project implementation should funding come available. These employees would track ongoing projects and review completed projects, ensuring that the needs of the landowner are met and that water quality is protected. One overall director could be hired to track budgets, supervise employees, etc. This director would also be in charge of grant seeking efforts to maintain a solid financial base for the program. In order to ensure a relationship of trust between these employees and the landowners, emphasis would be placed on hiring locally and any hiring of employees would be subject to the approval of the associated county quorum court. Landowners would not have to work directly with any state or federal officials through this program, the three employees would act as liaisons between the local community and the state and federal agencies involved with the program.

The National Park Service would play a minimal role in the program once it became established, acting as an information source for project proposal and project implementation as well as serving on a local board to help prioritize and rank project proposals. The process of proposal approval might go as follows. The County quorum courts could approve proposals from their county and forward them to the prioritization group, consisting of local farmers from conservation district boards, and state and federal water quality professionals. The prioritization group ranks proposals until the money is expended for a given year and forwards the prioritized list to the local approving board. The prioritization group could also review past projects and any related monitoring to keep efforts focused on protecting water quality. The local approving board could consist of the Newton County Judge, the Searcy County Judge, the Marion County Judge, the U.S. Forest Service Supervisor, and the Buffalo National River Superintendent. Any member of the local approving board would have veto authority for any project or the placement of employees and would have shared authority over the program in general. The final approving board would prevent improper use of funding sources and would allow for equal protection of private property rights and water quality. Projects could also be funded on city, county, state, or federal properties. These projects would follow the same approval process and be subject to the same criteria as landowner projects.
The National Park Service would not have direct control over any of the funding and accountability would be a shared responsibility among the local board.

Watershed Management

<u>Degrading Water Quality</u>

Buffalo National River's water quality is threatened by the rapid rate of land conversion from forest to pasture. Over a 27-year study period, the annual increase in agricultural land was found to be almost equal to the annual decrease in forested land, as shown in Table 11 (Scott and Hofer, 1995). Scott and Hofer (1995) found that about 94.6% of the annual loss of forest could be accounted for by an increase in pasture (Figure 50 a and b). If this trend continues, by the year 2050, pasture acreage in the watershed will be equal to forest acreage. Forest conversion rates are similar in many tributaries of the Buffalo River. Big Creek and the Little Buffalo River lost over 9,000 acres of forest in their watersheds and Bear Creek and Tomahawk lost around 6,000 acres each in the 27-year period (Scott and Hofer, 1995). The watersheds of Clabber, Upper and Middle Mill Creeks, Rush Creek, and Davis Creek lost over 15% of their land area originally in forest in 1965 (Scott and Hofer, 1995). These losses were nearly offset by gains in pasture.

Table 11. Estimated land use characteristics of the Buffalo River Watershed
(data from Scott and Hofer, 1995)

Land Use Category	1965	1972	1974	1979	1992
		acres			
Forest	725,545	701,488	681,934	673,220	626,782
Agriculture	122,175	145,912	160,466	174,525	214,955
Urban and barren	2,562	5,097	5,097	3,063	9,175
Water	2,812	2,812	2,812	2,812	2,812
Transportation, power, and communication	3,883	3,883	3,883	3,883	3,883

Figure 50a. Land use in 1965 in the Buffalo River Watershed
(Scott and Hofer, 1995)

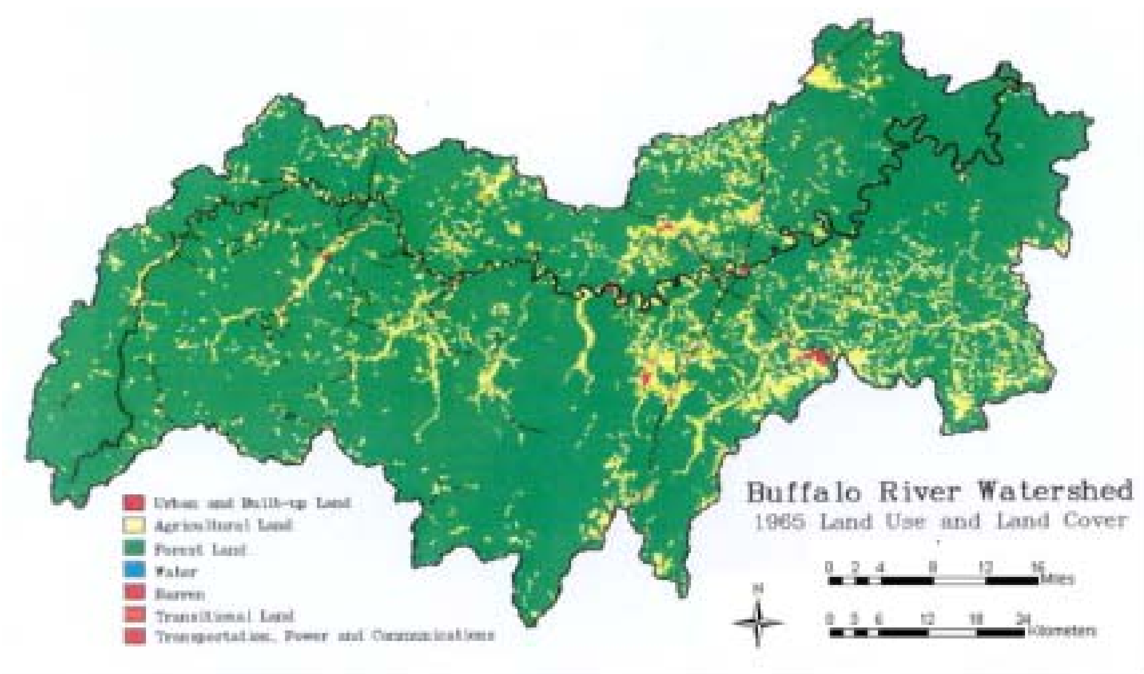
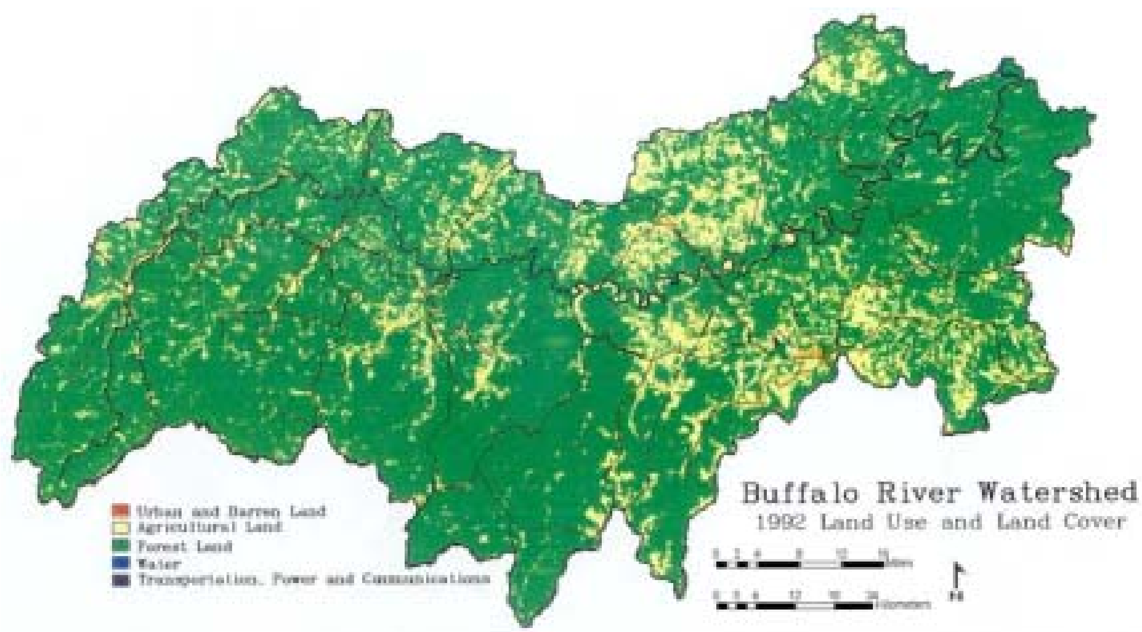


Figure 50b. Land use in 1992 in the Buffalo River Watershed (Scott and Hofer, 1995)
Note: The increase in yellow to green is change in land use from forest to agriculture over 27 years



Based on 10 years of water quality monitoring data, the water quality along the middle portion of the Buffalo River is declining, exemplified by elevated nitrogen levels. The source is likely from middle river tributaries which are losing a large portion of their forested land to pasture (Mott, 1997). Bryant (1997) also found lower diversity of the macroinvertebrate communities along the middle sections of the river and Usrey (2001) found similar results with increased Corbicula populations in the middle river.

Steele and Mott (1998) chose three middle river tributaries to investigate the effect of agriculture activity on water quality. These streams were chosen because they provided the most fecal bacteria (almost half of the fecal coliform load), nitrate and nitrite, and phosphorous to the Buffalo River despite comprising only 13% of the watershed (Steele and Mott, 1998). These agricultural tributaries were compared to a control site, a pristine tributary with a watershed near the headwaters of the Buffalo River. All three tributaries consistently had nutrient and bacteria concentrations and loads two to three orders of magnitude greater than the control site (Steele and Mott, 1998). Fecal coliform bacteria and nutrient concentrations were 125 times higher for bacteria and 44 times higher for nutrient concentrations at peak discharges compared to the pristine site (Steele and Mott, 1998). Bacteria storm loads for the tributaries were even greater when compared to the pristine site. These large increases in concentrations and loads are indicative of agricultural impacts on water quality. While is not always consistent to rank tributaries based on the amount of agricultural activity in their watershed due to variation in other physical factors, the tributaries sampled still rank in order as predicted by the indicators of agricultural activity (Steele and Mott, 1998). Bear Creek was the largest contributor of storm derived pollutants to the Buffalo National River, followed by Calf Creek and then Tomahawk Creek. Bear Creek also had the greatest percentage of agriculture in its watershed, followed by Calf Creek and then Tomahawk Creek (Steele and Mott, 1998).

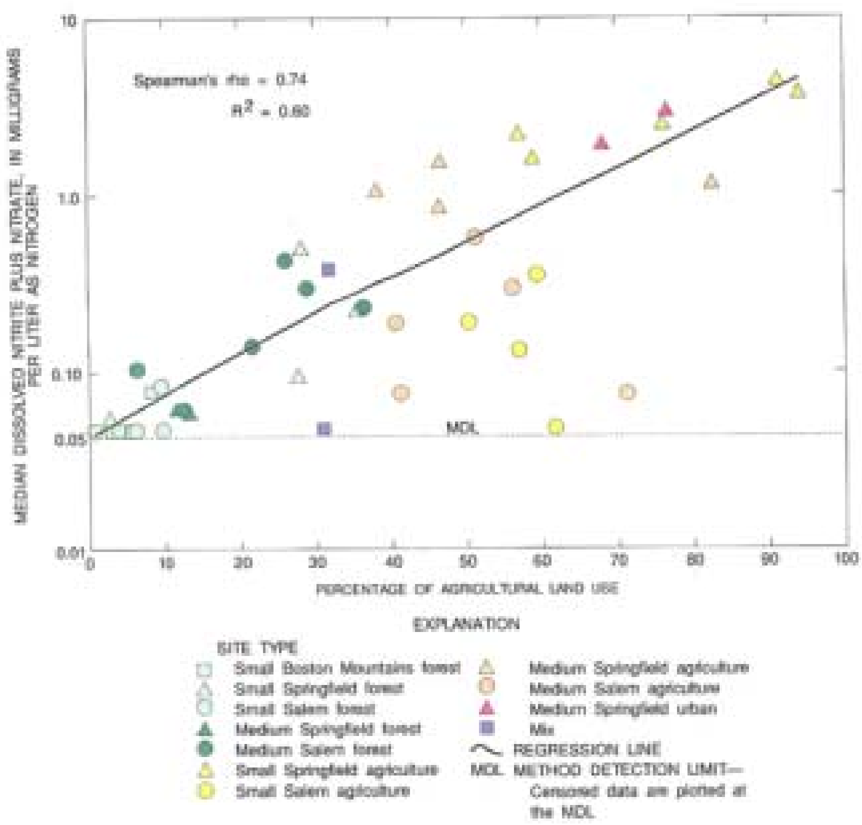
The agricultural impact on water quality is greatest during storm events. Steele and Mott, 1998, found that nutrient and bacteria levels were two to five orders of magnitude higher during storms than during base flow. The total load of a storm can have the equivalent load of hundreds or even thousands of base flow days. For example, three days of storm flow during November at Bear Creek contributed a fecal coliform load to the Buffalo that was equivalent to 1,752,000 days of base flow at the control site (Steele and Mott, 1998). During storms, bacteria and nutrients (with the exception of nitrate) increased in concentration as total suspended solids increased. Nitrogen and phosphorous are absorbed and incorporated into the organic matter of the suspended sediment. The result of a nutrient flux due to a storm event can be present for weeks or months following the storm. This study found that TKN (Total Kiehldal Nitrogen) and TP (Total Phosphorous) are transported with the sediments and deposited during the storms. These elements are then stored in the stream until base flow and hyporheic waters leach the nutrients from the sediment (Steele and Mott, 1998). This increase in nutrients affects the aquatic biological community, often resulting in algal blooms.

While state standards for Bear, Calf, and Tomahawk creeks were rarely exceeded during base flow conditions, standards for fecal coliform, sulfate, and total phosphorous were exceeded on occasion during baseflow (Steele and Mott, 1998). During storms, almost

100 percent of the samples exceeded standards for fecal coliform bacteria and turbidity. Large increases in fecal coliform bacteria (over 40,000 colonies/100ml) far exceeded the 200 to 400 colonies/100ml standards set for primary recreation contact waters and the maximum concentration at the pristine site of 250 colonies/100ml (Steele and Mott, 1998). Bacteria concentrations at these levels are a potential health threat for humans and animals that come in contact with the water. The total phosphorous guideline of 0.1 mg/l was often exceeded as well during storm events (Steele and Mott, 1998).

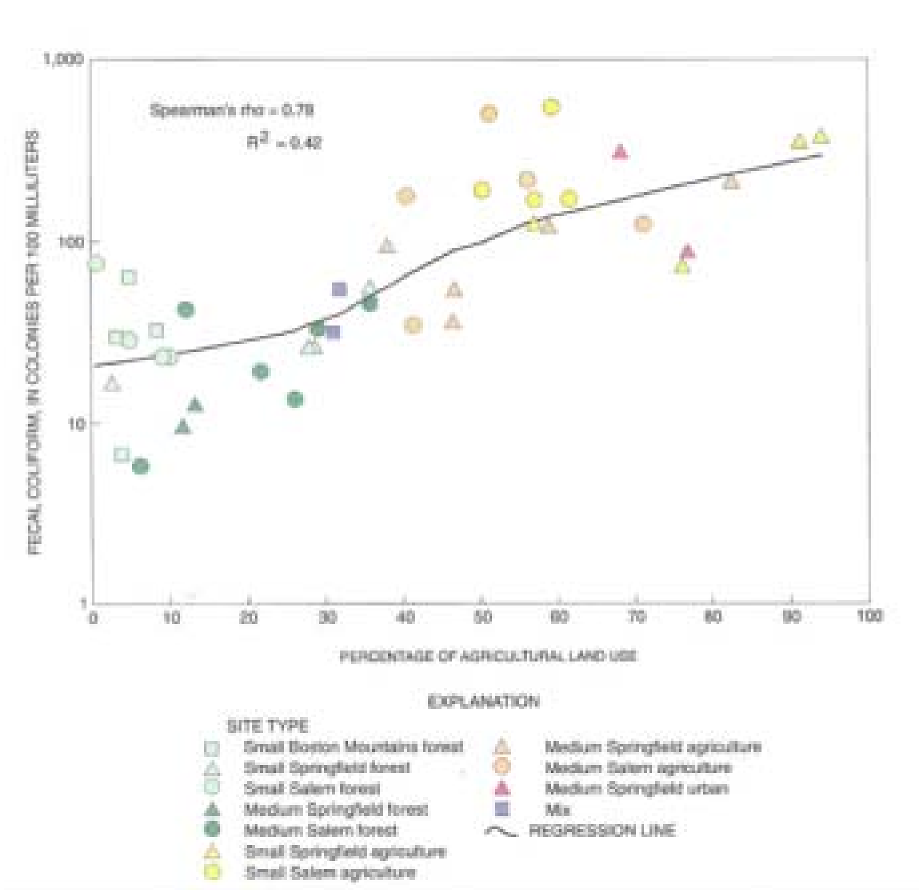
Other studies have found similar connections between watersheds with a high percentage of agriculture activity and degrading water quality (Davis, 1995). Water quality data were collected between 1970 and 1990 for 83 surface water sites and from 1970 to 1992 for 395 groundwater sites in the Ozark Plateaus study unit for the National Water Quality Assessment Program (NAWQA) (Davis, 1995). This report analyzed samples for nutrients, suspended sediments, and suspended solids for sites all across the Ozarks, including two sites on the Buffalo. Nutrient concentrations were found to be larger at sites associated with agricultural activities than sites with forested basins for both surface and groundwater samples (Figure 51) (Davis, 1995). Nutrient concentrations were the largest for groundwater samples where the water source was shallow in origin and in an agricultural basin. The study found that livestock and poultry waste is a major source of nutrient loading, particularly Northwestern Arkansas (Davis, 1995).

Figure 51. Relation of dissolved nitrite plus nitrate concentrations to the percentage of agricultural land use in the Ozark Plateau study region (Davis, 1995)



Davis and Bell (1998) in a related assessment found that with the exception of one site, all sites representing forestland had lower fecal coliform counts than sites representing agricultural land. Fecal coliform counts showed a positive correlation with percent of agricultural land use (Figure 52) (Davis and Bell, 1998).

Figure 52. Relation of fecal coliform counts to the percentage of agricultural land use in the Ozark Plateau study region (Davis and Bell, 1998)



Recommendation:

NPS will continue to monitor water quality on a seasonal basis along the river and throughout its watershed. This is important information but it does not protect water quality, it only documents its decline or improvement. Money is one factor needed to implement change. The water resources staff of Buffalo National River has for many years and will continue to develop projects and seek funds outside of the park's base funding for assessment and restoration projects on the river and its tributaries.

To address the problem within the watershed but outside of NPS boundaries, the goal of this plan is to develop a program to communicate with and assist landowners with the process of seeking funds to implement Best Management Practices (BMPs) for erosion control, bank stabilization, riparian zone protection buffers, and manure management.

These goals will best be accomplished if a private, citizen based watershed protection group is formed representing the Buffalo River. The most significant opportunity for a rural partnership is in addressing agricultural runoff from private property along the river and its tributaries. When farmers become part of the partnership, farm issues can be better addressed through mediation between the park and the citizen based group. NPS understands that it is a difficult issue because often those being asked to take economic risks for environmental benefits are not in a financial position to contribute to the greater benefit of society. Farmers are struggling in today's economy and they simply do not have the time or money to do land improvements on their own. This group could provide the go-between for landowners and the National Park Service; it could be the main source of information and help for landowners on the best ways to seek money to implement BMPs. Landowners would not have to deal directly with the federal or state government. This is an opportunity for local communities to truly make a difference and help in the cooperation to prevent degradation of the Buffalo River's water quality.

There is federal funding available to support both the start up costs of forming these groups and to assist in watershed management projects the groups develop. Because the Buffalo River is a unit of the National Park system, money could also be made available through the Land and Water Conservation Fund (LWCF). This fund uses offshore oil leasing revenues to support recreational enhancement of public lands. Matching grants available through the LWCF can be applied to watershed protection efforts for the Buffalo River. Money for the LWCF is approved by Congress in the Interior Appropriations Bill and split among the National Park Service, the Forest Service, the Fish and Wildlife Service, and the Bureau of Land Management. The remaining money is given to states. There are several routes through which this money could be sought and many other sources of money not mentioned above, but it would take the cooperation of local citizens and state and federal agencies to utilize it for watershed protection.

Some work is already beginning in the watershed through the local watershed assistance program. One such project works with local dairy farmers and state and federal agencies to implement a better manure management program in the watershed. Dairy farmers do not have adequate equipment to handle manure generated while the cattle are confined and this program will provide assistance to farmers through the Buffalo River Conservation District Office. Money comes from a Clean Water Act section 319 grant. Farmers are being assisted in the management of both dry and liquid waste while at the same time maximizing fertilizer benefits and minimizing farm impacts to the environment. The funds are being used to purchase a submersible pump and pit agitator for cleaning out the solids in the milk parlor wastewater storage tanks and a truck mounted side-discharge spreader for land application of manure from storage tanks. Additional funds are being used to train and pay the salary for an equipment operator. The program will pay up to 60% of the money for watershed farmers who utilize the services and also will provide up to 60% for annual holding pond clean outs with a contract service. The purpose of this subsidy is to encourage farmers to utilize good management practices and take advantage of the manure handling services available to them through the Buffalo River Conservation District and consequently protect the water quality of the Buffalo River.

Other projects of similar nature, both with single landowners or assistance programs for an entire county need to be developed and implemented. Money is out there and with a citizen based group representing the local community, it can be found and used to implement projects that will provide benefits to landowners and improve water quality. Protecting the water quality of the Buffalo does not mean that private property rights would be taken away, local taxes would be increased, farmers would be fined if they chose not to cooperate, or economic development would be slowed. By working through the community and a local citizen formed group, it is the intention of NPS to develop a relationship based on cooperation and open communication with the public. It is vital to prevent the degradation of water quality on the Buffalo River now rather than reacting to the problem years from now when the tourism based economy begins to suffer and the problems become much more difficult to solve.

Riparian Zones and Bank Erosion

Not only is forest rapidly being converted to pasture in the watershed, these pastures are commonly overgrazed with concentrated grazing along riparian areas. Endophyte infested tall fescue causes livestock to develop a fever that leads them to stand in streams to cool (NRCS, 1995). This results in the direct deposition of fecal material in the stream. In some areas the river is confined by bedrock; in others it meanders through alluvial bottoms. It is common for the alluvial flood plains to be farmed up to the channel banks with little or no riparian buffer strips between cleared ground and the river. This type of farming practice occurs throughout the region and has increased the vulnerability of the river banks to erosion and accelerated channel migration. 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 lateral channel migration, especially in areas where riparian forests are removed (Mott, 1994).

The loss of riparian forests has contributed to changes in the physical characteristics of stream channels by decreasing the resistance of bank materials resulting in areas of active stream bank erosion. The results of erosion are shallower and wider stream channels, impairment of the aesthetic value of the corridor, degradation of aquatic habitat, and increased sediment loads and turbidity. Chronically eroding stream banks and channel instability are almost exclusively associated with areas where agricultural clearing of riparian vegetation occurs. Even with cessation of farming activities, many stream bank erosion sites experience soil loss at such a rapid rate (over 40,000 tons per year at one site on the Buffalo) as to preclude natural re-vegetation processes from stabilizing the bank (Mott, 1994). In these areas, erosion could continue unimpeded resulting in a loss of tons of exposed soil along with cultural, archeological, and natural resources.

Restoration of riparian buffers has numerous ecological benefits as well as preventing loss of farmland and soil. When stabilized by tree roots and other riparian vegetation, streambanks produce highly productive aquatic habitats, usually characterized by lateral pools with stable undercut banks, over-hanging trees, and extensive mats of exposed roots (Rabenni and Jacobson, 1993). Riparian vegetation also restores a more natural flow of sediment and stream flow energy through the riparian corridor. This reduces stream velocity which prevents flood plain scour and loss of property along the stream (Mott, 1994). Streamside trees also provide opportunities for scour pools to form where large rootwads persist in the channel from year-to-year, creating excellent game fish habitat (Mott, 1994).

Cropland erosion accounts for 38% of the 1.5 billion tons of sediment that reaches the nation's waters each year (Welsch, 1991). Pasture and range erosion account for another 26%. Riparian buffers help sediment to settle out as the speed of flow is reduced. Phosphorous levels are reduced as sediment flux into the streams is reduced because about 85% of available phosphorous is bound to the small soil particles in the sediment (Welsch, 1991). With a forest riparian buffer, about 80% of the attached phosphorus is removed (Welsch, 1991). Streamside forests also transform nitrate to nitrogen gas. Under well-oxygenated conditions in the soil, bacteria and fungi convert nitrogen in runoff and decaying organic debris into nitrate, which can then be synthesized by plants and bacteria into proteins. In anaerobic conditions, denitrifying bacteria convert dissolved nitrogen into various nitrogen gasses, returning it to the atmosphere.

Using pasture or forest buffer areas to serve as overflow treatment systems below poultry and cattle waste application sites has proven very effective in removal of nutrients and sediment in the runoff. They have been shown to reduce runoff velocity and increase sedimentation of pollutants that are absorbed to particulate matter (Moore et. al, 1998). They also reduce the volume of runoff by increasing infiltration into the soil (Moore et. al, 1998).

Buffers also provide a barrier to prevent cattle from entering the stream. A study by Dale et al. (1978), conducted along several tributaries in the upper section of the Buffalo, demonstrated the impact cattle have on water quality. For the study, four sampling stations were selected on the upper end of the Buffalo between Boxley and Pruitt. Sixteen sites on five tributaries were also sampled. In dry weather, the highest mean for any station for fecal coliform was 150 colonies/100ml. Fecal coliform levels showed a clear decrease when cattle were kept 100 feet and 5,000 feet from the river. In wet weather, all stations with direct cattle access to the river showed mean fecal coliform concentrations of 910 colonies/100ml or greater. During wet weather, streams that did not have direct access of cattle rarely exceeded 200 colonies/100ml. The same held true for streams where the cattle were not present within 5,000 feet upstream from the sampling site. Streams with access of cattle within 100 feet or less upstream from the site almost always exceeded the 200 colonies/100ml standard during rain events.

Recommendation:

Buffalo National River initiated a three-year streambank stabilization and riparian restoration project in 1994 under the National Park Service's Natural Resources Preservation Program (NRPP). The purpose of this project was to stabilize eroding streambanks and restore riparian areas disturbed by agricultural clearing prior to the establishment of the National River. Field reconnaissance identified 14 streambank restoration sites totaling 5,763 feet in length which were mitigated using cedar revetments and other bioengineering techniques (Mott, 1994). In addition, 26 riparian zones totaling 18,881 feet in length were replanted to establish 100-feet wide forested buffers (Mott, 1994). Over 150-thousand native seedlings were planted covering a total of 54.4 acres at these 26 sites. Over two miles of fencing were also constructed to keep cattle from impacting reforestation and restoration sites (Mott, 1994). While this project restored many eroding streambanks and riparian areas, there are still many areas along the river and in the watershed that need work. Banks that have been worked on need to be reassessed for their stability and any repairs or improvements should be made. Additional funds should be sought for a project of this nature.

Gravel Mining

Brown and Lyttle (1992) assessed the impacts of gravel mining on fish communities in Ozark streams. Three streams were selected, Crooked Creek, the Kings River, and the Illinois River. Study sites were located above, at, and below gravel mining operations. Impacts on fish community structure, habitat, biofilm accumulation, aquatic macroinvertebrates, and macrophytes were assessed. The results indicated that gravel mining significantly degrades the quality of Ozark stream ecosystems and that the effects of this are detectable even though these streams have a long history of anthropogenic disturbances. Alterations of physical habitat appear to more significantly influence the biotic community than limitations imposed on other resources (such as food supply), but these probably interact synergistically to limit some populations (Brown and Lyttle, 1992).

Brown and Lyttle (1992) found that the natural riffle pool sequence was altered by gravel mining. Pools located downstream from gravel mines tended to be longer and shallower than the upstream reference pools. The expected sequence of the spacing of riffles every 5 to 7 channel widths did not occur at disturbed sites but was found at all reference sites. Channel widths increased by an average of more than 10 meters at disturbed and downstream sites in all three rivers. The gravel mining process also resulted in the removal of woody debris and aquatic macrophytes at disturbed sites, decreasing channel stability and habitat diversity. Larger gravel particles form an effective armor plating on the smaller particles and alluvial deposits. When these larger particles are removed, as they are in gravel mining, the armoring is removed and exposed sediments are more easily transported. This process, in conjunction with channelization effects, causes increased sediment loading and turbidity.

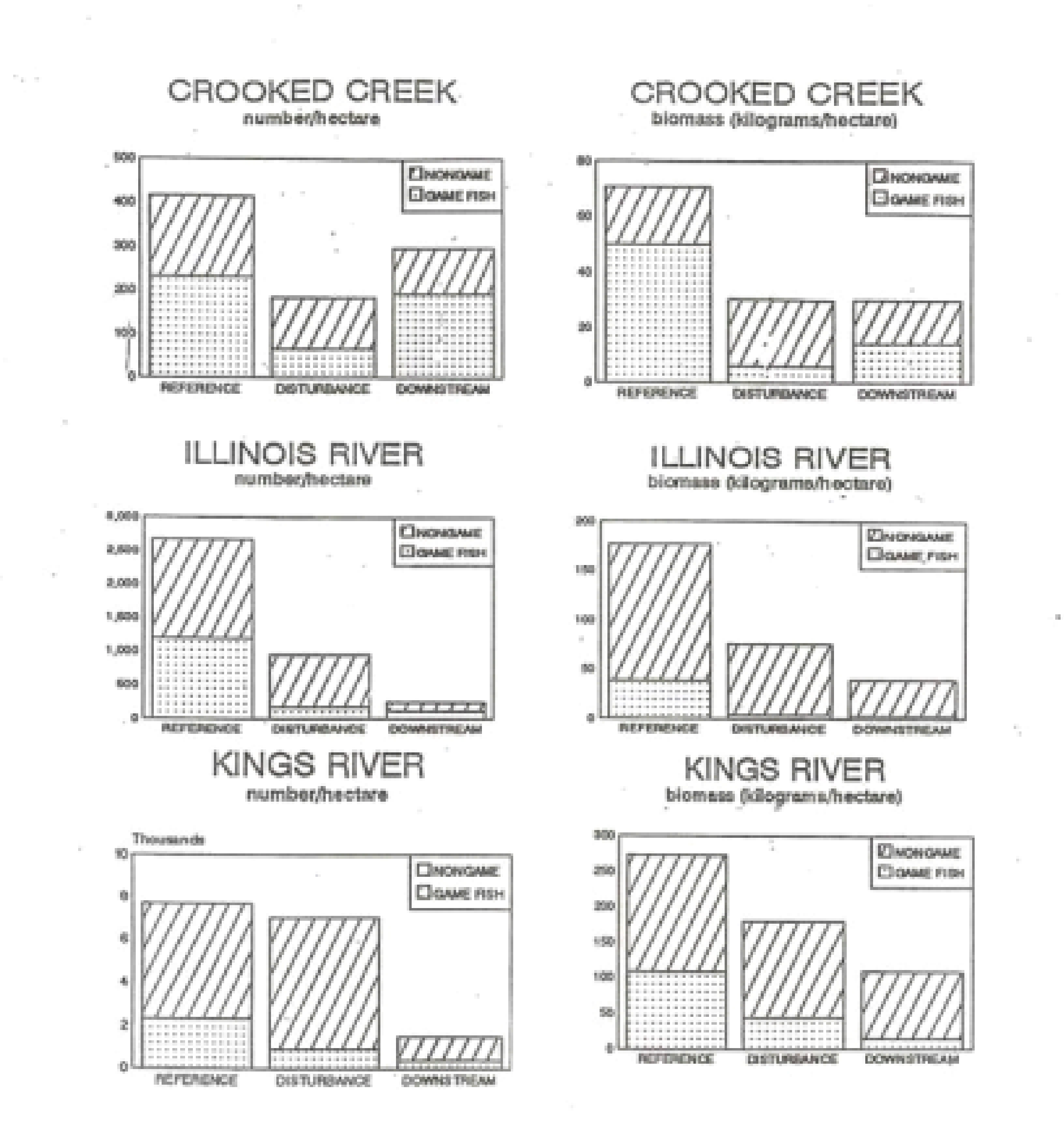
Turbidity levels were not significantly different when gravel was not being harvested among the sites (Brown and Lyttle, 1992). However, turbidity was significantly higher at disturbed and downstream sites compared to reference sites while mining was in progress (Brown and Lyttle, 1992). Increased turbidity affects fish by reducing their feeding efficiency and tolerance for disease. Increased sediment loads affect the viability of fish eggs and fry. AG&FC found that on the Kings River, there was a 50% decrease in smallmouth bass downstream from gravel mines due to a 15-fold increase in turbidity (Femmer, 2002).

Brown and Lyttle (1992) documented several impacts upon fish communities from gravel mining. In all three streams, the number of fish per hectare was higher in upstream reference pools when compared to downstream and disturbed pools. Game fish in both biomass and in numbers per hectare were significantly higher in reference pools compared to disturbance and downstream pools. Silt sensitive species were consistently more abundant in reference pools and riffles. Logperch (*Percina caprodes*) and black redhorse (*Moxostoma duquesnei*) were absent from downstream pools. Silt sensitive species, including Northern hogsuckers (*Hypentelium nigricans*), greenside darters (*Etheostoma blennioides*) and the streamline chub (*Erimystax dissimilis*) were repressed in numbers downstream from the mine sites. Other species not considered silt sensitive were low in abundance downstream from mining sites. The yellow bullhead (*Ameiurus natalis*) in Crooked Creek and the Kings River, the spotted gar (*Lepisosoteus oculatus*) in the Kings River, and the redear sunfish (*Lepomis microlophus*) in the Illinois River were absent from mining sites. These fish may be mobile enough to avoid disturbed areas. The only species that benefited from gravel mining was the stoneroller minnow (*Campostoma sp*.). A wide and more shallow channel allowed greater light penetration and increased algal production, benefiting the grazing stoneroller. The impact of gravel mining on game fish species versus non-game fish is shown in Figure 53.

The overall result of gravel mining in the Ozarks is habitat degradation and reduction in the numbers of most fish species. Stream channels are altered, sedimentation rates and turbidity levels increase, downstream riffles become reduced and pools become more shallow. Riverbanks are destabilized and riparian zones are lost. This results in changes in the fish community which favor non-game fish more tolerant of disturbed conditions.

Figure 53. A comparison of densities (N/ha) and biomass (kg/ha) of game and non-game fish at reference, disturbed, and downstream sites near larger gravel mines in three Ozark streams (Brown and Lyttle, 1992)

Note that all three streams show a decrease in game fish and an increase in nongame fish by proportion but a decrease in total fish at the gravel mine disturbance site and below the site when compared to the reference site.



Recommendation:

There is currently no assessment of the state of gravel mining in the Buffalo River watershed. Gravel mining operations do occur in some tributaries but their impacts on the ecosystems of these streams and consequently the Buffalo are unknown. The studies mentioned above looked only at the effects upon streams being mined, they did not assess what impacts may occur on higher order streams that receive water from the gravel mined tributaries. Buffalo National River needs to develop a project to assess the current state of gravel mining in the watershed and assess the impacts on biological resources, geomorphology, and water quality of the tributaries and the river. Gravel mining is a legal operation in Arkansas and this is not a recommendation to stop all gravel operations in the watershed. However, if negative impacts on the Buffalo River were found from such an assessment, then work would begin to develop management actions to protect the river.

Development

Development has not been a major issue affecting water quality in the Buffalo River watershed. Populations are relatively low and there is limited urban development within the watershed. Searcy and Marion counties have population densities of less than 15 people per square mile and Newton County has less than 10 residents per square mile (Gordon and Baker, 1995). The Ozarks area in general is growing however and these trends may begin to affect communities in the Buffalo River watershed. An economic and population assessment of the Ozarks Highlands region (southern Missouri, northwestern Arkansas, and eastern Oklahoma), found that the assessment area grew by 48% between 1970 and 1996, compared to a 31% growth rate both for Arkansas and the United States (USDA-USFS, 1999). This growth rate reflects the increase in tourism in several parts of the Ozarks over the last 30 years, particularly in Baxter County (AR) and Stone and Taney Counties in Missouri. Growth rates are predicted to continue to increase within the Ozarks Highlands region; the study projected growth of 17% between 1996 and 2010 (USDA-USFS, 1999). Counties with National Forest land are predicted to grow by 33% between 1996 and 2010 (USDA-USFS, 1999). More recent data from the 2000 Census show that the three major counties in the Buffalo's watershed have grown in the last 10 years. This data is summarized in Table 12 (U.S. Dep. of Commerce, 2001).

Table 12. Census Data (1990 to 2000)

	% of land in watershed	2001 Estimated Population	% Change in Population (1990 to 2000)
Arkansas		2,692,090	13.7
Newton County	46.24	8,518	12.3
Searcy County	37.28	8,189	5.4
Marion County	11.13	16,268	15.2

Septic tanks from small urban areas near the river and tributaries have impacted the river. Gilbert, Arkansas provides a good example of the impact septic tanks can have on the river and of how the problem was resolved to the satisfaction of both the community and the National Park Service. The town of Gilbert, Arkansas, is the only town that adjoins Buffalo National River's boundary. Its incorporated limits lie less than 500 feet from the Buffalo River. The town's permanent population is only about seventy people, but summer tourism brings additional 1,000 visitors to the town on a daily basis. Gilbert has one restaurant, numerous cabin rentals, bed and breakfast operations, canoe rentals, a general store, and other amenities. The town's wastewater production is routed to individual on-site septic systems, which are situated over karstic limestone bedrock within shallow soils. Karst systems are highly susceptible to groundwater pollution because of their internal drainage, numerous sinkholes, caves, and springs. Several sinkholes lie within Gilbert city limits and recharge through these sinkholes and nearby septic leach fields provides flow to one of the park's largest springs, Gilbert Spring, located between the town and the Buffalo River. Water quality monitoring over the past 15 years has shown this spring to be the most contaminated spring within the park. Fecal coliform bacteria counts have been observed in excess of 17,000 col/100 ml in Gilbert Spring after a precipitation event (as compared to the state standard of 200 col/100 ml) (Mott, 2002). Average nitrate values are thirteen times higher than average nitrate values in the Buffalo National River (Mott, 2002).

A series of three town meetings were held at Gilbert to discuss this project with the mayor, city council members, and residents. The residents were initially concerned about what they would be required to do if the investigators found problems. Buffalo National River's superintendent and representatives from ADEQ assured them that this was not an effort to force people into some type of compliance and that fair measures to correct problems would be sought. A number of residents volunteered to have their septic systems tested at this meeting. Over 30 individual dye traces were conducted from 29 septic systems in the town of Gilbert (85 percent of the targeted systems) (Mott, 2002).

There were two major objectives defined for the septic system traces: 1.) determine if septic systems constructed in accordance with Arkansas State Regulations for septic systems are capable of functioning in the karst setting of Gilbert, and 2.) find any systems that contribute leachate directly to Gilbert Spring. To address the first objective, seven of the best septic systems identified in Gilbert were traced simultaneously using two types of dye. Very small amounts of fluorescein were recovered from these traces, and it was concluded that these systems are over 98 percent efficient in removing the tracer dye from the leachate. This indicates that septic systems can and do work well in Gilbert's karst setting when they are properly constructed and maintained (Mott, 2002).

To address the second objective, the remaining 22 septic systems were traced using four types of tracer dyes over a three-month period. Two systems were found to rapidly contribute dye directly to Gilbert Spring in large quantities. Two other systems contributed measurable but minor quantities of dye to Gilbert Spring, and the remaining 18 systems contributed negligible amounts of dye to Gilbert Spring. Of the two systems that contributed leachate directly to Gilbert Spring, one was found to be discharging to an old cistern, and the other was found to have a broken pipe running from the house to the septic tank. The system using the old cistern was completely replaced through cost-share assistance provided by Buffalo National River, and the system with the broken pipe was repaired by the landowner. The community of Gilbert should be commended for its cooperation with NPS. The success of this program can easily be applied to other communities in the watershed that may have septic leachate problems. Money is available to assist in septic tank replacement and repair.

Point source pollution is also occurring in the Buffalo River's watershed but overall contaminant load is minimal compared to contributions from nonpoint source pollution. Whenever a municipality, industry, or other entity wishes to discharge treated wastewater to a surface water, they must first obtain a National Pollutant Discharge Elimination System (NPDES) permit from the ADEQ Water Division. NPDES permits regulate wastewater discharges by limiting the quantities of pollutants to be discharged and imposing monitoring requirements and other conditions. The limits and/or requirements in the permit help ensure compliance with Arkansas Water Quality Standards and federal regulations.

There are four wastewater treatment plants with NPDES permits in the Buffalo River watershed. These locations include the cities of Jasper and Marshall, the Buffalo Point Campground, and Marble Falls. Each plant has contaminant release limits, which are summarized in Table 13. Tyler Bend campground also has a waste disposal system but it is regulated under a state water permit because it is a no-discharge system. It does not directly discharge to any surface waters.

Table 13: Specific contaminate release limits for wastewater treatment plants under NPDES regulations in the Buffalo River watershed

(minimum and maximum values based on 7 day averge and average values based on monthly average, one sample per day*)*

Discharge Limits	City of Jasper			City of Marshall			Buffalo Point Campground			Marble Falls		
	average	*min*	*max*	*average*	*min*	*max*	*average*	*min*	*max*	*average*	*min*	*max*
Dissolved Oxygen (mg/L)		**5.0**									**4.0**	
Total Suspended Solids (mg/L)	**30**		**45**	**15**		**23**	**15**		**23**	**15**		**22.5**
pH		**6.0**	**9.0**		**6.0**	**9.0**		**6.0**	**9.0**		**6.0**	**9.0**
Biological Oxygen Demand (mg/L)	**15**		**23**	**10**		**15**	**10**		**15**	**10**		**15**
Ammonia (mg/L)	**5.0**		**8.0**	**5.0**		**8.0**	**5.0**		**8.0**	**4.0**		**6.0**
Total Nitrogen (mg/L)						**10**						
Fecal Coliform (# of colonies/100ml)	**200**		**400**	**200**		**400**	**200**		**200**	**1000**		**2000**
Discharge (MGD)	**0.1**			**.292**			**.022**					

Recommendation:

Water quality monitoring through seasonal grab samples that analyze the chemistry and bacteria levels in the water is important and can detect ongoing problems, particularly leaking septic tanks that are consistently discharging pollutants. Information obtained from these samples could be an important tool for ADEQ to enforce NPDES regulations. The park should continue to support the water quality monitoring program. However, water sampling alone is not sufficient. Often point source pollution is released as a wave of contaminants that pass through the stream or river and is missed by a grab water quality sample. The only evidence of an illegal discharge could be in the biological community, particularly aquatic macroinvertebrates. The organisms are sensitive to changes in water quality and a change in community structure would be indicative of a problem. Establishing a biomonitoring program to supplement data collected by water quality monitoring would allow detection of problems missed by grab water samples.

The development of a public outreach and educational program on proper septic maintenance is also important. The problems with septic tank leachate that occurred in Gilbert are likely occurring in other small communities throughout the watershed. The staff of Buffalo National River could easily apply the same techniques and approach to other areas. Gilbert serves as an example of what happens when the doors of communication are opened between the National Park Service and local citizens. Problems get solved and the community benefits. The park should develop and implement a plan which applies methodologies and knowledge obtained from the Gilbert project towards helping communities with septic tank improvements.

Roads

There are currently 83 miles of active dirt/gravel roads being maintained inside the boundaries of Buffalo National River and an unknown number of inactive or abandoned roads. Most of these roads were in existence when the park was established in 1972 and were not designed to conform to any state or federal standards. In the 1,338 square miles of the watershed of the Buffalo there are an estimated 2,000 miles of roads. The roads have been built across natural drainage areas, into steep mountainsides, and in some instances are located within the riparian buffers of tributaries to the Buffalo River. Most of the roads are poorly constructed and do not meet basic road standards. There is a lack of drainage structures to disperse flows, allowing large volumes of storm water runoff to collect in road ditches before it is released. Dirt and gravel roads have been clearly shown in many studies within the Ozarks to be the largest source of sediment to streams, outweighing the combined impacts of pasture erosion, logging, or natural erosion (USDA, 1986). For example, a study of erosion in the Beaver Lake Watershed, which is adjacent to the Buffalo River watershed and similar in topography, concluded that gravel and dirt roads and road banks account for 42 percent of all erosion and 51 percent of the total sediment (USDA, 1986).

The impervious road surface, rivulets, and ditch networks intercept both road surface runoff and hill slope drainage producing concentrated flows which result in accelerated erosion. Ditchline turnouts direct these concentrated flows, which carry silt and other fine sediments along with road aggregate, down the hillside. In many instances, these exit points form deep gullies that cut into the hillside, often intersecting with natural drainages. On Steel Creek Road, for example, a long steep stretch of the roadway contains no ditch relief structures and all of the flow has been directed down the ditchline. A ditch turnout has been placed at a sharp bend where it has formed a gully down the hillside. This gully is approximately five feet wide and more than eight feet deep and cuts down the hillside for more than one quarter of a mile. It deposits directly into the Buffalo River where it has developed a miniature alluvial fan. Numerous roads inside the park were designed to channel storm runoff into streams and natural drainages. This has increased the sediment load to these systems. Similar impacts are associated with roads throughout the watershed.

Recommendation:

There is currently a project near completion by the water resources staff to inventory and assess active and abandoned roads inside the park boundary and within the watershed and their impacts to water quality. Road drainage problems are being documented with GPS technology and results are being spatially analyzed. The ultimate goal is to develop a long-term cost effective mitigation strategy. Additional funding may also be sought to assess active and abandoned roads in wilderness areas around the park, particularly the Lower Wilderness of Buffalo National River.

Recreation

From 2000 to 2002, annual visitation was approximately 800,000 people. Peak visitation occurred in the late 1980's and early 1990's when the total number of visitors approached one million each year (www.nps.gov/infozone). Most activities involve canoeing, camping, caving, picnicking, hiking, swimming, sight-seeing, hunting and fishing (NPS, 1983). Only a small portion of the recreational use involves overnight stays in backcountry areas even though approximately 80 percent of the National River is considered backcountry (NPS, 1983).

Because water levels fluctuate widely on the Buffalo, visitor use in the three park districts follows seasonal patterns according to temperature and river levels. Peak river use begins in April and ends in August. With decreasing precipitation in June, the floatable portion of the river recedes in the downstream direction. The most intensive use occurs on the upper river from Ponca to Pruitt during April and May. River use peaks on the middle river from June to July and from Maumee to the confluence with the White River, adequate flows for canoeing exist year round (Apel, 1996). River use is not evenly distributed. Thirty percent of the river receives seventy percent of the canoe traffic (Apel, 1996). Two of the three most used segments of the river pass through wilderness (Ponca to Kyles and Buffalo Point to Rush). Perceptions of crowding have likely resulted in some canoers seeking recreation elsewhere. A 1982 survey of floaters on other area rivers found that 78.7% had floated the Buffalo at least once and 60.9% were displeased with the increased use there (Apel, 1996). More than half said their visits to the Buffalo had become less frequent due to the increased crowding (Apel, 1996).

The River Use Management Plan (NPS, 1983) addresses recreational river use and has established maximum use levels for various river segments and time periods (weekends vs. weekdays) based on data collected in 1981. The plan also called for on-going surveys to monitor visitor use within these segments but none have been initiated since 1981. The lack of use data for individual river segments has made it difficult to assess the success of management efforts to achieve the plans' objectives. Most usage occurs along four sections of the river: Ponca/Steel Creek to Kyles Landing, Kyles Landing to Pruitt, Maumee to Buffalo Point, and Buffalo Point to Rush. Most use occurs on Saturdays and Sundays (NPS, 1983). Well over half the visitors that float the Buffalo rent canoes; the parks method of controlling canoe use has been to limit the number of canoes allotted to each concessionaire by district (NPS, 1983).

Major recreational impacts on the river include trash, boat launch area maintenance, bank erosion at popular access points, and trail erosion. One of the most common misunderstandings regarding the Buffalo River is that the large number of people visiting the river is responsible for pollution. The water quality data and studies collected to date do not support that argument. If swimmers and canoers were the major source of bacteria, concentrations would be highest during base-flow in the summer. In reality, the highest concentrations are observed during periods of storm runoff, regardless of season or intensity of visitor use (Mott, 1997). Also, intensive sampling of public use sites conducted in 1985 showed no obvious difference between times when people were swimming and times when swimmers were absent. Fecal coliform samples at Pruitt, one of the busiest summer swimming beaches on the river, were very low (Mott, 1997).

Boat launch areas are the major recreational issue of concern. Overuse of launch areas combined with natural geologic processes have caused erosion and stream channel instability in several areas along the river. A section 404 permit was obtained in 2000 to stabilize and protect an eroding streambank at a major access on the upper section of the river, the Steel Creek launch area. Two native rock vanes at points along a two hundred fifty-foot section of the eroding bank were installed in 2001. The rock structures dampened the impact of the river flow and moved the thalweg away from the eroding bank. This created eddies that facilitate the deposition of sediment and gravel. So far the rock vanes have survived several spring seasons of high flooding with minimal bank erosion at the launch. A similar structure has also been constructed at Kyles access.

Prior to installation of the rock vanes, maintenance of the launch involved the replacement of the original bank material with gravel and clay, and recurrent replacement of more gravel and clay after each high flow event. Tens if not hundreds of truck loads of sediment and gravel have been washed down river. Similar problems exist at launch areas throughout the park.

Recommendation:

The recreational impact to the river is minimal when compared to larger watershed issues and recreational value is one of the reasons preserving and maintaining the scenic value of the river is a priority. The water resources staff will continue to monitor water quality at major access points along the river and analyze the data for any recreational impacts. In order to maintain this minimal recreational impact, this plan recommends that the park launch an educational campaign for visitors during the heavy use season on wilderness ethics, perhaps something as simple as a brochure handed out by concessionaires and park rangers at campgrounds and canoe launches. Visitors should be reminded of the importance of taking out what you pack in and proper disposal of waste.

The issues of overuse and overcrowding, particularly on the upper river, are evident by simply visiting access points like Ponca or Kyles on a warm spring weekend. Buffalo National River developed a Wilderness and Backcountry Plan (NPS, 1994). This plan address overuse issues and provides recommendations, including conducting river use surveys, particularly on high use segments of the river. Results of these surveys could be used to determine whether levels of use remain within the limits set by the River Use Management Plan (NPS, 1983) and implement strategies to limit use if maximum levels are exceeded. Buffalo National River needs to revisit the Wilderness and Backcountry Plan and implement it into park policy. Currently the only limit to river access is through concessionaire boat rentals. River surveys need to be conducted to determine if these policies should be modified.

While canoeing is the main activity of visitors, hiking and horseback riding along established trails throughout the park is also popular. New trails are being constructed throughout the park, including the Ozark Highlands Trail and Buffalo River Trail. Trail use has increased steadily with increased trail construction. Most trail use is by day hikers and horseback riders, which is increasing river wide but at a more rapid rate in the upper district of the park.

Little information is available on the impact of trail erosion and runoff on the river. Some areas, like Indian Creek near Kyles, do not have established trails but have growing erosion problems due to overuse. The high use period for trails is during the spring, which coincides with the rainy season when runoff and erosion are at their peak. This report recommends a trail assessment study be conducted to determine the impact of runoff from hiking and horse trails in the park.

According to the Master Plan (NPS, 1977), "It is essential that increased recreational use of the watershed does not contaminate the river." A major negative implication of large numbers of people using the river is trash. While the environmental impacts of trash are not as harmful as other issues like land clearing and bank erosion, it can still impact water quality and wildlife. An even more pressing issue is the loss of scenic value along the river. The enabling legislation mandates that NPS preserve the scenic and recreational value of the river. Allowing trash to accumulate within the park does not meet this mandate. Along with a public educational program as mentioned above, a trash pickup program needs to be developed by the park. Possibilities for this include hiring a seasonal employee, volunteer, or student intern whose main duties are floating the river and picking up trash during peak usage times. Other options include organizing several Buffalo National River employee trash pick up float trips throughout the park, trying to cover the entire river. This would provide the opportunity for park employees that don’t get the opportunity to get out on the river very often to get outside and see the resource they are working to preserve. Trash pickup outings would be an excellent activity for local Stream Teams to become involved with as well. Area concessionaires provide a good example of the success of these outing, as they have already taken initiative with organizing trash pickups along the Buffalo.

Reservoirs and Impoundments

Proposals to dam the Buffalo River date back to the 1930s and plans for two dams in the 1960s stimulated 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 River. The potential development of impoundments or diversion projects on major tributaries outside the Buffalo National River boundaries remains a locally perceived need and obtaining instream flow data to address this issue is critical.

Federal regulations and the parks' enabling legislation (P.L. 92-237) state the following in regard to impoundments and diversion projects:

> The Federal Power Commission shall not license the construction of any dam, water conduit, reservoir, powerhouse, transmission line, or other project works under the Federal Power Act (41 Stat. 1063), as amended (16 U.S.C. 791a et seq.), on or directly affecting the Buffalo River and no department or agency of the United States shall assist by loan, grant, license, or otherwise in the construction of any water resources project that would have a direct and adverse effect on the values for which such river is established, as determined by the Secretary. Nothing contained in the foregoing sentence, however, shall preclude licensing of, or assistance to, developments below or above the Buffalo River or on any stream tributary thereto which will not invade the area or unreasonably diminish the scenic, recreational, and fish and wildlife values present in the area on the date of approval of this Act. No department or agency of the United States shall recommend authorization of any water resource project that would have a direct or adverse effect on the values for which such river is established, as determined by the Secretary, nor shall such department or agency request appropriations to begin construction on any such project, whether heretofore or hereafter authorized, without, at least sixty days in advance, (i) advising the Secretary, in writing, of its intention so to do and (ii) reporting to the Committees on Interior and Insular Affairs of the United States House of Representatives and the United States Senate, respectively, the nature of the project involved and the manner in which such project would conflict with the purposes of this Act or would affect the national river and the values to be protected by it under the Act.

A recent example of a proposed water resource development project in the Buffalo River watershed occurred in 1997 and the series of events that followed is described below. This situation serves as an example of how complex and controversial water rights issues can become, even in eastern states that are covered by riparian doctrines. The final outcome of this situation could set precedence for future water rights issues and interpretation of Buffalo National River's enabling legislation regarding diversion and impoundment issues.

In February of 1997, the Searcy County Regional Water District (SCRWD) proposed a dam on Bear Creek, a major tributary of the Buffalo and they applied for a Section 404 permit from the U.S. Army Corps of Engineers (COE) to build the dam and reservoir in the headwaters of Bear Creek (Figure 54 and 55). In May of 2000, the Little Rock District COE denied the permit, citing the presence of a less environmentally damaging alternative. This alternative, favored by NPS and USFWS, involves piping water from Greer's Ferry reservoir through the town of Clinton's water treatment and distribution facilities, and up to Leslie and Marshall along the Highway 65 corridor. Water could then be distributed to customers through the existing Searcy County Regional Water District. The costs of building a pipeline have been estimated to be less than the costs of building a dam on Bear Creek.

SCRWD issued an appeal to the Dallas COE office and in August of 2001, the COE issued a permit for impoundment and reservoir construction. NPS and several other federal agencies issued letters of disagreement with the Corps' decision, citing the need for time to research the issue, prepare an Environmental Impact Statement (EIS) as required by NEPA, and to await NPS determination that the dam could be allowed under Buffalo National River's enabling legislation. The COE did not revoke the permit or make additional effort to research environmental impacts from the dam.

In October of 2001, the Ozarks Society, Arkansas Canoe Club, Sierra Club, National Parks and Conservation Association, American Rivers, Save Our Streams, and the Arkansas Wildlife Federation filed a lawsuit against the Corps of Engineers. The complaint alleged that the COE was in violation of the following: (1) Buffalo National River's enabling legislation by issuing the permit, (2) NEPA by failing to prepare an EIS, and (3) the Clean Water Act and Administrative Procedures Act because the permit was issued within the presence of a less environmentally damaging practical alternative.

After several meetings with NPS and USFWS officials and a finding by the Department of Justice that the Secretary of Interior was required by Buffalo National River's enabling legislation to make a determination regarding the impacts of a proposed dam, the COE issued a letter to the SCRWD in April of 2002. The letter stated that before any dam construction could begin, the county must await final determination by the Department of Interior regarding Buffalo River's enabling legislation. Then in December of 2002, the COE sent a letter to the SCRWD officially revoking the permit. The lawsuit was later denied as moot. A Technical Team, consisting of NPS, Corps of Engineers, SCRWD, NRCS, and Arkansas Soil and Water Conservation Commission officials, has been formed to address the SCRWD's water supply needs. The Technical Team will also address what studies will be required to complete the Secretarial Determination as required by the Department of Justice.

While the permit to dam Bear Creek has been denied, the threat of impoundments and water diversions remain. While each situation is unique, general questions need to be answered regarding ecological and hydrological impacts of impounding or diverting water in tributaries along the Buffalo. Research is currently underway to gain a more broad understanding of the dependence between a river and its tributaries. Studies include an assessment of larval fish migration and drift from the headwaters of Bear Creek to the

Buffalo and an associated study is analyzing macroinvertebrate drift on Bear Creek.

A study recently completed by the USGS analyzed the sensitivity of stream habitat to hydrologic and geomorphic dynamics along a reach of Bear Creek, about 1 km upstream from the junction of Bear Creek and the Buffalo River (Reuter et.al., 2003). Data were taken over a one year time period and then entered into a two-dimensional hydraulic model. This model was used to assess sensitivity of habitats to changes in frequency and magnitude of flow. The results of this study found that high and low flows do play a role in maintaining physical habitats on Bear Creek and those physical habitats are dependent upon a continuation of this spectrum of flow. The study showed that different flows play different roles in establishing habitat. High flows determine the geomorphic structure of the stream by scouring pools, transporting and re-depositing sediments in riffles, and rebuilding benthic habitats. Low flows help maintain this geomorphic template so that habitats may be created. While this study did not measure all the factors that might influence habitat changes in the future, it did suggest that Bear Creek has a high sensitivity to habitat alternations, especially in regards to riffle- and race-dwellings species such as the rainbow darter *(Etheostoma caeruleum)* and the Ozark minnow *(Notropis nubilus)*. These species could be at risk if the flow regime was altered significantly.

Another USGS study found that flows from Bear Creek can have a substantial impact on water levels of the Buffalo River. The drainage area of Bear Creek at its mouth is 91.6 mi^2 and the drainage area for the Buffalo River area just below its confluence with Bear Creek is 935 mi^2. Bear Creek comprises nearly 10% of the Buffalo River's drainage area at the location just below their confluence. During periods of low flow in the late summer and early fall, Bear Creek comprised from 18% to 25% of the same day flow of the Buffalo River (Petersen et al., 2002).

Figure 54. Headwaters of Bear Creek
(photos by Joanna Reuter)

Figure 55. Bear Creek just above confluence with the Buffalo River

Recommendation:

As the surrounding area develops and water supply needs change, other communities in the Buffalo River watershed may need to augment their water supplies and it is likely that other water resource development proposals will be forthcoming. While establishment of the National River has effectively quelled the issue of dams within the boundary, the potential for alterations in the flow of major tributaries by impoundments or diversions remains a possibility. Long-term recommendations for addressing this issue and the potential ecological and hydrological impacts must await the outcome of ongoing research on Bear Creek. Recommendations to handle future proposals for impoundments or water diversions from tributaries along the Buffalo are situation specific; it is not practical or useful to make broad general recommendations regarding this issue.

Groundwater and Karst Geology

One of the basic needs related to protecting the water quality of the Buffalo is determining the sources of water that feed the river. This is a relatively simple task in most areas as one simply follows topographic boundaries. However, the true watershed of the Buffalo River does not follow topographic boundaries. The Buffalo River is located in a karst basin characterized by underground drainage networks where groundwater recharge areas lying outside the topographic watershed can be significant in both size and in the amount of pollutants they transmit. Other than during periods of precipitation-generated runoff, water flowing to the Buffalo is supplied by groundwater recharge. Groundwater flow to the river originates primarily from karstic aquifers within the Springfield Plateau. The largest spring and cave systems within the park are associated with a 400-ft-thick Mississippian-aged limestone formation comprising this plateau. John Eddings Cave and spring lies within the park and they contain unique aquatic and cave habitats utilized by an estimated 2,500 endangered gray bats. Hundreds of other karst features including caves, springs, losing streams, and sinkholes also occur in the project area.

Some important studies have been conducted in response to specific issues related to the river and its karst geology. One study was in response to a proposed landfill outside the Buffalo River's topographic boundary. It was permitted by the State and ready for construction. Groundwater tracing, conducted by Aley and Aley (1989) for the park's largest spring, Mitch Hill Spring, revealed that approximately sixty-five percent of the recharge area for this spring lies beyond the perimeter of the surface watershed boundary. Detailed geologic mapping revealed previously undetected faults which provide a continuous pathway for the interbasin transfer of groundwater along these solutionally enlarged lineaments (Hudson, 1998). The issue was finally settled in court by a judge ruling that the state had been negligent in their assessment of the potential groundwater impacts in this highly karstic groundwater area, and the permit was rescinded. To the west, Mill Creek was shown to contribute 96% of the nitrate load in the Buffalo National River below their confluence. After many years of investigation, the source of the nitrates was linked to interbasin transfer of groundwater from a more intensively developed agricultural basin to the north. In fact, 80% of the recharge area for the springs at the head of Mill Creek lie outside their surface watershed. Geologic mapping illustrated that spring discharge was localized at the base of the Mississippian limestone aquifer near the intersection of two previously undetected faults (Hudson, 1998). In one case, dye introduced into a sinkhole filled with cattle carcasses moved over two miles from the Crooked Creek basin to the Dogpatch Springs at the head of Mill Creek in less than five days. This rapid groundwater transport can only be accomplished through conduit flow; conduit flow does not allow for filtration of pollutants.

The Davis Creek basin, an area where a current karst assessment project in its final stages, has also been a hot spot of controversy, especially within the vicinity of John Eddings Cave. In the early 1990's, ADEQ received an application to construct a 500-animal confined hog operation, with the proposed location being within ½ mile from the park boundary and almost directly on top of mapped passages for John Eddings Cave. NPS calculations showed that this operation would have an equivalent waste production of a town of 3,000 people, considerably larger than any existing town in the watershed. ADEQ groundwater modeling showed a clear potential for significant nitrate contamination in the river as a result of the karst setting. However, instead of denying the permit outright, the director of ADEQ placed a moratorium on new confined animal operations utilizing liquid waste management systems in the Buffalo River watershed.

Recommendation:

In the short term, project work should continue in trying to understand the karst groundwater network and where the water that supplies the base flow of the Buffalo River comes from. A two-year project to commence in fiscal year 2003 will inventory the springs and perennial streams within the Buffalo River watershed. This information will provide a baseline for further assessments of interbasin groundwater transfer and other karst related problems. These studies will help with important management decisions involving land use activities in the Buffalo River's watershed.

A more long-term goal, protecting the water quality of the Buffalo River, involves landowner education and implementation of Best Management Practices to prevent improper land use activities in sensitive karst areas. Land clearing in sinkhole recharge areas and trash dumping in sinkholes are ongoing problems within the watershed. An ongoing recommendation throughout this report is the establishment of a non-profit group designed to bring landowners and resource managers together with the common goal of preserving the water quality of the Buffalo.

Exotic Species

While there are many problems associated with the Buffalo River flowing into the cold dam released waters of the White River, one positive consequence is that these cold waters may shield the river from invasion of warm water exotic species that might otherwise be introduced through the White River, of particular note, the zebra mussel. It should be noted that while the cold water barrier may help, it does not exclusively protect the river from introductions, in particular, from introductions along the river above the White. However, due to the lack of a consistent long-term monitoring program for aquatic species, particularly mussels and macroinvertebrates, the introduction of exotic species may go unnoticed.

The only exotic species that has a documented impact on the river's aquatic ecosystem is

Corbicula. The free swimming larvae of this species allows for its rapid spread. Bryant, 1997 found that Corbicula only invades native mussel communities that are already under distress, it can survive in disturbed habitat and poor water quality conditions. Usrey (2001) found that on the Buffalo, Corbicula populations were the highest along the middle reaches of the river and that declining water quality and increasing Corbicula populations are positively correlated with each other. Freshwater mussel species are one of the most threatened groups on the planet. During the past 30 years freshwater mussel abundance and diversity has declined throughout the United States and Canada, and freshwater mussels are imperiled disproportionately to terrestrial species. The Nature Conservancy recognizes that 55% of North America's mussels are extinct or imperiled compared to only 7% of the continent's bird and mammal species (Master, 1990). This alarming decline in mussel distribution, abundance, and diversity is primarily due to habitat degradation and destruction associated with human activities (Williams et al. 1993).

As mussel communities decline throughout North America, many NPS units are destined to become important refuges for this increasingly endangered group of mollusks (Jennings, 2000). A preliminary survey of 27 NPS units potentially having native mussel communities indicated that 37% of the responding units did not have baseline inventories, and 66% of the parks with inventories had mussel species that were under protection by state and federal laws. Buffalo River is one of the NPS units that provide refuge for mussel species of concern (Jennings, 2000). Long-term threats to mussel populations within NPS units include; general pollution from numerous non-point sources, instream channel instability (channelization, dredging, or bridge construction and maintenance), barriers to fish migration (low-water bridges and dams), and the introduction of non-native species such as the zebra mussel (*Dreissena polymorpha*) and the Asian clam (*Corbicula fulminea*) (Jennings, 2000). With the exception of the zebra mussel, all of these threats occur within the Buffalo River system. Two mussel assessments have been conducted, one in 1996 and one in 1921, but neither were comprehensive enough to base management decisions upon.

The European wild hog, or feral pig, is another exotic species in the park that may be impacting water quality. Feral pigs can very damaging to vegetation causing nutrient leaching and erosion in pig feeding areas. Studies in Great Smokey Mountain National Park found increased bacteria loads into streams near wallowing and rooting areas and increased erosion from soil disturbance. Again, there is little knowledge on the size of the feral pig population at Buffalo National River and no studies have been done to assess their impact on water quality.

Recommendation:

Public education and a consistent inventory and monitoring program are the most effective ways to control invasion of exotic species, particularly regarding the macroinvertebrate and mussel communities. A monitoring program needs to be implemented in conjunction with the ongoing water quality monitoring program for many reasons, and control of exotic species is a very important one. Management actions may be taken before populations become too large to control if the exotic species is caught early. An important research focal point should be to better understand the role, if any, the cold tail waters of the White River play in exotic species introductions into the Buffalo, particularly with the zebra mussel.

Because native freshwater mussels are under a demonstrated risk at Buffalo National River and around the continent, an immediate assessment of the mussel community should be conducted to determine the status of the population on the river. A study of this magnitude would provide insight on what impact Corbicula is having on the native mussel communities and determine the extent and magnitude of the Corbicula population along the river and its relation to degrading water quality.

Public education is also extremely important in preventing the introduction and spread of exotic species. The public needs to be informed about how exotic species are introduced, what characteristics to look for when identifying an exotic species, and what they can do to prevent their spread. This education effort is particularly important in regards to the spread of zebra mussels. Information kiosks could be set up at major access points where boat traffic is most intense educating visitors about zebra mussels, how they spread, and how to inspect their boats before launching into the river.

Human Health

The excellent water quality of the Buffalo River is one of the main attractions to the nearly 800,000 people that visit the park annually. The state standard for fecal coliform concentrations in primary contact recreation waters is 200 col/100ml for a geometric mean of five samples collected over a 30 day period. The average geometric mean concentrations for samples taken during base concentrations have never come close to exceeding the state primary contact standard. In over 10 years of water quality monitoring, the highest geometric mean concentration occurred at Ponca, 13 col/100ml. This does not represent a significant health threat. Springs and tributary streams also showed levels safely below primary contact standards. During storm events, bacteria levels may exceed state standards, with fecal coliform values increasing as discharge increases. The current water quality monitoring program does not test for compliance with state standards however, counts can be very high during storm events. In tributaries with significant amounts of agricultural activity, counts can be over 40,000 col/100ml (Mott, 1990). During rain events, bacteria counts in the tributaries routinely displayed peak concentration over 90 times higher than background peaks and 112 times higher than standards for Extraordinary Resource and Natural and Scenic Waterways (Mott, 1990). This means that visitors may face bacteria counts exceeding standards many times through the course of the year following storm events and this could pose a health threat.

Recommendation:

The current water quality monitoring program has limited storm event sampling, with the exception of high flow data collected at random, incorporated into it. Incorporation of some form of storm event sampling would provide a larger set of data to base management decisions upon. Nonpoint source pollution is storm event driven and the water quality monitoring program is not. Analysis of hydrographs from the Buffalo River show that the river is in the rising or falling portion of storm hydrographs between 15 to 20 percent of the time (Mott, 1997) and that 30 percent of the total yearly flow is derived from surface runoff. Therefore, a monitoring program that utilizes a random sampling time (such as the current monitoring program) can expect an average of only 15 to 20 percent of the samples to reflect some component of nonpoint source runoff. Of the 65 days per year when storm-flow could be assessed, only 15 days could be considered to be near-peak discharges, which is when the most nonpoint source loading is occurring (Mott, 1997). Nonpoint source pollution is identified as the number one water quality problem in Arkansas, yet the monitoring program in place is not designed to target nonpoint runoff and further work is needed to assess storm-loads. A standardized storm event sampling protocol needs to be established and incorporated into the water quality monitoring program already in place.

Another issue that needs to be addressed, which will be discussed in more detail in a subsequent section, is the need for development of specific water quality standards in the streams of the Buffalo River watershed. Current standards do not account for runoff events that produce peak coliform in excess of primary contact standards.

Finally, the only long-term solution to reducing fecal coliform concentrations in the river and its tributaries is the development of a plan to work with local landowners to implement BMPs on their property. This again goes back to the formation of a local non-for-profit group to work with communities, landowners, and resource managers in protecting the watershed. High fecal coliform levels during runoff events are a natural occurrence and many times, even in drainage basins with no agricultural activities, coliform levels will still exceed natural levels. However, overall, changes in land use and farming practices can reduce the number of times safe levels are exceeded and reduce the overall health risk.

Environmental Education Programs

Many of the problems associated with preserving the water quality and aquatic ecosystem of the Buffalo River are linked to problems outside of NPS boundaries. When problems are outside of the park, their solutions depend upon local communities and citizens working together with resource managers. One important forum to communicate the importance of preserving the integrity of Buffalo National River's resources is the classroom. Working with students and providing hands on environmental educational experiences gives them a new perspective on how important it is to preserve and protect a river they have grown up with in their backyards. Reaching these students at an early age will build a strong foundation of environmental stewardship that will carry over later in life. If these students remain in the communities they grew up in, they can make a significant difference in turning around the current degrading water quality trends along the river and its tributaries.

One important program that has taken place for several years at Buffalo National River is

Project W.E.T. This is state and federal program that brings environmental education on aquatic ecosystems into the classroom. The program focuses on high school and junior high school age students. Students from three local high schools were given two days of water quality monitoring training by resource management staff and then assigned a tributary of the Buffalo to sample monthly. Samples were taken and data were analyzed by the students. This program was successful for several years, with some students taking science fair projects associated with Project WET activities to national competitions. However, funding was limited and the program has not been administered in recent years.

Recommendation:

The park needs to reprioritize environmental education programs and focus on more hands on, aquatic related activities with high school and junior high students. One option is to seek new funding sources and revitalize an educational program that involves resource management staff. Opportunities to get resource management staff involved in classroom or field activities with students helps build upon the important and currently lacking connection between Buffalo National River and its surrounding communities.

Another option is the establishment of a Learning Center at Buffalo National River. The park has been selected for possible funding as part of a nationwide system of learning centers to be formed through Natural Resource Challenge funding. Learning Centers are a network of cooperating scientists and NPS staff that will support research activities, the accumulation and synthesis of information, and the direct transmission of information to the public. Each center will provide computer access, and laboratory, office, and dormitory space. They will have a small core staff and rely heavily on partnerships for operational expenses. The centers will provide environmental education and outreach opportunities to the public through an education specialist that works with park interrupters and resource management staff. A Learning Center at Buffalo National River would be an excellent tool to communicate and educate park visitors and the surrounding community about natural resource issues, particularly watershed issues. It could be an important resource to help bridge the gap that currently exists between the park and communities in the watershed.

Regulatory Designations/Standards

Existing state standards do not provide the proper framework for assessing nonpoint source pollution. State standards do not address such critical nonpoint source issues as peak concentrations, parameter loads, degradation with respect to background sites, or nutrient concentrations. A water quality program that utilizes random water quality sampling can expect on average only 15 to 20% of the samples to reflect some component of nonpoint source runoff because these sampling method miss most of the major runoff events, when most nonpoint source pollution occurs.

The Buffalo River is also designated an Extraordinary Resource Water (ERW) by the state of Arkansas. The ERW designation has an accompanying anti-degradation policy that, among other things, statutorily requires maintenance of existing water quality

(ADPCE, 1995). This process that identifies impaired waterbodies has a limited potential to discern streams most affected by nonpoint source runoff because of the low probability that peak runoff events will be sampled, due to the random sampling regime currently in practice. Furthermore, the process is strongly directed toward impaired waters and, in effect, does not recognize the important need for protecting the existing water quality of Extraordinary Resource Waters such as the Buffalo River.

Recommendation:

The current standards and designations for the Buffalo River include a mandate for the Park Service to "preserve" the Buffalo River and an "antidegradation policy" applicable to ERW designation under ADEQ Reg. #2. Both of these mandates are vague and their strict interpretation/enforcement is unrealistic. It may be beneficial to adopt water quality standards applicable specifically to the Buffalo River and its tributaries based on the large volumes of existing water quality data. This, in conjunction with a water quality monitoring program that incorporates storm event sampling and biological monitoring would provide for best protection and preservation of the water quality of the Buffalo.

Cumulative Effects/Ecosystem Disruptions

The overarching problem with the above issues is that they are viewed and addressed independently of each other. In reality, these issues are all going on simultaneously and they are having a cumulative impact upon the aquatic communities of the river and its tributaries. The magnitude of those cumulative effects is unknown. The question to ask is will solving one or two of these issues stop degradation of water quality or biological communities or will it take a more interdisciplinary approach to prevent long-term damage to the aquatic ecosystem.

Recommendation:

Future research is essential to understand and manage the aquatic resources of the river but focusing on the definition and resolution of one issue at a time may not solve the overall problems with degrading water quality throughout the watershed. Research projects need to be developed around a more interdisciplinary approach in order to address the overall impact on resources rather than the effects of a single parameter or issue. One way to begin the process of addressing water resource issues in the park and to understand the cumulative impact of resource degradation is by implementation of a rigorous biological monitoring program. Currently no program of this nature exists. The water quality of the Buffalo River is declining and land in the watershed is rapidly being converted to pasture but the ecosystem disruptions that these changes may be causing have not been documented.

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Appendix A. Federal Acts, Regulations, and Policies Specific to Administration of National Park Units

Federal acts, regulations and policies specific to administration of National Park Units

There are three laws that constitute the primary authorities for administration of the National Park System.

National Park Service Organic Act (1916)

In the 1916 Congress created the National Park Service in the Department of the Interior to:

> promote and regulate the use of the Federal areas known as national parks, monuments, and reservations . . . by such means and measures as conform to the fundamental purpose of said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wild life 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. (NPS organic act, 16 USC 1)

The basis for Park management policies was specifically addressed for the first time by Secretary of the Interior Franklin K. Lane in a letter to the first director of the National Park Service, Stephen T. Mather, on May 13, 1918, Secretary Lane stated that administrative policy should be based on three broad principles:

First, that the national parks must be maintained in absolutely unimpaired form for the use of future generations as well as those of our own time; second, that they are set apart for the use, observation, health, and pleasure of the people; and third, that the national interest must dictate all decisions affecting public or private enterprise in the parks.

National Environmental Policy Act (1969)

This law requires a systematic analysis of federal actions with the potential to affect the human and natural environments. The analysis includes a consideration of reasonable alternatives and an analysis of short- and long-term irretrievable, irreversible, and unavoidable impacts. If a federal action may result in major impacts, an environmental impact statement is prepared. The EIS ensures evaluation of the impacts of proposed projects and facilitates public review.

Regulations implementing NEPA require the cooperation of federal agencies and encourage the reduction of duplication through cooperation with state and local agencies including early efforts of joint planning, hearings and environmental assessments.

General Authorities Act (1970)

The General Authorities Act of 1970 defines the national park system as including "any area of land and water now or hereafter administered by the Secretary of the Interior through the National Park Service for park, monument, historic, parkway, recreational, or other purposes" (16 USC lc(a)). It states that "each area within the national park system shall be administered in accordance with the provisions of any statute made specifically applicable to that area" (16 USC lc(b)) and in addition with the various authorities relating generally to NPS areas, providing the general legislation does not conflict with specific provisions.

Redwood National Park Act (1978)
In a 1978 act expanding Redwood National Park, NPS general authorities were further amended to add:

The authorization of activities shall be construed and the protection, management, and administration of these areas shall be conducted in light of the high public value and integrity of the National Park System and shall not be exercised in derogation of the values and purposes for which these various areas have been established, except as may have been or shall be directly and specifically provided by Congress. (16 USC la-l)

<u>Federal Acts relevant to federal land management</u>

Clean Water Act

The Federal Water Pollution Control Act, more commonly known as the Clean Water Act, was first promulgated in 1972 and amended in 1977, 1987, and 1990. This law was designed to restore and maintain the integrity of the nation's water. Goals set by the act were swimmable and fishable waters by 1983 and no further discharge of pollutants into the nation's waterways by 1985. The two strategies for achieving these goals were a major grant program to assist in the construction of municipal sewage treatment facilities and a program of "effluent limitations" designed to limit the amount of pollutants that could be discharged.

As part of the act, Congress recognized the primary role of the states in managing and regulating the nation's water quality within the general framework developed by Congress. All federal agencies must comply with the requirements of state law for water quality management, regardless of other jurisdictional status or land ownership (section 313). States implement the protection of water quality under the authority granted by the Clean Water Act through best management practices and through water quality standards. Best management practices are defined by the U.S. Environmental Protection Agency (EPA) as methods, measures, or practices selected by an agency to meet its nonpoint control needs. These practices include but are not limited to structural and non-structural controls, operational procedures, and maintenance procedures. They can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters (Code of Federal Regulations 1990).

Water quality standards are composed of the designated use or uses made of a water body or segment, water quality criteria necessary to protect those uses, and an anti-degradation provision to protect the existing water quality.
Section 404 of the Clean Water Act further requires that a permit be issued for discharge of dredged or fill materials in waters of the United States including wetlands. The Army Corps of Engineers administers the Section 404 permit program with oversight and veto powers held by the EPA.

Clean Water Act and regulations are generally implemented by the states with the EPA serving in an oversight role. A triennial review of a state's water quality regulatory program is conducted by each state's water quality agency to determine if its standards are adequate to meet federal requirements. These standards are then forwarded to the EPA for approval.

Rivers and Harbors Appropriations Act of 1899, as amended (33 U.S.C. 401-466n)

This was the first general legislation giving the Corps of Engineers jurisdiction and authority over the protection of navigable waters. Under it, permits from the Department of the Army are required for structures and/or work in or affecting navigable waters of the United States (33 CFR 322.3(a)). Regulation of activities under the Rivers and Harbors Act is often, though not always, used in concert with regulation under Section 404 of the Clean Water Act. Rivers and Harbors Act jurisdiction is not limited to activities in navigable waters but also includes any actions that "affect" those waters. (33 CFR 322.3(a)) The Corps is allowed broad discretion in making this determination. Jurisdiction of the Corps of Engineers over navigable waters reaches laterally to the ordinary high water mark in freshwater areas (33 CFR 329.11(a)). Also, it has been determined that jurisdiction extends to an area over which a river customarily flows from time to time in its natural meandering (Want 1996). If there is a possibility that an action in a park could affect navigable waters, park staff should: (1) Contact the local Corps office to determine if there are navigable waters in the park, and (2) if there are, determine the requirements for obtaining a permit. Activities which often require a permit include: piers, ramps or docks; transmission lines, cables or pipes over, under or through the water; jetties, bulkheads, revetments. or breakwaters; water withdrawals; etc. (Bridges require Coast Guard authorization under a section 9 permit).

Floodplain Management (Executive Order 11988, 1977)

The objective of this executive order is to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. For non-repetitive actions, the Executive Order states that all proposed facilities must be located outside the limits of the 100-year floodplain. If there were no practicable alternatives to construction within the floodplain, adverse impacts would be minimized during the design of the project. National Park Service guidance pertaining to Executive Order 11988 can be found in Directors Order 77-2.

Wetlands Protection (Executive Order 11990, 1977)

This executive order directs the NPS to 1) provide leadership and to take action to minimize the destruction, loss, or degradation of wetlands; 2) preserve and enhance the natural and beneficial values of wetlands; and 3) to avoid direct or indirect support of new construction in wetlands unless there are no practicable alternatives to such construction and the proposed action includes all practicable measures to minimize harm to wetlands.

National Park Service Management Policies and Guidelines

The National Park Service Management Policies (2001) give broad policy guidance for the management of National Park System Units. Some of the topics included are: park planning, land protection, natural and cultural resource management, wilderness preservation and management, interpretation and education, special uses of the parks, park facilities design, and concessions management. Recommended procedures for the implementation of service-wide policy are described in the NPS guideline series. Guidelines most directly related to actions affecting water resources include: 1) DO-2 for the Planning process, 2) DO-12, for Compliance with NEPA, including preparation of EIS, EA, and categorical exclusions, 3) DO-75, for Natural Resources Inventory and Monitoring, 4) DO-77, for Natural Resource Management, and 5) DO-83 for Public Health Management.

Some aspects of water resources will be important considerations in the GMP because it is the primary planning tool for making decisions about land use in the park, including the placement of facilities. The occurrence of flood hazards and wetlands will influence these decisions, because the NPS policy is to first avoid conflicts with these resources, by identifying sensitive areas, and not locating facilities in them. If facilities must be located in wetlands or floodplains (boat launch ramps, for example, must be located in floodplains), a Statement of Findings is required to document the necessity of using that particular location. The state designation of major portions of the riverway as Outstanding Resource Waters, will also influence facility location and design, because wastewater discharge permits will be difficult, if not impossible, to obtain.

Endangered Species Act (1973)

This act provides for the conservation, protection, restoration, and propagation of selected species of native fish and wildlife that are threatened with extinction. All federal agencies must consult with the Secretary of the Interior on activities that potentially effect endangered flora and fauna.

Section 7 outlines procedures for interagency cooperation to conserve federally listed species, species proposed for listing and for designated critical habitat and proposed critical habitat. Section 7(a)(1) requires federal agencies to use their authorities to further the conservation of listed species and section 7(a)(2) prohibits federal agencies from undertaking, funding, permitting or otherwise authorizing actions that are likely to jeopardize the continued existence of listed species or that would destroy or adversely modify critical habitat.

Water Quality Improvement Act (1970)

This act requires federally regulated activities to have state certification that they will not violate water quality standards.

Safe Drinking Water Act (1974) and Amendments (1986)

This act sets national minimum water quality standards and requires regular testing of drinking water for developed public drinking water supplies.

Appendix B. Pertinent Information Relevant to Protected and Sensitive Species

Pertinent Information Relevant to Protected and Sensitive Species
*information obtained from the Arkansas Natural Heritage Commission, 2002
** federal species of concern information obtained from U.S. Fish and Wildlife Service

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 Trillum	INV, G3, S3
Valerianella ozarkana	Corn-Salad	INV, G3, S3
Insects		
Pseudactium ursum	Ozark Pseudactium	INV, G?, S1
Derops 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

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 distrubances.
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-Domonstrably widespread, common, and secure in the state and essentially ineradicable under present conditions.

B-Breeding Status
N-Non-breeding status

Appendix C: Newton County Quorum Court Resolutions 99-5 and 99-6

and

Interim Study Proposal and Summary Report ISP 99-25

RESOLUTION NO. 99-5

A RESOLUTION OF NON-PARTICIPATION IN
THE NATIONAL PARK SERVICE WATER
RESOURCE MANAGEMENT PLAN (WRMP)
FOR THE BUFFALO RIVER NATIONAL PARK DISTRICT

BE IT RESOLVED BY THE QUORUM COURT
OF THE COUNTY OF NEWTON, STATE OF ARKANSAS:

WHEREAS, the National Park Service has been conducting water quality monitering of the Buffalo River Watershed from 1985 to present; and

WHEREAS, the Water Resource Management Plan is not a water plan but a land plan to control the surrounding nine counties' (Baxter, Newton, Searcy, Marion, Pope, VanBuren, Stone, Boone and Madison) lands that make up the Buffalo River Watershed; and

WHEREAS, sixty percent of the above land is private property and out of the jurisdiction of the National Park Service; and

WHEREAS, this is a blatant attempt by the National Park Service Buffalo National River District to gain more control of the private property of the citizens of Arkansas.

NOW, THEREFORE BE IT RESOLVED BY THE QUORUM COURT OF NEWTON COUNTY, ARKANSAS, THAT:

SECTION 1: The Newton County Quorum Court, being adamantly opposed to any attempts by the National Park Service Buffalo National River District to gain more control of the private property of the citizens of Arkansas, resolves not to participate in the National Park Service Water Resource Management Plan (WRMP) for Buffalo River National Park District.

This Resolution Adopted in Regular Session this _____ day of __________, 1999.

APPROVED: Harold Smith
COUNTY JUDGE

ATTEST:

SUBMITTED BY:

NEAL GIBSON

____
COUNTY CLERK

RESOLUTION NO. 99-6

A RESOLUTION REQUESTING ARKANSAS
GOVERNOR MIKE HUCKABEE REVOKE
ALL OF THE ARKANSAS EXTRAORDINARY RESOURCE
WATER DESIGNATIONS (ERWS) DUE TO THEIR
ILLEGAL FORMATION

BE IT RESOLVED BY THE QUORUM COURT
OF THE COUNTY OF NEWTON, STATE OF ARKANSAS:

WHEREAS, by definition, an ERW regulates the entire "land watershed" of the body of water designated, and, therefore, as written with their rules and regulations constitute a "taking" under the Constitution of the State of Arkansas; and

WHEREAS, the Constitution of the State of Arkansas clearly provides that private property shall not be taken, or appropriated for public use, without just compensation therefor; and

WHEREAS, the Arkansas Department of Pollution, Control and Ecology designated all of the Arkansas ERWS without legal public hearings or environmental impact statements as required by law.

NOW, THEREFORE BE IT RESOLVED BY THE QUORUM COURT OF NEWTON COUNTY, ARKANSAS, THAT:

SECTION 1: The Newton County Quorum Court respectfully requests Governor Mike Huckabee revoke all of the Arkansas Extraordinary Resource Water Designations (ERWS) due to their illegal formation.

This Resolution Adopted in Regular Session this _____ day of ___________, 1999.

APPROVED: Harold Smith
COUNTY JUDGE

ATTEST:

____
COUNTY CLERK

SUBMITTED BY:

NEAL GIBSON

SUMMARY REPORT: BUFFALO NATIONAL RIVER

By The
LABOR and ENVIRONMENT SUBCOMMITTEE

Of The
HOUSE INTERIM COMMITTEE ON PUBLIC HEALTH, WELFARE AND LABOR

SUMMARY REPORT ON
ISP 99-25

"Requesting the House Interim Committee on Public Health, Welfare and Labor to study the relationships between federal and state agencies which have authority to promulgate regulations for the management of water resources for Buffalo National River and related issues"

06/13/00

LABOR and ENVIRONMENT SUBCOMMITTEE
of the
HOUSE INTERIM COMMITTEE ON
PUBLIC HEALTH, WELFARE AND LABOR

SUMMARY REPORT ON
ISP 99-25

"Requesting the House Interim Committee on Public Health, Welfare and Labor to study the relationships between federal and state agencies which have authority to promulgate regulations for the management of water resources for Buffalo National River and related issues"

The Labor and Environment Subcommittee held meetings on September 14, 1999, October 18, 1999, and January 11, 2000 to consider ISP 99-25. The full House Interim Subcommittee on Public Health, Welfare and Labor met and heard testimony on this issue on October 28, 1999. A glossary and definition of terms can be found in **Attachment A**. Minutes of the meetings are under **Attachment B**. Attendance for these meetings can be found in **Attachment C**. An Attorney General's Opinion on this topic is included in **Attachment D.**

Representative Randy Laverty, Representative Mike Hathorn, and Representative Jimmy Milligan were co-sponsors of the interim study proposal. The need for the study arose when a group of constituents in the legislators' districts questioned the existence of a Water Resources Management Plan for the Buffalo National River watershed. The residents were deeply concerned that if such a plan were implemented increased regulations would greatly limit or curtail private use on private land. An additional concern involved questions about the "Man and the Biosphere Reserve" project and its potential to effect the property rights of individual landowners.

HISTORY

In 1972, Congress (P.L. 92-237) mandated the National Park Service to preserve the Buffalo River as a free-flowing stream, thereby establishing the Buffalo River as America's first National River. The mandate is "for the purpose 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 for the benefit and enjoyment of present and future generations". The Buffalo River National Park encompasses 132 miles of the river and contains 95,730 acres within its corridor. The Buffalo National River draws over one million visitors each year, and provides $39 million in gross tourism dollars and 550 tourism-related jobs to the economically depressed counties of the watershed.

From the very beginning, this project has greatly impacted the entire northern part of the state. The National Park Service and the Office of Land Acquisition, in the process of establishing the Buffalo National River, displaced many landowners from their family homes. Some of the methods used were perceived to be overly harsh and placed great hardships on many of the families. This fostered an atmosphere of mistrust and apprehension between property owners and the Park Service. This environment of distrust continues to this day and many residents meet any activities promulgated by the Park Service with skepticism and suspicion.

ERW Designation

In 1988, the Arkansas Department of Pollution, Control & Ecology (ADPCE) designated The Buffalo River as an Extraordinary Resource Water (ERW), and a Natural and Scenic Waterway having extraordinary recreation and aesthetic values, giving the river the highest ranking of stream quality in the State's hierarchy. ADPCE applies specific standards to the Buffalo River, which exceed those standards applied to waters lacking these designations. The Buffalo National River is also protected through the State's Antidegradation Policy.

Legal requirements were met when ADPCE, in 1987, changed stream designations from AA to ERW's. The change was not a substantive change at the time. Controversy over the new designations for streams did not occur until the legislature made gravel mining illegal in ERW streams. Landowners then began questioning what an ERW designation encompassed. Landowners feel that these changes in stream designations were put in place with little or no input from area residents. Public notices and meetings were poorly advertised and were lacking in number. Due to these insufficient notification procedures, very little public input was garnered and many residents feel that they were left out of the process. **This study determined that public notification was inadequate and is an area that must be improved.**

WATER RESOURCES MANAGEMENT PLAN (WRMP)

The Park Service's recent efforts to develop a Water Resources Management Plan for the Buffalo River has greatly concerned many landowners in the river's watershed. They see it as an attempt by the Park Service and other agencies to regulate and control all activities not just on state lands but on private lands. A number of residents believe that the Park Service has completed a WRMP for the Buffalo River and that the Park Service has refused to admit that the plan exists. The Park Service has stated categorically that there is not a completed plan and a table of contents is the only section of the WRMP that has been drafted. Area residents were infuriated by the lack of notice given by the Park Service for the preliminary meetings that were held on feasibility of establishing a WRMP for the Buffalo River watershed. Because there has been so much local resistance to the WRMP and subsequent concerns over potential application of the document outside of the park boundary, the Park Service has agreed to curtail work on that portion of the plan designed to address issues outside its boundary until there is more support by area conservation districts, agencies, and groups. Another problem that was pointed out was that in writing the grant proposal for the WRMP, the Park Service gave an imprecise representation of the involvement of ADEQ in the WRMP. Involvement by ADEQ has been on a minor level and is not in partnership on the WRMP. ADEQ has not endorsed the WRMP.

In response to the concerns by landowners over attempts by the Buffalo National River to establish voluntary best management practices for water quality outside its discrete boundaries, the National Park Service's published response is; "the WRMP is not an attempt to justify government control of private lands. Land acquisition, zoning, new regulations, or infringement on private property rights will not be considered in the WRMP". The Buffalo National River has fixed boundaries as defined by Congressional law in 1972. A new act of Congress would be required to make any changes in the Park's borders. The Park Service has stated that they have no plans for any park expansion.

The Park Service has acknowledged that it intends to model its Buffalo River WRMP on the St. Croix National Scenic Riverway WRMP. Subcommittee members feel that Park Service personnel have not been forthcoming in admitting that much of their WRMP will be based on the St. Croix plan. The Subcommittee has insisted that the Buffalo National River staff make the St. Croix plan available so that the public will have a better concept of what a completed WRMP encompasses.

Due to continued distrust of the Park Service's intentions, property owners are worried that park personnel are not releasing all their goals and objectives in regards to future plans. The Subcommittee strongly recommends to Park Service staff, in order to repair and improve relations between the Buffalo National River and landowners, the Park Service must be totally forthcoming with all potential plans. It is unfair to area residents to exclude them from the planning process. Again, the Subcommittee strongly recommends that the Park Service implement a policy of openness and inclusion in all future developments and obtain public input at all stages of any new measures or plans.

WATER QUALITY STANDARDS AND REGULATIONS

Pursuant to the provisions of SubChapter 2 of the Arkansas Water and Air Pollution Control Act, and in compliance with the requirements of the Federal Water Pollution Control Act, the Arkansas Department of Environmental Quality Commission promulgates Regulation 2 in establishing water quality standards for all surface waters, interstate and intrastate, of the State of Arkansas. Guidance is also provided through the federal Clean Water Act.

Regulatory restrictions for ERW's are: (1) significant physical alterations of instream habitat are not allowed, e.g. channelization of significant portion of the stream bed; construction of a major impoundment on an ERW stream, (2) all point source discharge into an ERW stream must meet "advanced treatment" technology and other narrative and numeric water quality standards, (3) bacterial standards for ERW's are the same as the primary contact standard for the entire year, (4) removal of gravel below the ordinary high water mark from an ERW stream is prohibited.

Pollution prevention activities required for ERW streams are: (1) requires a thorough review and incorporation of the highest level of pollution prevention for Governmental and Corporational activities in the watershed, e.g. new road and bridge construction; major pipeline construction; location of hazardous waste or solid waste disposal sites, (2) results in higher priority ranking for lands in an ERW watershed to receive technical and financial assistance for voluntary watershed protection projects, (3) increases the priority ranking to receive voluntary water quality improvement incentive streams. The Sierra Club has filed a lawsuit with EPA against ADEQ addressing this issue. The Subcommittee feels it is vital that ADEQ maintain comprehensive records on these studies and their results and make them readily available to anyone who wishes to peruse them.

FREEDOM OF INFORMATION ACT REQUESTS (FOIA)

Private citizens made two FOIA requests to the Park Service for the release of all materials related to any correspondence concerning the Buffalo National River. The Subcommittee found that these requests were not handled in a timely and complete manner. Available documents were eventually provided in response to the first request. The second request for copies of all correspondence between the NPS and ADEQ from 1987 to August 1999 was found to be contained within 43 file drawers requiring two to three hours to research for each drawer. Due to the large amount of material, FOIA allows the Park Service to charge for the cost to research and copy the material. The persons who requested this information were informed of the cost to research and provide the items. The Subcommittee stated categorically that in the future there must be prompt and complete compliance with such requests. Any attempts to delay or conceal documents continues to promote distrust and increases suspicion.

The Subcommittee found that FOIA requests to ADEQ were met with reluctance by the agency to comply in a prompt and forthcoming manner. Eventually, according to the director of ADEQ, all documents requested from his agency, which are still on file, have been provided. Most ADEQ documents from the 1980's and early 90's were purged by a previous director and are no longer available. All ADEQ division heads who still have material on file concerning the Buffalo River have confirmed that all their files have been made accessible to the public.

The Subcommittee found that when a legislative FOIA request was made, additional information was provided that was not provided in response to the requests by private citizens. This seriously troubles Subcommittee members that the agencies did not make their compliance with such requests a high priority and that they did not fully cooperate with the individuals' requests. The Subcommittee deems it of vital importance that all agencies make certain that any future requests be met with swift and complete cooperation.

ADDITIONAL FINDINGS

Subcommittee members strongly recommend that any agency, especially ADEQ, when making changes to its rules or regulations, go beyond what many consider very inadequate requirements of legal notice when informing the public of its proposed changes. Agencies must publish more and better public notices in local newspapers, courthouse, libraries, and radio stations. Public notification is vital. Full participation by local residents, who will be directly effected by any changes, should be of the highest priority for any state or federal agency.

The use of worst-case descriptions when writing grants or identifying needs or problems is inflammatory and promotes misunderstandings. Ordinary citizens who are unfamiliar with a project or situation would be prone to misinterpret these "gloom and doom" descriptions. It is highly advisable that agencies should moderate such descriptions when composing grant language.

In regards to the status of the United States "Man and the Biosphere" Program, the Ozark Highlands MAB project is not going forward. A recent response from the ten agencies involved indicates little or no support for the MAB at the present time. Based upon their response, the Buffalo National River will take no further action on this program.

The Subcommittee heard testimony on the proposed impoundment of Bear Creek in the Buffalo River watershed. This impoundment will be used to provide water to Searcy and Newton counties. ADEQ has issued a 401 permit. The project is waiting on the Corps of Engineers to issue a 404 permit. The members listened to the Park Service's position on their opposition of the project, as well as input from other agencies and residents in the Bear Creek area. At this time, the Subcommittee has taken no action. Further hearings on this issue may be needed at a future time. The Subcommittee intends to stay informed on this issue.

As the nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

NPS D-120, February 2004