Appendix 3.2 Ouachita Mountains Ecoregional Assessment

Note: The boundaries used in this assessment differ somewhat from those of Woods and others (2004) used elsewhere in this document. They most closely approximate the boundaries of the Ouachita Mountains combined with the Arkansas Valley ecoregions.

Ouachita Mountains Ecoregional Assessment

December 2003

Ouachita Ecoregional Assessment Team
Arkansas Field Office
601 North University Ave.
Little Rock, AR 72205

Oklahoma Field Office
2727 East 21st Street
Tulsa, OK 74114

Table of Contents

Executive Summary

In 1996 The Nature Conservancy developed an ecoregional approach to conservation, outlined in *Conservation by Design: A Framework for Mission Success*, stating that biodiversity conservation requires working at larger scales and along ecological instead of geopolitical lines. Ecoregions, large units of land and water delineated by characteristic biotic and abiotic factors, provide a better geographic basis than state boundaries for organizing our conservation priorities and actions. Strategic planning on an ecoregional scale encourages review of many species and ecological communities at once, providing a structure for capturing genetic and ecological variability within species or communities.

The major products of an ecoregional assessment include: 1) identification of a portfolio of sites that, if protected, collectively conserve the biodiversity of the ecoregion, 2) an implementation strategy to protect the sites, including strategies and conservation partners, and 3) identification of data gaps to improve the quality of future conservation decision-making and ensure ecoregional assessment updates capture relevant and useful data. A critical element of the conservation areas is the data captured through the plan, which not only provides a science-based foundation for ecoregional assessments but also provides a starting point for site conservation planning in the implementation phase.

This plan serves as an update of sorts to the 1994 Ouachita Mountains Conservation Initiative plan, which included many of the analyses, information and strategies that are integral to the ecoregional assessments that are the basis for the Conservancy's conservation efforts today.

The Ouachita Mountain Ecoregion includes parts of Arkansas and Oklahoma, and comprises a landscape of approximately 11.48 million acres of rugged mountain ridges, broad valleys, and the headwaters of several large river systems. The complex geological formations and soils of this forested landscape have created a tremendous diversity of habitat reflected in a biodiversity of ancient lineage; the Ouachitas have been available for continuous occupation by terrestrial and aquatic life for 225 million years, and are a center for endemism in North America, particularly in the realm of aquatic species.

The Ouachita Ecoregion is home to 48 endemic species and 68 species with limited ranges. More than one-third of the endemic species are aquatic. There are fourteen federally listed species and 28 others that are recognized as potentially endangered by the United States Fish and Wildlife Service (USFWS) in the ecoregion. There are 79 terrestrial communities identified in the ecoregion, 9 of which are endemic. Most of the remaining communities are shared only with the Ozark Ecoregion within the area collectively referred to as the Interior Highlands.

This ecoregional assessment identified 40 portfolio conservation areas as integral to conservation of the Ouachita's biodiversity. In this iteration of the plan, the aquatic, landscape scale and small patch conservation areas cover a total of 6,068,258 acres, or 53% of the ecoregion. This number, however, can be misleading due to the fact that the watershed area of aquatic conservation areas was used in its calculation. Terrestrial sites alone total 2,494,920 acres or approximately 21% of the ecoregion. Currently, 2,280,231 acres or 38% of conservation areas include land managed under some type of public conservation ownership. This figure increases to 91% when only the area of terrestrial conservation areas is used in the calculation. Of all the conservation areas that are managed for conservation, 2,120,340 acres or 35 % are federally owned; 159,890 acres or 3% are state or locally owned; and 4,028 acres or 0.07% are privately owned.

Terrestrial ecosystems in Ouachitas are stressed by habitat destruction/conversion, habitat fragmentation, and alteration of natural fire regimes. These stresses have incompatible forestry practices, development, conversion and agriculture, and fire suppression as their sources. Aquatic systems are stressed by incompatible land use practices leading to sedimentation and runoff, and other nonpoint source pollution. Conversion includes land uses associated with grazing and plantation forestry. Habitat alteration and incompatible land use include incompatible agricultural (grazing, confined animal feeding operations) and commercial timber use, as well as development.

The portfolio conservation areas depicted in this iteration of the Ouachita ecoregional assessment are intended as a prioritization management tool for conservation action and resources. This plan also contains the supporting data for each portfolio conservation area, as well as an ecoregional management strategy applicable to the portfolio management areas. Portfolio management action areas are prioritized by biodiversity, threats, complementarity, and potential leverage. Results and data from this ecoregional assessment process should be used to create working site conservation plans as part of the initial implementation phase of the plan.

Introduction

The mission of The Nature Conservancy is to preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive (TNC, 2001). The Nature Conservancy has worked to fulfill this mission for over 50 years through land acquisition and management, creating partnerships and involving stakeholders and communities in the conservation process. As the threats to biodiversity and their corresponding immediacy increase, TNC has been growing and changing to better fulfill its mission; one key change has been the movement from an opportunistic approach towards strategic conservation management. Strategic conservation is represented here in the ecoregional assessment. *Conservation by Design* (TNC, 1996) defined the framework on which this ecoregional assessment is based by planning for biodiversity at the landscape scale.

An ecoregion is generally defined as relatively large areas containing geographically distinct assemblages of natural communities, where communities share a large majority of their species, dynamics, and environmental conditions, and the communities also function together as a conservation unit at large scales (Ricketts, et al. 1999). TNC based initial ecoregion design on the efforts of the US forest Service (Bailey, 1995) and further refined to sub-ecoregions (Keys, et al., 1995).

Ecoregional assessments endeavor to set the groundwork for regional, state, local, and community based conservation through strategic, long-term priorities and strategies. An ecoregional assessment should:

- Prioritize TNC resources and management action,
- Provide a scientific basis for community based conservation action by delineating geographic areas that should be managed for conservation and biodiversity,
- Provide a general conservation strategy for those sites, and
- Clearly illustrate data gaps discovered during the planning and implementation process, and provide a roadmap for reconciling those gaps.

A complete ecoregional assessment contains not only the ecological sites, but tools for the conservation planners and practitioners:

- Data to support those sites and priorities,
- Strategy to implement the plan, and
- A mechanism to review, update and measure the success of a plan.

The portfolio conservation areas, supporting data, and the applicable management and conservation strategies are based on the best available science, and therefore provide a roadmap for the best use of TNC and partner resources. An ecoregional assessment is also useful as a data bank and data gap analysis. As such, it is a living document that requires review and updates as necessary.

Note that while the goal of an ecoregional assessment effort is to delineate the minimum or priority areas necessary to conserve an ecoregion's biodiversity, different conservation areas represent different goals and not all sites represent functional landscapes. Plan users should carefully review each site description and strategy to ensure plan success.

Within ecoregions, portfolio conservation areas are designed to conserve biodiversity by managing viable native community, zoology and botany targets identified during the planning process. Protection of high quality sites that conserve multiple, unprotected or nontarget occurrences are preferred conservation strategies. To best fulfill the conservation goals of the plan, practitioners need to restore and maintain ecosystem patterns and processes that species and communities need to survive (Turner, 2000).

While conservation area boundaries were conceptually drawn based on element occurrences and not the location of public lands, several of these conservation areas are located entirely within federal ownership based on necessity. For instance, the Ouachita Novaculite Glade ecological system is located entirely within the Ouachita National Forest acquisition boundaries. Therefore, there can be no private lands component to a site like this one except for privately owned inholdings to the Forest which are insignificant in size. This scenario repeated itself for several systems entirely or for large parts of them. As a result, the plan may appear to have a bias toward publicly owned land.

This document represents a 2002 update of sorts to the 1994 plan completed by Douglas Zollner, called the Ouachita Mountains Conservation Initiative, because many of the components of this earlier plan are the very parts required under the Conservancy's ecoregional assessment guidelines. The plan will provide a portfolio of conservation areas, including priority or action areas, the data compiled and created during this planning effort, methodology, the data gaps identified, and a strategies for plan implementation. It is hoped that conservation planners, site-based conservation staff, and TNC partners use this plan to effectively manage the biodiversity of the ecoregion. Successful use, however, will require a commitment of cooperation, resources and time, as well as the sharing of responsibility and effort.

Background

Ecoregional Boundary Delineation

The Ouachita Ecoregion is approximately 11.48 million acres or 17,937 square miles in size, and encompasses parts of Arkansas and Oklahoma. It is bordered by 4 other ecoregions. To the north, the boundary meets the Ozark Ecoregion with which the Ouachitas are often lumped together as the "Interior Highlands," despite their distinct differences in geology. The Ouachita Mountains share much of its diversity with the Ozark ecoregion. To the east, the ecoregion borders the Mississippi River Alluvial Plain, and the Crosstimbers and Southern Tallgrass Prairie Ecoregion to the west. Finally, the Ouachitas are bordered by the Upper West Gulf Coastal Plain to the south.

The northern part of the ecoregion includes an area north of the Arkansas River in Pulaski, Faulkner and White Counties, Arkansas, which is geologically related to the Ouachita Mountains and has the typical east-west ridge lines. However, the terrestrial communities of this area actually have a more Ozark ecoregion character than the rest of the Ouachitas. In this iteration of the plan the Arkansas River Valley is included in the Ouachita Mountains Ecoregion despite its landscape of isolated mountains and oak-hickory forest which is unlike those found in the Ouachitas. Bailey (1982) actually included this area with the Upper West Gulf Coastal Plain ecoregion despite the fact that the two are separated by at least 20 miles. The Arkansas River Valley should perhaps be more appropriately included within the Mississippi River Alluvial Plain ecoregion because of its alluvial geology and similarities in the associated bottomland plant communities.

To the west, the boundary follows the geology as the Ouachitas disappear under the western plains. Vegetationally, the western edge is dynamic; the pine-oak, tallgrass prairie, oak savanna (cross timbers) ecoregions meet along this edge. The boundaries of these floristic association intergrade, advance and retreat with historic changes in climate.

To the south, the boundary follows the divide between the Upper West Gulf Coastal Plain (UWGCP) and Ouachita Mountains. High levels of faunal diversity are found in the rivers that flow south out of the Ouachitas and into the Red River system. The upland forest ecosystem also extends south in this area to where it intergrades with the vegetation types found on the Coastal Plain.

A portion of the Coastal Plain was incorrectly included within the Conservancy's boundary of the Ouachita Mountains Ecoregion. The characteristics of this subsection include deep alluvial deposits (sand, silt, clay) of Pleistocene age which contrasts strongly with the geology of the Ouachitas. It is an irregular plain with low relief (100-300 feet elevation), historically vegetated by oak woodlands and flatwoods. This area will be assessed as part of an UWGCP ecoregional assessment update, and its removal from the Ouachita ecoregional boundary will be addressed in a future iteration of the Ouachita plan.

Geology

The Ouachita Mountains Physiographic Subprovince covers 11.48 million acres in central and western Arkansas and southeast Oklahoma, extending in a broad belt eastward from Atoka county, Oklahoma to the vicinity of Little Rock, Arkansas. The Ouachitas form the southern section of the Interior Highlands, which includes the Ozark Plateau. These geologic features were created 345 million years ago by the same geophysical action that formed the Appalachian Mountains and Central Plateau of Texas. To the east, structural and stratigraphic features are buried by Cretaceous and Tertiary rocks and deposits of the Mississippi Embayment and to the west the structural trend curves south and is buried by Cretaceous strata of the Central Plains (Bryan Tapp, pers. comm., 1992; Miser, 1929). This process has left the Ouachitas isolated from other mountain systems.

The landform of the Ouachita Mountains is an accretionary prism composed of intensely folded and deformed sandstone, shale and chert units that form one of the major fold-belt mountain ranges of the North American continent. Initial sedimentation occurred in deeply submerged ocean troughs. Silty oceanic ooze was metamorphosed into thin layers of shale and chert during Paleozoic times. Occasional units of sandstone occur in the succession, probably emplaced by ocean currents and as fans at the heads of submarine canyons. Strata of Ordovician, Silurian, Devonian and Mississippian ages are exposed in the Ouachitas and represent this early phase of sedimentation. During late Mississippian and early Pennsylvanian periods huge deposits of sand entered the ocean from rivers which had their deltas in the area of present day Poteau, Oklahoma. These rivers deposited great volumes of sand and mud in the basin with accumulations reaching thicknesses of 45,000 feet. These strata are represented by the Stanley, Jackfork, Johns Valley and Atoka formations (Bryan Tapp pers. comm., 1992; Miser, 1929).

The collision of Lanoria with the North American plate resulted in a mountain building process referred to as the Ouachita Orogeny. Metamorphosed oceanic oolithic and deltaic deposits were intensely deformed by compressive forces which were directed north toward the stable interior of the American continent. Twisted, warped and overturned folds and thrust faults reflect this violent collision (Bryan Tapp pers. comm., 1992; Miser, 1929). Deformed Paleozoic rocks were intruded during the Cretaceous by veins of igneous rock. The hot springs of Hot Springs National Park and the diamond-bearing Kimberlite formation near Murfreesboro, Arkansas are results of this activity (Croneis, 1930).

Erosion has been the dominant geological force over the last 300 million years. Soft shales have been eroded away or deposited in valleys while resistant sandstones, cherts and novaculites have been formed into the dominant ridges we see today. This ridge and valley formation is characterized by long, hogback ridges with relief as great as 1600 feet above the valley floors and total elevations of between 600 and 2,750 feet above sea level. These ridges run east-west and generally have long north and south facing slopes. Because of the way the rock strata fractured north facing slopes tend to be steeper than south facing slopes. Surface rocks are sandstones, shales and cherts (Croneis, 1930).

The Ouachita Mountains can be divided into four geologically distinct subsections (Croneis, 1930; Bryan Tapp, per. comm., 1992):

1) Northern Hogback Frontal Belt (Fourche Mountains): Includes the rugged sandstone ridges of Fourche, Poteau, Winding Stair, Kiamichi, Rich, Black and Boktukola Mountains. These ridges are composed of massive formations of sandstone underlain in places by various shales.
2) Broken Bow-Benton Novaculite Uplift (Central Ouachita Mountains): The most rugged terrain in Arkansas with sharp narrow ridges piled close together, shallow soils and narrow stony valleys. The ridges are capped with fractured novaculite, a hard, resistant siliceous rock which has influenced the formation of glade communities. This area is noted for its numerous springs and seeps.
3) Athens Plateau (Piedmont): The novaculite formation gives way in the south to a gentler topography. Rivers turn south and drop over the fall line to the Gulf Coastal Plain. This is an area of low ridges 150-220 feet high. Uplifted toward the end of the Ouachita orogeny, this plateau was dissected by downcutting rivers.
4) Arkansas River Valley: Divides the geologically simple Ozarks from the geologically complex Ouachitas, with elements of each, was formed between 320 – 286 Ma during the Pennsylvanian era. The river valley is a typical alluvial plain characterized by rapid infilling of clastic sediments and development of growth faults along northern basin margin. As the basin shallowed, plant debris accumulated in nearshore swampy areas (AGC, 1997).

Soils

The Ouachita Mountains are very diverse in terms of aspect, slope and bedrock. The valleys between the ridges are underlain by shale and have a gentle relief. The ridges are composed of sandstone and chert and extremely steep slopes with numerous rock exposures. The ridge tops often have very shallow soils and rock glaciers have formed the steepest slopes.

Most soils of the Ouachita Mountains Natural Division are assigned to the Ultisol order, with a few Inceptisols and Alfisols. Ultisols are intensively weathered soils and characterized by low fertility. They are low in base saturation, and therefore acidic, due to long periods of weathering during the Pleistocene and Holocene epochs. Soils in this order form in humid climates under pine-hardwood forests. They are generally moist throughout the year. Westward, the soils are subject to an annual dry period during the hot season of the year. The soils are deep, strongly leached, generally of medium texture and moderate permeability (Steila, 1989).

This mixture of bedrock, slope, aspect and soils has created unique plant assemblages across rather small areas of mountain ridge. Together with the many small seeps and springs these small areas of biodiversity form an important part of the total biodiversity of the Ouachita Mountains. The low soil fertility led to the failure of most homesteading efforts in the Ouachita Mountains. Crop farming rapidly diminishes the already low fertility of the soils and it was mostly abandoned early in this century. Cleared land would not easily support a farmer and his family let alone make a profitable excess (Smith, 1986). For this reason most of the landscape has remained or returned to forest. Farmers today raise small livestock (chickens/hogs) in intensive feeding operations or graze cattle on mostly improved pastures. Several large wood product corporations have established large plantations (tree farms) in areas with gentler relief.

In the Arkansas River Valley, soils are from the Quaternary Period, Holocene Epoch and include Steprock, Taft, Roxana, Eram, Spadra, Okay, and Stigler.. Alluvial deposits of present streams include gravels, sands, silts, clays, and mixtures of any and all of these clastic materials. The partition of this unit from other Holocene alluvial deposits was on the basis of geomorphic considerations rather than age or lithology. Fossils are rare and modern. The lower contact is unconformable and the thickness is variable (McFarland, 1998).

Climate

The Ouachita Mountains are located in the humid subtropical zone. Hot, sultry summers and moderately cool winters with some snow, but no accumulations, are normal. The climate is controlled by two different air masses. Warm, moist air from the Gulf of Mexico generally dominates especially in the spring and summer. Cooler, dryer air from the Central Plains enters the area in the winter. (Stroud and Hanson, 1981)

Precipitation is well distributed throughout the year. As one moves from east to west spring rainfall becomes more important with doughty conditions likely in the summer. Total precipitation ranges from 1100mm-1500mm decreasing from east to west. The taller mountains ranges receive additional rainfall due to orographic effects (Smith, 1989). Droughts occur most likely during late summer and fall (Stroud and Hanson, 1981). Moderate droughts occur at 15-20 year intervals with sever, multi-year droughts even less frequent. Tornadoes and floods may occur in any month but are most likely during the spring. Strong winter winds with sleet and freezing rains occur in late December, January and February.

Temperatures average from 4-10 degrees Celsius in January to 21-32 degrees Celsius in July. The peak high temperatures usually occur in August. Elevation can be an important factor influencing temperatures in the mountains.

Ecological Systems

TERRESTRIAL SYSTEMS

The Ouachita Highlands terrestrial community targets were updated from original lists kept by Doug Zollner and Milo Pyne. Descriptions for each community as it is represented in the ecoregion are attached as an appendix. System names have been generalized to conform to the Southern Resource Office's and Association for Biodiversity Information's database. Though system complex names may be used across ecoregions, the composition of each as it occurs in the ecoregion is unique and endemic to the ecoregion. Further, community associations as they are described for this ecoregion that belong to a terrestrial community complex are endemic to the Ouachitas; therefore even though some groups are noted for not containing localized endemic or rare species, the associations themselves may be rare or endemic. The systems and the associated communities are:

Forest And Woodland Systems

Ozark-Ouachita Fen
This small patch fen community type is found in the Interior Highlands region of the United States. Stands occur on the sideslopes of hills in narrow valleys, bases of bluffs, rock ledges, and terraces of streams and rivers, where the soil or substrate is saturated by calcareous groundwater seepage. Soils are moist to wet, mucky peat or mineral, with pH above 6.5, and vary from shallow (0-40 cm) to moderately deep (40-100 cm), depending on natural disturbance and slope. The parent material is a mixture of gravel and dolomite with fragments of deeply weathered bedrock present, or colluvium over bedrock. The bedrock strata are exposed, especially in hanging fens where the slope is greater than 35 degrees. Hydrophytic plants dominate the fen, which varies from mixed grass or sedge fen with complex zonation to more tallgrass prairie species mixed with calciphiles. Fires are possible in some of the larger prairie fens.

Central Interior Highlands Dry Acidic Glade and Barrens
This small patch system is found in the Interior Highlands of the Ozark, Ouachita, and Interior Low Plateau regions. It occurs along moderate to steep slopes or valley walls of rivers along most aspects. Parent material includes chert, igneous and/or sandstone bedrock with well- to excessively well-drained, shallow soils interspersed with rock and boulders. These soils are typically dry during the summer and autumn, becoming saturated during the spring and winter. Grasses such as *Schizachyrium scoparium* and *Sorghastrum nutans* dominate this system with stunted oak species (*Quercus stellata, Quercus marilandica*) and shrub species such as *Vaccinium* spp. occurring on variable depth soils. This system is influenced by drought and infrequent to occasional fires. Prescribed fires help manage this system by maintaining an open glade structure.

Ouachita Montane Oak Forest
This large patch system represents hardwood forests of the highest elevations of the Ouachita Mountains, including Mount Magazine. Vegetation consists of either forests or open woodlands dominated by *Quercus alba* or *Quercus stellata*. Canopy trees are often stunted due to the effects of ice, wind and cold conditions, in combination with fog, shallow soils over rock, and periodic severe drought. Some stands form almost impenetrable thickets.

Ozark-Ouachita Dry Oak Woodland
This small patch system occurs in the Ozark and Ouachita Highlands and far western portions of the Interior Low Plateau regions along gentle to steep slopes and over bluff escarpments with southerly to westerly aspects. Parent material can range from calcareous to acidic with very shallow, well- to excessively well-drained soils, sometimes with a fragipan that causes "xero-hydric" moisture conditions. This system was historically woodland in structure, composition, and process but now includes areas of more closed canopy. Oak species such as *Quercus stellata, Quercus marilandica*, and *Quercus coccinea* dominate this system with an understory of grassland species such as *Schizachyrium scoparium* and shrub species such as *Vaccinium arboreum*. Drought stress is the major

dynamic influencing and maintaining this system. On flatwoods with fragipans, *Quercus stellata* is the major dominant.

Ozark-Ouachita Dry-Mesic Oak Forest
This matrix system is found throughout the Ozark and Ouachita Highlands ranging to the western edge of the Interior Low Plateau. It is the matrix system of this region and occurs on dry-mesic to mesic gentle to moderately steep slopes. Soils are typically moderately to well-drained and more fertile than those associated with oak woodlands. A closed canopy of oak species (*Quercus rubra* and *Quercus alba*) often associated with hickory species (*Carya* spp.) typify this system. *Acer saccharum* (or *Acer barbatum* to the south) may occur on more mesic examples of this system. Wind, drought, lightening, and occasional fires can influence this system.

Ozark-Ouachita Mesic Hardwood Forest
This small patch system is found on toeslopes and valley bottoms within the Ozark and Ouachita regions, as well as on north slopes. In the Ozarks, *Quercus rubra* increases in abundance compared to dry-mesic habitats, and *Acer saccharum* is sometimes a leading dominant. On more alkaline moist soils *Quercus muehlenbergii, Tilia americana*, and *Cercis canadensis* may be common. In the Boston Mountains, mesic forests may also be common on protected slopes and terraces next to streams. Here *Fagus grandifolia* may be the leading dominant, with codominants of *Acer saccharum, Liquidambar styraciflua, Tilia americana, Magnolia acuminata*, and others. Similar habitats occur in the western Ouachita Mountains.

Ozark-Ouachita Shortleaf Pine-Oak Forest and Woodland
This matrix system represents forests and woodlands of the Ouachita and Ozark mountains region of Arkansas, adjacent Oklahoma, and southern Missouri in which *Pinus echinata* is an important or dominant component. Although examples of this system occur throughout this region, there is local variation in the extent to which they were present. For example, this system was historically prominent only in the southeastern part of the Ozark Highlands where sandstone derived soils were common (USFS 1999); being limited from other areas by inadequate winter precipitation, and non-conducive soils. In contrast, pine was "virtually ubiquitous in the historical forests of the Ouachitas" (USFS 1999). In nearly all cases (at least in the Ouachitas), *Pinus echinata* occurs with a variable mixture of hardwood species. The exact composition of the hardwoods is much more closely related to aspect and topographic factors than is the pine component (Dale and Ware 1999). In some examples of this system, the aggregate importance of hardwoods may be greater than pine, especially on subxeric and mesic sites (Dale and Ware 1999).

<u>Steppe ans Savanna Systems</u>

Central Interior Highlands Calcareous Glade and Barrens
This small patch system is found primarily in the Interior Highlands of the Ozark, Ouachita, and Interior Low Plateau regions along moderate to steep slopes and steep valleys on primarily southerly to westerly facing slopes. Limestone and/or dolomite bedrock typify this system with shallow, moderately to well-drained soils interspersed with rocks. These soils often dry out during the summer and autumn, and then become saturated during the winter and spring. *Schizachyrium scoparium*

dominates this system and is commonly associated with *Andropogon gerardii, Bouteloua curtipendula*, and calcium-loving plant species. Stunted woodlands primarily dominated by *Quercus muehlenbergii* interspersed with *Juniperus virginiana* occur on variable-depth-to-bedrock soils. Fire is the primary natural dynamic, and prescribed fires help manage this system by restricting woody growth and maintaining the more open glade structure.

Ouachita Novaculite Glade and Woodland
This small patch system represents a mosaic of glades and woodlands found on novaculite geology in the central Ouachita Mountains of western Arkansas. Novaculite is a weakly metamorphosed rock of sedimentary origin that is primarily composed of microcrystalline quartz and chalcedony. Examples of this system generally occupy ridgetops at 450-640 m (1476-2100 feet) elevation. They are a mosaic of small woodlands scattered on ridges and upper slopes with outcrops and patches of talus scattered throughout. Some woodland or forest patches may appear as almost linear strips interspersed with grassy openings. Wooded patches have a variable, often patchy, structure with some areas of dense canopy interspersed with more open canopies and open grassy patches. In general, the grassy openings occur on shallow soils with exposed bedrock, while the woodlands occur on somewhat deeper soils. In all cases, these are fairly extreme growing conditions due to droughty, rocky soils.

Herbaceous Systems

Arkansas Valley Prairie and Woodland
This small patch system of prairies and associated woodlands is found in the Arkansas River Valley region of Arkansas and adjacent Oklahoma. This region is distinctly bounded by the Boston Mountains to the north and the Ouachita Mountains to the south, although it has been considered part of the Ouachita Ecoregion (TNC Ecoregion 39). The valley is characterized by broad, level to gently rolling uplands derived from shales and is much less rugged and more heavily impacted by Arkansas River erosional processes than the adjacent mountainous regions. In addition, the valley receives annual precipitation total of 2-6 inches less than the surrounding regions due to a rainshadow produced by a combination of prevailing western winds and mountain orographic effects. The shale-derived soils associated with the prairies are thin and droughty. The combined effect of droughty soils, reduced precipitation, and prevailing level topography create conditions highly conducive to the ignition and spread of fires. Stands are typically dominated by *Andropogon gerardii, Sorghastrum nutans, Panicum virgatum*, and *Schizachyrium scoparium*.

Southeastern Great Plains Tallgrass Prairie
This large patch system is found primarily within the Flint Hills of Kansas and the Osage Plains of Oklahoma; however, it can range into the Ozarks of Missouri, the Arbuckle Mountains of Oklahoma, and the Arkansas River Valley. It is distinguished from Central Tallgrass Prairie (CES205.683) by having more species with western geographic affinities and the presence of a thin soil layer over limestone beds ranging to more acidic substrates, although some areas of deeper soils are found within the region, especially on lower slopes. Because of the presence of the rocky substrate close to the surface and the rolling topography, this area is relatively unsuitable for agriculture. The Flint Hills contain one of the largest remaining, relatively intact pieces of tallgrass prairie. The vegetation in this system is typified by tallgrass species such as *Andropogon gerardii, Panicum virgatum, Schizachyrium scoparium*, and *Sorghastrum nutans* forming a dense cover. A moderate to high density of forb species

such as *Oligoneuron rigidum (= Solidago rigida), Liatris punctata, Symphyotrichum ericoides, Lespedeza capitata*, and *Viola pedatifida* also occur. Areas of deeper soil, especially lower slopes along draws, slopes and terraces, can include *Baptisia alba var. macrophylla, Liatris pycnostachya*, and *Vernonia missurica*. Shrub and tree species are relatively infrequent and, if present, constitute less than 10% cover in the area. Fire and grazing constitute the major dynamic processes for this region. Although many of the native common plant species still occur, grazing does impact this region. Poor grazing practices can lead to soil erosion and invasion by cool-season grasses such as *Bromus inermis*.

Wetland Systems

Central Interior Highlands and Appalachian Sinkhole and Depression Pond

This small patch system is found in the Interior Highlands of the Ozark, Ouachita, and Interior Low Plateau regions, as well as the adjacent Appalachian region. Stands occur in basins of sinkholes or other isolated depressions on uplands. Soils are very poorly drained, and surface water may be present for extended periods of time, rarely becoming dry. Water depth may vary greatly on a seasonal basis, and may be a meter deep or more in the winter. Some examples become dry in the summer. Soils may be deep (100 cm or more), consisting of peat or muck, with parent material of peat, muck or alluvium. Ponds vary from open water to herb-, shrub-, or tree-dominated systems. Tree-dominated examples typically contain *Quercus* species or *Nyssa* species, or a combination of these. In addition, *Liquidambar styraciflua* may be present in southern examples. *Cephalanthus occidentalis* is a typical shrub component.

Ouachita Mountain Forested Seep

This small patch system of forested seeps occurs in the Ouachita Mountains of central Arkansas. Examples may be found along the bottom slopes of smaller valleys where rock fractures allow water to seep out of the mountainsides and in the riparian zones of larger creeks, sometimes extending upslope along small ephemeral drainages. The soil remains saturated to very moist throughout the year. The vegetation is typically forested with highly variable canopy composition. *Acer rubrum var. trilobum, Nyssa sylvatica, Liquidambar styraciflua*, and *Quercus alba* are common and typical. Other canopy species may include *Fagus grandifolia* and *Magnolia tripetala*. Canopy coverage can be moderately dense to quite open. The subcanopy is often well-developed and characteristically includes *Ilex opaca var. opaca, Magnolia tripetala, Carpinus caroliniana*, and *Ostrya virginiana*.

Mixed Upland and Wetland Systems

Ozark-Ouachita Riparian

This linear system is found along streams and small rivers within the Ozark and Ouachita regions. In contrast to larger floodplain systems, this system has little to no floodplain development and often contains cobble bars and steep banks. It is traditionally higher gradient than larger floodplains and experiences periodic, strong flooding. It is often characterized by a cobble bar with forest right adjacent with little to no marsh development. Canopy cover can vary within examples of this system, but typical tree species include *Liquidambar styraciflua, Platanus occidentalis, Betula nigra*, maples species (*Acer* spp.), and oaks (*Quercus* spp.). The richness of the herbaceous layer can vary significantly, ranging from species-rich to species-poor. Likewise, the shrub layer can vary considerably, but typical species may include *Lindera benzoin, Alnus serrulata*, and *Hamamelis vernalis*. Small seeps and fens can often be found within this system, especially at the headwaters and terraces of streams. These areas are typically dominated by primarily wetland obligate species of sedges (*Carex* spp.), ferns (*Osmunda* spp.), and other herbaceous species such as *Impatiens capensis*. Flooding and scouring strongly influence this system and prevent the floodplain development found on larger rivers.

South-Central Interior Large Floodplain
This linear floodplain system is found throughout the Interior low Plateau, Cumberlands, Southern Ridge and Valley, Western Allegheny Plateau, and lower elevations of the Southern Blue Ridge. Examples occur along large rivers where topography and alluvial processes have resulted in a well-developed floodplain. A single occurrence may extend from river's edge across the outermost extent of the floodplain or to where it meets a wet meadow or upland system. Many examples of this system will contain well-drained levees, terraces and stabilized bars, and some will include herbaceous sloughs and shrub wetlands resulting, in part, from beaver activity. A variety of soil types may be found within the floodplain from very well-drained sandy substrates to very dense clays. It is this variety of substrates in combination with different flooding regimes that creates the mix of vegetation. Most areas, except for the montane alluvial forests, are inundated at some point each spring; microtopography determines how long the various habitats are inundated. Although vegetation is quite variable in this broadly defined system, examples may include *Acer saccharinum, Platanus occidentalis, Liquidambar styraciflua*, and *Quercus* spp. Understory species are mixed, but include shrubs, such as *Cephalanthus occidentalis* and *Arundinaria gigantea ssp. gigantea*, and sedges (*Carex* spp.). This system likely floods at least once annually and can be altered by occasional severe floods. Impoundments and conversion to agriculture can also impact this system.

Barren Systems

Central Interior Calcareous Cliff and Talus
This small patch system is found primarily in non-Appalachian portions of the Central Interior Division. It ranges from the Ouachitas east to the Cumberlands and north into the Western Allegheny Plateau and Lake states. Limestone and dolomite outcrops and talus distinguish this system. Examples range from moist to dry and from sparsely to moderately well-vegetated. Woodland species such as *Thuja occidentalis* can establish along the ridgetops. Understory species can range from grassland species such as *Andropogon gerardii* on drier slopes to more mesic species in areas with higher moisture and more soil development. Wind and water erosion along with fire are the primary natural dynamics influencing this system.

AQUATIC SYSTEMS

All watersheds within the Ouachita Ecoregion are located within the Mississippi River basin, although the rivers may not drain directly into the Mississippi itself. The ecoregion can be divided into three main drainages: the Arkansas, the Ouachita, and the Red River systems. Aside from the Arkansas River and the Red Rivers proper, all other stream systems originate within the ecoregion, flowing into either the Mississippi River Alluvial Plain or the Upper West Gulf Coastal Plain ecoregions. Aquatic systems represented in the Ouachita Ecoregion include riverine systems as high-order/big rivers, and low-order/small headwater streams, sloughs and swamps, and seeps. Man-made lakes and impoundments are not included in this summary.

A total of 24 fish families are represented in the ecoregion, with most species located within the minnow (Cyprinidae), perch (Percidae), sucker (Catistomidae), sunfish (Centrarchidae), and catfish (Ictaluridae) families. The Ouachitas host a total of 8 ecoregionally endemic fish species, most of which are limited in geographic range within the ecoregion. The aquatic invertebrate diversity of the ecoregion is also quite impressive; twelve crayfish and three mussels are found nowhere else except the Ouachita Mountains. Collectively, the Interior Highlands are home to at least 190 native species of fish, 18 percent of all native freshwater fishes on the continent.. This diversity is due in large part to the complex drainage history of the region which started in the Pleistocene Age and involved multiple mixing, division, and isolation of fish faunas (Pell, Clingenpeel, et al., 1999). The result of these changes and continual occupation of aquatic species for 225 million years is a region that is a center of aquatic endemism for North America.

Low-order/small streams and rivers

Small streams originate in the ecoregion through surface and sheetflow-fed seeps and through sheetflow, groundflow, and surface flow drainage. Reaches of low-order streams and rivers originating in the Ouachitas are considered more typical upland cool low-order streams, and offer the most diverse fish communities in the ecoregion. Substrates can be composed of sand, gravel, cobble, or exposed bedrock. Pool/riffle/run systems are a common feature of these systems. Water is commonly clear and cool with medium to high gradients. These systems provide critical habitat for mussel communities and beds, many of which are species targets, and flow into higher-order/big rivers which have lower gradients. Fish target species found in low-order streams include catfish, shiners, and darters (Robison, 1988, Smith, 1992). Ecological processes in many small streams and rivers have been affected by dams.
In fact, all rivers within the Ouachitas have mainstem dams except for the Glover and Saline. The Middle Fork of the Saline River has many of its tributaries dammed with the remaining free-flowing stream targeted for future impoundment.

High-order/large rivers

Small streams feed into high-order larger rivers of the ecoregion, which in turn contribute to slough/swamp systems. However, most if not all of the slough/swamp habitat in the ecoregion is associated with the Arkansas River and its tributaries within the Arkansas River Valley. The largest of the rivers which originates in the ecoregion is the Ouachita River. Transitioning from low-order streams, gravel and cobble give way to more fine substrates, such as sand and silt. Ecological processes in many of the large-order rivers in the Ouachitas have been affected by locks, dams, or dredging.

As a result of serious alteration of the lower Arkansas River associated with dam construction, the Arkansas River is not a target within this river system; the Arkansas has a total of 6 navigation dams and a larger dam that impounds Lake Dardanelle, all which have had dramatic effects on habitat. Many important aquatic targets, such as the Arkansas shiner, *Notropis girardi*, have been extirpated from the reach found within the boundaries of the ecoregion. These targets should be addressed more appropriately in adjacent ecoregions where habitat is not limiting or absent.

Socioeconomics

There exists a vast body of local knowledge and research into the socio-economic history and current conditions in the Ouachita Mountains. Only a small fraction of this data is presented here because of the variability between the two states and the many localized effects and conditions of economic development patterns. Generalities and averages present a distorted picture and are not useful in planning and implementing specific projects.

POPULATION

The population of the Ouachita Ecoregion in 1990 was 470,000 with 395,000 in Arkansas and 75,000 in Oklahoma. Most of this population is concentrated in Little Rock and its western suburbs (220,000 or 47%). Little Rock is located on the eastern edge of the Ouachitas downstream from the significant riverine ecosystems. Urbanization, suburban sprawl, and recreation pressures are the main impacts of Little Rock on the ecosystems of the Ouachitas. Hot Springs and its satellite retirement communities are home to another 75,000 people (16%) bringing urbanization and recreational pressures to the Saline River and Lake Ouachita. The rural and small town population of the Ouachitas in Arkansas stands at 100,000 and has decreased in every census since the 1920's. Most of these small towns are located on the periphery of the ecoregion where the mountains meet the Gulf Coastal Plain. In the Oklahoma third of the Ouachitas, the population (75,000) has decreased or remained stable in every census since the 1920's.

The Arkansas and Oklahoma populations are very different. The population of the Ouachitas in Arkansas have higher levels of education and income than the state average and the minority population is low. However, in the Oklahoma portion of the Ouachitas, education and income levels are well below state average and a large minority population resides in the area.

LAND OWNERSHIP PATTERNS

Of the 11.48 million acres in the Ecoregion 1.61 million (15%) is managed by the U.S. Forest Service. Approximately 2.6 million acres is owned by timber or resource extraction interests. Other state and federal agencies manage 10% of the ecoregion. A majority of the balance (~40%) is in small private holdings. The distribution of land ownership is very different between the two states and consequently will be discussed separately as this pattern affects the local political scene.

The majority of federal ownership is in Arkansas with 30% of the ecoregion managed by the federal or state government. Timber corporations, such as Weyerhaeuser and Green Bay Packaging, manage another 25%, with the balance (45%) in private, generally small ownership. In Oklahoma, the largest landowner is Weyerhaeuser Corporation with 775,000 acres (26%), 550,000 acres of which lies in McCurtain county alone. The Forest Service manages 150,000 acres (5%) of the ecoregion in Oklahoma. Another 5% is managed by other state and federal agencies with the balance (55%) in the hands of smaller private landowners.

ECONOMIC PATTERNS

The timber industry is the largest economic force in the Ouachita Ecoregion followed by tourism and small livestock production. It is expected that this pattern will continue as timber corporations transfer operations from the Pacific Northwest to the South, tourism increases and high density chicken farms saturate the area. The spread of chicken farms has done more to raise the incomes of the poorer, land based, rural population than any other economic trend. Mining of sand, gravel and stone as well as drilling for gas and oil are also locally important.

LOCAL ATTITUDES AND FUTURE TRENDS

In Arkansas, the impacts from timber practices, recreation and urbanization will increase and continually effect and modify Conservancy conservation plans and objectives. Generally, people of the Arkansas Ouachitas are familiar with conservation efforts by both environmental groups and governmental agencies. The Conservancy's efforts to work with the private timber industry will be vital to the success of this project.

In Oklahoma, impacts from timber practices are also key with increases in recreational use and urbanization expected but not yet evident. However, the resident population is generally more wary of government and "outside" efforts in environmental conservation.

Where the Conservancy proposes to work in specific locations within the Ouachitas, more detailed data on socio-economic conditions, history and attitudes will need to be researched. The Conservancy will move to enlist the support of organizations with the expertise and local knowledge base in providing and developing this essential information.

Human Use and Historical Impacts to Ecoregion

Humans have been a powerful force in the ecological dynamics of the Ouachita Mountains for thousands of years. Shortleaf pine spread throughout the Ouachita Mountains 1600 to 1000 years ago (Delcourt and Delcourt, 1990). This spread was accompanied by the extensive use of fire by aboriginal Americans. For more than 4000 years aboriginal Americans used fire to increase forage for game animals. They also cleared fertile areas in the major river valleys to raise crops and introduced new species of plants and animals to the Ouachitas. Their fishing and mussel harvesting impacted riverine ecosystems. These activities together with a complex geological and evolutionary history created the anthropogenic phenomenon that was the tessellated landscape present when the first European settlers penetrated the area.

Intrusions by Europeans began approximately 450 years ago with the first Spanish explorations. Newly introduced diseases caused native populations to crash and the human influence on the landscape lessened for a time. Bison spread eastward from the plains during this interval. Anthropogenic influence increased again when the Ouachitas were resettled in the 1850's by Europeans, when wagon trains five across could be driven through a fire-maintained landscape. By then, the herds of bison were gone, followed shortly by the woodland elk, ocelot, black bear, red wolves, Florida panther, and even white-tailed deer. Overharvesting and changes in ecosystem processes and community composition and structure also resulted in the extirpation as breeding species - two fish, nine birds and twelve plants. Some of these species are now extinct, some are recovering or have been reintroduced.

The forests of the Ouachita Mountains were completely cut over by the late 1920's and the second growth forest cut again in the 40's and 50's. Only scattered fragments remain in a "pre-settlement" condition within this completely reordered landscape. Even within these fragments, 70 years of fire suppression have taken a toll. The riparian ecosystem was completely disrupted by the building of railroads to extract timber and the cutting of hardwood cross-ties. Many riparian areas were then homesteaded and have not regenerated. Construction of large impoundments in the 1950's and 1960's exacerbated the destruction of riparian forests and devastated many riverine ecosystems.

An excellent opportunity exists for conservation of the remaining biodiversity and restoration of these ecosystems. The reintroduction of ecosystem processes, such as fire, and the full range of community structures, such as old growth, that maintained and defined the original ecosystems will go a long way toward restoring the entire range of ecosystem functional qualities and values.

The stresses on ecosystem integrity identified in the following section come from a variety of human activities which degrade existing ecosystem functions and communities or prevent recovery of these communities and systems. These stresses are diverse in origin and complex in their short-term and long-term consequences. Stresses on ecological systems are cumulative and interactive in their deleterious effects. In order to assess and prioritize these stresses, a stress assessment has been completed. This analysis provided a framework by which we rank both our evaluation of the degree of ecological stress and our understanding of its effects and consequences. Further research may cause priority reorganization. As our understanding of ecosystem processes deepens, the degree of perceived risk may increase or decrease.

Stresses and Sources of Stress to Ecological Systems

Upland Forest Ecosystems

Stresses: Habitat destruction/conversion, altered composition/structure, alteration of natural fire regimes, fragmentation
Source: conversion to silviculture

Over the last 20 years, two million acres of second growth forest have been converted to pine plantation. These plantations consist mostly of genetically "improved" loblolly pine not naturally found in the forested upland ecosystem. Although conversion has slowed due to the lack of economically viable areas to convert and decisions by the USFS to abandon this management practice, it is an ongoing stress to the forest ecosystem. The ecosystem stress is derived from the impact of having large areas in what amounts to a monoculture of early serial stage exotics. Furthermore, the stress is continuous through the second, third and fourth rotations ad infinitum.

Conversion to plantation removes native trees, involves intensive site preparation, such as bedding and fertilizing, and planting of genetically improved stock. The trees are harvested on a 28-32 year rotation. Many miles of dirt and gravel roads have been constructed for easy access to these trees, fragmenting the landscape and contributing to the sedimentation in rivers. Plantations use biocides and fertilizers heavily, and are often surrounded by plowed firebreaks. The result is the complete loss of ecosystem integrity through the destruction of community composition, structure and natural processes. This process threatens further loss of rare species, unique communities, ecosystem structure, and composition and processes – essentially the integrity of the large forested landscape.

In comparison, conversion for uses other than forestry is relatively minor except in the flat Arkansas Valley. Row cropping was never sustainable on Ouachita Mountain soils (doesn't apply to the Arkansas Valley) and was abandoned long ago. Livestock farming is a common practice. The preparation of pasture by herbiciding and chaining the forest has been a widespread on private lands in Oklahoma. This is a serious stress on the forested ecosystem at the western end of the Ouachitas. Because all trees are not eliminated and pastures generally remain in native grasses, the long-term effect of conversion to livestock or pasture is not likely to be as severe as conversion to plantations. Still, these practices destroy natural communities and degrade ecosystem functions, and can increase erosion rates.

All factors of urbanization and sprawl disrupt ecosystem processes and landscape integrity. Urbanization and sprawl occurs around the city of Hot Springs and the western suburbs of Little Rock. Its effects on the total ecosystem are localized but serious in some areas. In addition to commercial and residential development, one practice that is having a particularly negative impact on ridgetop forest communities is the placement of communication towers on tall peaks in the range. The forest communities found on these peaks are unique because the stressful environmental conditions lead to many local adaptations, and tend to be old because ridgetop tree harvest was not economical. Increased urbanization also leads to the fragmentation of the forest with utility right-of-ways, roads and strips of development.

The conversion of large forested ecosystems to other uses such as impoundments, agricultural fields and urban conglomerations destroys the habitat that birds need to sustain their numbers. Such habitat changes favor generalist species over others, mostly migratory songbirds. Neo-tropical migrants generally require interior forest area, often with a specific community structure to reproduce successfully. Industrial forests tend to keep large areas in earlier serial stages, create edges that are often abrupt, and suppress other ecological processes (such as fire and insect outbreaks which are part of the functional qualities of the forest ecosystem).

Stresses: habitat destruction/conversion, Altered composition/structure, alteration of natural fire regimes, fragmentation
Source: Incompatible forestry Practices

The forest industry is the single largest economic force in the Ouachita Mountains. With at least six million acres of maturing forest, logging pressures will remain high. Traditional silvicultural practices have affected the forest ecosystem in a number of ways over the past 90 years. The emphasis has been on the harvesting and growing of pine, which has changed community composition and structure in different ways across the forested landscape.

Although traditional forestry practices conserve forested areas, until recently, little consideration has been given to the conservation of unique communities and essential ecosystem processes. Matrix forest structure in the Ouachitas has changed from an open, savanna-woodland community with large trees in the overstory and a grass dominated understory to a dense closed canopy forest with many small trees and a depauperate understory. The forested ecosystem has become a more uniform one created by timber harvesting and the alteration of fire regimes, without the patterns created by natural ecosystem processes and diverse natural communities.

On Forest Service land the emphasis on management for pine timber has changed. It is still common on private lands to clear mesic north-slope hardwood forests and plant pine and attempts are made in other forest communities to control hardwoods with herbicides to increase the pine component. Trees in wooded seeps, springs and along cliff lines have been harvested, thus eliminating mesic conditions and the associated dependent species. Old growth conditions are virtually non-existent, the largest fragment being the 14,000-acre McCurtain County Wilderness Area. Old growth dependent species or species that need large forested areas as habitat may be eliminated from forest communities. The lack of research and extension in sustainable forestry alternatives results in a large data gap.

The forested upland ecosystem is fire dependent and many forest communities cease to exist without this essential ecosystem process. Seventy years of fire suppression in the Ouachita Mountains has drastically altered community composition and structure. Fire reduces tree density, favors some species and communities over others, changes community structure and adds diversity to the forested landscape. Glades, prairies, woodlands, savannas and pine-oak forests are examples of fire dependent communities.

Good progress has been made over the last 8 years toward restoring altered fire regimes in pine dominated ecosystems, and a partnership of interested agencies and others is working toward the same for the Oak dominated ecosystems of the Ouachitas at the necessary landscape scale. Within these restorations, fires must be allowed to burn at different intensities during different seasons of the year and across transitional boundaries to maintain ecotones. These efforts need to be continued and expanded to ensure conservation of the ecoregional fire dependent targets.

Incompatible forestry practices can also lead to increased erosion and fragmentation from harvesting and road building. The use of biocides and introduction of exotic species during wildlife "improvement" projects also decreases biodiversity and degrade ecosystem processes. Aquatic systems are also indirectly effected by these forestry practices

Traditional silvicultural practices alter the composition and structures of forest communities. These practices have virtually eliminated old growth conditions in the Ouachita Highlands. Some species are able to take advantage of these forestry operations while others cannot; the result is that forestry operations artificially favor some species over others. Those species that are dependent on old growth conditions, unfragmented or large blocks of mature forest or other ecosystem processes decline, while generalists species or those favoring young or small patches of forest increase.

Stresses: habitat destruction or conversion, fragmentation, erosion/sedimentation, toxins/contaminants
Source: Mining Practices

This activity is very localized but has the potential to threaten unique communities in the Ouachitas. Glades, seeps and cliff lines are particularly vulnerable to the exploitation of mineral resources.

The frontal belt in Oklahoma and the Poteau Mountains of Oklahoma and Arkansas adjoin the Arkoma Basin, which has experienced extensive development of fuel resources (oil, gas, and coal). Oil exploration has moved into the frontal belt with over 100 wells drilled between 1986-1990 alone.

Many of these wells have yielded gas or oil and exploratory activity is continuing. The right of ways (pipelines, roads) associated with this type of development are serious sources of forest fragmentation. Coal resources are not currently being developed although it has been considered. If developed, the geology would dictate strip mining methods similar to those found to the north.

Stresses: habitat disturbance, erosion/sedimentation, introduction of exotic species
Source: Recreational Uses

Recreational uses are often concentrated in special areas. The complete destruction of the natural communities found in the natural hot springs of the Ouachitas occurred historically before any research was completed. Glades and other more open areas in the forest make great campgrounds both official and casual. Mountain peaks with their viewscapes, cliff lines and waterfalls with their delicate natural communities are examples of areas heavily used by hikers.

Riparian Ecosystems

Stresses: alteration of habitat destruction, change in hydrologic regime, introduction of invasive species
Source: Dam Construction, water withdrawals

The construction of impoundments has drowned hundreds of miles of riparian forest and destroyed hundreds of miles of riverine aquatic habitat. The Ouachita valley suffered the loss of fully two-thirds of its riparian forests to impoundments along its lower end. The other major river valleys have lost between 20-30% of their riparian forests and riverine aquatic habitats to impoundments. Seventeen major dams have been built and there are plans for an additional six.

Aggravating this direct habitat loss is the associated change in hydroperiods, which reverse normal ecosystem processes. The timing, duration, depth and velocity of flooding has been altered or stopped due to impoundments. Floodwaters stored behind the dams are released slowly at a time when the rivers would normally be low. Floodwaters also move large volumes of silt and sediment which should be naturally deposited on the floodplains during flood events. Nutrient rich silts and sediments are now trapped behind the dams. The seasonal expansions of riverine water onto floodplains are critical to the lifecycle of many aquatic species. The scouring action of floodwaters and deposition of silts and sediments are essential ecosystem processes. Furthermore, the permanent retention of sediment in these impoundments results in an often severe alteration of the system's natural sediment budget which can cause geomorphological instability and associated severe streambank erosion downstream of the dam. This erosion can alter and even destroy large amounts of the riparian ecosystem. Overall, the interruption of this complex ecological process has far reaching impacts on the flora and fauna, some of which may take decades to become noticeable. The results are destruction of the riparian forest, or changes in forest composition, structure and growth rates and a concurrent change in fauna as riparian ecosystems adjust to new parameters.

Ecosystem processes in riparian zones are intact only above the high level mark of the impoundments. These areas also have the narrowest strips of riparian forest. The larger floodplains with their large bottomland hardwood forests have been most impacted.

Stresses: habitat alteration/destruction, habitat fragmentation, introduction of exotic species.
Sources: Conversion

Historically, riparian areas have been used as travel corridors, as a pathway to upland timber removal, and for homesteading. Riparian areas were cleared for railroads and the hardwoods used as crossties. These areas were then settled and farmed; seldom were they allowed to regrow. Beginning in the 1930's and continuing today, many homesteads were abandoned and riparian areas allowed to reforest through natural processes.

Recent trends in forestry toward large plantations has resulted in the conversion of riparian forest to softwoods. The replacement of riparian forests (mostly hardwoods) with plantations of loblloy pine leads to diminished biological diversity. This practice is most widespread where flooding has been controlled. The result is the destruction of ecological communities, reduction of riparian forests to narrow strips along river corridors, and the loss of ecosystem processes and functions. Some of the practices associated with traditional forestry can also degrade riparian areas. Inappropriate harvesting methods, road building and disturbances which allow the spread of exotic species will degrade riparian forests through fragmentation, changes in species composition and community structure, and a loss of biological diversity.

Conversion to agriculture is not as great a concern. Past agricultural clearing is reversing itself as agriculture becomes economically marginal. In the narrower upper watershed the riparian forests have mostly reestablished themselves. Those areas that have been converted to agriculture continue to degrade riparian ecosystems by fragmenting the forest. In many places there is no riparian buffer strip at all. Free ranging livestock (also feral hogs) have had deleterious impacts on understory vegetation and forest reproduction through heavy and uncontrolled access and use of riparian zones. This disturbance has also been a pathway for the introduction of exotic species.

Urbanization threatens riparian ecosystems throughout the Ouachita Mountains. Currently these developments are limited in extent and in most cases tied to the recreational opportunities and industries associated with the large impoundments. New roads and other developments are inevitably restricted to the relatively flat areas of floodplains found in riparian ecosystems. Southeast Oklahoma is the poorest area in the state, and consequently many development efforts are underway to encourage industrial and recreational uses, including new and improved corridors, assistance to industrial parks and promotion of recreational opportunities. Arkansas has similar, if less extensive, development assistance programs. Particularly worrisome is the proposed interstate highway connection which would run north-south along the Arkansas-Oklahoma border from Fort Smith to Texarkana. At present there are no quick and easy routes through the Ouachitas. A highway such as this opens up large areas of rather remote and hard to reach areas to development.

Urbanization increases the fragmentation of riparian forests and accelerates the spread of exotic species. Urban development also makes the restoration of ecosystem processes, such as functional hydroperiods, difficult or impossible.

As a whole, riparian forest conversion and clearing can also have dramatic effects on aquatic systems. Forested riparian corridors provide important shade which plays a role in keeping water temperatures low. These forests also play a key role in curbing streambank erosion, whether at natural or accelerated rates associated with stream or watershed alterations; sedimentation is a major threat to aquatic targets of the ecoregion. In fact, soil is the largest pollutant by volume in the ecoregion. Furthermore, riparian forests provide fish and invertebrate habitat in the form of branches and even whole trees. Leaves and other inputs also play an important role in the carbon cycle, fueling the food chain of aquatic systems.

Stresses: habitat degradation, habitat fragmentation, introduction of exotic species
Source: Recreational Uses

Riparian zones are popular recreational sites. Most of the recreational opportunities are concentrated along the major impoundments where boating, fishing and camping use is heavy. All the larger streams receive heavy use in the summer from campers, canoeists and day users in both developed and undeveloped recreation sites. Where overuse occurs erosion, habitat destruction, forest fragmentation and the spread of exotic species are problems.

Riverine Ecosystems

Stresses: habitat destruction, habitat disturbance, loss of genetic diversity, alteration of hydrologic regimes, thermal alteration, resource depletion, sedimentation, salinity alteration
Source: Dam Construction, Water Diversions and Withdrawals, operation of dams/reservoirs

The ecological integrity of the rivers and streams of the Ouachita Mountains has been severely compromised by numerous dams. Only the Glover River and the mainstems of the upper forks of the Saline River have escaped impoundment. Seventeen major impoundments and uncountable small, private dams have been built. At least six additional major dams are planned and several have various levels of approval. These would impound the Glover and Saline (North Fork) Rivers and further impound the Little and Kiamichi Rivers.

Impoundments physically destroy large areas of riverine ecosystem, and therefore alter the hydrology of the downstream portion of the entire ecosystem; it is disrupted and often destroyed. Impoundments also block the normal movement and migration of species, allow the introduction of exotics, and create thermal pollution downstream. Mussel glochidia (young) are parasitic though harmless to their often species specific host fish. Various fish species serve as hosts to the glochidia depending on the species of mussel. By hosting mussel glochidia, migratory fish perform an important function of distributing mussels throughout a river system; impoundments make such repopulation impossible. This disruption may have doomed some species of mussel to extinction even though the senescent populations are still extant. Overtime reduced reproductive productivity caused by interrupted breeding migrations leads to general population decline for both fish and mussels.

Texas water authorities, specifically Dallas in partnership with State of Oklahoma are currently exploring interbasin transfer options, including diversion from the Kiamichi River.

The destruction of a natural riffle-pool environment dislocates fish communities as well as other aquatics species, including amphibians and mussels. With impoundments in place, many big river fish can no longer migrate upstream to breed.

Downstream ecological disruption occurs because impoundments generally reverse and regulate the hydropattern of the dammed rivers. Water is impounded during high flows and released slowly throughout the year. The water temperature, oxygen levels and natural sediment transfer process are drastically altered. The scouring action produced by large storm events is an essential ecosystem process which remakes riverine topography, opening up new habitat for disturbance dependent species and communities. Further, without the natural variation in flow, seasonal flooding of riverine water onto floodplains, critical to the lifecycle of many aquatic species, is lost. For example, many fish species use seasonally flooded areas for spawning. Similarly, the permanent retention of sediment in these impoundments results in an often severe alteration of the system's natural sediment budget which can lead to severe streambank erosion downstream of the dam. This often severe erosion can result in increases in sedimentation and habitat destruction.

River reaches upstream of impoundments can also be effected. Although these reaches are often targeted as conservation priorities, isolation from downstream reaches can result in shifts in community composition, local extirpation of species present prior to dam construction, and even reduction in species richness (Lienesch et. al 2000). Headwaters, stream reaches typically isolated by reservoirs, are more dramatically affected by abiotic factors that can temporarily render certain habitats inhospitable, making access to downstream refuge areas important. Isolation cuts off colonizers from downstream areas that play a key role in re-establishing the fish populations after these catastrophic events, such as flooding and severe drought.

Stresses: sedimentation/erosion, toxins/contaminants, habitat destruction, alteration of hydraulic regime
Source: Incompatible Forestry Practices

Forestry is the primary land use in every major watershed in the Ouachita Mountains. The USFS and large forest industries manage well over half the landscape. The thousands of smaller non-industrial landowners also manage much of their land for the economic benefits derived from timber production. As with any heavily timbered landscape, poor in agricultural resources (soil) and with over 2,000,000 acres in plantations, forestry is likely to remain the major economic use of the land.

Forestry operations which do not use best management practices cause many non-point source pollution problems. Erosion and sedimentation occurs during and after tree harvesting and as a result of unsound construction, placement, and maintenance of roads. Sediment deposited on the river substrate alters the habitat used by fish and mussels. It smothers breeding sites and eggs and reduces reproductive productivity. In suspension it reduces light penetration, alters the micro flora and fauna, increases water temperatures, reduces mussel feeding time and causes a general degradation of riverine ecosystems.

Intensive forestry operations (plantations) are heavy users of biocides and fertilizers. Poor application procedures result in degradation of riverine ecosystems through toxic poisoning and increased nutrient load. Extensive manipulation of vegetative cover results in changes in the infiltration and runoff of precipitation. Usually these changes increase short term runoff and decrease the amount of water available over the longer term.

Mussels are particularly sensitive to the toxins released by biocides, and the stress to micro flora and fauna causes degradation and local extirpation. These poisons have both acute and chronic effects to aquatic communities.

Stream crossing construction often occurs at riffles areas; unfortunately, riffles are primary habitat for many mussels and darters. The destruction of riffle habitat causes localized degradation and extirpations. It also destructively alters the hydrology of the streambed, leading to scour and increases chronic sedimentation problems. Biocides, sedimentation, and other runoff enter riverine systems at road crossings. Poorly placed and designed culverts and low water bridges alter stream hydrology and habitat and block the normal movement and migration of species.

Stresses: nutrient loading, toxins/contaminants, alteration of hydrologic regime, sedimentation, habitat destruction
Source: Agricultural Practices

The agricultural practices in the Ouachita Mountains consist of grazing livestock, hay mowing and confined animal feeding operations, mostly hogs and chickens. Historically the river valleys were settled and cleared for farming and have the best soils. Although the amount of land devoted to these practices is relatively small they are most often located in the river valleys along the streams where they can have the greatest, most direct impacts. These practices are the source of many non point source pollution problems. These stresses are the similar to those produced by forestry operations, including increased sedimentation from overgrazing, land clearing with biocides, and alterations in runoff and stream hydrology. Landowners have traditionally allowed livestock free access to riverine areas. This practice can result in streambank instability and decreased riparian understory which leads to increased sedimentation.

A particular problem in the Ouachita Mountains occurs with small livestock operations because of the large amount of animal waste produced and concentrated near streams. Runoff from these operations increases nutrient loading and degrades water quality. Nutrient enrichment causes changes in community composition and ecosystem processes, or their outright destruction.

Stresses: Sedimentation, habitat destruction
Source: roads, unpaved permanent and temporary

Sedimentation from the thousands of miles of unpaved road systems that run throughout the Ouachitas is a huge source of sediment. These roads, usually not designed and built with sediment retention in mind, provide a direct conduit for sediment to reach a stream – even the best streamside buffer cannot reduce this kind of runoff. The Natural Resources Conservation Service estimated that approximately ¼ of the sediment entering an Ozark stream comes from road runoff. Ouachita streams face the same threat. This number is likely similar for all Ouachita streams meaning that one quarter of sediment entering Ouachita streams has an easily identifiable source to target for action.

Sediment deposited on the river substrate alters the habitat used by fish and mussels. It smothers breeding sites and eggs and reduces reproductive productivity. In suspension it reduces light penetration, alters the micro flora and fauna, increases water temperatures, reduces mussel feeding time and causes a general degradation of riverine ecosystems.

Stresses: toxic poisoning, nutrient enrichment/loading
Source: Point source discharge, wastewater treatment, catastrophic contaminant spills

The Ouachita Mountains Physiographic Province contains one city (Hot Springs), various towns, and over 300 small villages, settlements, crossroads, state parks, forest campgrounds and recreation areas, one military base and the western suburbs of Little Rock. Each of these entities has one or more permitted point source discharges into the ecoregion's rivers. The majority of these discharges (including Little Rock) are from the settled area along the periphery of the Ouachita Mountains where the major roads follow the fall line. However, though individual point sources are permitted, no current federal or state policy or management takes the cumulative effect of these discharges into account.

Toxins and nutrient loadings from municipal sewage, wood processing mills and chicken factories have major negative impacts on sensitive species such as mussels and microorganisms. Repeated discharges and spills depauperate riverine ecosystems. Inorganic contaminants include mercury and arsenic.

Stresses: erosion/sedimentation, habitat destruction, toxins/contaminants, alteration of hydrologic regime
Source: Mining

There is very little mining activity in the Ouachita Mountains aquatic systems, but some stone and gravel mining does occur. During road and bridge construction stone and gravel are often mined from riverbeds. These operations, while generally localized and small, can cause havoc when they take place instream. Changes in hydrodynamic flow, very high rates of sedimentation, localized habitat destruction and long term changes in the physical parameters of the river bed can disrupt riverine ecosystems over the long term. These operations have acute localized and long term chronic effects on the aquatic ecosystem.

There is exploratory drilling for gas and oil in the northern part of the ecoregion. This activity is not currently impacting the riverine ecosystems of concern. Low-quality coal reserves, apparently occur in the area, but many of the historical mining sites, such as those for coal in the Arkansas River Valley and for Barite in the Caddo watershed, are being restored

Stress: extraordinary resource competition, habitat destruction/alteration, extraordinary predation/parasitism/disease
Sources: Introduction of Exotic Species

Exotic aquatic species have been documented in the riverine ecosystems of the Ouachita Mountains. Aquatic invasives—plants and animals—are both purposefully and accidentally introduced into riverine ecosystems. The Asian clam (*Corbicula fluminea*) is now a permanent resident throughout most of the continental U.S. Of particular concern is the rapid expansion of the zebra mussel (*Dreissenia polymorpha*); invasion has been documented in the Lower Mississippi and Arkansas Rivers, but not in the Red River system. No effective means have been developed to control zebra mussel spread, and with its large impoundments and heavy recreational marine traffic, invasion may be an eventuality in the Red River system. It is possible for populations of this mussel to disrupt the entire aquatic community structure of a river by changing the food chain base. Further, by growing on the shells of native mussels, Zebra mussels will kill natives by smothering them outright.

The stocking of exotic game fish can also pose problems. Traditionally state game and fish organizations have introduced various species of sport fish, and as a result, exotic bait fish are also widespread. Game fish tend to be apex predators, which can decimate smaller native fish species and outcompete native apex predators. The introduction of the smaller species of fish used as bait disrupts native ecosystems due to competition for breeding and spawning sites.

The impact of predation by resident animals is not well documented and is probably significant only where populations have been severely impacted by other negative stresses. Muskrats, raccoons and turtles all eat mussels, as do some fish. Monitoring of endangered populations may show cause for concern. It is believed that heavy predation, in conjunction with habitat loss and reduction of other prey species, has in some cases prevented the recovery of endangered species of mussel with reduced populations (Neves, 1992).

Other rare species of fish and reptiles are preyed on as well by these and other species. Rare species could be forced into extinction, or may be unable to recover under high rates of "natural" predation. Human predation takes the form of collecting; mussels for their shells or food, fish for food, bait to catch fish, and amphibians and reptiles for bait or collecting.

Stresses: habitat destruction, nutrient enrichment, sedimentation, introduction of invasive species
Source: Recreational Uses

Water attracts recreation users. Canoeing is a particularly popular activity in Arkansas and is increasing in Oklahoma. Since the Dallas metropolitan area is only two hours away from the Kiamichi river there is the potential for great increases in the recreational use of this area. The rivers of Arkansas already receive a great deal of recreational use. Heavy recreational use can result in localized habitat destruction, increase in nutrient levels, and increased sedimentation.

Stresses: habitat destruction, habitat fragmentation, modification of water levels
Source: commercial/industrial development, development of roads and utilities, primary and secondary home development.

Hot Springs is a rapidly growing small city, with retirement homes in the area (Hot Springs Village). Second home development is becoming popular throughout the ecoregion, and is especially visible around Mena, Broken Bow and some of the reservoirs. Little Rock is likewise growing and losing urban population to its outlying suburban and rural areas. Census data shows sprawl is in effect as large and small urban areas lose populations to outlying suburban and rural areas (U.S. Census, 1999). Habitat destruction, increased municipal discharge, water diversions and conversion of habitat to other uses are the greatest threats to aquatic systems from urbanization. .

Stresses by Site: Landscape-Scale Terrestrial Sites:

Cherokee Prairies: Fragmentation, conversion (to rangeland and urbanization around Fort Smith), altered fire regime.

Magazine Mountain: Change in structure/composition: incompatible timber practices, altered fire regime, recreation, habitat destruction.

Pine-Bluestem Restoration Area: Change in structure/composition: incompatible timber practices, altered fire regime.

Novaculite Uplift: Change in structure/composition: incompatible timber practices, altered fire regime.

Beaver Bend Hills: Change in structure/composition : incompatible timber practices , altered fire regime;.

North Shore Glades: Change in structure/composition: incompatible timber practices , altered fire regime, fragmentation (timber practices); fragmentation, habitat destruction/conversion.

Rich Mountain: Change in structure/composition; altered fire regime.

Stresses by Site: Other Terrestrial Sites:

Pushmataha: Change in structure/composition; incompatible wildlife management, altered fire regime, incompatible timber.

Meadow-Rue Seeps: Change in structure/composition; alteration hydrologic regime: grazing, conversion; incompatible agriculture (pasture).

Sugarloaf Mountain: Change in structure/composition altered fire regime, incompatible timber practices, recreation (off-road vehicle use).

Least Terns sites: Alteration of hydrologic regime; barge, traffic, no flooding predation, change in structure/composition; habitat destruction.

Goose Pond: Changes in hydrologic regime, habitat destruction conversion incompatible forestry incompatible recreation (duck management), nutrification.

Cove Creek: Change in structure/composition—altered fire regime.

Little Rock Air Force Base: Incompatible land use, altered fire regime, data gaps.

Holland Bottoms: Incompatible timber, change in structure/composition, altered hydrology.

Flatside / Forked Mountain: Change in structure/composition—altered fire regime, , incompatible timber practices, recreation.

Brady Mountain: Change in structure/composition—altered fire regime.

Crayfish Complexes: Change in structure/composition habitat destruction: predation..

Stresses by Site: Aquatic sites

The stresses to aquatic systems in the Ouachita Ecoregion are varied, but most sites face a similar suite of stresses:

Name	Stress Rar	Site Stresses	Priority
Kiamichi River	High	Stresses: :Altered hydrologic regime, water withdrawals, operation of dams/reservoirs, dam construction. no. 1 priority.	1
Glover River	High	Stresses: Roads/sedimentation (logging), incompatible forestry/sedimentation sedimentation/runoff from land use, alteration of natural hydrologic regime, water withdrawals. no. 2priority	2
Upper Saline River	High	Stresses: toxins/pollution from CFOs, urbanization, dam construction/operation, extraction, incompatible forestry/sedimentation high 3-4 priority.	3
Upper Little River	High	Stresses: Roads/sedimentation (logging), incompatible forestry/sedimentation sedimentation/runoff from land use, alteration of natural hydrologic regime, water withdrawals, dam construction or maintenance. tied as no. 2 priority	4
Caddo River	Medium	Stresses: historic mining/extraction, recreational use, current gravel mining on mainstem, and nutrification from CFOs. 3-4 priority.	4
Ouachita Headwaters	High	Stresses: Point-source pollution, CFOs, incompatible forestry/sedimentation pasture/conversion	4
Mountain Fork	Medium	Stresses: Roads/sedimentation (logging), incompatible forestry/sedimentation sedimentation/runoff from land use, alteration of natural hydrologic regime, water withdrawals, dam construction or maintenance..--threats not as extreme as in Glover and Upper Little.	5
Cossatot River	Low	Stresses: Roads/sedimentation (logging), incompatible forestry/sedimentation, sedimentation/runoff from land use, alteration of natural hydrologic regime, water withdrawals, dam construction or maintenance..	5
Little Missouri River	Medium	Stresses: Road construction/maintenance, recreation, incompatible forestry/sedimentation	5
Fourche La Fave River	Medium	Stresses: nutrification	6

Plan Implementation: Addressing Stresses/Threats Through Multi-Site Strategies

Multi-Site Strategies - Background

Multi-site strategies were developed to enable implementation of the ecoregional assessment through clear, prioritized, cohesive measurable action. Participants in the multi-site strategy were asked to review literature and guidance pertaining to multi-site strategies, including relevant *Geography of*

Hope chapters, implementation sections from other ecoregional assessments, and the results of multi-site strategy meetings from other ecoregions. Initial activities were to review the major systems in the ecoregion, then review stresses and threats to determine multi-site stresses and their sources. The stresses/sources of stress assessment relied on the Geography of Hope definitions of a stress, source of stress, and threats[1]. For the purposes of this chapter and activity these definitions have been truncated: "stress" is defined as an ecological or biological element (e.g. sediments), "sources" are defined as anthropogenic in nature (e.g. roads or development), and "threats" can be any combination of sources or stresses.

Ecoregional assessments are translated to implementation through conservation action at individual sites and through implementation of multi-site strategies. Note that many multi-site strategies also address or link several threats. Major terrestrial and aquatic systems in the ecoregion were reviewed, then multi-site threats and top sources of stresses were developed and listed. The multi-site strategies below are simply outlines; a formal plan should be developed than includes specific goals, outcomes, and timelines.

The following are system threats identified in the experts meeting. Terminology was structured from the initial Geography of Hope based stresses/sources of stress analyses.

Terrestrial system threats:
- Conversion: Industrial forestry
- Agricultural conversion (present/historic) – pasture except for row cropping in the in the Arkansas River valley
- Incompatible forestry
- Altered Fire Regime
- Conversion/destruction from commercial and residential development
- Fragmentation

Aquatics system threats:
- Hydrologic alteration: dam/reservoir construction and operation, water withdrawals, dredging, channelization, instream structure and "training", thermal pollution/alteration
- Incompatible agriculture, (including CAFOs)
- Silviculture/incompatible forestry
- Roads and right-of-way construction
- Extraction/mining, (mineral as well as water extraction)
- Non-point source pollution
- Exotic species

The implementation team decided on the following as the top threats, in order of priority based on severity and pervasiveness of threat:

1. Dams/water withdrawal
2. Altered fire regime/forestry management

[1] *Stress*: something that impairs or degrades the size, condition, or landscape context of a conservation target, resulting in reduced viability; *Source*: a human or biological factor that infringes upon a conservation target that results in stress; *Threat*: the combined concept of stresses to a target and the sources of that stress to that target.

3. Nonpoint source pollution (including roads)
4. Conversion – industrial forestry
5. Conversion – agriculture
6. Development – residential/commercial
7. Exotic species

Multisite strategies are outlined below for the top threats in order of priority. See Table 1 for a list of sites included within each multi-site strategy.

The Multi-site Strategies

1. Altered Hydrology/Water Diversions

   Although variability in season flows exists for natural systems, alterations associated with dam construction and water diversions can alter these flows beyond the natural range of variability to which the aquatic species and communities have evolved or adapted. Similarly, the threat of dam construction also results in large-scale habitat destruction and alteration. These threats are of some level of concern for all aquatic sites in the ecoregion, although they are the "killer" threat for the aquatic systems in the southwestern Ouachitas, including the Kiamichi, Glover, and Upper Little Rivers where some of the rarest or most threatened species in the ecoregion are found. As a result, there exists a strong need for a multi-site strategy that addresses these threats. Specifically, this strategy will address the following linked threats:

- Altered hydrologic regime
- Habitat destruction/conversion
- Habitat fragmentation/migration barrier
- Thermal alteration
- Geomorphic instability

To address these threats, the following goals should be incorporated into a formal Multi-Site Strategic Plan, the first step in implementing a multi-site strategy:

STRATEGY: Ensure protection or initiate restoration of natural flow regimes of target aquatic sites. The strategy will be accomplished through demonstration projects, external affairs work, and cultivation of a suite of partners.

Goals:

- Assessment of the specific source of these threats for each site (Conservation Area Plans)
- Development of capacity within existing staff to understand legal issues
- Formulation of ecosystem flow prescriptions or desired site conditions for each site
- Enlisting of partners necessary to implement strategy across suite of sites
- Utilization of existing/ongoing work at Kiamichi River as ecoregional "demonstration" site
- Development of agreements with regulatory agencies and their local counterparts responsible for dam management or water withdrawals in order to implement ecosystem flow prescriptions

- Development of a monitoring program for those parameters that fall outside the standard aquatic measures of success (e.g. physical parameter monitoring)

The completion of a multi-site strategic plan will likely include other goals not listed above, and should involve a diverse group of staff and partners to fully address this threat. Furthermore, the site conservation plans for effected sites should incorporate parts of the strategic plan where appropriate.

2. Altered Fire Regime/Forestry Management

The forested upland ecosystem of the ecoregion is fire dependent and many forest communities cease to exist without this essential ecosystem process. Seventy years of fire suppression in the Ouachita Mountains has drastically altered community composition and structure. Fire reduces tree density, favors some species and communities over others, changes community structure and adds diversity to the forested landscape. Glades, prairies, woodlands, savannas and pine-oak forests are examples of fire dependent communities. As a result, there is a strong need for a multi-site strategy that addresses this pervasive threat.

STRATEGY: Reestablish natural fire regime to the suite of forest communities and the systems within these matrix forests at a scale necessary to conserve viable populations of terrestrial targets across all ecoregional sites. The strategy will be accomplished through demonstration projects, external affairs work, and cultivation of a suite of partners.

Goals:

- Expand number and size of restoration projects on public lands, particularly those in the Ouachita National Forest and Ft. Chaffee, toward a defined, desired future outcome
- Participate in Ouachita National Forest plan revision process to incorporate appropriate use of fire and forest thinning toward desired future outcomes for suite of fire dependent systems as part of most appropriate management alternative to conserve target species and communities
- Incorporate large-scale restoration successes into Ouachita National Forest plan revision process
- Ensure that National Forest restoration success stories are utilized to educate the public, government officials, and agency staff

The completion of a multi-site strategic plan will likely include other goals not listed above, and should involve a diverse group of staff and partners to fully address this threat. Furthermore, the site conservation plans for effected sites should incorporate parts of the strategic plan where appropriate.

3. Nonpoint Source Pollution

Some type of nonpoint source pollution (NPS) is a threat to all aquatic sites in the Ouachita Ecoregion. The multi-site threat abatement project that will address this issue will have two components – a set of goals associated with sedimentation and a set of goals associated with nutrients. First, sedimentation is a key threat to the biodiversity targets of these systems; sources of this threat include unpaved roads (permanent and temporary), incompatible forestry practices, and to a much lesser extent, incompatible agricultural practices. To address this component of the multi-site strategy, the following strategy and goals should be included, keeping in mind that some of these goals will be addressed by a similar strategy underway for the Ozark Ecoregion and need not be duplicated. In fact, it may be appropriate and more feasible to address this threat for the entire Interior Highlands.

STRATEGY 1: Develop and promote river-friendly road maintenance practices utilizing existing research data and/or new data for use throughout the Ouachitas. This strategy will be accomplished through a demonstration project and an associated focused educational program that uses specialized training and fact sheets for county officials and their road crews.

Goals:

- Compile reference materials on sedimentation associated with roads and any research into combating (Best Management Practices) this problem
- Enlist partners necessary to develop and implement a demonstration/research project that is based on the best available knowledge, including academia, government, and NGOs
- Identify a site most suitable for road sedimentation demo project (probably in conjunction with Forest Service) based on partners, funding, opportunity, and leverage, and then implement the demonstration project with partners, ensuring that it addresses the identified threat
- Based on reference materials and initial results of demonstration project, develop a workshop for key audience of county judges and road crews that work within target watersheds
- Develop a monitoring program that can be implemented outside of demonstration site to collect additional data to document changes in stream quality
- Play a key role in the research component of project to ensure that focus remains on answering TNC's questions

Second, nutrients associated confined animal feeding operations (CAFO) are threatening many ecoregional aquatic sites. This component of the multi-site strategy is also being addressed for the Ozark ecoregion, although the type of CAFO differs somewhat for the Ouachita Mountains. The following strategy and goals should be included in the multi-site plan:

STRATEGY 2: Develop and promote best management practices associated with confined animal feeding operations. This strategy will be accomplished via demonstration farms, innovative workshops, and direct landowner and corporate outreach and associated brochures and fact sheets. This strategy will also have a government relations program designed to funnel Farm Program dollars into programs toward best management practice cost-shares in the Ouachitas that make the most significant improvement in water quality.

Goals:

- Compile reference materials on sedimentation associated with agricultural operations (cattle and hog CAFO) and any research into combating (BMPs) this problem
- Enlist additional partners necessary to implement demonstration/research project that is based on the best available knowledge, including corporations, academia, government, and NGOs
- Utilize NRCS technical advisory committees in each stae to guide funding toward priority sites based on ecological significance

- Enlist partners necessary to develop and implement CAFO waste demonstration/research project that is based on the best available knowledge, including corporations, academia, government, and NGOs
- Identify a site most suitable for CAFO demo project based on partners, funding, opportunity, and leverage, and then implement the demonstration project with partners, ensuring that it addresses the identified threat
- Conduct compatible CAFO workshops for landowners within target watersheds

The completion of a multi-site strategic plan will likely include other goals not listed above, and should involve a diverse group of staff and partners to fully address this threat. Furthermore, the site conservation plans for effected sites should incorporate parts of the strategic plan where appropriate.

Table 1. *Sites to be included within each multi-site strategy described above.*

Altered Hydrology/Water Diversions	Altered Fire Regime/Forestry Management	Nonpoint Source Pollution
Kiamichi River	Cherokee Prairies	Kiamichi River
Glover River	Magazine Mountain	Glover River
Upper Saline River	Pine-Bluestem Restoration Area	Upper Saline River
Upper Little River	Novaculite Uplift	Upper Little River
Mountain Fork	Beaver Bend Hills	Mountain Fork
Cossatot River	North Shore Glades	Caddo River
	Rich Mountain	Ouachita River Headwaters
	Pushmataha	Cossatot River
	Sugarloaf Mountain	Little Missouri River
	Cove Creek	Fourche La Fave
	Little Rock Air Force Base	
	Flatside / Forked Mountain	
	Brady Mountain	

Multi-Site Strategies Reference and Comparison Table

Multi-Site Strategy	Strategy Statement	Threats Addressed	Sites Included
Altered Hydrology/ Water diversions	STRATEGY: Ensure protection or initiate restoration of natural flow regimes of target aquatic sites. The strategy will be accomplished through demonstration projects, external affairs work, and cultivation of a suite of partners.	• Altered hydrologic regime • Habitat destruction/conversion • Habitat fragmentation/migration barrier • Thermal alteration • Geomorphic instability	• Kiamichi River • Glover River • Upper Saline River • Upper Little River • Mountain Fork • Cossatot River
Altered Fire Regime/ Forest Management	STRATEGY: Reestablish natural fire regime to the suite of forest communities and the systems within these matrix forests at a scale necessary to conserve viable populations of terrestrial targets across all ecoregional sites. The strategy will be accomplished through demonstration projects, external affairs work, and cultivation of a suite of partners.	• Fire suppression • Change in structure/ composition	• Cherokee Prairies • Magazine Mountain • Pine-Bluestem Restoration Area • Novaculite Uplift • Beaver Bend Hills • North Shore Glades • Rich Mountain • Pushmataha • Sugarloaf Mountain • Cove Creek • Little Rock Air Force Base • Flatside/Forked Mountain • Brady Mountain

NonPoint Source Pollution	STRATEGY 1: Develop and promote river-friendly road maintenance practices utilizing existing research data and/or new data for use throughout the Ouachitas. This strategy will be accomplished through a demonstration project and an associated focused educational program that uses specialized training and fact sheets for county officials and their road crews. STRATEGY 2: Develop and promote best management practices associated with confined animal feeding operations. This strategy will be accomplished via demonstration farms, innovative workshops, and direct landowner outreach and associated brochures and fact sheets. This strategy will also have a government relations program designed to funnel Farm Program dollars into programs toward best management practice cost-shares in the Ozarks that make the most significant improvement in water quality.	• Sedimentation • Nutrification • Habitat destruction	• Kiamichi River • Glover River • Upper Saline River • Upper Little River • Mountain Fork • Caddo River • Ouachita River Headwaters • Cossatot River • Little Missouri River • Fourche La Fave

2002 Plan Update Rollout Data

Target Goals

Goals were set using defaults available through TNC ecoregional guidance including *Geography of Hope and Guidelines for Representing Ecological Communities in Ecoregional Plans*. All goals and targets underwent expert review. Default goals from Geography of Hope were used for most targets, although some target goals were adjusted according species rarity, known occurrences, and availability. Specifically, no target number for a G1 species could be more than the number of known population occurrences in the ecoregion and no G2 species could have a goal over 20 by Heritage definition. In addition, because of the complexities associated with using element occurrence records to identify aquatic species populations (i.e. how many element occurrences constitute a population?), particularly those of mussels, aquatic G3-G4 species are considered "captured" if occurrences are located in at least three aquatic conservation areas, which in this assessment are 8-digit watersheds.

Requested roll-out information was completed as per Geography of Hope (Groves, et al., 2000) and was approved by update team leader in June 2003.

Where is the data generated from ecoregional planning efforts stored, in what format, who is responsible for information management?
Data is stored on the latest version of the plan CD-ROM for the ecoregion. Data was collected in Microsoft Access 2000 using CPT versions 1.3 and 1.5 as the operating platform. Please see the Methodology and data management section for further data information. The Project Manager is responsible for information management.

A list of conservation targets by species, terrestrial/aquatic community, marine habitat, or ecological system
Please see the Rollout Report (Appendix B).

For each Conservation target provide: percentage of all targets that met their conservation goals; percent of targets that met their conservation goals by species, communities, and ecological system (aquatic/terrestrial); percent of G1 and G2 species that met their conservation goals; percent federally listed threatened and endangered species that met their conservation goals.
Please see the Rollout Report (Appendix B) for all lists. Percentages follow:

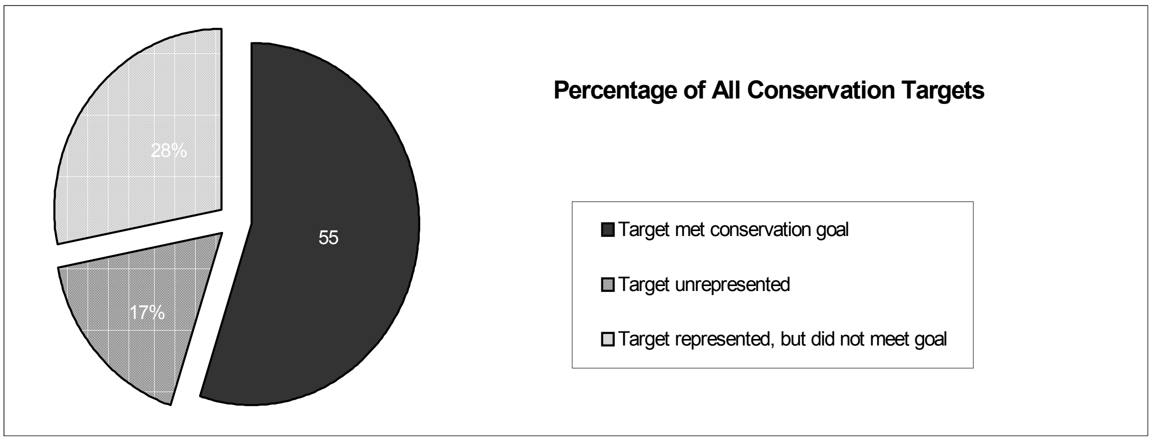
- Percent of all targets that met their conservation goals: 56% (139 of 246)
- Percent of targets that met their conservation goals by species, communities, and ecological system (aquatic/terrestrial): see below.
- Percent of G1 and G2 species that met their conservation goals: see below.
- Percent federally listed threatened and endangered species that met their conservation goals: see below.

Targets That Met Goals Matrix

Amphibians:	69% (9 of 13)	**Insects:**	63% (10 of 16)
Birds:	57% (11 of 19)	**Invertebrates:**	100% (7 of 7)
Communities:	60% (47 of 78)	**Mammals:**	50% (1 of 2)
Crustaceans:	71% (5 of 7)	**Mussels:**	100% (17 of 17)
Fish:	100% (19 of 19)	**Plants:**	31% (20 of 64)
		Reptiles:	50% (2 of 4)
All G1 Targets:	88% (22 of 25)	**All G2 Targets:**	71% (25 of 35)
OOHA PETs:	92% (26 of 28)	**All G1 – G3:**	70% (94 of 134)
Listed as Endangered:	83% (5 of 6)		
Other federal listing:	25% (3 of 12)		

Figure 1 illustrates the percentage of all conservation targets that met their goal, percentage of targets that did not meet their goal, and percentage of unrepresented (no element occurrences) targets in the portfolio.

Figure 1.



Representative populations: representative populations were used when inaccurate, outdated, inappropriate, or nonexistent point data was available for an occurrence, or if the number of individual occurrences present could be considered collectively to form a population or community. Representative populations comprise 47% of the occurrences considered viable. Of those, 78% were created from expert knowledge in the absence of contemporary ground-truthed data points (proto-EOs); 25% of the representative populations came from the OOHA data.

List up to five critical threats (sources of Stress) to targets that recur at many conservation areas across most or all of the ecoregion
Please refer to the "Threats, Sources of Threats, and Multi-Site Strategies" section.

The number of conservation areas in the ecoregion
There are 40 sites within the ecoregion. Ten of the sites are landscape-scale sites designed to conserve aquatic targets and communities; six are landscape-scale sites designed to conserve terrestrial targets and communities. There are 12 sites that are designed to be part of a network of small sites.

The number of conservation areas in the ecoregion that are considered protected
No site in the ecoregion is considered completely protected; the degree of protection determined by ownership or management plan/mission alignment with TNC has not been determined.

The number of sites that contain aquatic communities/systems and species targets
Ten sites contain aquatic communities, systems, or targets.

The number of action sites in the ecoregion
Action sites have not been determined.

The number of action sites that are landscape sites
Please see above.

An estimate of the area of all conservation areas, all action sites, all landscape-scale sites in the ecoregion.

- Acres Terrestrial Landscape-Scale Sites: 2,411,461 or 21% of ecoregion
- Acres Aquatic Landscape-Scale Sites (watershed): 3,573,338 or 31% of ecoregion
- Acres non-landscape scale terrestrial sites: 256,375 or 2% of ecoregion
- Acreage all terrestrial sites: 2,667,836 or 23% of ecoregion
- Acreage all sites: 6,068,258 or 53% of ecoregion

Management/ownership percentage of the conservation areas broken down by Federal, state, private, TNC

- Total Public Ownership: 2,113,139 acres; 79% of terrestrial conservation areas (34% if watersheds of aquatic conservation areas are included)
- Total State (AR + OK) Ownership: 112,872 acres; or 4% of terrestrial conservation areas
- Total Federal 2,000,267 Acres; or 75% of terrestrial conservation areas
- Total TNC: 8,287 acres or 0.07% of terrestrial conservation areas

Forty conservation areas were identified as part of this ecoregional assessment. In this iteration of the plan, the aquatic, landscape scale and small patch conservation areas cover a total of 6,068,258 acres, or 54% of the ecoregion. This number, however, can be misleading due to the fact that the watershed area of aquatic conservation areas was used in its calculation. Similarly, the fact that certain systems are located entirely within federal ownership may incorrectly suggest a strong federal ownership bias in conservation area selection. However, there exists nearly 2 million acres of Forest Service lands alone in the ecoregion. As a result , many conservation areas, like the geologically restricted novaculite uplift system, are found almost entirely within the Ouachita National Forest ownership. Therefore, capture of the entire site includes a predominance of federal ownership.

Terrestrial sites total 2,667,836 acres or approximately 23% of the ecoregion. Currently 2,113,139 acres or 79% of those terrestrial portfolio conservation areas are being managed under some type of public conservation ownership. Of the conservation areas that are managed in some way for conservation, 2,000,267 acres or 17% are federally owned; 8,287 acres or 0.7% are state or locally owned; and 4,028 acres or 0.07% are owned by TNC. Table 1 provides acreage for each conservation area.

Table 1. Complete list of Portfolio Conservation Areas chosen for the Ouachita Ecoregion and the corresponding acreage for each.

Site Name	Acres	TYPE
North Shore Glades	217,739	Terrestrial
Beaver Bend Hills	272,735	Terrestrial
Holland Bottoms	9,568	Terrestrial
Cove Creek Natural Area	537	Terrestrial
Goose Pond	13,858	Terrestrial
Crayfish Complex 1	307	Terrestrial
Crayfish Complex 2	232	Terrestrial
Crayfish Complex 3	968	Terrestrial
Crayfish Complex 4	410	Terrestrial
Crayfish Complex 5	576	Terrestrial
Crayfish Complex 6	331	Terrestrial
Crayfish Complex 7	461	Terrestrial
Crayfish Complex 8	391	Terrestrial
Rich Mountain	528,196	Terrestrial
Sugarloaf Mountain	24,108	Terrestrial
Little Rock Air Force Base	7,370	Terrestrial
Bradey Mountain	10,611	Terrestrial
Meadow Rue Seep	1,234	Terrestrial
Meadow Rue Seep	1,075	Terrestrial
Pine Bluestem Restoration	317,630	Terrestrial
Flatside-Forked Mountain	81,762	Terrestrial
Crayfish Complex	799	Terrestrial
Crayfish Complex	799	Terrestrial
Novaculite Uplift	565,685	Terrestrial
Pushmataha Wildlife Management Area	32,568	Terrestrial
Least Terns Site 1	15,110	Terrestrial
Cherokee Prairies	122,922	Terrestrial
Magazine Mountain	173,153	Terrestrial
Least Terns Site 2	7,137	Terrestrial
Kiamichi River	1,165,716	Aquatic
Glover River	290,722	Aquatic
Upper Little River	235,708	Aquatic
Mountain Fork Creek	279,327	Aquatic
Cossatot River	139,485	Aquatic
Little Missouri River	79,142	Aquatic
Caddo River	193,373	Aquatic
Upper Saline River	431,671	Aquatic
Fourche La Fave River	393,510	Aquatic
Ouachita Headwaters	364,679	Aquatic

A total of 245 targets were selected; 168 species targets (46 aquatic and 122 terrestrial) and 78 community targets (8 matrix, 51 small patch, 18 large patch) were identified. A total of 148 targets or 60% met their goals.

Of the targets that met their goals, 33% were communities, 15% were plants, and 52% were animals. Of the 168 species targets, 100 or 59% met their goals. Of the 78 community targets, 47 or 60% met their goals. 39 targets or 27% of the targets that did not reach their goal (15% of all targets) did not do so due to data gaps, outdated data, or occurrences outside of portfolio conservation areas.

208 or 84% of the targets made some progress towards their goals, that is, some though not necessarily all occurrences necessary to complete a goal were recorded. Of the 1502 occurrences, 20% were heritage-recorded ranks of A, AB, B, BC or E, and 80% were representative, that is, population based, goal-derived, or expert-derived.

Of the species that met their conservation goals 23 or 15% were ranked as G1. Eight or 5% are listed endangered or threatened, and 20 or 15% are ranked as G2. Seventy percent or 94 of the 134 targets ranked G1 through G3 targets met their goals. Seventy-nine of 104 or 75% of the zoology targets, 22 of 64 or 34% of the plant targets, and 46 of 78 or 58% of the community targets met their goals. Table 2 provides a breakdown of conservation targets by global rank. Note that Combined ranks are rolled into the next highest full rank (e.g., G1G2s are counted with G2s, G2G3s are counted with G3s):

Table 2. The number of targets within each global ranking unit.

Target Type	G1	G2	G3	G4	G5	Total
Aquatic Animals	9	11	12	8	5	45
Terrestrial Animals	10	11	5	11	21	58
Plants	3	6	21	10	23	63
Terrestrial Communities	6	22	31	6	14	79
Total	28	50	69	35	63	245

Many, though not all conservation areas in the Ouachitas, contain areas that are already managed for conservation or protected by a state, federal, TNC, or other privately entity. However, rarely do these management areas encompass the entirety or even a majority of the individual conservation areas. There are approximately 2,113,139 acres or 34% of conservation areas already under some type of conservation or wildlife management (e.g., owned by state or federal government, or TNC) within the ecoregion. 14 of the 40 have this type of protection component.

Of the areas in the portfolio conservation areas that are already managed for biodiversity, 2,000,267 acres or 75% are under federal management; 112,872 acres or 4% are under some form of state management; and 8,287 acres or 0.07% are under TNC or other private conservation management. Table 1 provides a breakdown of protected areas within the portfolio.

TERRESTRIAL COMMUNITIES

78 community targets were used for this plan; of those 9 were endemic, and 40 were limited in range. 47 of the 78 community targets, or 60% met their goals. Five of the community targets that made their goal are considered matrix size; 10 are considered large patch, and 32 are considered small patch communities. Table 3 illustrates the number of community targets that met assessment goals.

Table 3. Percent of each community target type that met assessment goals.

Spatial Pattern	Goals Met / Total Targets	Percent Targets Meeting Goals
Small Patch	32 / 52	62%
Large Patch	10 / 18	55%
Matrix	5 / 8	62%
Total	**47 / 78**	**60%**

ZOOLOGY AND BOTANY TARGETS

There were 64 plant targets; 6 of which are endemic, and 7 limited in range; 20 or 31% of the plant targets met their goals.

There were 104 zoological targets determined; 35 endemics, 32 endemic zoology targets or 91% met their goal. 16 limited range targets met their goal. Eighty-three of the 104 or 79% of the zoology targets met their goal.