SPRING RIVER WATERSHED CONSERVATION ACTION PLAN

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INTRODUCTION

The Spring River watershed in Missouri and Arkansas is among the most biodivers watershed in north America, with a total of 114 fish and 46 freshwater mussel species known historically to occur within the watershed. A number of the fish and mussel species are globally rare or endemic, or are identified as species of greatest conservation need (SGCN) (Appendix 1). in the Arkansas Wildlife Action Plan (AGFC 2006). The fish assemblage has included the the Ozark shiner (*Notropis ozarkanus*), and the Sabine Shiner (*Notropis sabinae*). Both Notropis species are Ozark endemics found only in a few viable populations. Historically many of the mussels are globally rare and have either federal or state status, including the endangered scaleshell (*Leptodea leptodon*) and Curtis Pearlymussel (*Epioblasma florentina curtisi*). The Ozark Hellbender salamander (*Crytobranchus alleganiensis bishopi*) has also historically been found in Spring River, one of only three watersheds in Arkansas with recent localities.

The Spring River is also known for its recreational fisheries. Historic records indicate that salmonids have been stocked since the 1890s. Approximately 500,000 rainbow and cutthroat trout are stocked annually in the Mammoth Spring to Many Island reach of the mainstem. Tiger Muskie, walleye, striped bass, bluegill, redear sunfish, and smallmouth bass are also stocked in the mainstem (www.ozarkmtns.com)

Due to its outstanding biodiversity and historically excellent water quality, the Spring River watershed has been identified by The Nature Conservancy as a priority area for conservation efforts in its Ozarks Ecoregional Assessment (TNC 2003). It is listed in the Conservancy's *Rivers of Life* (TNC 1995) as the number 12 priority watershed for conservation of freshwater biota in North America. The Spring River is also recognized as an Extraordinary Resource Water (ERW) by the Arkansas Department of Environmental Quality (ADEQ).

Within the last few decades, stream water quality has declined noticeably in most Ozark streams, including the Spring River. Certain land uses can result in water quality degradation, leading to pressures on the aquatic ecosystems. Many aquatic animals serve as bioindicators, responding negatively to decreases in water quality associated with factors such as increased sedimentation or nutrification. A direct relationship exists between water quality and indicator species, so as water quality degradation continues over time, the numbers of sensitive species decline proportionally. The aquatic species that are found in the Spring River are particularly sensitive to ecological stressors and face an uncertain future as revealed by recent absences of historical species. In 2006 ADEQ designated parts of the Spring River as impaired under Section 303d of the Clean Water Act due to sedimentation and water temperature impairments (ADEQ 2008). The impairment for water temperature affects stocked trout and other species. The increased sedimentation affects the entire aquatic ecosystem.

In 2006, The Nature Conservancy (TNC) began a project to identify threats and develop a conservation action plan (CAP) to reduce aquatic impacts in the watershed. The project was partially funded from the State Wildlife Grant (SWG) program, which is administered by Arkansas Game and Fish Commission (AGFC). The project focused primarily on the Arkansas portion of the watershed. This report is the final report for the SWG project. The objectives of this project were as follows:

1. Develop a list of threats to the Spring River system based on input from experts;
2. Analyze historical flow patterns and water quality data to determine extent of hydrologic alteration, if any;
3. Using GIS technology, complete a watershed analysis to determine extent and location of land use practices that contribute to water quality, hydrology; and other threats identified as part of step one;
4. Prioritize threats for system and by sub-watershed to guide future conservation efforts.
5. Develop a prioritized list of targeted high leverage (% reduction vs. $ and time) strategies to address the top-ranked threats identified in objective 4.

BACKGROUND

SITE DESCRIPTION

Watershed

The 1,231 square mile Spring River Watershed is located in South Central Missouri and Northeastern Arkansas (Figure 1). Approximately 61% of the watershed is located in Arkansas (Fulton, Sharp, Lawrence and Randolph counties) with the remainder in Missouri. Two large tributaries (Warm Fork, and South Fork) and Mammoth Spring comprise approximately 75% of the total streamflow in the watershed Both of the tributaries rise in Missouri (near West Plains and Southfork respectively). The Spring River mainstem arises from Mammoth Spring at the town of Mammoth Spring, Arkansas. Warmfork and Southfork rivers flow through Howell and Oregon counties in Missouri before joining the Spring River mainstem just downstream of Mammoth Spring and in the town of Hardy respectively.

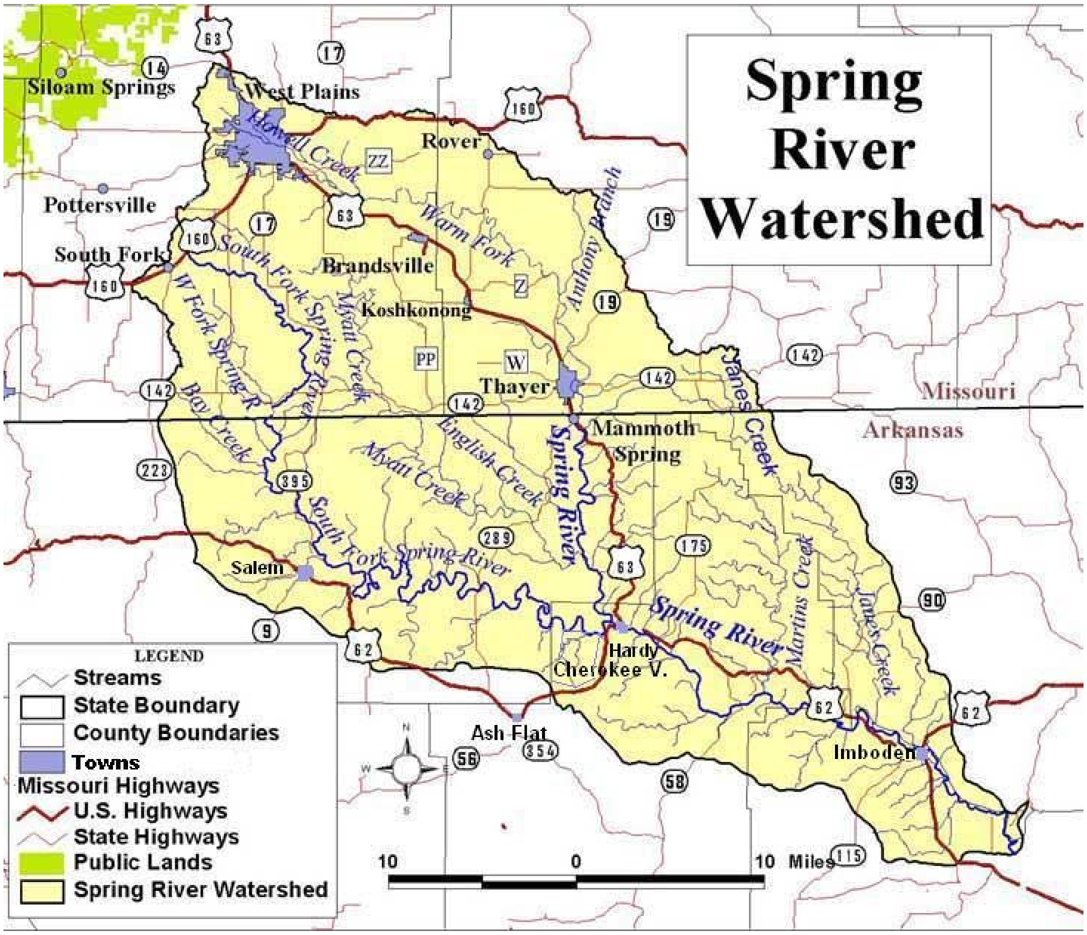


Figure 1. Spring River Watershed Map.

Karst and Groundwater

Much of the watershed area is underlain with dolomitic limestone containing highly soluble calcium carbonate, a mineral that is often linked with high stream productivity. The extremely karstic geology of the upper watershed results in a ground water transfer of approximately 9 million gallons per hour from surface sources in Missouri to the Spring River mainstem outflow at Mammoth Spring. The enormous outflow at Mammoth Spring results in its standing as the one of the world's largest freshwater springs (Encyclopedia of Arkansas 2009). The spring contributes approximately 30% of the entire watershed flow during low rainfall periods and is nearly equal to the combined inflows of Warm Fork and South Fork. Surface water is lost in hundreds of sinkholes and losing stream segments in Missouri (Figures 2 and 3). Approximately 79 miles of losing stream segments are present in the Missouri portion of the watershed.

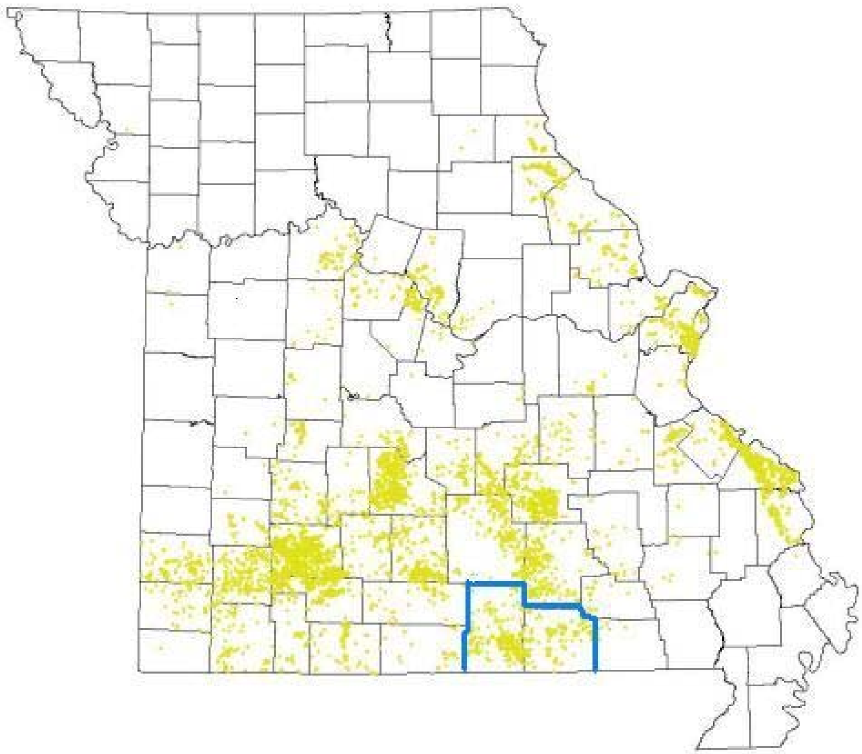


Figure 2. Documented sinkhole locations in Oregon and Howell Counties, MO.

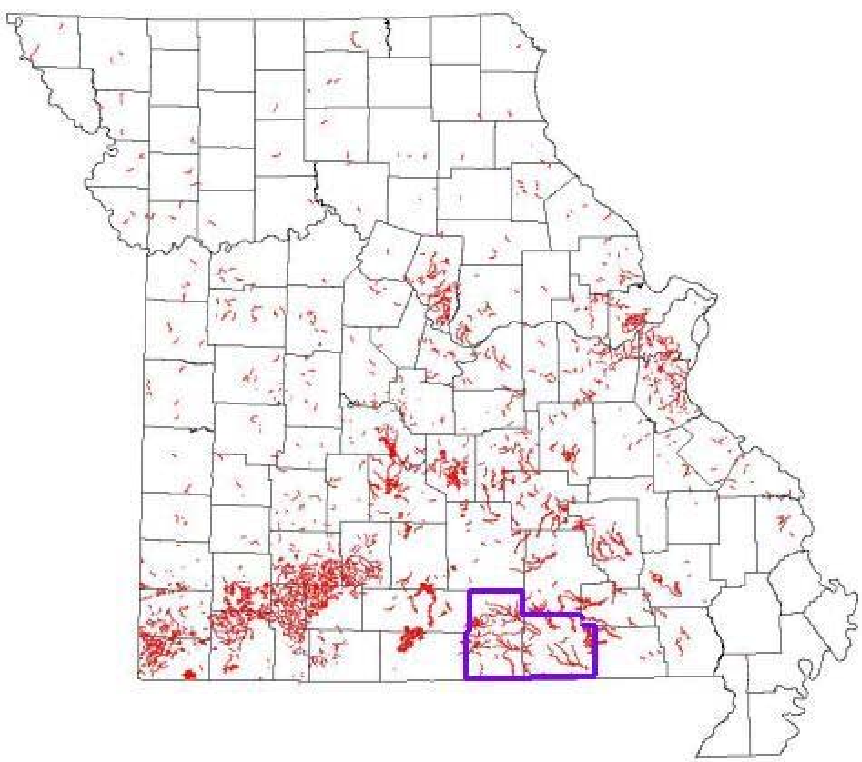


Figure 3. Losing stream reaches in Oregon and Howell Counties, MO.

Dye trace studies conducted in Missouri indicate that much of the flow of Mammoth Spring originates in the northern and western side of the Missouri portion of the watershed (Figure 4). Interbasin transfer was also discovered from the North Fork and Eleven Point watersheds. Major surface water infiltration localities are the West Plains (pop 8,913) area and Grand Gulf (MDC 2009). An urban recharge zone presents unique hazards as illustrated by the emergence of e-coli 20 miles away at Mammoth Spring and 12 days after the sink hole induced collapse of the Howell County sewage lagoon in 1978 (Gillman et al 2007). Conversely, surface water gathered from a 20 square mile area (with extensive livestock production) at Grand Gulf is at risk of elevated nitrate/nitrite and e-coliform levels(Bickford 2001).

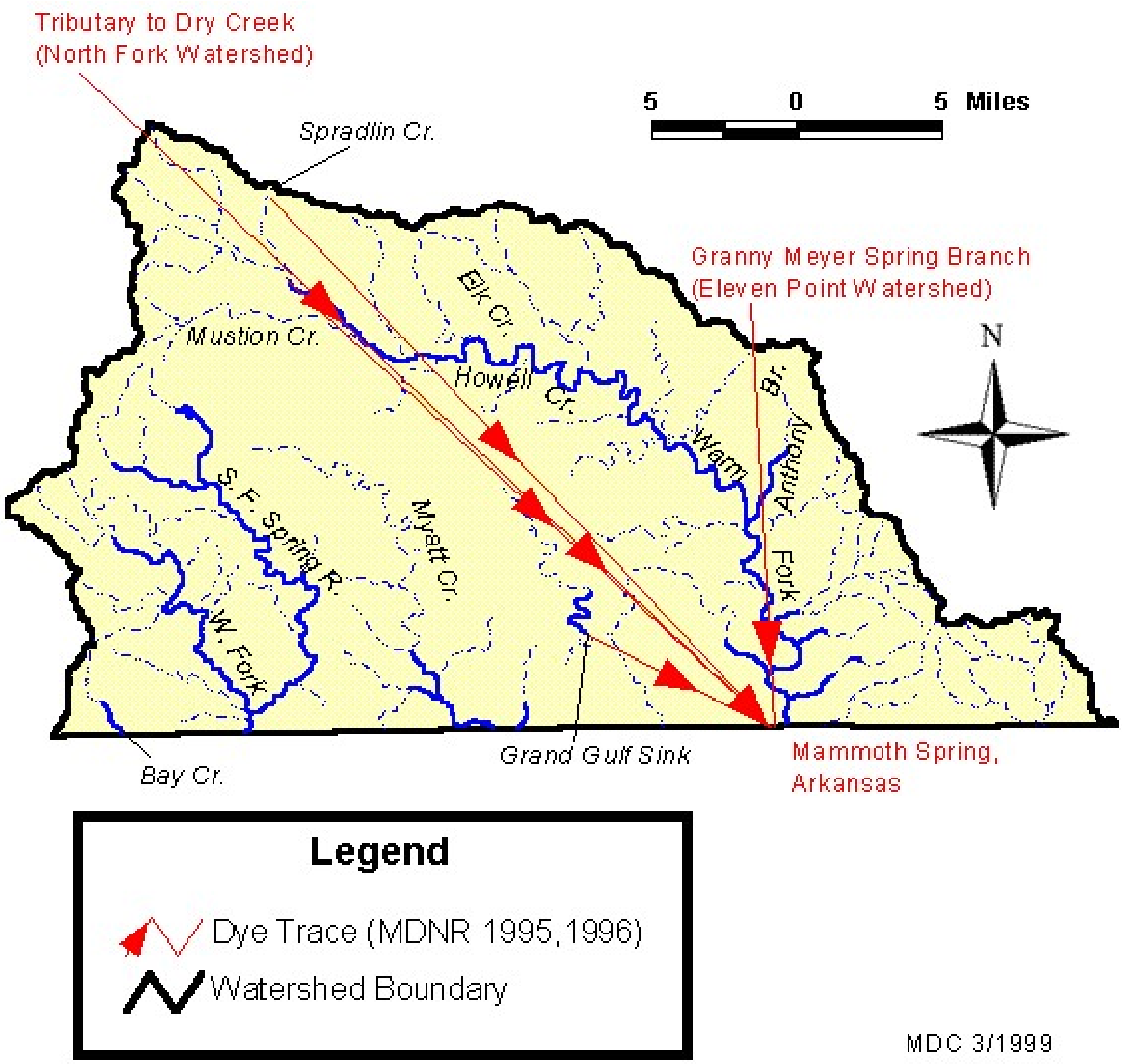


Figure 4. Ground Water Movement in the Spring River Watershed (MO).

Ownership and Landuse

Virtually the entire watershed is comprised of privately owned property. Approximately 52 % of the total watershed is forested, 46 % is in agriculture, and only 2 % has been developed for residential or business use. Primary economic activities are cattle and timber production, although timber production is quite limited. Shallow soils in the watershed limit row crop production to the alluvial zones in the downstream reaches of the watershed.

Two coldwater hatcheries (Mammoth Spring National Fish Hatchery and Spring River State Fish Hatchery) are located in the first few miles of the Spring River mainstem due to the constant flow of 61degree F water from the spring. Additionally several low head dams were built in the first few miles of stream for hydroelectric production during the early part of the 20th century. Dam 2 located approximately 1.0 mile downstream of Mammoth Spring) was removed during the 1980s.

METHODS

Initial scientific analyses were performed to provide information to project members prior to completing a conservation action plan. These scientific analyses included Indicators of Hydrologic Alteration (IHA) and a land use analyses using geographic information systems (GIS).

INDICATORS OF HYDROLOGIC ALTERATION

IHA Introduction

Although no flood control structures exist in the Spring River, other factors may also alter the natural hydrologic regime. Riparian vegetation removal within the floodplain can decrease landscape roughness, thus hastening drainage of floodwaters, but with the insidious risk of channel destabilization by increased hydrologic force. Resulting stream widening can be dramatic, and eroded bank materials can greatly increase stream sediment load. Water diversion during the growing season may further impair the aquatic community during this period associated with lowest flows. Thus, both water quantity and quality can be altered by land use practices adjacent to the stream channel.

Flooding of the Spring River occurs frequently, with surface water elevation rising up to 40 feet above the high water mark (Crawford 2008). Thus comparison of flood decline rates among contemporary and historical flood events would serve as an indication of the extents to which contemporary land management practices influence the hydrologic regime of the Spring River. Similarly, comparisons of historical and contemporary low flows during warm months of the growing season can identify significant water diversions that may adversely affect ecological integrity of this stream.

IHA Methods

USGS gauge data procurement: Three USGS gauges occur on the Spring River in Arkansas: at Mammoth Springs, at Imboden and at the Town Branch confluence in Hardy. Mammoth Springs and Town Branch gauge data dated back to the 1980s and the 2000s, respectively. Imboden gauge dated from 1937, and thus allowed a greater time frame within which to separate data into historical and contemporary categories. Two small dams were constructed near Mammoth Springs, but these were designed for recreational rather than flood control purposes, and only influence the flow regime locally. Effects of these local impoundments would have no influence on gauge measurements in Imboden.

Since no large-scale impoundments or channelizations have been performed intentionally to modify the hydrologic regime of the river, no date was available by witch to partition flow data into pre- and post-treatment categories. Instead, daily discharge Imboden gauge data were subdivided into two intervals of equal duration. Data set 1 contained water years 1937-1971 and data set 2 contained water years 1972-2006. Since daily flow data from 1995 through 2001 were not included in the data. In order to maintain symmetry among the data sets, data from 1941-1947 were excluded to compensate for the unavailability of 1995-2002 flow data. Water years were defined as beginning in April.

Hydrologic alteration analysis: Indicators of Hydrologic Alteration, or IHA, software (The Nature Conservancy 2006) was used to perform two-period nonparametric analyses to determine statistical significance of hydrologic alterations among historical and contemporary data. Non-parametric analyses were performed to eliminate biased results from data that do not demonstrate the statistical requirements for parametric analyses. Among 67 flow metrics (see Results) evaluated by IHA, 33 metrics, called IHA parameters, measured general hydrologic differences among data sets. The additional 34 metrics, called Environmental Flow Component parameters, or EFC parameters, measured hydrologic differences within an ecological rather than a primarily hydrologic context.

Non-parametric analyses were performed by randomly rearranging water years among sample periods. The medians of resampled periods were computed for each of 1,000 randomization iterations. If metrics computed from resampled data exceeded the maxima or deceeded the minima of metrics computed from observed data for 50 or more comparisons to the 1,000 resampled data sets, than the differences among observed data sets were attributed to random processes. That is, there was a probability of 5 % or greater (i.e. 50/1,000) that differences among observed data set flow metrics were attributed to random rather than structuring influences. If the probability was less than 5%, the metric was considered to indicate a significant flow alteration.

IHA Results

Mean annual flow was lower (1,307 cfs) in historical time than in recent years (1,467cfs), but a significance in this difference was not tested using a parametric comparisons among means. Among all 67 metrics evaluated, 11 of 33 IHA (Table 1) and 6 of 34 EFC (Table 2) parameters indicated significant differences between historical and contemporary flow conditions. Significantly higher flow occurred during most fall and winter months in recent years (Figure 5). Further, kernelled 1-day, 3-day, 7-day, and 30-day minimum flows (Figure 6) were significantly lower during the historical time frame.

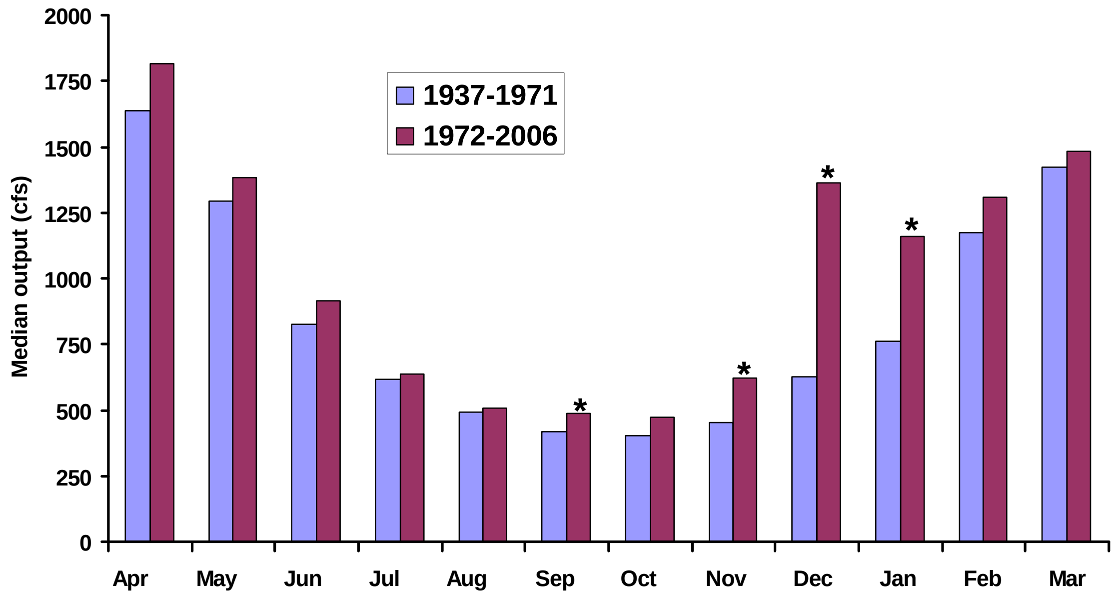


Figure 5. Median monthly flows during September, November, December, and January in recent years in comparison to the historical time frame.

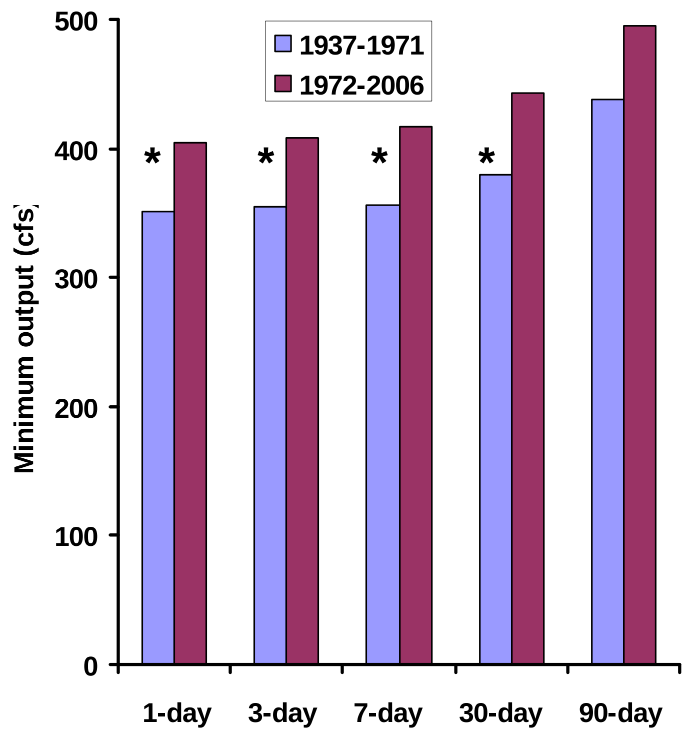


Figure 6. Kernelled minimum output was significantly lower for 1-, 3-, 7-, and 30-day intervals during the historical time frame in comparison to recent years.

Table 1. IHA parameter scorecard. Significant parameters are in bold.			
	Historical medians	Recent medians	Significance
Monthly parameters			
April	1638	1818	0.5125
May	1295	1385	0.7057
June	825.8	915.3	0.2152
July	616.5	638	0.6196
August	494	509	0.4915
September	417.8	489.5	**0.03604**
October	402.5	471.5	0.05005
November	453.8	624.3	**0.02703**
December	627.5	1365	**0**
January	763	1160	**0.03504**
February	1173	1308	0.3433
March	1425	1485	0.8358
Period parameters			
1-day minimum	351	404.5	**0.02202**
3-day minimum	354.5	407.8	**0.02703**
7-day minimum	355.7	416.9	**0.01301**
30-day minimum	379.1	443.4	**0.04805**
90-day minimum	437.7	495.6	0.07407
1-day maximum	22950	19950	0.7207
3-day maximum	14490	13200	0.6707
7-day maximum	8766	8219	0.6436
30-day maximum	4102	3910	0.5566
90-day maximum	2213	2522	0.2523
Number of zero days	0	0	
Base flow index	0.3162	0.2942	0.5696
Date of minimum	282.5	280	0.7678
Date of maximum	67.5	86.5	0.2873
Pulse parameters			
Low pulse count	5.5	4	0.1411
Low pulse duration	5.5	6	0.8408
High pulse count	10	7	**0.03604**
High pulse duration	3.75	5.75	**0.003003**
Low Pulse Threshold	458		
High Pulse Threshold	1380		
Rise rate	57.5	68.5	0.5185
Fall rate	-44.5	-36.5	0.3884
Number of reversals	104.5	94.5	**0.02503**

Table 2. EFC parameter scorecard. Significant parameters are in bold.			
	Historical medians	Recent medians	Significance
EFC Low flows			
April	1108	1011	0.4645
May	1035	1030	0.9469
June	789.3	890.5	0.2272
July	604.5	628.8	0.5716
August	505	503	0.9349
September	430	491	0.08609
October	402.5	471.5	**0.04204**
November	463	540	0.0951
December	525	957.5	**0**
January	655	1020	**0.01101**
February	811.3	1043	0.09009
March	990.8	1040	0.8028
EFC Parameters			
Extreme low peak	320.5	327.5	0.2803
Extreme low duration	2	3	0.1672
Extreme low timing	300.5	277	0.3203
Extreme low freq.	0	0	
High flow peak	2503	2228	0.4384
High flow duration	5	5	0.0961
High flow timing	88.5	234.3	0.1321
High flow frequency	10	8.5	0.05105
High flow rise rate	807.9	514.1	**0.007007**
High flow fall rate	-308.4	-224.1	**0.009009**
Small Flood peak	30000	29100	0.7718
Small Flood duration	40	84.5	0.08008
Small Flood timing	65	67	0.99
Small Flood freq.	0	0	
Small Flood rise rate	5185	1230	**0.2913**
Small Flood fall rate	-1223	-557.6	0.3433
Large flood peak	48600	86100	**0.06006**
Large flood duration	67	21.5	0.3594
Large flood timing	62.5	30	0.7538
Large flood freq.	0	0	
Large flood rise rate	7474	21840	0.07007
Large flood fall rate	-865.3	-4750	**0.04805**
EFC high flow lower percentile threshold:		730	
EFC high flow upper percentile threshold:		1380	
EFC extreme low flow threshold:		335	
EFC small flood peak flow threshold:		22950	
EFC large flood peak flow threshold:		45170	

IHA Discussion

Climatic variation among time intervals may explain significant changes in pulse duration and cold season flows. For example, large flood peak for recent years was significantly greater, and explains increased pulse duration possibly as a consequence of prolonged periods of rain. Although flood events were more extreme in recent years,

high flow rise rate and fall rate (Table 2) were significantly lower in recent years, indications typically associated with decreased morphologic resistance to flow associated with factors such as channelization, dredging, and decrease in floodplain roughness. Similarly associated with decreased morphologic flow resistance was the significantly decreased number of both pulses and flow reversals in recent years. Effectively, less variation occurred in flow during flow pulses in recent years.
There were no significant differences in warm-month median flows (Table 1) nor in warm-month low flows (Table 2), indicating that water withdrawal, either subterranean or in-stream, has not increased in recent years.

In summary, IHA analyses can be interpreted to demonstrate that morphological resistance to flow may have decreased in recent years, but these alterations have not adversely impacted warm-month low flows, nor has increased water diversion from the stream.

GIS LAND USE ANALYSIS

A GIS-based land use characterization and analysis was performed to inform project members of the conditions within the watershed for identifying threats. Once conservation strategies were later identified, the results of the GIS analysis identified subwatersheds where implementation of these strategies would be most needed.

Land Use / Land Cover

USGS 12-digit hydrologic units (HUC-12) were used to define 21 subwatersheds in the study area. An analysis of land use / land cover (LULC) was completed for 1993 and 2004 to compare change over time. The source of the 1993 LULC was the Arkansas Gap Analysis Project (GAP). The source for the 2004 data was the Center for Advanced Spatial Technologies (CAST) at the University of Arkansas. Figure 7 shows the 2004 LULC data and the HUC-12s in the study area. In this and following maps, the HUC-12 is labeled by the last four digits of its numeric code, since all 21 HUC-12s had the same first eight digits. For each HUC-12, the total area and % of the HUC were calculated for each LULC class. Classes included water / barren, urban, herbaceous / pasture, irrigated crops, and forest. Table 3 shows land use classes for 2004. Table 4 shows land use classes for 1993. A change analysis was performed to identify the change in land use classes for each HUC from 1993 to 2004. Table 5 shows the results of the LULC analysis.

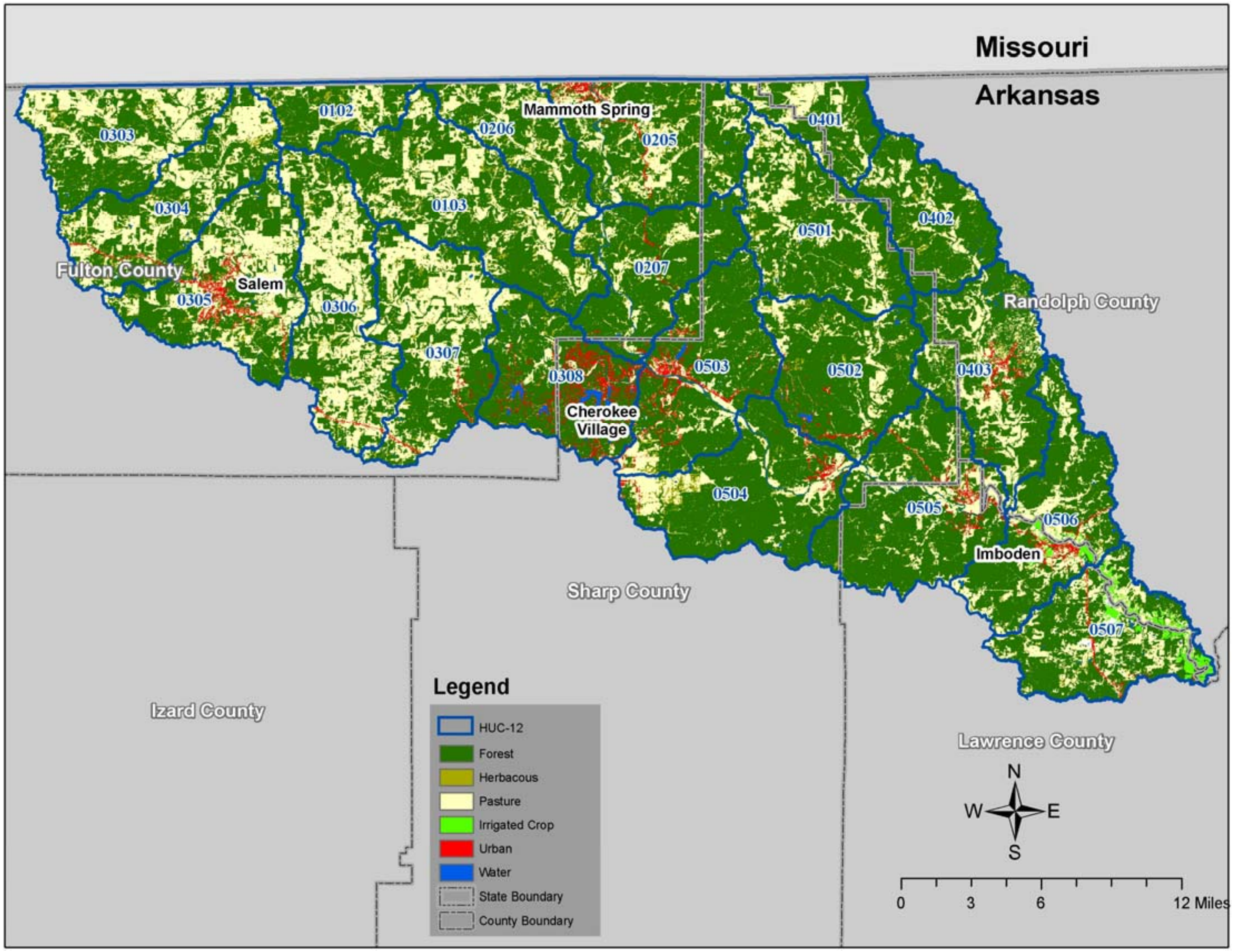


Figure 7: 2004 Land use / land cover and 12-digit HUC for the Spring River watershed in Arkansas.

	Subwatershed	Water / Barren		Urban		Herbaceous / Pasture		Irrigated Crops		Forest	
HUC	Area (mi^2)	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%
0102	15	0.0	0%	0.0	0%	5.0	34%	0.0	0%	9.6	66%
0103	49	0.0	0%	0.0	0%	17.4	36%	0.0	0%	31.5	64%
0205	40	0.3	1%	1.1	3%	12.1	30%	0.0	0%	26.4	66%
0206	22	0.0	0%	0.0	0%	7.9	36%	0.0	0%	14.2	64%
0207	31	0.3	1%	0.4	1%	5.6	18%	0.0	0%	25.2	80%
0303	32	0.0	0%	0.0	0%	14.7	45%	0.0	0%	17.6	54%
0304	36	0.1	0%	0.2	1%	16.1	44%	0.0	0%	19.8	55%
0305	41	0.3	1%	1.7	4%	18.1	44%	0.0	0%	20.9	51%
0306	42	0.1	0%	0.2	1%	22.4	53%	0.0	0%	19.5	46%
0307	40	0.1	0%	0.4	1%	18.1	45%	0.0	0%	21.6	54%
0308	33	1.1	3%	4.2	13%	3.6	11%	0.0	0%	24.2	73%
0401	17	0.0	0%	0.0	0%	6.0	35%	0.0	0%	11.2	65%
0402	25	0.1	0%	0.0	0%	4.6	19%	0.0	0%	19.9	81%
0403	38	0.2	0%	0.7	2%	11.1	29%	0.0	0%	25.9	68%
0501	39	0.2	0%	0.0	0%	11.8	30%	0.0	0%	27.0	69%
0502	35	0.2	1%	0.6	2%	6.4	18%	0.0	0%	27.7	80%
0503	40	0.4	1%	2.3	6%	7.1	18%	0.0	0%	30.0	75%
0504	41	0.2	1%	0.7	2%	8.5	21%	0.0	0%	31.2	77%
0505	46	0.2	1%	1.1	2%	9.3	20%	0.0	0%	35.4	77%
0506	37	0.2	1%	0.9	2%	9.4	26%	1.1	3%	25.3	68%
0507	36	0.8	2%	0.5	1%	10.8	30%	2.9	8%	21.1	58%
Total	**735**	**4.7**	**1%**	**15.2**	**2%**	**225.9**	**31%**	**4.1**	**1%**	**475.6**	**65%**

Table 3: 2004 Land use / land cover by HUC.

	Area	Water / Barren		Urban		Herbaceous / Pasture		Irrigated Crops		Forest	
HUC	Area (mi^2)	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%
0102	15	0.0	0%	0.0	0%	3.9	27%	0.0	0%	10.1	69%
0103	49	0.1	0%	0.0	0%	15.0	31%	0.0	0%	33.9	69%
0205	40	0.4	1%	0.2	1%	9.4	24%	0.0	0%	29.6	74%
0206	22	0.0	0%	0.0	0%	6.3	28%	0.0	0%	15.5	70%
0207	31	0.5	2%	0.0	0%	5.3	17%	0.0	0%	25.7	82%
0303	32	0.0	0%	0.0	0%	11.5	35%	0.0	0%	20.1	62%
0304	36	0.1	0%	0.0	0%	12.8	35%	0.0	0%	23.2	64%
0305	41	0.3	1%	0.1	0%	15.5	38%	0.0	0%	25.0	61%
0306	42	0.1	0%	0.0	0%	19.4	46%	0.0	0%	22.7	54%
0307	40	0.1	0%	0.9	2%	15.8	39%	0.0	0%	23.4	58%
0308	33	1.4	4%	9.8	30%	3.4	10%	0.0	0%	18.4	56%
0401	17	0.0	0%	0.0	0%	5.2	30%	0.0	0%	12.0	70%
0402	25	0.0	0%	0.0	0%	4.0	16%	0.0	0%	20.5	83%
0403	38	0.1	0%	0.0	0%	8.3	22%	0.0	0%	29.6	78%
0501	39	0.0	0%	0.0	0%	11.8	30%	0.0	0%	27.1	70%
0502	35	0.2	1%	0.0	0%	5.9	17%	0.0	0%	28.6	82%
0503	40	0.6	2%	0.8	2%	7.3	18%	0.0	0%	31.1	78%
0504	41	0.5	1%	0.0	0%	8.6	21%	0.0	0%	31.6	78%
0505	46	0.5	1%	0.0	0%	8.8	19%	0.0	0%	36.8	80%
0506	37	0.3	1%	0.1	0%	9.3	25%	0.0	0%	27.2	74%
0507	36	0.6	2%	0.0	0%	14.1	39%	0.0	0%	21.4	59%
Total	**735**	**6.0**	**1%**	**12.1**	**2%**	**201.7**	**27%**	**0.0**	**0%**	**513.5**	**70%**

Figure 4: 1993 Land use / land cover by HUC.

	Subwatershed	Water / Barren		Urban*		Herbaceous / Pasture		Irrigated Crops		Forest	
HUC	Area (mi^2)	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%	Area (mi^2)	%
0102	15	0.0	0%	0.0	0%	1.1	7%	0.0	0%	-0.5	-3%
0103	49	0.0	0%	0.0	0%	2.4	5%	0.0	0%	-2.4	-5%
0205	40	-0.2	0%	0.9	2%	2.7	7%	0.0	0%	-3.2	-8%
0206	22	0.0	0%	0.0	0%	1.6	7%	0.0	0%	-1.4	-6%
0207	31	-0.2	-1%	0.4	1%	0.3	1%	0.0	0%	-0.5	-2%
0303	32	0.0	0%	0.0	0%	3.2	10%	0.0	0%	-2.5	-8%
0304	36	0.0	0%	0.2	1%	3.2	9%	0.0	0%	-3.4	-9%
0305	41	0.0	0%	1.6	4%	2.6	6%	0.0	0%	-4.1	-10%
0306	42	0.0	0%	0.2	1%	3.0	7%	0.0	0%	-3.2	-7%
0307	40	0.0	0%	-0.5	-1%	2.3	6%	0.0	0%	-1.8	-4%
0308	33	-0.3	-1%	-5.6	-17%	0.2	1%	0.0	0%	5.7	17%
0401	17	0.0	0%	0.0	0%	0.8	4%	0.0	0%	-0.8	-4%
0402	25	0.0	0%	0.0	0%	0.5	2%	0.0	0%	-0.6	-2%
0403	38	0.1	0%	0.7	2%	2.8	7%	0.0	0%	-3.6	-10%
0501	39	0.1	0%	0.0	0%	0.0	0%	0.0	0%	-0.1	0%
0502	35	0.0	0%	0.6	2%	0.4	1%	0.0	0%	-1.0	-3%
0503	40	-0.3	-1%	1.5	4%	-0.1	0%	0.0	0%	-1.1	-3%
0504	41	-0.2	-1%	0.7	2%	-0.1	0%	0.0	0%	-0.4	-1%
0505	46	-0.3	-1%	1.1	2%	0.5	1%	0.0	0%	-1.4	-3%
0506	37	-0.1	0%	0.8	2%	0.1	0%	1.1	3%	-1.9	-5%
0507	36	0.1	0%	0.5	1%	-3.3	-9%	2.9	8%	-0.2	-1%
Total	**735**	**-1.3**	**0%**	**3.1**	**0%**	**24.2**	**3%**	**4.0**	**1%**	**-28.3**	**-4%**

Table 5. Land use / land cover change from 1993 to 2004, summarized by HUC.

Roads and Stream Crossings

The length and density of roads within each HUC were analyzed to determine potential impacts. Unpaved roads can be a significant source of sediment into Ozark rivers. Paved roads and highways are impervious surfaces that can alter watershed hydrology by reducing infiltration and increasing runoff of rainfall. The number and density of road stream crossings were also calculated. Unpaved road crossings can increase sediment flow into streams. Paved and unpaved crossings can impact habitat and migration for aquatic biota by acting as barriers to movement.

Road and highway from Arkansas Highway and Transportation Department (AHTD) from 2002 were used for roads analysis. The AHTD GIS layer indicated paved and unpaved roads, as well as highway classes. Figure 8 shows the AHTD roads and the 21 HUCs used for analysis. Total length of paved and unpaved roads was calculated for each HUC. The road density was calculated for each HUC using the HUC area and the total road length. Table 6 shows the length and density within each HUC for paved, unpaved, and all roads combined. Paved roads included highways in this summary. Table 7 shows the count and density of road stream crossings per HUC.

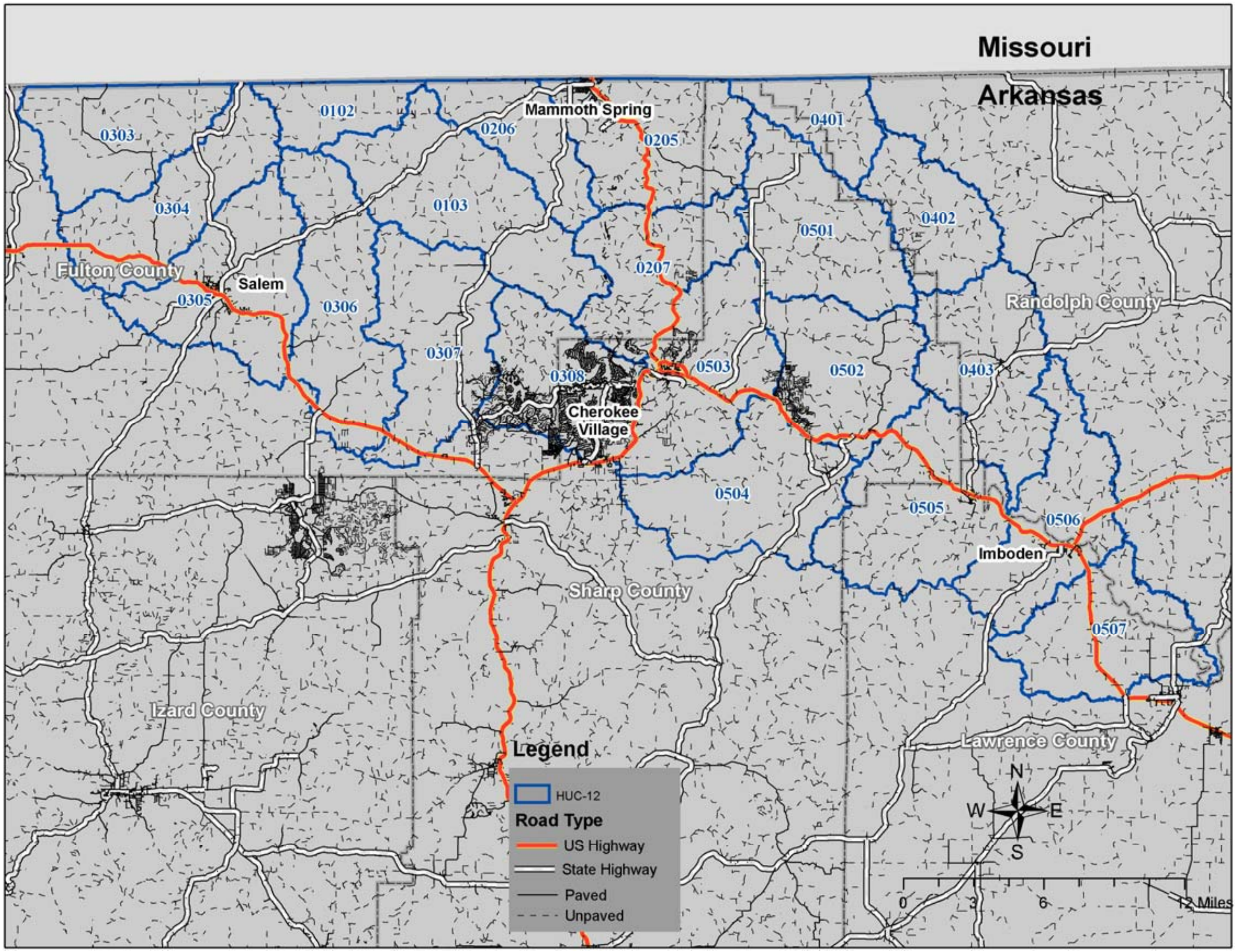


Figure 8: Roads and Highways in the study area.

	Subwatershed	Total Length (m)			Density (km / km2)			Impervious Area	
HUC	Area (m)	Paved	Unpaved	All	Paved	Unpaved	All	Area (10m width)	% of Sub-watershed
0102	37801632	0	32109	32109	0.000	0.849	0.849	0	0.00%
0103	126882555	16504	107595	124098	0.130	0.848	0.978	165037	0.13%
0205	103213320	48318	135903	184221	0.468	1.317	1.785	483179	0.47%
0206	57222264	13854	44425	58279	0.242	0.776	1.018	138536	0.24%
0207	81566220	14368	148491	162859	0.176	1.820	1.997	143677	0.18%
0303	83924189	7830	71900	79730	0.093	0.857	0.950	78305	0.09%
0304	93780772	24841	78200	103042	0.265	0.834	1.099	248415	0.26%
0305	106089035	64778	79008	143786	0.611	0.745	1.355	647780	0.61%
0306	109164558	19439	104060	123499	0.178	0.953	1.131	194393	0.18%
0307	104127651	30333	112530	142863	0.291	1.081	1.372	303334	0.29%
0308	85600658	307606	190585	498192	3.594	2.226	5.820	3076064	3.59%
0401	44483414	0	41860	41860	0.000	0.941	0.941	0	0.00%
0402	63664425	0	90305	90305	0.000	1.418	1.418	0	0.00%
0403	98321256	21789	110759	132548	0.222	1.127	1.348	217893	0.22%
0501	100948337	12144	111327	123471	0.120	1.103	1.223	121445	0.12%
0502	90081126	53042	135628	188670	0.589	1.506	2.094	530423	0.59%
0503	103206065	60208	155026	215234	0.583	1.502	2.085	602079	0.58%
0504	105313132	20275	97265	117541	0.193	0.924	1.116	202755	0.19%
0505	119502514	21046	158687	179733	0.176	1.328	1.504	210465	0.18%
0506	95595055	26353	104575	130928	0.276	1.094	1.370	263529	0.28%
0507	93690050	17540	89996	107536	0.187	0.961	1.148	175403	0.19%
Total	**1904178227**	**780271**	**2200234**	**2980505**	**0.410**	**1.155**	**1.565**	**7802710**	**0.41%**

Table 6: Summary of road length, density, and impervious area by HUC.

	Subwatershed	Total Crossings				Density (Count / km2)			
HUC	Area (m)	Paved	Unpaved	Highway	All	Paved	Unpaved	Highway	All
0102	37801632		23		23	0.00	0.61	0.00	0.61
0103	126882555		81	8	89	0.00	0.64	0.06	0.70
0205	103213320	13	57	13	83	0.13	0.55	0.13	0.80
0206	57222264		35	12	47	0.00	0.61	0.21	0.82
0207	81566220	2	73	4	79	0.02	0.89	0.05	0.97
0303	83924189	10	45	2	57	0.12	0.54	0.02	0.68
0304	93780772	7	61	16	84	0.07	0.65	0.17	0.90
0305	106089035	15	65	33	113	0.14	0.61	0.31	1.07
0306	109164558	3	65	11	79	0.03	0.60	0.10	0.72
0307	104127651	6	46	12	64	0.06	0.44	0.12	0.61
0308	85600658	87	57	12	156	1.02	0.67	0.14	1.82
0401	44483414		17		17	0.00	0.38	0.00	0.38
0402	63664425		39		39	0.00	0.61	0.00	0.61
0403	98321256	9	50	5	64	0.09	0.51	0.05	0.65
0501	100948337	2	57	6	65	0.02	0.56	0.06	0.64
0502	90081126	13	63	6	82	0.14	0.70	0.07	0.91
0503	103206065	10	73	8	91	0.10	0.71	0.08	0.88
0504	105313132	2	32	8	42	0.02	0.30	0.08	0.40
0505	119502514	2	77	7	86	0.02	0.64	0.06	0.72
0506	95595055	1	52	8	61	0.01	0.54	0.08	0.64
0507	93690050	1	56	6	63	0.01	0.60	0.06	0.67
Total	**1904178227**	**183**	**1124**	**177**	**1484**	**0.10**	**0.59**	**0.09**	**0.78**

Table 7: Summary of roads crossing count and density by HUC.

Forested Riparian Buffer

Forested riparian buffers are an important landscape feature for watershed integrity. These areas can provide terrestrial habitat, shading to streams, and can reduce the impacts of upland sediments and nutrients on stream water quality. A simple analysis was performed to compare the riparian buffer extent within each HUC. The USGS National Hydrologic Dataset (NHD) GIS stream layer was used for the analysis. High-resolution streams, which are equivalent to blue lines on a 1:24,000 scale USGS quadrangle map, were used for the analysis. These NHD streams were buffered by 45 meters on each side, creating a riparian buff with a total width of 90 meters. More advanced and accurate methods exist for delineating riparian areas (Inlander 2002, Sutula et al 2006), but this buffering method has been implemented by other projects in the past (Narumalani and et al 1997). The 2004 LULC data were used to represent forested areas, but only within the 90 meter buffer. The percent of the total riparian buffer area that was forested was determined for each HUC. These calculations are represented in Table 8. The average and maximum length of forested and non-forested stream segments was also calculated. This was done by "erasing" the NHD streams using the LULC forest cover data. The remaining stream segments were analyzed, and the results are also in Table 8. Figure 9 shows HUC 0304, which had the lowest forested riparian percentage of all the HUCs (47%). Figure 10 shows HUC 0502, which had the highest forested riparian percentage of all the HUCs (75%).

	All Streams	Forested Stream Reaches				Non-Forested Stream Reaches			
HUC	Total (m)	Total (m)	% of Total	Avg Length	Max Length	Total (m)	% of Total	Avg Length	Max Length
0102	57,741	33,636	58%	306	2,966	24,105	42%	423	2,223
0103	215,663	143,503	67%	353	1,974	72,160	33%	312	1,889
0205	164,829	109,291	66%	297	2,240	55,538	34%	280	2,031
0206	101,166	61,649	61%	268	1,901	39,517	39%	369	1,372
0207	130,551	95,498	73%	419	3,329	35,053	27%	260	1,463
0303	160,875	83,561	52%	220	2,055	77,314	48%	310	1,724
0304	152,988	72,192	47%	200	2,495	80,796	53%	354	2,144
0305	197,053	97,434	49%	159	1,831	99,619	51%	259	1,880
0306	172,045	94,473	55%	209	1,754	77,571	45%	364	1,992
0307	158,056	97,515	62%	294	3,651	60,541	38%	386	2,855
0308	140,180	95,331	68%	334	2,282	44,849	32%	255	1,552
0401	62,431	39,896	64%	395	2,869	22,535	36%	297	2,252
0402	98,814	72,927	74%	333	2,692	25,887	26%	201	1,159
0403	170,007	101,219	60%	275	2,057	68,788	40%	346	1,634
0501	156,723	111,859	71%	357	1,861	44,864	29%	222	1,248
0502	134,420	100,673	75%	393	2,242	33,748	25%	196	1,244
0503	159,609	112,969	71%	412	2,893	46,640	29%	288	1,880
0504	163,295	128,620	79%	378	3,458	34,675	21%	222	1,400
0505	178,857	134,786	75%	363	3,588	44,071	25%	238	2,632
0506	147,699	104,003	70%	333	4,393	43,696	30%	303	1,625
0507	147,505	85,176	58%	227	2,996	62,328	42%	348	2,214
Total	**3,070,504**	**1,976,211**	**64%**		**4,393**	**1094293**	**36%**		**2,855**

Table 8: Summary of riparian forest characteristics for HUCs.

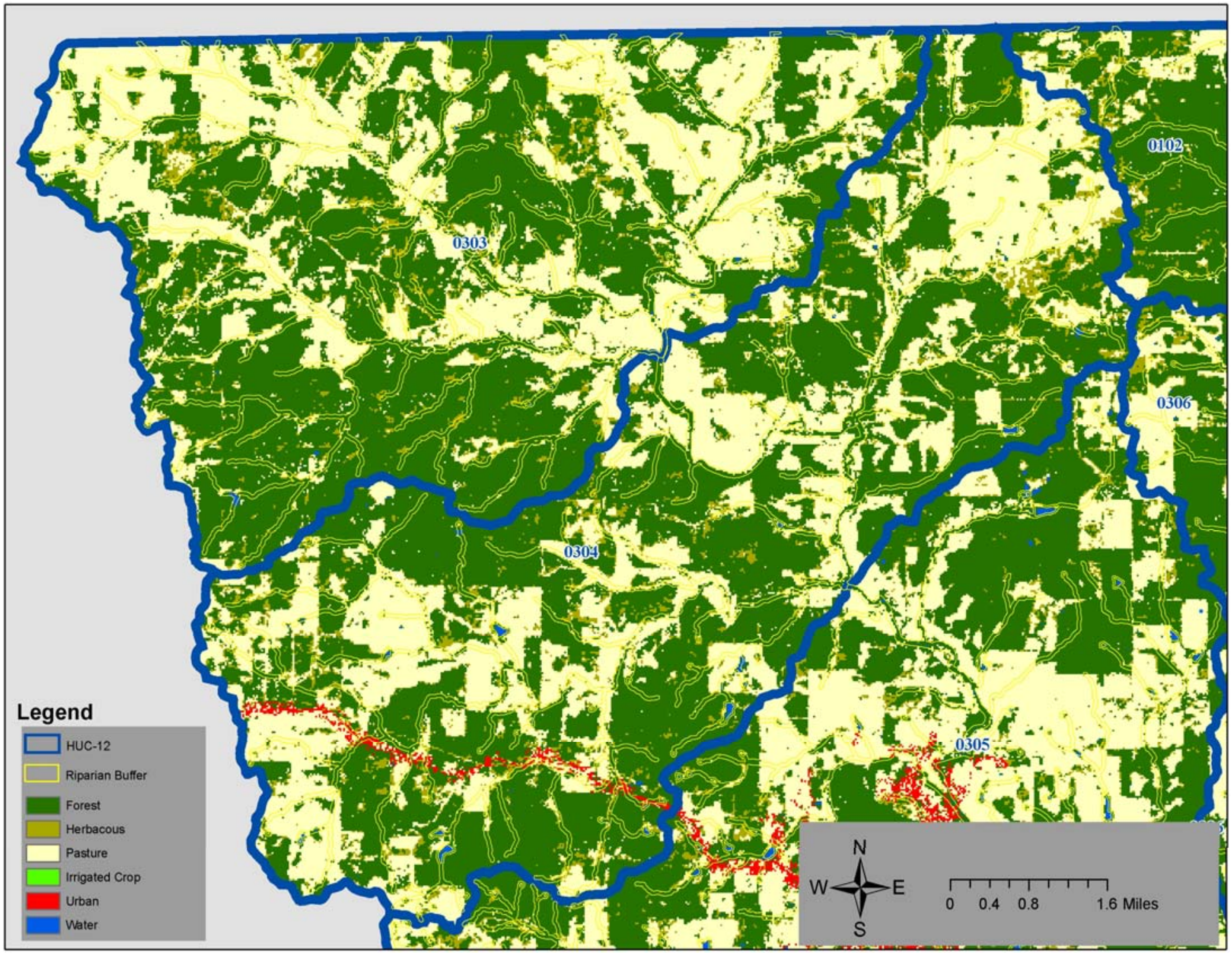


Figure 9: Riparian forest cover in HUC 0304, the HUC with the lowest percentage of riparian forest.

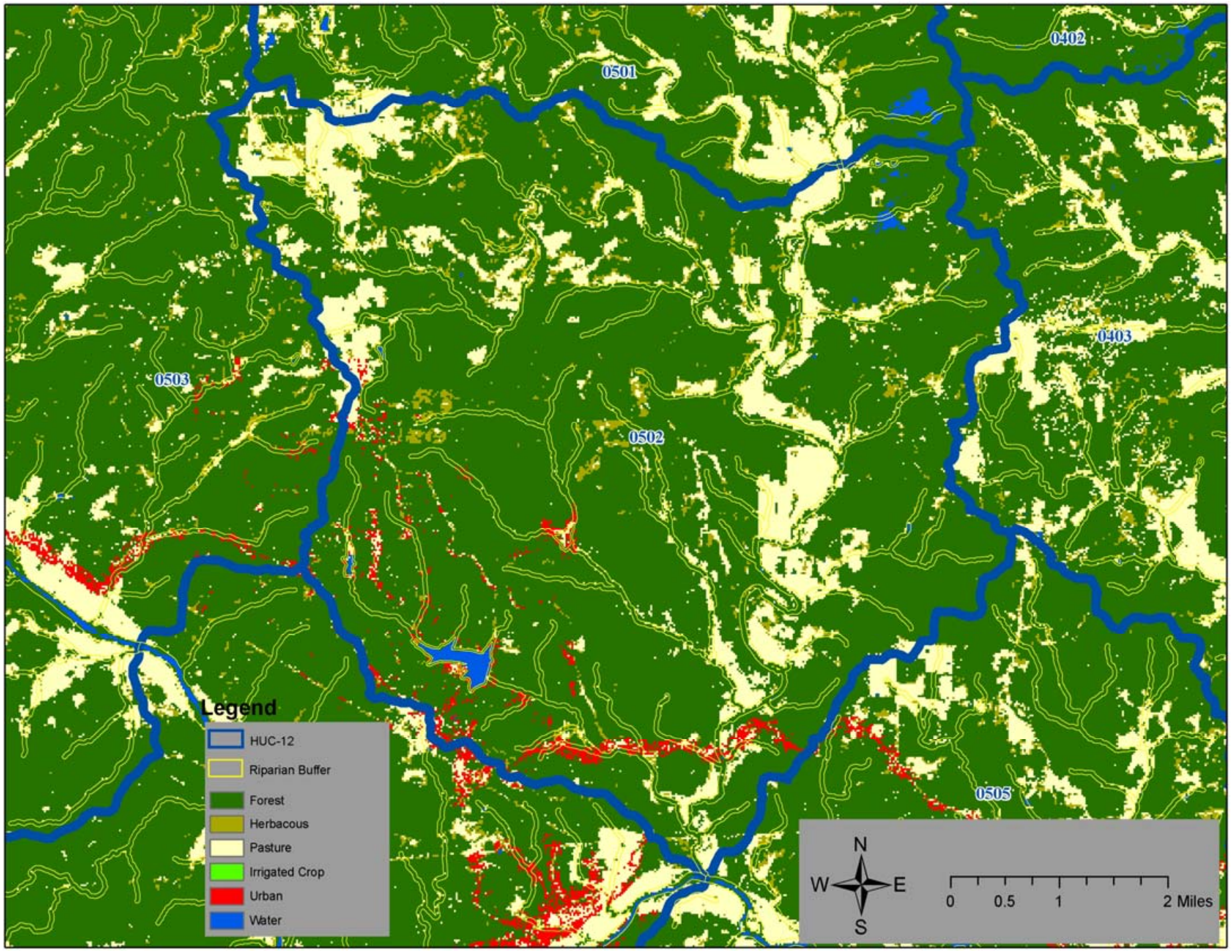


Figure 10: Riparian forest cover in HUC 0502, the HUC with the highest percentage of riparian forest.

GIS Indices
Three GIS indices were generated from multiple characteristics of the HUCs to identify priority sub-watersheds for future conservation actions.

Sediment Index
A Sediment Index was generated to identify sub-watersheds where sediment reduction BMPs and other activities would likely have the most benefit toward reducing sediment delivery into water bodies. Table 9 shows the components used for this simple sediment index. The index was comprised of land use and roads characteristics. The first characteristic was the percent of the HUC in forested land use. The assumption for including this in a sediment index was that more forest in a watershed would lead to less erosion than other land uses. The HUC with the greatest percent forested area was assigned a rank of "1", and the least forested HUC was assigned a rank of "21" since there are 21 HUCs in the study area. A similar rank was assigned for percent pasture, with the assumption that pastures generate more sediment than forest. In this case a "1" was assigned to the HUC with the *lowest* percent pasture, i.e. the HUC in the best condition for this variable. The unpaved roads characteristics included unpaved road density and unpaved road crossing density, since both these characteristics are considered to contribute to sediment to water bodies. Again, a rank of "1" was assigned to the HUC with the lowest density of these features. The Sediment Index was simply an average of the ranks for the four land use and road characteristics described above. The lowest index equates to the HUC with the least sediment impacts. Figure 11 maps the Sediment Index by HUC.

Impervious Index
Table 10 shows an Impervious Index and the characteristics used to generate the index. It was comprised of the percent of the HUC in urban land use, and the paved road density. Paved roads included highways. Ranks were assigned as above. The HUC with the least urban land use or lowest paved road density received ranks of "1". Figure 12 maps the Impervious Index by HUC.

Riparian Forest Index
Table 11 shows a Riparian Forest Index and the characteristics used to generate the index. It was comprised of the percent of the riparian buffer that was forested, and the forest gap length. The highest percentage forested, and the shortest average gap length were criteria for a rank of "1". Figure 13 maps the Riparian Forest Index by HUC.

	Sub-Watershed Rank				
	Land Use / Land Cover		Unpaved Roads		
HUC	% Forested	% Pasture	Road Density	Crossing Density	Sediment Index
0102	12	3	5	2	5.5
0103	14	18	4	21	14.3
0205	11	15	15	11	13.0
0206	15	8	2	4	7.3
0207	2	4	20	18	11.0
0303	18	16	6	6	11.5
0304	17	17	3	14	12.8
0305	20	20	1	16	14.3
0306	21	21	9	17	17.0
0307	19	19	11	7	14.0
0308	7	1	21	12	10.3
0401	13	5	8	1	6.8
0402	1	2	17	5	6.3
0403	10	13	14	8	11.3
0501	8	14	13	13	12.0
0502	3	6	19	15	10.8
0503	6	7	18	19	12.5
0504	5	9	7	3	6.0
0505	4	10	16	20	12.5
0506	9	11	12	9	10.3
0507	16	12	10	10	12.0

Table 9: Characteristics, rankings and values for Sediment Index by HUC.

	Sub-Watershed Rank		
HUC	% Urban	Paved Road Density	Impervious Index
0102	1	1	1
0103	1	6	3.5
0205	18	17	17.5
0206	1	13	7
0207	11	8	9.5
0303	1	4	2.5
0304	9	14	11.5
0305	19	20	19.5
0306	8	9	8.5
0307	10	16	13
0308	21	21	21
0401	1	2	1.5
0402	1	3	2
0403	15	12	13.5
0501	1	5	3
0502	13	19	16
0503	20	18	19
0504	14	11	12.5
0505	17	7	12
0506	16	15	15.5
0507	12	10	11

Table 10: Characteristics, rankings and values for Impervious Index by HUC.

	Sub-Watershed Rank		
	Riparian Buffer		
HUC	% Forested	Forest Gap Length	Riparian Buffer Index
0102	16	21	18.5
0103	10	14	12.0
0205	11	9	10.0
0206	14	19	16.5
0207	5	8	6.5
0303	19	13	16.0
0304	21	17	19.0
0305	20	7	13.5
0306	18	18	18.0
0307	13	20	16.5
0308	9	6	7.5
0401	12	11	11.5
0402	4	2	3.0
0403	15	15	15.0
0501	6	3	4.5
0502	3	1	2.0
0503	7	10	8.5
0504	1	4	2.5
0505	2	5	3.5
0506	8	12	10.0
0507	17	16	16.5

Table 11: Characteristics, rankings and values for Riparian Forest Index by HUC.

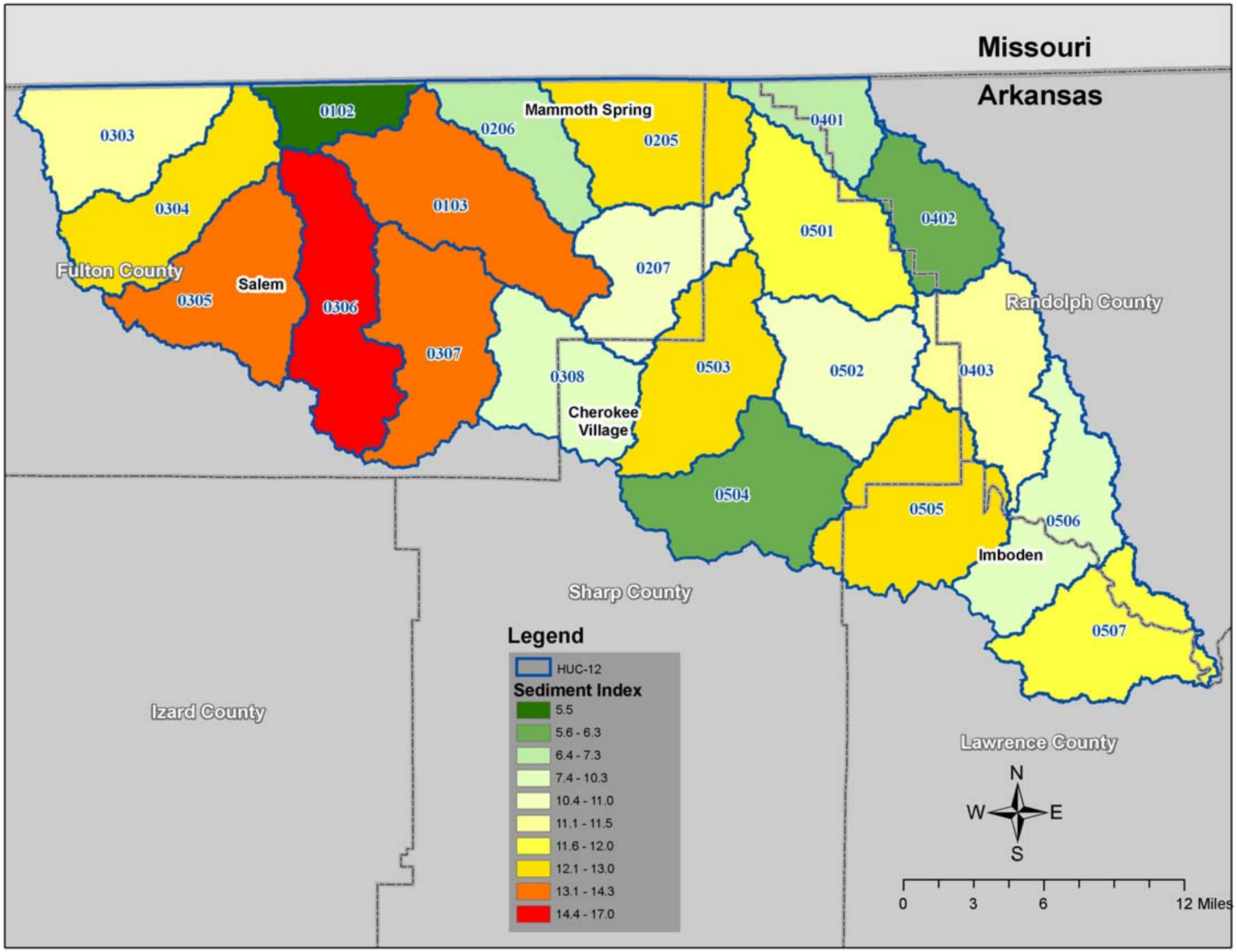


Figure 11: Map of Sediment Index values by HUC.

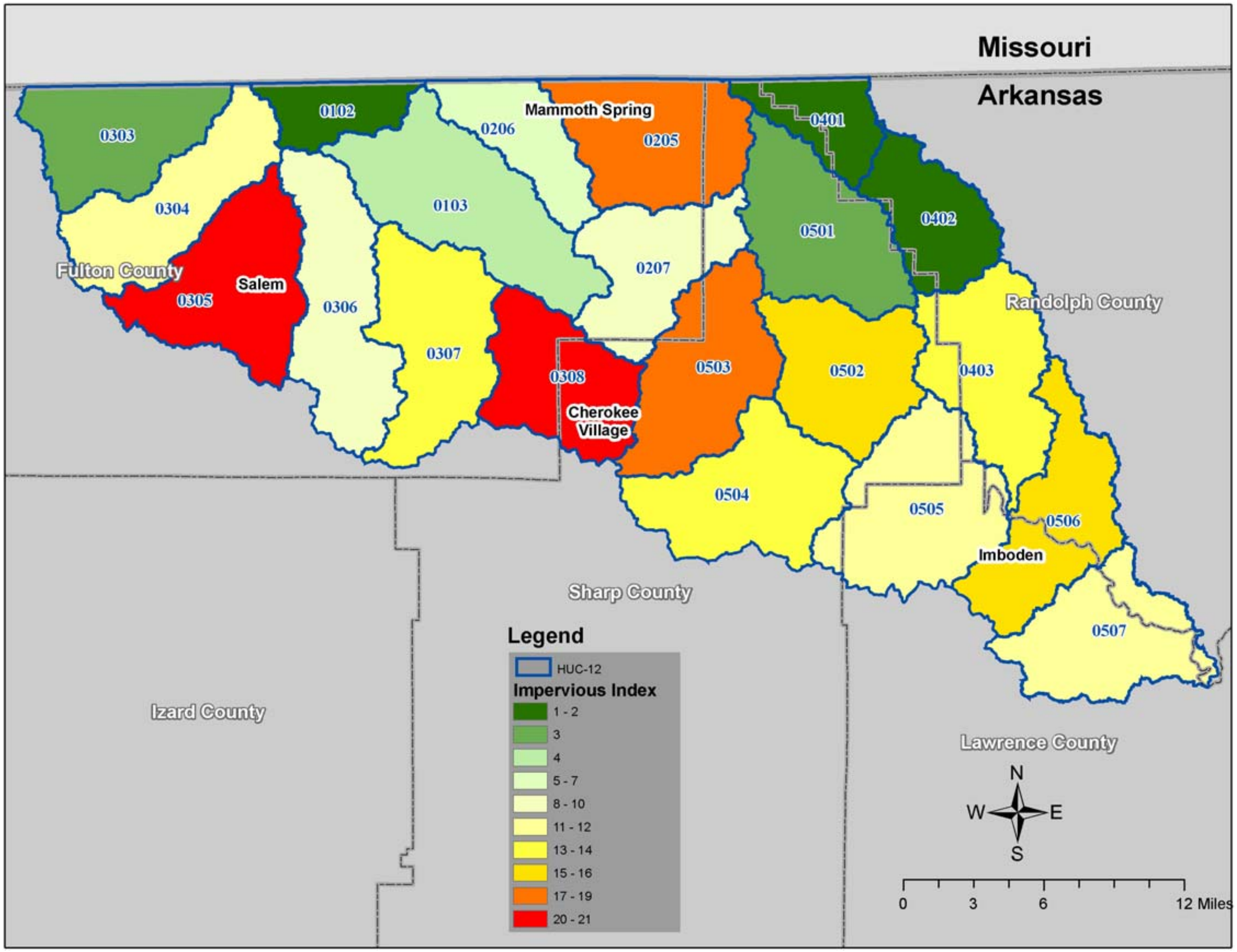


Figure 12: Map of Impervious Index values by HUC.

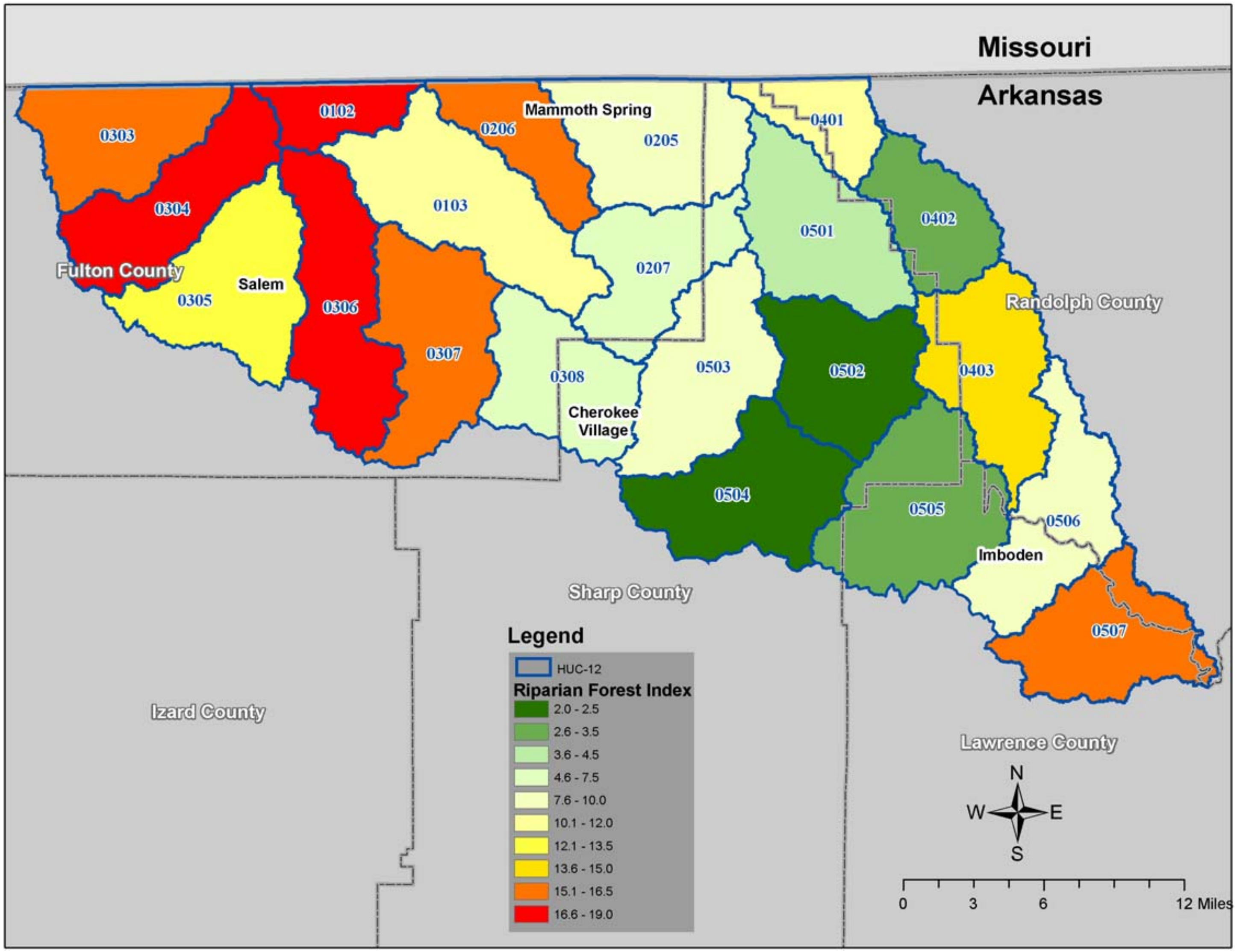


Figure 13: Map of Riparian Forest Index values by HUC.

CONSERVATION ACTION PLAN

Conservation action plans are used by conservation practitioners to develop site-specific conservation strategies and prepare for taking action and measuring success. These plans follow the "5-S Framework."

- **Systems**. The conservation area planning team identifies the species and natural communities that will be the conservation targets for the area.
- **Stresses**. The team determines how conservation targets are stressed, such as by habitat reduction or fragmentation, or changes in the number of species or habitat quality.
- **Sources**. The team then identifies and ranks the causes, or sources, of stress for each target. The analysis of stresses and sources together make up the threat assessment.
- **Strategies**. An important step in the process is finding practical, cooperative ways to mitigate or eliminate the identified threats and enhance biodiversity.
- **Success**. Each plan outlines methods for assessing our effectiveness in reducing threats and improving biodiversity – usually by monitoring progress toward established biological and programmatic goals.

This conservation action plan (CAP) was developed by a team made up of members of governmental and non-governmental conservation organizations as well as university professors and experts. The primary work group and authors of the CAP were TNC Arkansas employees Maria Melnechuk, Ethan Inlander, John Stark, and Daniel Millican. The planning team utilized the conservation action planning tool, Miradi™ (miradi.org).

Conservation Targets

Conservation targets are those elements of diversity on which protection and stewardship efforts will be concentrated and where their conservation serves to ensure the protection of all biodiversity. In the Spring River Watershed, the target selected was the overall aquatic community because the system is best planned for as a whole.

<u>Spring River Aquatic Community</u>

The focal target for this planning effort was a fully functional river system where key ecological processes are restored or maintained within the historical range of variability in order to conserve viable populations of the entire suite of aquatic species.

<u>Nested Targets</u>

Within the aquatic system target, important nested targets include the freshwater mussel assemblage; the midwater schooling fishes; the benthic riffle fish assemblage; and, the coldwater crayfish. The nested targets are species assemblages whose conservation needs are subsumed in the focal conservation targets. These nested targets are also used as indicators to assess and track the health of the aquatic community focal target.

Freshwater Mussel Assemblage

The Spring River System historically is home to a wide array of freshwater mussels, a number of which are federally or state listed species. The importance of this collection was documented as having the highest mussel conservation ranking in the US Forest Service's *Ouachita and Ozark Highlands Assessment (1999).* Although relatively recent sampling in 2005 and 2006 has failed to find evidence of live Curtis Pearlymussel or Scale Shell (Martin personal communication 2007), a suite of G2-G3 mussels still are present in sufficient numbers to maintain viable populations. Freshwater mussels are among the most endangered fauna in North America with fully 30% of all known species extinct and large portions of historic habitat altered or destroyed.

Freshwater mussels are among the most sensitive of aquatic invertebrates to environmental degradation and thus serve as good indicator organisms for this group. The vulnerability of mussels is linked to their habitat needs and feeding methodology. Generally speaking, most mussel species require firm and stable stream substrates for long-term persistence of adults. Increased sedimentation often inundates riffle-run areas with shifting loose material that is unsuited to these nearly stationary organisms thereby reducing available habitat. In extreme flood events, mussels in loose sediment are dislocated and often perish. Additionally mussels filter large volumes of water to extract nutrients. Suspended sediment or toxic pollutants are also filtered from the water column and may lead to chronic or acute physiological stress and death.

Midwater Schooling Fishes
The Spring River is home to an outstanding assemblage of mid-water schooling fishes. As a group, these fishes are the most sensitive vertebrate organisms to increased turbidity (suspended sediment). It has been inferred that reduction of water clarity detrimentally impacts fishes such as mid-water schooling fishes that are highly dependant sight feeders.

Within the schooling fishes some of the most sensitive species of all appear to be the Ozark (*Notropis Sabinae*) and Sabine (*Notropis Ozarkanus*) shiners. These fish were once widespread in most Ozark stream systems although never numerically dominant. However during the last 20 years these fish have disappeared from many streams. A vast reduction in abundance also appears to have taken place in streams where the Ozark shiner persists such as the Kings, Spring, and Strawberry rivers (Robison 1997). A common trend among these streams is increased turbidity and/or sedimentation over the past two decades. In fact, Ozark shiner numbers have only remained at historic levels in the Buffalo River where turbidity levels are normally less than 1.0 NTU.

Benthic Riffle Fish
Another large group of sensitive fishes is the benthic riffle fish assemblage composed of such groups as the darters, sculpins, madtoms, suckers, redhorse, and stonerollers. Darters are particularly sensitive to increased sedimentation due to the associated reduction in invertebrate forage and loss of habitat from the filling in of spaces between large gravel and cobble-sized particles. The darters are a diverse and relatively ubiquitous group found in virtually all of the watershed.
The benthic riffle fishes of note in the Spring River include the Blue Sucker (*Cycleptus elongatus*), Shorthead Redhorse (*Moxostoma macrolepidotum*), and Crystal Darter (*Crystallaria asperella*). The relatively widespread and water quality sensitive nature of darters as a whole makes them an outstanding choice as a conservation target.

Coldwater Crayfish
The coldwater crayfish (*Orconectes eupunctus*) is listed as a state species of concern (S2) and is confined to a handful of coldwater stream reaches in the state. Crayfish as a group are sensitive to chemical pollutants and the coldwater crayfish'distribution near several significant spring outflows in the Spring River watershed make them an excellent indicator should water quality continue to degrade.

In each case, the aquatic conservation targets were selected from the most sensitive groups of invertebrate and vertebrate organisms in order to protect all highly vulnerable aquatic biodiversity and would likely result in the conservation of less environmentally sensitive organisms as well.

Target Viability
For the focal target, the expert team carefully determined how to measure its health over time. The next step was to identify how the target is doing today and what the desired target condition might look like. This step is the key to knowing which of the nested targets and indicators are most in need of immediate attention and for measuring success of actions over time (Table 12).

Table 12: Viability Assessment for the Spring River Watershed, AR.

Item	Poor	Fair	Good	Very Good	Current Measurement
Aquatic Community		**Fair***	*Good***		
Key Ecological Attribute: Intact Riparian Buffer		**Fair**	*Good*		
Indicator: Percent forested Riparian Buffer	> 50%	**51-70%**	*71-85%*	86-100%	64% forested riparian buffer
Key Ecological Attribute: Hellbender population size	**Poor**	*Fair*			
Indicator: Hellbender size frequency distribution	**n ≤ 10 with uneven distribution**	*N = 11-50 with uneven distribution*	n = 51-99 with even distribution	n > 100 with even age distribution	n=10
Key Ecological Attribute: Species diversity			*Good****		
Indicator: Crayfish species diversity	less than 3 species	3-4 species	***5-10 species***	11+ species	7 species
Indicator: Fish species diversity	less than 70	**70-89**	*90-114*	115+	83 species
Key Ecological Attribute: Water quality			***Good***		
Indicator: Turbidity	OFTEN exceeds standards	**OCCASIONALLY exceeds standards**	*RARELY exceeds standards*	NEVER exceeds standards	
Indicator: Dissolved Oxygen (mg/l)	OFTEN falls below 6 mg/l	OCCASIONALLY falls below 6 mg/l	***RARELY falls below 6 mg/l***	NEVER falls below 6 mg/l	

* Bold text indicates the current condition of the key ecological attribute and the indicator.
**Italic text indicates the desired condition of the key ecological attribute and the indicator.
***Italic and bold text indicates the current condition is the same as the desired condition.

Stress and Source-Of-Stress Assessment

Stresses and sources of stress discussed in this section will concentrate specifically on the Spring River watershed, although many of these stresses and their sources are the same as throughout the Ozark Ecoregion. The stress analysis consists of a discussion of stresses to the system and the sources of those stresses.

The Nature Conservancy organized and held a Watershed Conservation Planning workshop during May 23-24, 2006. Workshop participants from the Arkansas Game and Fish Commission, Arkansas Natural Resources Conservation, The Nature Conservancy Arkansas and Missouri chapters, Fulton County Water District, and Arkansas State University attended and/or provided watershed data in the form of presentations. Attendees presented, discussed, and voted to determine primary stresses and sources of stress for aquatic targets.

Stress Assessment for Specific Conservation Targets

In the following sections, stress and sources of stress are identified and discussed for each of the four conservation targets for the Spring River project site. Stresses acting on the conservation targets are quantified in terms of the *severity* of the stress and the *scope* of the stress. Values assigned for these parameters are then scored to present an overall ranking that reflects the impact of the specific stress on the conservation target under discussion. The results of these criteria for stress and source of stress assessment for the conservation target in the Spring River Watershed are presented on the following pages.

Four stresses are identified as impacting the aquatic community within the Spring River Watershed (see Table 13). The highest ranked stress is habitat loss or alteration (high) and sedimentation (high). Two stresses were ranked medium: altered water chemistry and nitrification.

Table 13: Overall Ecosystem Stress Summary Ranking for the Spring River Watershed

Stress	Scope	Severity	Magnitude
Habitat Loss/Alteration	High	Very High	High
Sedimentation	Medium	Very High	High
Altered Water Chemistry	High	High	Medium
Nutrification	High	Medium	Medium

Conservation Target/Threat Summary

A summary analysis of the severity and scope of the stresses and sources of stress discussed in the previous sections is presented in Table 14. The objectives of this summary analysis are to provide an overall ranking of the threats to the Spring River Site and to identify the most critical threats to the conservation targets. For the Spring River Watershed, the most severe threats contribute to one or more system stresses. The highest ranked sources of stress are road crossings, unstable streambanks, unpaved roads, incompatible development, gravel mining, and dams.

Table 14: Overall Ecosystem Sources of Stress Summary Ranking for the Spring River Watershed

Source of Stress	Aquatic Community
Road crossings	High
Unstable stream banks	High
Unpaved roads	High
Incompatible development	High
Gravel Mining	High
Dams	High
Recreation	Medium
Incompatible Grazing	Medium
Fish hatcheries	Low
Waste water point-sources	Low
Overall Threat Rank	**Very High**

Conservation Strategies
Five strategies and related actions have been developed to reduce threats (sources of stress) identified for the four conservation targets of the Spring River Watershed. Table 15 is a summary of the five strategies and their ranks. The strategy ranking presented integrates all of the factors regarding severity of threat and effectiveness of strategy to identify the most effective strategies for implementation at the site. Parameters used to develop the overall ranking of the strategies include threat abatement, lead individual/institution, ease of implementation, and cost. Based upon the and current efforts in the nearby watersheds, efforts should be concentrated on developing appropriate rural road maintenance procedures with county road officials to the address sediment control from road reaches, the implementation of protection of priority riparian lands, and working cooperatively with partners to re-establish stable streambanks and riparian forests.

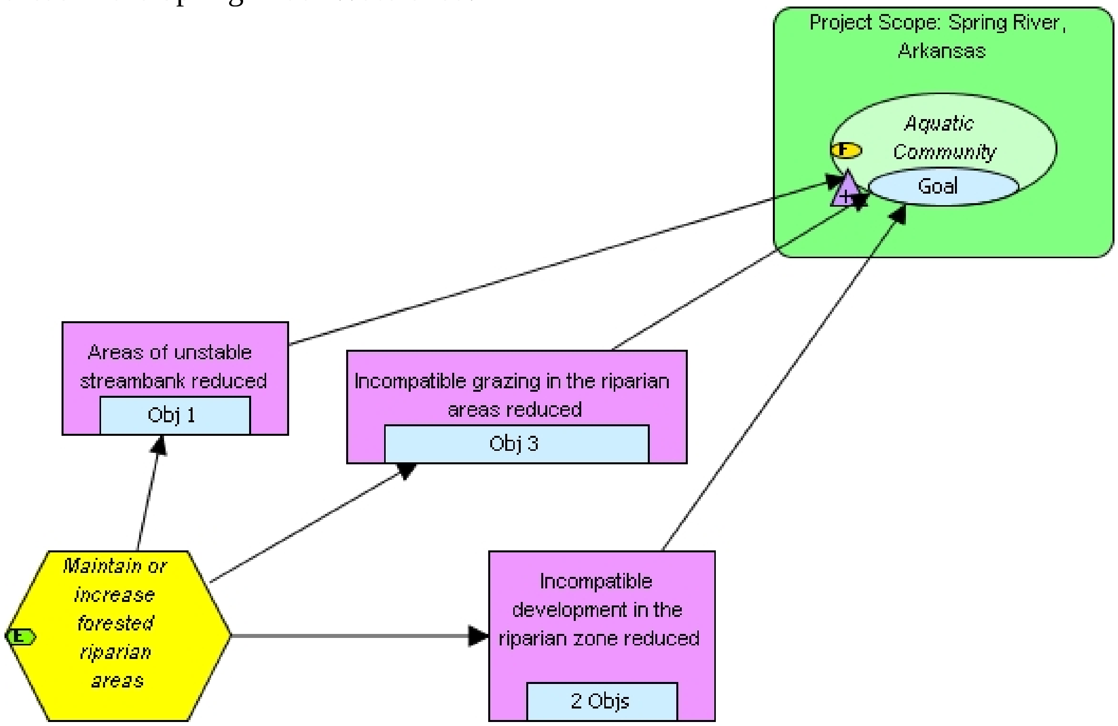
Table 15 . Summary of Strategies for the Spring River Watershed.

Strategy	Priority Ranking
Maintain or increase forested riparian areas in key stream reaches of the Spring River.	Effective
Work with county officials to investigate feasibility and potential funding sources for alternative road surfaces, facilitate training to county road departments through technical workshops, and develop road Environmentally Sustainable Management Practices (ESMP).	Effective
Reduce or eliminate instream gravel mining in the Spring River and its tributaries.	Effective
Re-establish stable streambanks and riparian forests on priority private lands through federal, state, and Conservancy or other private cost-share/grant programs.	Effective
Prevent the establishment of new dams on the mainstem or tributaries of the Spring River.	Less Effective

Results Chains

A results chain is a tool that shows how a project team believes a particular action it takes will lead to some desired result. More specifically, for conservation projects, a results chain represents a team's assumptions about how project or program strategies will contribute to reducing important threats, leading to the conservation of priority biodiversity targets. In essence, results chains are diagrams that map out a series of causal statements that link short-, medium-, and long-term results in an "if…then" fashion. Using this process, the project team developed results chains for each strategy and defined objectives and activities (Figure 14). The results chains for the remaining strategies are included in Appendix 2.

Figure 14: Results chain for the strategy to maintain or increase key forested riparian areas in the Spring River Watershed.



After analyzing strategies using the results chain process, objectives and activities were identified as a means to conserve and restore the Spring River Watershed and its aquatic ecosystem (Table 16).

Table 16. Summary of Strategies, Objectives, and Activities for the Spring River Watershed.

Strategy 1: Maintain or increase forested riparian areas in key stream reaches of the Spring River.

- Objective: By 2012, 25% of key riparian corridors are protected through acquisition or easement.
- Objective: By 2012, 25% of key riparian corridors are protected or restored through private land incentive programs for riparian buffers

Strategy 2: Work with county officials to investigate feasability and potential funding sources for alternative road surfaces, facilitate training to county road departments through technical workshops conducted by experts in the field, and develop road Environmentally Sustainable Management Practices (ESMP).

- Objective: By 2012, implement improvements on 25% of the road crossings most negatively affecting targets.
- Objective: By 2012, implement improvements on 25% of the most significant sediment contributing road segments in 2 subwatersheds.
- Activities:
    - Inventory and prioritization
    - Engage road managers
    - ESMP training for road managers
    - Acquire funding for ESMPs

Strategy 3: Reduce or eliminate instream gravel mining in the Spring River and its tributaries.

- Objective: By 2012, eliminate commercial gravel mining in the watershed.
- Objective: By 2012, work with county officials to reduce non-commercial gravel mining in the watershed.

Strategy 4: Re-establish stable streambanks and riparian forests on priority private lands through federal, state, and Conservancy or other private cost-share/grant programs.

- Objective: By 2012, implement improvements on 25% of the most significant sediment contributing streambank segments in 2 subwatersheds.

Strategy 5: Prevent the establishment of new dams on the mainstem or tributaries of the Spring River.

- Objective: Ensure no new dams are placed on the Spring River or its tributaries by working with local regulatory agencies.

Monitoring Plan

The primary measurement for success of conservation actions in the watershed will be the condition of the nested targets and indicator species as well as water quality measurements (Table 17).

Table 17: Viability indicators for the Spring River Watershed aquatic community health.

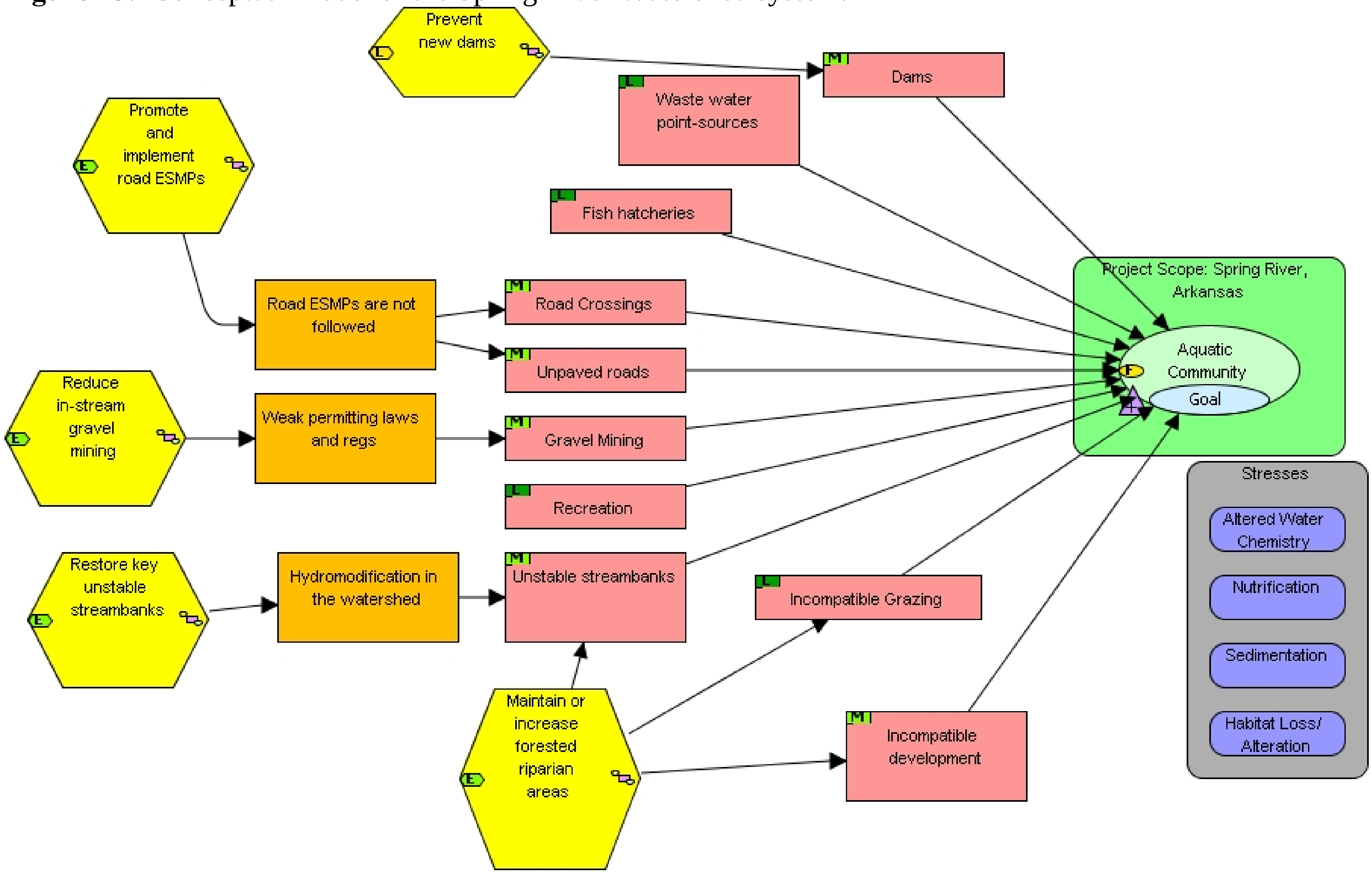
Goal: Increase quality of aquatic habitat for all nested targets	
Indicator	**Data Source**
Crayfish species diversity	AGFC crayfish database
Dissolved Oxygen (mg/l)	Water quality monitoring
Fish species diversity	From AGFC fish database
Hellbender size frequency distribution	Stan Trauth's Spring River research (1978-2004) and ongoing watershed research
Percent forested riparian buffer	GIS analyses
Turbidity	Water quality monitoring

The first monitoring task for the watershed it to determine the historical range of variability for ecological parameters such as flow, sediment, turbidity, and (if possible) abundance and diversity of target assemblages and/or indicator species. From this baseline, the condition of the aquatic habitat can be assessed after conservation activites have been implemented. Effectiveness monitoring of strategies, objectives, and activities should also be measured annually. The following outcomes would indicate success for aquatic habitat in the watershed.

- Improved water quality and sediment conditions over baseline conditions (set within a range of variability).
- Increase in abundance or occurrence of target species.
- Lowering of threat/stress level.

The planning process can be summarized in the conceptual model output from the planning software Miradi. The model shows the target, stresses, threats, contributing factors, and strategies most important in conserving the Spring River Watershed (Figure 15).

Figure 15: Conceptual model of the Spring River Watershed system.



Taking Action

Priority conservation actions for the Spring River Watershed were identified through the planning process.

1. Build partnerships with governmental agency and nongovernmental organizations for the success of the Spring River Watershed Plan. Continued involvement of the USDA Farm Services Administration and Natural Resource Conservation Service offices, the Arkansas Game and Fish Commission, Arkansas Department of Environmental Quality and Arkansas Soil Natural Resources Commission are very important to long term project success.

2. Seek project funding from State and Federal agencies and private organizations for implementing conservation actions to reduce soil erosion in the watershed.

3. Convey priority (riparian) watershed lands into permanent conservation status.

4. Identify and initiate restoration and/or protection of riparian/streambank corridor in the top priority sub-watersheds.

5. Engage in cooperative county road sediment control projects in each of the top priority sub-watersheds.

6. Restore and/or protect riparian/streambank corridor in the top priority sub-watersheds.

7. Continue with measures of success monitoring and refine as necessary. Evaluate data trends in first formal evaluation of implemented watershed conservation strategies.

Appendix I. Species of Concern List

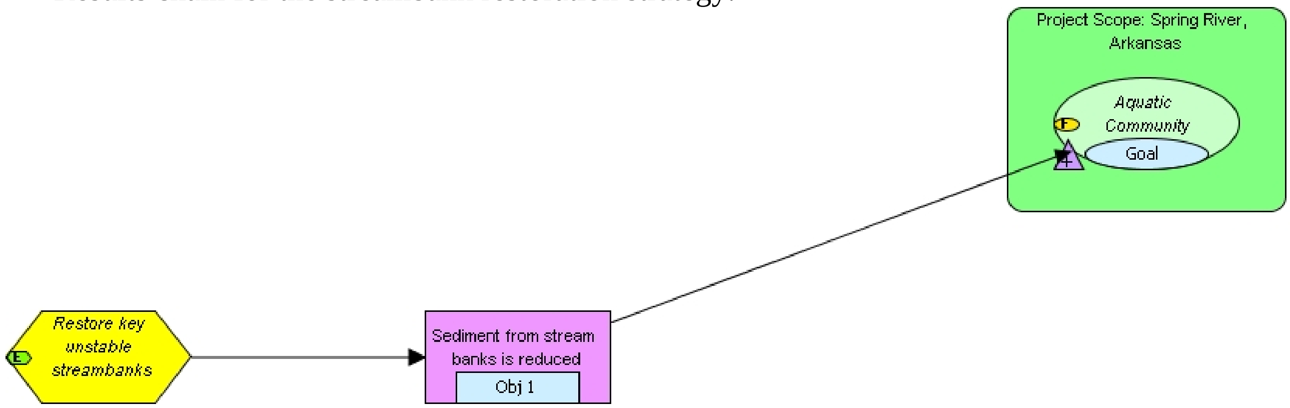
Aquatic species of the Spring River identified as Species of Greatest Conservation Need in the Arkansas Wildlife Action Plan.

Common Name	*Scientific Name*	Rank*
Fish:		
Blue Sucker	*Cycleptus elongatus*	G3G4S2
Crystal Darter	*Crystallaria asperella*	G3
Least Brook Lamprey	*Lampetra aepyptera*	G5S2?
Ozark Chub	*Erimystax harryi*	G3G4S3S4
Ozark Shiner**	*Notropis ozarkanus*	G3
Sabine Shiner	*Notropis sabinae*	G3S2
Stargazing Darter	*Percina uranidea*	G3
Shorthead Redhorse	*Moxostoma macrolepidotum*	G5S2?
Western Sand Darter	*Etheostoma clarum*	G3
Mussels:		
Arkansas Broken Ray**	*Lampsilis reeveiana*	G3
Butterfly	*Ellipsaria lineolata*	G4
Black Sandshell	*Ligumia recta*	G5
Bleedingtooth**	*Venustaconcha pleasi*	G3G4
Creeper	*Strophitus undulatus*	G5S3
Curtis Pearlymussel	*Epioblasma florentina curtisi*	G1T1S1
Elktoe	*Alasmidonta marginata*	G4
Fatmucket	*Lampsilis siliquoidea*	G5
Flutedshell	*Lasmigona costata*	G5S3
Hickorynut	*Obovaria olivaria*	G4S3
Little Spectaclecase	*Villosa lienosa*	G3
Ohio Pigtoe	*Pleurobema cordatum*	G3
Ouachita Kidneyshell	*Ptychbranchus occidentalis*	G3G4
Ozark Pigtoe**	*Fusconaia ozarkensis*	G2G3
Pink Mucket	*Lampsilis abrupta*	G2S2
Purple Wartyback	*Cyclonaias tuberculata*	G5
Purple Lilliput	*Taxolasma lividus glans*	G2G3T2T3
Rabbitsfoot	*Quadrula cylindrica*	G3S2
Rainbow	*Villosa iris*	G5S2S3
Rock Pocketbook	*Arcidens confragosus*	G4S3
Round Pigtoe	*Pleurobema sintoxia*	G4S3
Scaleshell	*Leptodea leptodon*	G1
Snuffbox	*Epioblasma triquetra*	G3
Western Fanshell	*Cyprogenia aberti*	G2
Crayfish:		
Coldwater Crayfish	*Orconectes eupunctus*	G3
Amphibians:		
Ozark Hellbender	Cryptobranchus alleganiensis bishopi	*G3G4T1QS2*
Insects:		
Unkown		

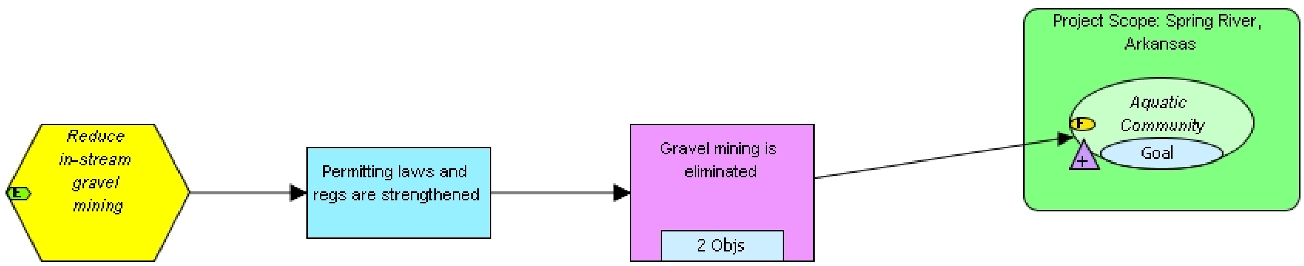
*** Heritage Ranking System:** G = global rarity ranking, T = global ranking, but with some taxonomic question; rarity is ranked 1 – 5, with 1 being the rarest
** Endemic to the Ozarks
***** Has not been collected during last 20 years**

Appendix II. Strategy Results Chains

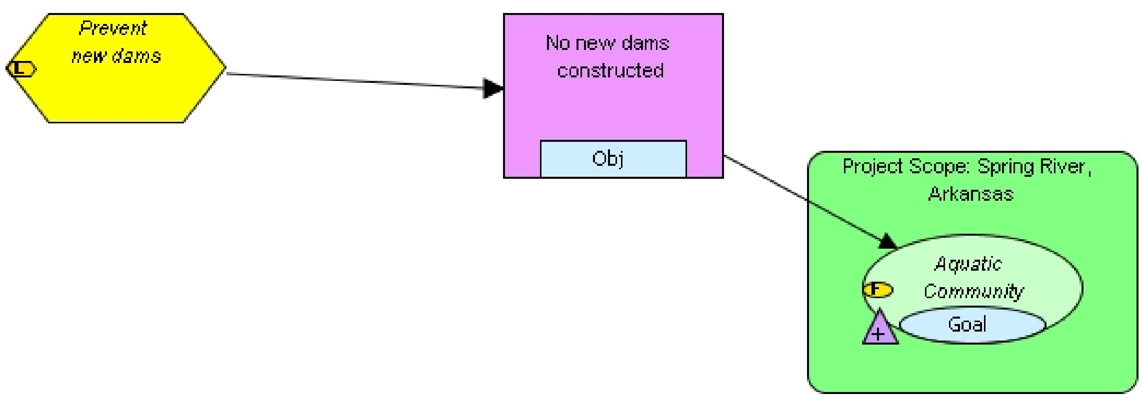
Results chain for the streambank restoration strategy.



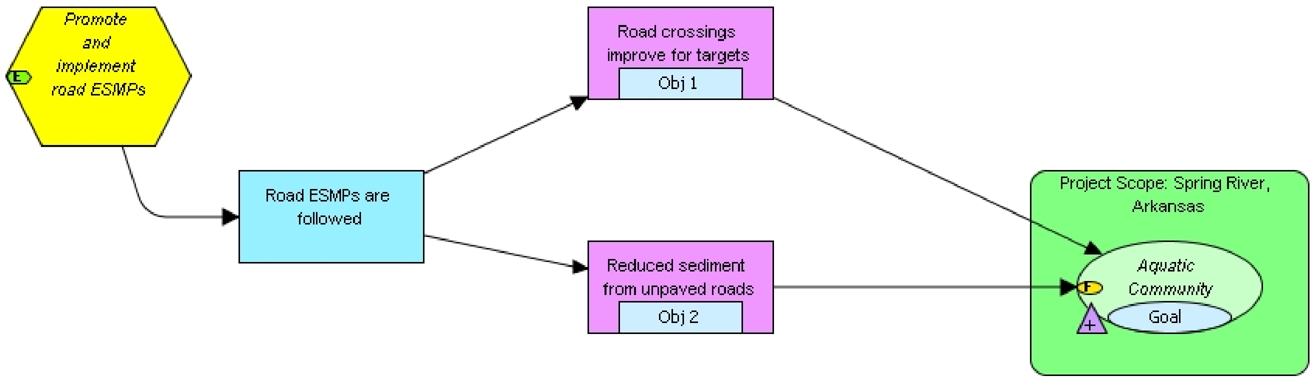
Results chain for the reduction of gravel mining strategy.



Results chain for the reduction of prevention of new dams strategy.



Results chain for the implementation of road Environmentally Sustainable Management Practices strategy.



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