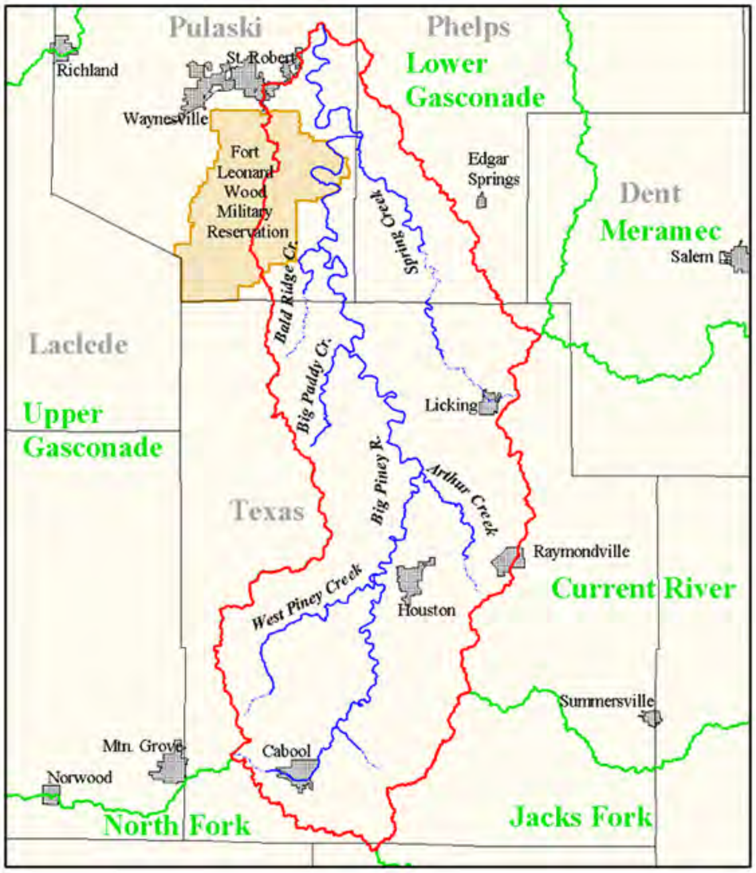

Big Piney River

Watershed and Inventory Assessment, June 2004

Prepared by Thomas F. Wilkerson Jr.

Missouri Department of Conservation, West Plains, Missouri

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Executive Summary

The Big Piney Watershed occupies an area of approximately 755 square miles in portions of 4 counties in Missouri. These counties include Texas, Howell, Phelps, and Pulaski Counties.

Most of the watershed (74%) lies within Texas County, while Pulaski, Phelps, and Howell Counties contain 14%, 12%, and less than 1% of the watershed respectively. The Big Piney Watershed is bounded on the west, north and a portion of the east side by the remainder of the Gasconade Basin. The Meramec, Current, and Jacks Fork Watersheds bound the Big Piney on the remainder of the East side, while the North Fork watershed lies on its southern boundary.

The Big Piney River begins as a first order stream approximately 4 miles northwest of Cabool, Missouri. From its beginnings, the stream flows in a southeasterly direction for approximately 4 miles before entering the city of Cabool, Missouri. It then continues in a southeasterly direction for 2 miles before turning northeast and following the outskirts of Cabool for an additional 2 miles. From Cabool, the river continues in a northeasterly direction for 35 miles before turning to the North, Northeast. The Big Piney continues to follow this general direction for approximately 67 miles before emptying into the Gasconade River 2.8 river miles north of Interstate 44.

The Big Piney Watershed has 5 cities and towns within or partially within its boundary. They include Cabool, Houston, Licking, Raymondville, and St. Robert. In addition, approximately 38% of the Fort Leonard Wood Military Reservation occurs within the watershed.

The Big Piney Watershed lies within the Salem Plateau Subdivision of the Ozark Plateau Physiographic Region. The Salem Plateau Subdivision is a highly dissected plateau with upland elevations ranging from 1000 to 1400 feet above mean sea level (msl) and local relief (local relief refers to the difference in elevation between two nearby points such as a valley and an adjoining ridge top) ranging from 100 - 200 feet in the uplands to 200 - 500 feet elsewhere.

Elevations within the watershed range from a maximum of approximately 1663 feet above msl in the uplands to approximately 688 feet above msl in the lower portions of the watershed. The Big Piney Watershed occurs within the Ozarks Soil Region. Eight soil associations occur within the watershed.

Ordovician dolomites and sandstone dolomites dominate the geology of the watershed, while small isolated remnants of Mississippian Limestone and Pennsylvanian Limestone occur in the upper portion of the watershed. As is the case in most watersheds of the Ozarks, the geology of the Big Piney Watershed (primarily consisting of soluble rock formations of dolomites and sandstone dolomites), in combination with an average annual precipitation of over 42 inches has created a karst landscape within the watershed. This karst landscape is characterized, in part, by a close relationship between the surface water and ground water systems. Within karst landscapes, points or areas of surface water/ground water interaction include losing streams, sinkholes, and springs.

There are 91 third order and larger streams within the watershed. These streams account for a total of approximately 602 stream miles or 30% of the total stream miles within the watershed. The Big Piney River is 110.5 miles long and becomes sixth order at the confluence of West Piney Creek.

Total drainage area of the Big Piney Watershed is 755 square miles (482, 956 acres). There are 5 major subwatersheds (based on 5th order streams) within the watershed. These include the subwatersheds of Spring Creek, West Piney Creek, Arthur Creek, Big Paddy Creek, and Bald Ridge Creek.

Historical land cover within the uplands of the upper Big Piney Watershed probably consisted of open woodlands comprised of post oak and black oak with an understory of shrubs and grasses such as bluestem. Occasional savanna openings were also probably common. The more dissected areas of the uplands most likely consisted of mixed oak woodland and forest. In the more central portion of the watershed, pine and oak-pine woodlands probably occurred on the uplands underlain by sandstones of the Roubidoux Formation, while oak and oak-pine forest probably dominated the lower slopes as well as

more dissected portions of this area. In valley bottoms having rich alluvial soils, a forest of mixed hardwoods likely existed. The land cover blanketing the rugged topography of the lower Big Piney watershed is believed to have consisted of oak and mixed hardwood forest open woodlands and scattered glades on exposed ridges and sideslopes with occasional fens in narrow valleys. Analysis of recent land cover data reveals that approximately 62.7% of the Big Piney Watershed is forested. Grassland is the second most prevalent land cover accounting for about 36.6% of the total watershed area. The categories of cropland and urban account for approximately 0.1% and 0.6% of the total watershed area respectively, while the land cover category of water accounts for approximately 0.1% of the watershed area.

The Big Piney Watershed is situated in one of the wetter parts of Missouri which receives from 32 inches of precipitation in the Northwest to 48 inches in the Southeast of the state. The United States Geological Survey had, as of 2002, two active surface discharge gage stations within the Big Piney Watershed. The annual daily mean discharge of the Big Piney River near Big Piney, Missouri is 542 cubic feet per second.

Approximately 264 stream miles and 10 impoundment acres within the Big Piney Watershed are classified and have designated beneficial uses as presented in Tables G and H of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality. Currently, a 0.2 mile segment of Brushy Creek is included in the 1998 303(d) listing of impaired waters. In addition, all waters within the Big Piney Watershed are currently (2004) included in a statewide fish consumption advisory for largemouth bass. Women who are pregnant, who may become pregnant, nursing mothers and children twelve (12) years of age and younger should not eat any largemouth bass over twelve (12) inches in length from anywhere in Missouri due to elevated levels of mercury. Periodically elevated phosphorous levels and fecal coliform counts have been noted at a few water quality sample sites within the watershed and two springs within the watershed have been determined to suffer from probable septic contamination. In addition, detections of pesticides and/or elevated levels of other constituents have been noted from some ground water and surface water quality sites. The Big Piney Watershed is unique to many other watersheds in Missouri in that a large military installation, at least in part, is located within its boundaries. The presence of Fort Leonard Wood presents unique water quality concerns which are not applicable to many other watersheds. Sixty-Eight sites have been identified in association with Fort Leonard Wood as "having the possibility to cause contamination". Remediation or interim remediation activities have been conducted at 11 sites. A total of 56 sites are listed as "response completed" sites, while 12 sites "have been identified for further investigation and/or remediation" or are otherwise considered active sites (USAEC 2003). Currently, all remediation activities are on track to be completed by 2009, with the Fort Leonard Wood's Installation and Restoration Program scheduled to be completed in 2017. Other items which have the potential to cause water quality problems include large numbers of livestock in riparian zones for extended periods of time, private septic system failure, increased nutrients from municipal sewage treatment facilities, improper sand and gravel removal, and poor land use practices such as land clearing without the use of appropriate soil and water conservation practices.

Within the Big Piney Watershed there are currently 6 dams which have records within the Dam and Reservoir Safety Program Database. All are reinforced earth structures with heights ranging from 12 to 27 feet. Impoundment areas range from 4 to 45 acres. Estimates based on analysis of National Wetlands Inventory data indicate that only about 3 miles of channelized stream exist within the Big Piney Watershed. All channelization within the watershed appears to be relatively small and localized. Riparian corridor land cover within the watershed consists of more forest/wetland (68.3%) than grassland/cropland (31.1%). Percentages for the remaining categories of urban and water are 0.2% and 0.4% respectively.

The Big Piney Watershed exhibits a diverse biotic community. Since 1930, an assemblage of 73 fish species, 32 mussel species and subspecies, 6 species of snails, 3 crayfish species, and 191 taxa of benthic macro- invertebrates (not including mussels and crayfish) have been identified throughout the watershed. A total of 41 terrestrial and aquatic species and subspecies of conservation concern are known to occur in the watershed. This list includes 4 fish species, 5 species of mussels, 2 species of amphibians, 1 species of crayfish, and 2 species of insects. The most common game fish species within the watershed include smallmouth bass, rock bass, and largemouth bass. In addition, two significant rainbow trout fisheries occur within the watershed. Sucker species provide an alternative consumptive recreational opportunity within the watershed. Invasive exotic aquatic species within the watershed include the Asian clam and the common carp.

The management goals, objectives, and strategies for the Big Piney Watershed were developed using information collected from the Big Piney Watershed Inventory and Assessment (WIA) effort and direction provided by the Ozark Regional Management Guidelines (1998), Missouri Department of Conservation (MDC) Strategic Plan, and the Fisheries Division Direction.

Objectives and strategies were written for in-stream and riparian habitat, water quality, aquatic biota, recreational use, and hydrography. All goals are of equal importance. These goals include

- improve riparian and aquatic habitats in the Big Piney Watershed,
- improve surface and subsurface water quality in the Big Piney Watershed,
- maintain the abundance, diversity, and distribution of aquatic biota at or above current levels while improving the quality of the sport fishery in the Big Piney Watershed,
- increase public awareness and promote wise use of aquatic resources in the Big Piney Watershed. The attainment of these goals will require cooperation with private landowners, other divisions within the Missouri Department of Conservation, as well as other state and federal agencies.

Location

The Big Piney Watershed is part of the larger Gasconade Basin and accounts for 21% of the drainage area of the Gasconade. The Gasconade (including the Big Piney) drains a large portion of the northern slope of the Salem Plateau which is a part of the Ozark Plateau. The Big Piney Watershed has an area of approximately 755 square miles in portions of 4 counties in Missouri (Figure Lo01). These counties include Texas, Howell, Phelps, and Pulaski Counties. Most of the watershed (74%) lies within Texas County, while Pulaski, Phelps, and Howell Counties contain 14%, 12%, and less than 1% of the watershed respectively. The Big Piney Watershed is bounded on the west, north and a portion of the east side by the remainder of the Gasconade Basin. The Meramec, Current, and Jacks Fork Watersheds bound the Big Piney on the remainder of the East side, while the North Fork watershed lies on its southern boundary.

The Big Piney River begins as a first order stream approximately 4 miles northwest of Cabool, Missouri. From its beginnings, the stream flows in a southeasterly direction for approximately 4 miles before entering the city of Cabool, Missouri. It then continues in a southeasterly direction for 2 miles before turning northeast and following the outskirts of Cabool for an additional 2 miles. From Cabool, the river continues in a northeasterly direction for 35 miles before turning to the North, Northeast. The Big Piney continues to follow this general direction for approximately 67 miles before emptying into the Gasconade River 2.8 river miles north of Interstate 44.

The Big Piney Watershed has 5 cities and towns within or partially within its boundary (Figure Lo02). They include Cabool, Houston, Licking, Raymondville, and St. Robert. In addition, approximately 38% of the Fort Leonard Wood Military Reservation (hereafter referred to as FLW in this document) occurs within the watershed.

The Big Piney Watershed includes approximately 1, 737 miles of roads (USDC 1997). This is miles of road for every square mile of drainage area. Two railroads (including the FLW spur), one interstate, two U.S. Highways, and 7 major state routes intersect the Big Piney Watershed (Figure Lo02)

Figure Lo01

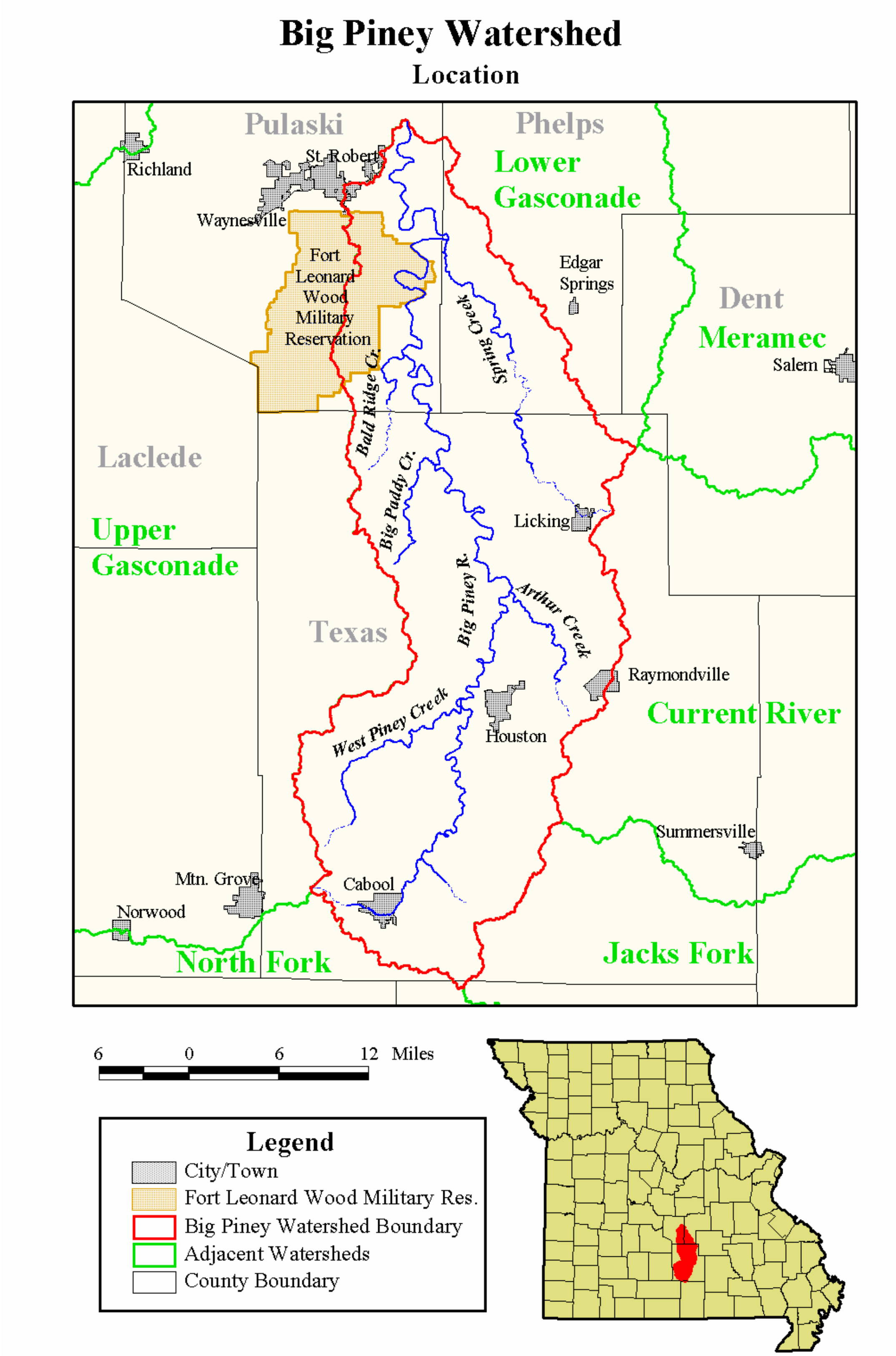
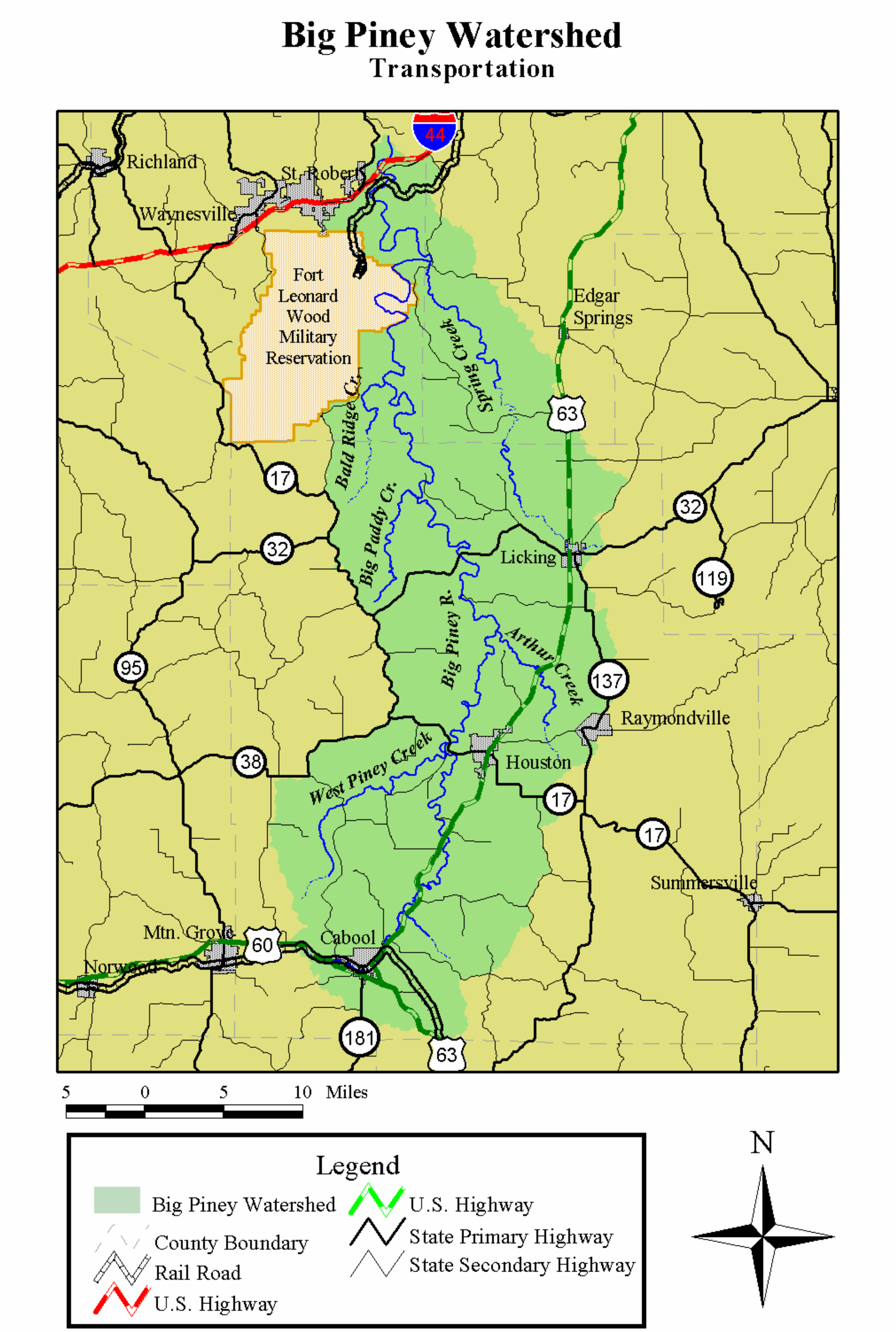

Big Piney Watershed
Location
Pulaski
Phelps
Lower Gasconade
Richland
St. Robert
Waynesville
Fort Leonard Wood Military Reservation
Edgar Springs
Dent
Meramec
Salem
Spring Creek
Bald Ridge Cr.
Laclede
Big Paddy Cr.
Upper Gasconade
Licking
Big Piney R.
Arthur Creek
Texas
Raymondville
Current River
West Piney Creek
Houston
Summersville
Mtn. Grove
Cabool
Norwood
North Fork
Jacks Fork
6
0
6
12
Miles
Legend
City/Town
Fort Leonard Wood Military Res.
Big Piney Watershed Boundary
Adjacent Watersheds
County Boundary

Figure Lo02


Big Piney Watershed
Transportation
44
Richland
St. Robert
Waynesville
Fort Leonard Wood Military Reservation
Edgar Springs
Spring Creek
Bald Ridge Cr.
63
17
Big Paddy Cr.
32
Licking
119
95
Big Piney R.
Arthur Creek
137
Raymondville
38
West Piney Creek
Houston
17
17
Summersville
Mtn. Grove
60
Cabool
Norwood
181
63
5 0 5 10 Miles
Legend
Big Piney Watershed
County Boundary
Rail Road
U.S. Highway
U.S. Highway
State Primary Highway
State Secondary Highway
N

Geology/Geomorphology

Physiographic Region

The Big Piney Watershed lies within the Salem Plateau Subdivision of the Ozark Plateau Physiographic Region. The Salem Plateau Subdivision is a highly dissected plateau with upland elevations ranging from 1000 to 1400 feet above mean sea level (msl) and local relief (local relief refers to the difference in elevation between two nearby points such as a valley and an adjoining ridge top) ranging from 100 - 200 feet in the uplands to 200 - 500 feet elsewhere (MDNR 1986). Elevations within the watershed range from a maximum of approximately 1, 663 feet above msl in the uplands to approximately 688 feet above msl in the lower portions of the watershed. Local relief data obtained from the Missouri Department of Conservation (MDC) Fisheries Research Fish Collection Database (1998a) indicates a minimum local relief of 56 feet and a maximum of 394 for MDC fish collection sites within the watershed.

Soils

The Big Piney Watershed occurs within the Ozarks Soil Region. Allgood and Persinger (1979) describe the Ozark Soils Region as

> *"cherty limestone ridges that break sharply to steep side slopes of narrow valleys. Loess occurs in a thin mantle or is absent. Soils formed in the residuum from cherty limestone or dolomite range from deep to shallow and contain a high percentage of chert in most places. Some of the soils formed in a thin mantle of loess are on the ridges and have fragipans, which restrict root penetration. Soil mostly formed under forest vegetation with native, mid-tall and tall grasses common in open or glade area."*

The following is a list of Ozark soil associations found in the Big Piney Watershed based on analysis of STATSGO soils database for Missouri (USDA-NRCS 1994):

- Arkana-Moko-Gassville
- Clarksville-Goss-Doniphan
- Gepp-Doniphan-Agnos
- Huntington-Nolin-Peridge
- Lebanon-Yelton-Viburnum
- Nixa-Coulstone-Clarksville
- Viraton-Clarksville-Lebanon
- Viraton-Scholten-Tonti

Geology and Karst

Ordovician dolomites and sandstone dolomites dominate the geology of the watershed, while small isolated remnants of Mississippian Limestone and Pennsylvanian Limestone occur in the upper portion of the watershed (Figure Ge01). Dolomites of the Jefferson City-Cotter Formation occur in the headwaters of the watershed and is absent in the Northeast portion of the watershed.

As streams become larger and move out of the headwaters, the Jefferson City-Cotter Dolomite is replaced by the dolomites and sandstones of the Roubidoux Formation. Streams in the lower elevations of the watershed as well as the valleys of much of the Big Piney River and Spring Creek incise Gasconade dolomite, a formation which is associated with most of the large springs in the Ozarks.

As is the case in most watersheds of the Ozarks, the geology of the Big Piney Watershed (primarily consisting of soluble rock formations of dolomites and sandstone dolomites), in combination with an average annual precipitation of over 42 inches, has created a karst landscape within the watershed. This karst landscape is characterized, in part, by a close relationship between the surface water and groundwater systems. Within karst landscapes, points or areas of surface water/ground water interaction include losing streams, sinkholes, and springs.

Losing streams are one manner in which surface water is transported or "lost" to the groundwater system. Within the Big Piney Watershed, 51 miles of streams have been designated as "losing" in the Rules of Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality (Table Ge01 and Figure Ge02) (MDNR 2000b). This is estimated at 1 mile of losing stream to 14.8 square miles of watershed area (1:14.8). While slightly higher, this concentration of losing streams is relatively similar to that which has been documented within the remainder of its parent watershed, the Gasconade, which has a ratio of 1 mile of losing streams to 16.0 square miles of watershed area. In comparison, the neighboring North Fork and Current River Watersheds have losing stream/area ratios of 1:7.7 and 1:12.5 respectively. The longest losing segment within the Big Piney Watershed occurs in a 17 mile portion of Spring Creek. Within MDNR 2000b, a losing stream is defined as "A stream which distributes 30% or more of its flow during low flow conditions through natural processes, such as through permeable geologic materials into a bedrock aquifer within two (2) miles flow distance downstream of an existing or proposed discharge". Due to the specific nature of this definition, many streams within the watershed, which possibly lose large amounts of flow to the groundwater system, may have yet to be surveyed or classified as being "losing" in the broader sense of the word. Further study may be needed in order to develop a comprehensive understanding of the role of losing streams within the watershed.

In addition to losing streams, sinkholes provide another point of surface to groundwater interaction. The MDNR has identified 153 sinkholes or probable sinkholes within the Big Piiney Watershed (Figure Ge02) (MDNR 2002). Additional detailed mapping of sinkholes (not included in this report) as well as other geologic features was completed on FLWMR and the surrounding area as part of an extensive geologic mapping project funded by FLWMR and conducted in 1994-1995 by the USGS in support of geohydrologic and water quality studies conducted there (Harrison et al. 1996).

Springs are the naturally occurring outlets of groundwater systems. Spring flow accounts, to a large extent, for the higher sustained flows of many Ozark streams, including the Big Piney, relative to streams in other regions of Missouri. Within the Big Piney Watershed there are 67 known springs (1 spring /11.3 square miles of watershed area) (Vineyard and Feder 1974 and MDNR 2000a) (Figure Ge01). Vineyard and Feder (1974) lists discharges for 17 springs within the watershed (Table Ge02). Ten of these springs have discharges exceeding 1 cubic foot per second (cfs). The largest spring within the watershed is Stone Mill Spring which has an average flow of approximately 29 cfs. Figure Lu02 shows recharge areas for 8 springs within the watershed and two springs which occur outside the watershed but whose recharge areas occur partially within the watershed.

Stream Order, Mileage and Permanency

Stream order is "a hierarchy in which stream segments are arranged" (Judson et al. 1987). The process of stream ordering is accomplished by examining maps and assigning orders to stream segments based on other streams which flow into them. Using the Strahler/Horton method of stream ordering, when two stream segments of the same order join, the new segment they create is the next highest order. For instance, a first order stream would be a stream in which no other streams intersect it. A second order stream is created by the joining of two first order streams. A third order stream is created by the joining of two second order streams and so on. If the main channel of a stream happens to be a lower order than that of the intersecting stream, the main channel assumes the higher order. If the main channel is a higher order stream than the intersecting stream, it maintains the higher order (Figure Ge03).

Maximum orders for streams within the Big Piney Watershed have been obtained from a 1:24, 000 scale Geographic Information System (GIS) hydrography coverage. There are 91 third order and larger streams within the watershed (Table Ge03 and Figures Ge04 and Ge05). These streams account for a total of approximately 602 stream miles or 30% of the total stream miles within the watershed. Of the 91 third order and larger streams within the watershed, 70 are third order (287.3 miles), 14 are fourth order (111.4 miles), and 6 are fifth order (92.6 miles). The Big Piney River is 110.5 miles long and becomes sixth order at the confluence of West Piney Creek.

Permanent stream mileage data based on the 1:24, 000 National Hydrography Dataset (NHD) for the Watershed indicates that approximately 322 stream miles (16%) within the watershed have permanent water. This equals approximately 1 mile of permanent stream for every 2.3 square miles of drainage area. The Big Piney River has permanent water for approximately 107 of its 111 mile length according to NHD data. Table Ge03 lists permanent stream mileage for the remaining third order and larger streams in the watershed.

It is important to note that permanent stream mileage data within the 1:24, 000 NHD is based on USGS Digital Line Graph hydrography data which, in turn is based upon USGS 1:24, 000 scale topographic maps (USGS 1998e, USGS 1999b, MoRAP 2002). The USGS assigns a stream permanent status based on that stream having flow twelve months out of the year during normal precipitation (Weirich 1993, Blanc etal. 1999). This method may not take into account periods of drought or the possible 'losing' nature of a stream.

Drainage Area

Total drainage area of the Big Piney Watershed is 755 square miles (482, 956 acres). There are 5 major subwatersheds (based on 5th order streams) within the watershed. These include thesubwatersheds of Spring Creek, West Piney Creek, Arthur Creek, Big Paddy Creek, and Bald Ridge Creek (Figure Ge06). The largest of these is the Spring Creek Subwatershed with a drainage area of 109 square miles (69, 448 acres). In order to facilitate analysis of watershed characteristics the watershed was divided based on eleven digit hydrologic units. This resulted in 4 units. The largest of these units is the Middle Big Piney Unit which drains approximately 254 square miles (162, 815 acres).

Stream Channel Gradient

Channel gradient was determined for all fifth order and larger streams within the watershed using data derived from 1:24, 000 scale hydrography and hypsography coverages for the Big Piney Watershed (Figures Ge07-12). Average gradients for fifth order and larger streams within the watershed range from 7.3 feet per mile to 38.9 feet per mile. The Big Piney River has an average gradient of 7.3 feet/mile. This is similar to the gradient of the Jacks Fork River which is 7.1 feet per mile.

Table Ge01. Big Piney Watershed stream reaches designated as losing in Table J Rules of Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Qualaity. Code of Regulations (MDNR 2000b).

Stream Name	Counties	Miles	From	To
Bradford Br.	Phelps	2.0	se se se 05 34n 09w	se nw ne 06 34n 09w
Unnamed Trib.	Pulaski	2.0	se sw sw 23 35n 11w	ne se ne 25 35n 11w
Dry Br.	Pulaski	4.0	se 11 35n 11w	c 25 36n 11w
Trib. to Big Piney R.	Pulaski	2.0	nw ne nw 34 35n 11w	nw nw sw 36 35n 11w
Round Pound Hollow	Pulaski	3.0	sw sw ne 33 36n 11w	se se nw 25 36n 11w
Brushy Cr.	Texas	2.5	sw nw sw 07 32n 08w	sw nw se 10 32n 09w
Spring Cr.	Texas	2.0	ne ne nw 32 33n 08w	nw sw se 36 33n 09w
Spring Cr.	Texas, Phelps	17.0	ne ne se 01 32n 09w	se nw se 36 35n 10w
Kelly Hollow	Texas	3.0	nw sw se 32 31n 08w	se sw nw 25 31n 09w
L. Paddy Cr.	Texas	1.5	nw ne nw 03 32n 11w	nw se se 35 33n 11w
B. Paddy Cr.	Texas	3.0	sw nw sw 24 32n 11w	ne ne ne 18 32n 10w
Bald Ridge Cr.	Texas, Pulaski	5.5	sw se nw 22 33n 11w	nw sw ne 36 34n 11w
Mooney Br.	Texas	2.0	ne ne ne 19 33n 09w	ne sw nw 12 33n 10w
Trib. to Piney Cr.	Texas	1.5	se se sw 04 29n 10w	ne ne ne 03 29n 10w
Watershed Total		51.0		

Table Ge02. Location and discharge (cubic feet per second) of selected springs in the Big Piney Watershed (Vineyard and Feder 1974).

Name	County	UGSG 7.5' Quad. Name	Discharge (CFS)
Boiling Spring	Texas	Prescott	13.40*
Cox Spring	Phelps	Flat	0.01*
Coyle Spring	Texas	Houston	0.60
Hales Cem. Spring	Pulaski	Devils Elbow	0.01
Hazelton Spring	Texas	Slabtown Spring	6.28*
Mathis Spring	Phelps	Flat	0.02*
Miller Spring	Pulaski	Big Piney	18.90*
Ousley Spring	Pulaski	Devils Elbow	0.75*
Pillman Spring #1	Phelps	Devils Elbow	8.61*
Prewett Spring	Pulaski	Slabtown Spring	17.45*
Pruett Spring	Phelps	Flat	0.15
Relfe (Coppedge) Spring	Phelps	Flat	19.40*
Roaring Spring	Texas	Slabtown Spring	1.31*
Shanghai Spring	Pulaski	Devils Elbow	18.00*
Slabtown Spring	Texas	Slabtown Spring	14.00*
Stone Mill Spring	Pulaski	Big Piney	29.00*
Unnamed	Phelps	Devils Elbow	<0.01

*Average of multiple measurements.

Table Ge03. Third order and larger streams of the Big Piney Watershed.

Note: Unnamed Streams are designated with the prefix 'BPW' (Big Piney Watershed) followed by a number assigned according to the streams location in the watershed hierarchy relative to other third order and larger unnamed streams.

Stream Name	Order	USGS 7.5' Quad at Mouth	Receiving Stream-Order	Permanent Miles*	Total Miles*
Anderson Creek	3	Beulah	Big Piney R.-6	0.0	2.8
Arthur Creek	5	Prescott	Big Piney R.-6	10.5	13.3
BPW001	3	Elbow	Big Piney R.-6	0.0	3.8
BPW002	3	Big Piney	Spring Cr.-5	0.0	2.4
BPW003	3	Flat	Elm Cr.-3	0.0	2.3
BPW004	3	Flat	Sherrill Cr.-4	0.0	2.7
BPW005	3	Beulah	Sherrill Cr.-4	1.5	2.9
BPW006	3	Maples	Sherrill Cr.-4	0.0	1.1
BPW007	3	Maples	Sherrill Cr.-4	0.0	3.0
BPW008	3	Flat	Spring Cr.-4	0.0	3.5
BPW009	3	Beulah	Spring Cr.-4	0.0	11.2
BPW010	3	Devils Elbow	Big Piney R.-6	0.0	3.0
BPW011	3	Big Piney	Big Piney R.-6	0.0	7.0
BPW012	3	Big Piney	Watts Hol.-4	0.0	2.0
BPW013	3	Slabtown Spring	Long Hol.-4	0.0	1.5
BPW014	3	Slabtown Spring	Big Piney R.-6	0.3	2.4
BPW015	3	Slabtown Spring	Big Piney R.-6	0.0	4.1
BPW016	3	Slabtown Spring	L. Paddy Cr.-4	0.0	2.1
BPW017	3	Slabtown Spring	L. Paddy Cr.-4	0.0	2.1
BPW018	3	Success	Big Paddy Cr.-4	0.0	2.0
BPW019	3	Success	Steam Mill Hol.-4	1.1	3.4

Stream Name	Order	USGS 7.5' Quad at Mouth	Receiving Stream-Order	Permanent Miles*	Total Miles*
BPW020	3	Prescott	Mullin Br.-3	0.0	2.3
BPW021	3	Success	Burton Br.-4	0.0	3.5
BPW022	3	Bucyrus	West Pine y Cr.-5	3.2	5.5
BPW023	4	Huggins	West Piney Cr.-5	0.0	4.0
BPW024	3	Huggins	BPW023-4	0.0	3.2
BPW025	3	Huggins	West Piney Cr.-4	1.5	4.8
BPW026	3	Houston	Indian Cr.-3	0.4	2.3
BPW027	3	Cabool NE	Big Piney R.-5	1.7	3.2
BPW028	3	Elk Creek	Elk Cr.-4	0.0	4.2
BPW029	3	Elk Creek	Elk Cr.-4	2.1	3.5
BPW030	3	Elk Creek	Elk Cr.-3	0.0	2.8
BPW031	3	Cabool NE	Big Piney R.-5	0.0	1.8
BPW032	3	Cabool SE	Potter Cr.-4	0.0	3.1
BPW033	3	Cabool SE	Potter Cr.-3	0.0	2.1
BPW034	3	Cabool SE	Big Piney R.-4	0.0	3.9
Bald Ridge Creek	5	Big Piney	Big Piney R.-6	5.8	11.5
Bear Creek	3	Cabool NE	Big Piney R.-5	1.3	4.2
Beeler Branch	3	Cabool NE	Big Piney R.-4	3.1	5.0
Bender Creek	4	Prescott	Arthur Cr.-5	3.3	10.4
Berry Branch	5	Cabool NE	Big Piney R.-5	2.4	4.4
Big Paddy Creek	5	Slabtown Spring	Big Piney R.-6	11.0	11.1
Big Piney River	6	Dixon	Gasconade R.	107.4	110.5
Boone Creek	3	Prescott	Big Piney R.-6	6.6	11.2
Bradford Branch	3	Flat	Spring Cr.-5	0.0	3.4
Bridges Hollow	3	Prescott	Steam Mill Hol.-4	0.0	3.1

Stream Name	Order	USGS 7.5' Quad at Mouth	Receiving Stream-Order	Permanent Miles*	Total Miles*
Brushy Hollow	3	Success	Big Paddy Cr.-4	0.0	3.4
Burton Branch	4	Prescott	Big Piney R.-6	5.0	7.8
Cap Hollow	3	Big Piney	Crossing Hol.-4	0.0	2.5
Chambers Hollow	3	Flat	Spring Cr.-5	0.0	2.9
Cole Hole Hollow	3	Licking	Bender Cr.-4	0.0	2.8
Crossing Hollow	4	Big Piney	Big Piney R.-6	0.7	6.9
Devils Hollow	3	Houston	Arthur Cr.-3	0.0	3.9
Dog Creek	3	Elk Creek	Hog Creek-4	0.0	3.4
Dry Creek	4	Devils Elbow	Big Piney R.-6	4.5	6.6
Elk Creek	4	Cabool NE	Big Piney R.-5	5.8	8.2
Elm Creek	3	Flat	Bradford Br.-3	0.0	3.2
Emery Hollow	3	Bucyrus	Big Piney R.-6	0.0	5.7
Falls Hollow	3	Big Piney	L.Bald Ridge Cr.-4	2.0	3.3
Flat Rock Hollow	3	Houston	Arthur Cr.-4	1.8	3.6
Hamilton Creek	3	Bucyrus	West Piney Cr.-5	8.6	12.8
Hog Creek	4	Bucyrus	Big Piney R.-5	8.1	10.9
Hooker Hollow	3	Devils Elbow	Big Piney R.-6	0.0	3.6
Hungry Hollow	3	Bucyrus	West Piney Cr.-5	0.0	3.1
Indian Creek	3	Houston	Big Piney R.-5	6.4	8.2
Jacktar Hollow	3	Prescott	Big Piney R.-6	1.4	1.4
Kelly Hollow	3	Raymondville	Flat Rock Hol.-3	0.0	4.2
Lawrence Hollow	3	Flat	Spring Cr.-5	0.0	2.6
Little Bald Ridge Cr.	4	Big Piney	Bald Ridge Cr.-5	3.2	4.9
Little Hog Creek	3	Elk Creek	Hog Cr.-4	1.8	3.6

Stream Name	Order	USGS 7.5' Quad at Mouth	Receiving Stream-Order	Permanent Miles*	Total Miles*
Little Paddy Creek	4	Slabtown Spring	Big Paddy Cr.-5	4.2	6.9
Long Hollow	4	Slabtown Spring	Bald Ridge Cr.	0.0	4.60
McCourtney Ho llow	3	Big Piney	Big Piney R.-6	0.0	8.
Mooney Branch	3	Slabtown Spring	Big Piney R.-6	0.0	9.8
Mullin Branch	3	Prescott	Arthur Cr.-5	2.2	4.6
Opossum Creek	3	Bucyrus	West Piney Cr.-5	4.0	6.3
Potter Creek	4	Cabool NE	Big Piney R.-5	7.6	8.7
Rocky Branch (1)	3	Slabtown Spring	Big Piney R.-6	2.1	4.5
Round Pond Hollow	3	Devils Elbow	Dry Cr.-4	0.0	2.2
Sherrill Creek	4	Flat	Spring Cr.-5	8.7	13.7
Slabtown Branch	3	Slabtown Spring	Big Piney R.-6	0.0	6.6
Smoky Hollow	3	Devils Elbow	Big Piney R.-6	0.0	5.2
Spring Creek	5	Devils Elbow	Big Piney R.-6	19.3	32.3
Spurlock Hollow	3	Bucyrus	West Piney Cr.-5	2.2	4.8
Steam Mill Hollow	4	Prescott	Big Piney R.-6	6.6	9.4
Teasley Hollow	3	Big Piney	Spring Cr.-5	0.0	5.2
Watts Hollow	4	Big Piney	Big Piney R.-6	0.0	8.4
West Piney Creek	5	Bucyrus	Big Piney R.-6	17.4	20.0
Wolf Hollow	3	Slabtown Spring	Big Piney R.-6	0.4	6.1
Brushy Creek	3	Houston	Big Piney R.-6	6.6	8.8
Rocky Branch (2)	**3**	**Bucyrus**	**Big Piney R.-5**	**0.0**	2.6

*Determined from Analysis of 1:24, 000 scale GIS hydrography coverage

Abbreviations: Br.-Branch, Cr.-Creek, Hol.-Hollow, R.-River

Figure Ge01.

Big Piney Watershed
Geology and Springs

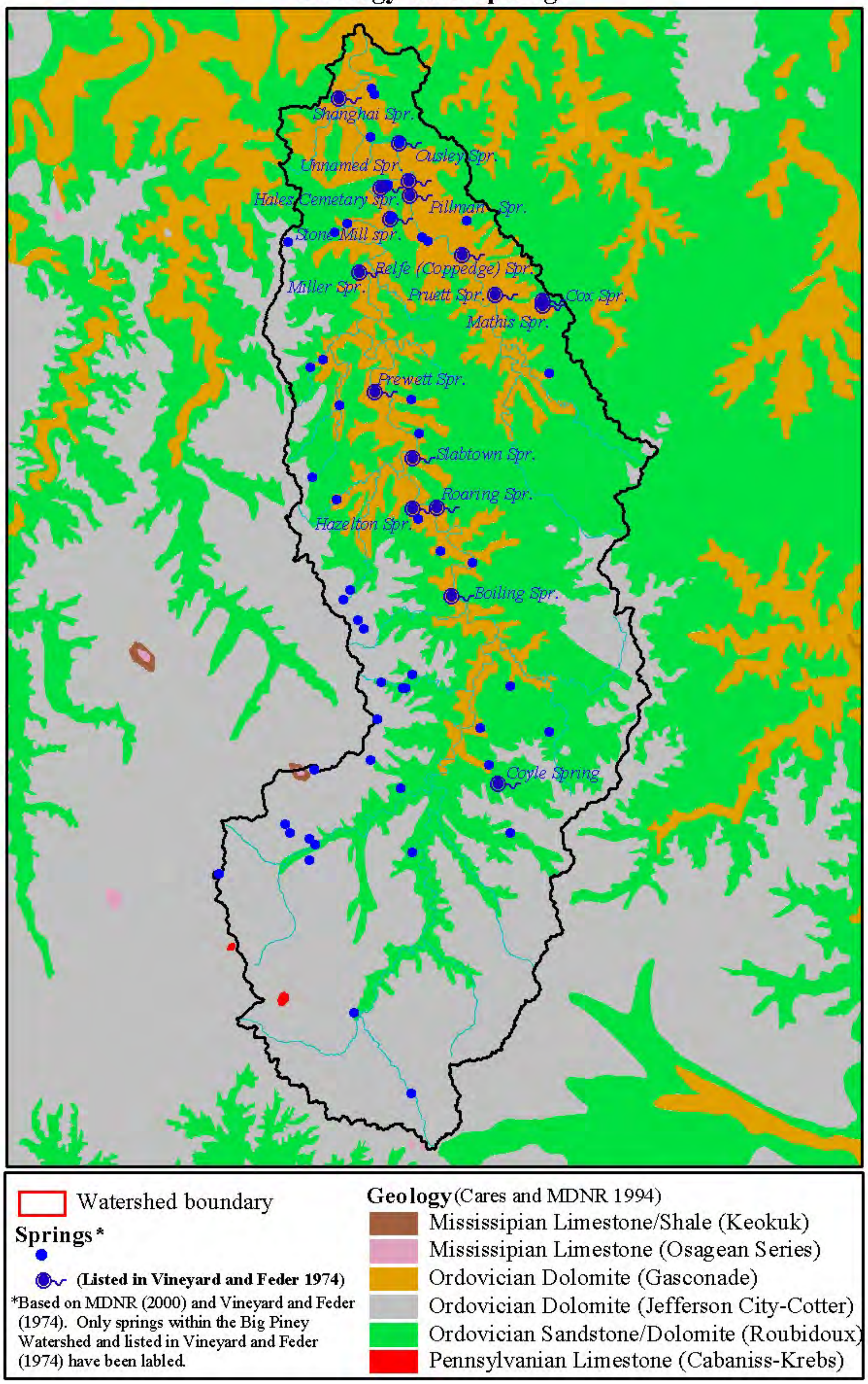


Figure Ge02.

Big Piney Watershed

Karst Features

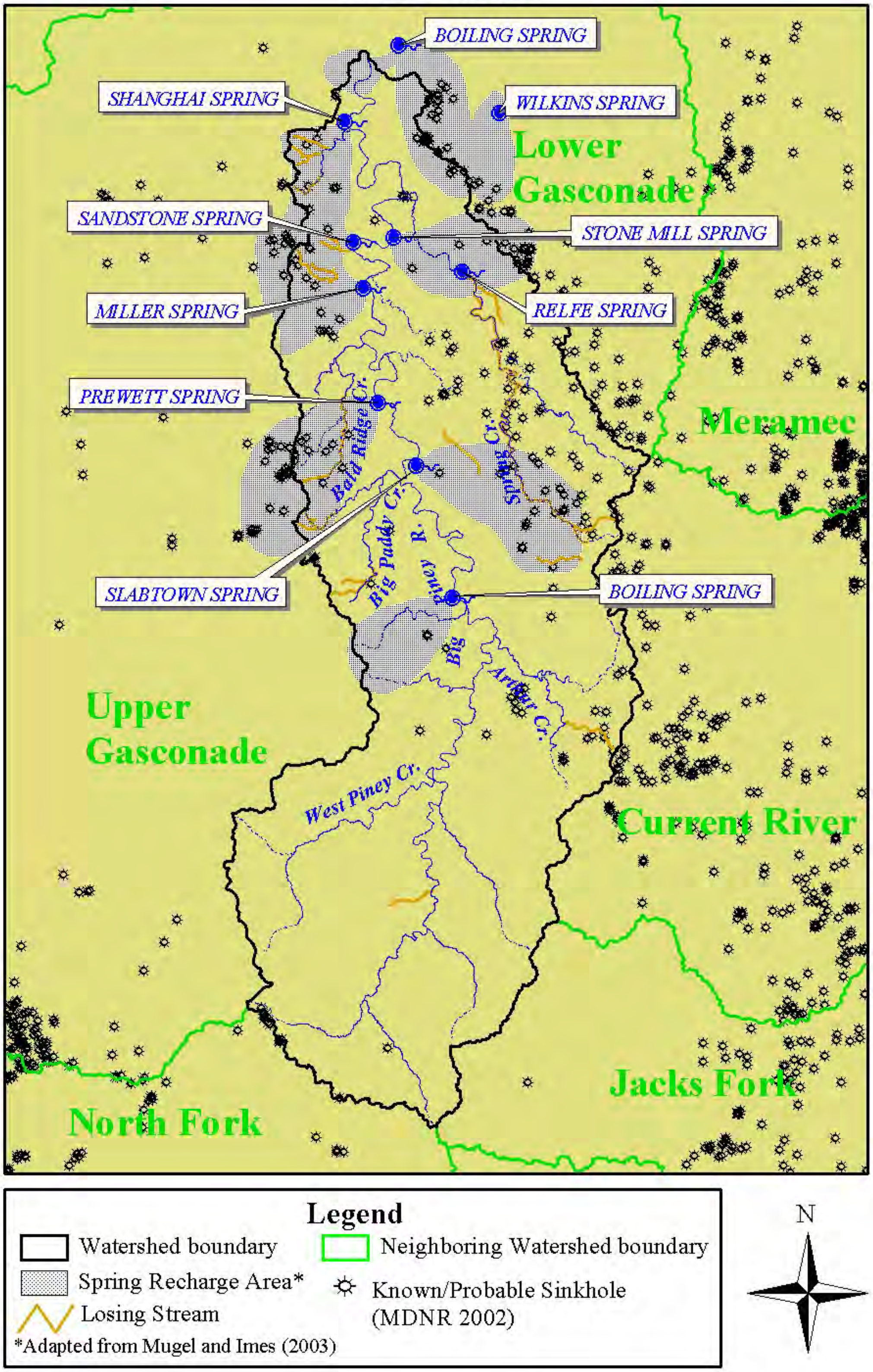
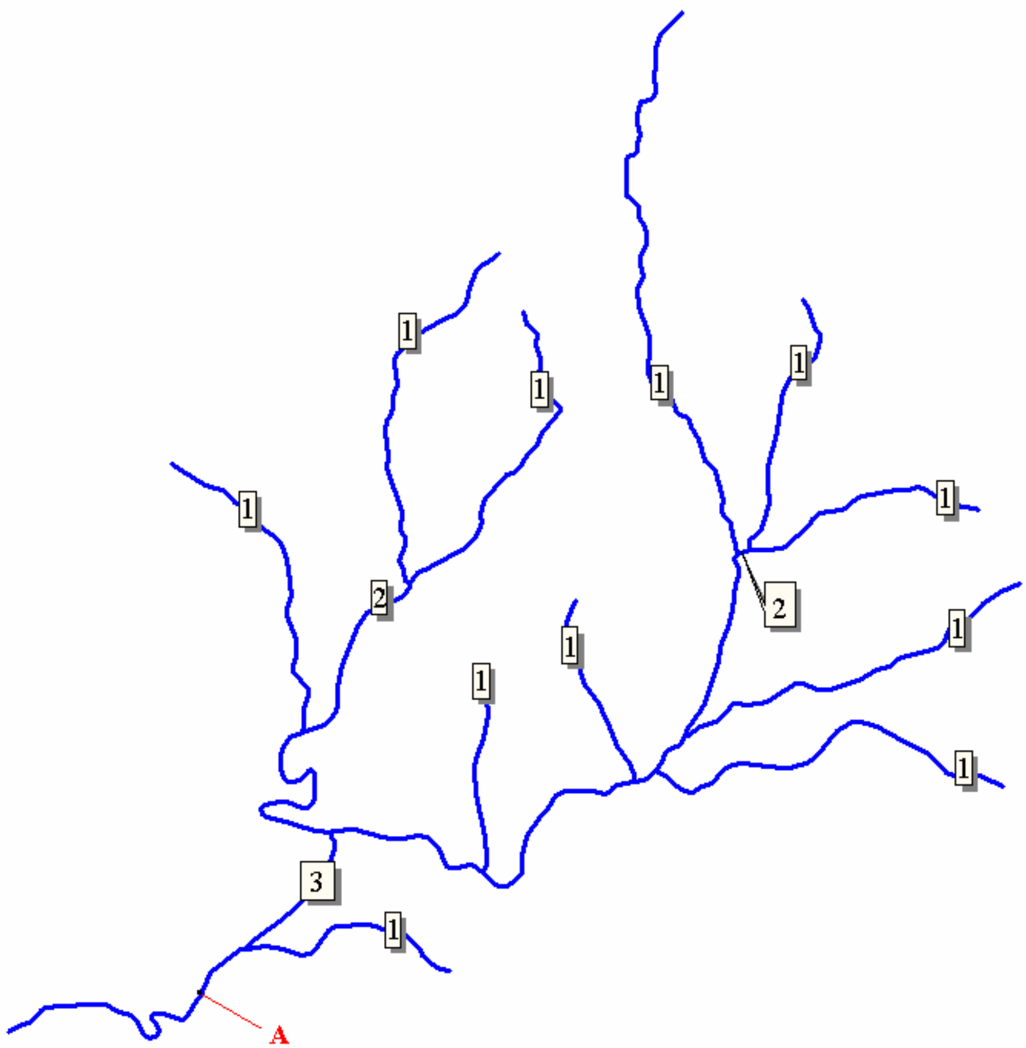


Figure Ge03. Example of Stream Order



The stream order at point "A" is 3.

Figure Ge04.

Lower Big Piney Streams
(Third Order and Larger)

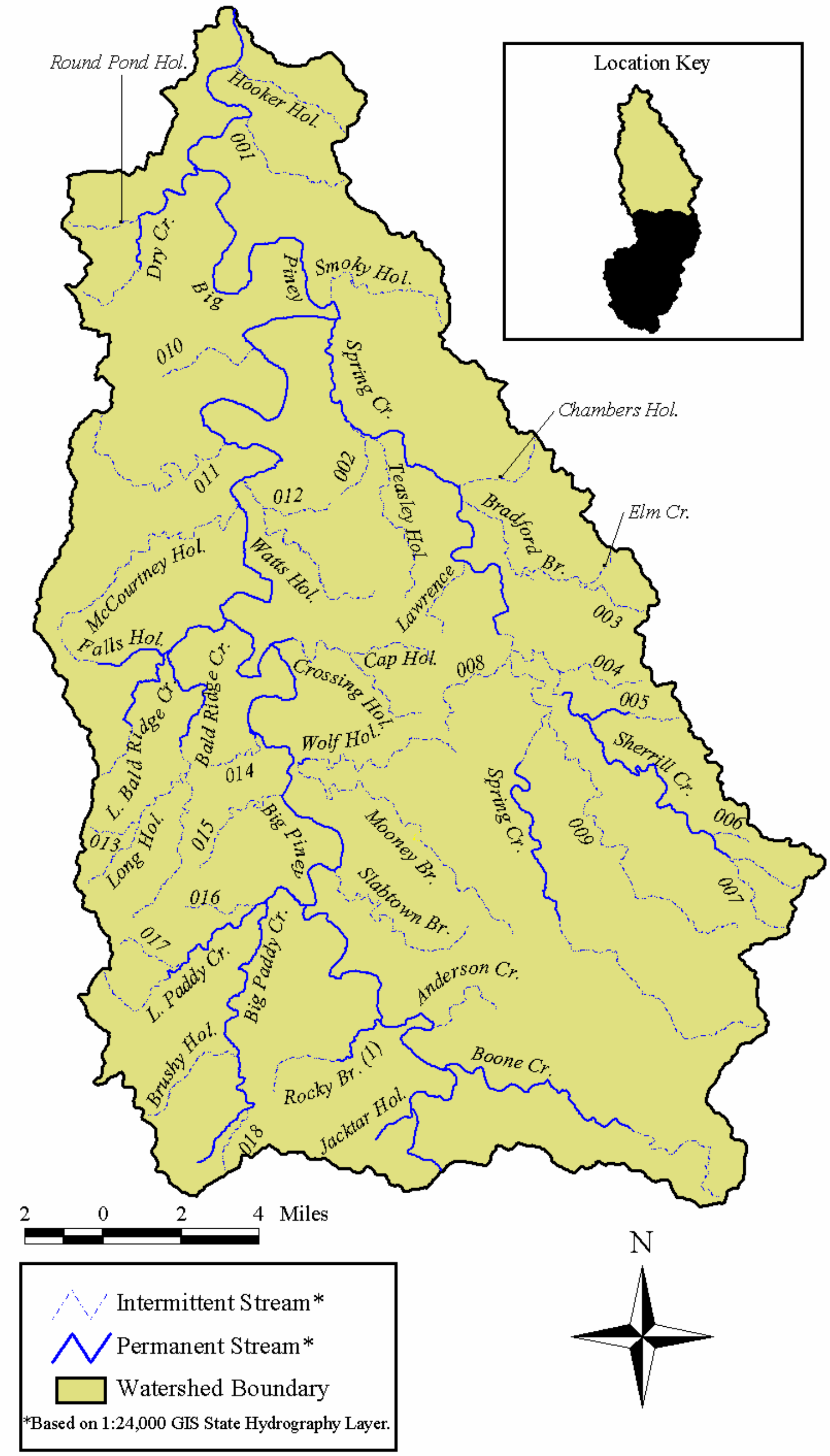


Figure Ge05. **Upper Big Piney Streams**
(Third Order and Larger)

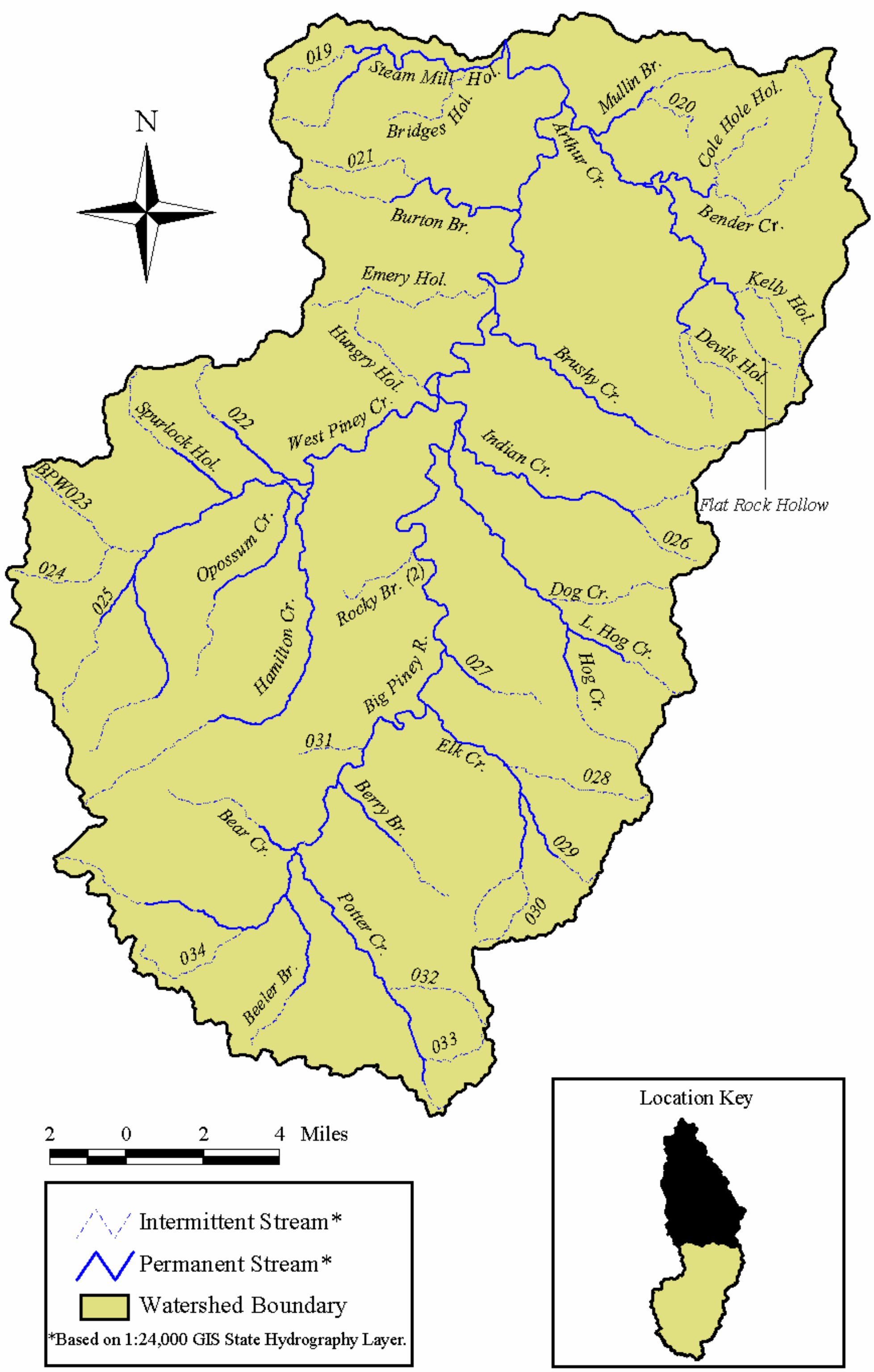


Figure Ge06.

Big Piney Watershed

Hydrologic Units & Subwatersheds

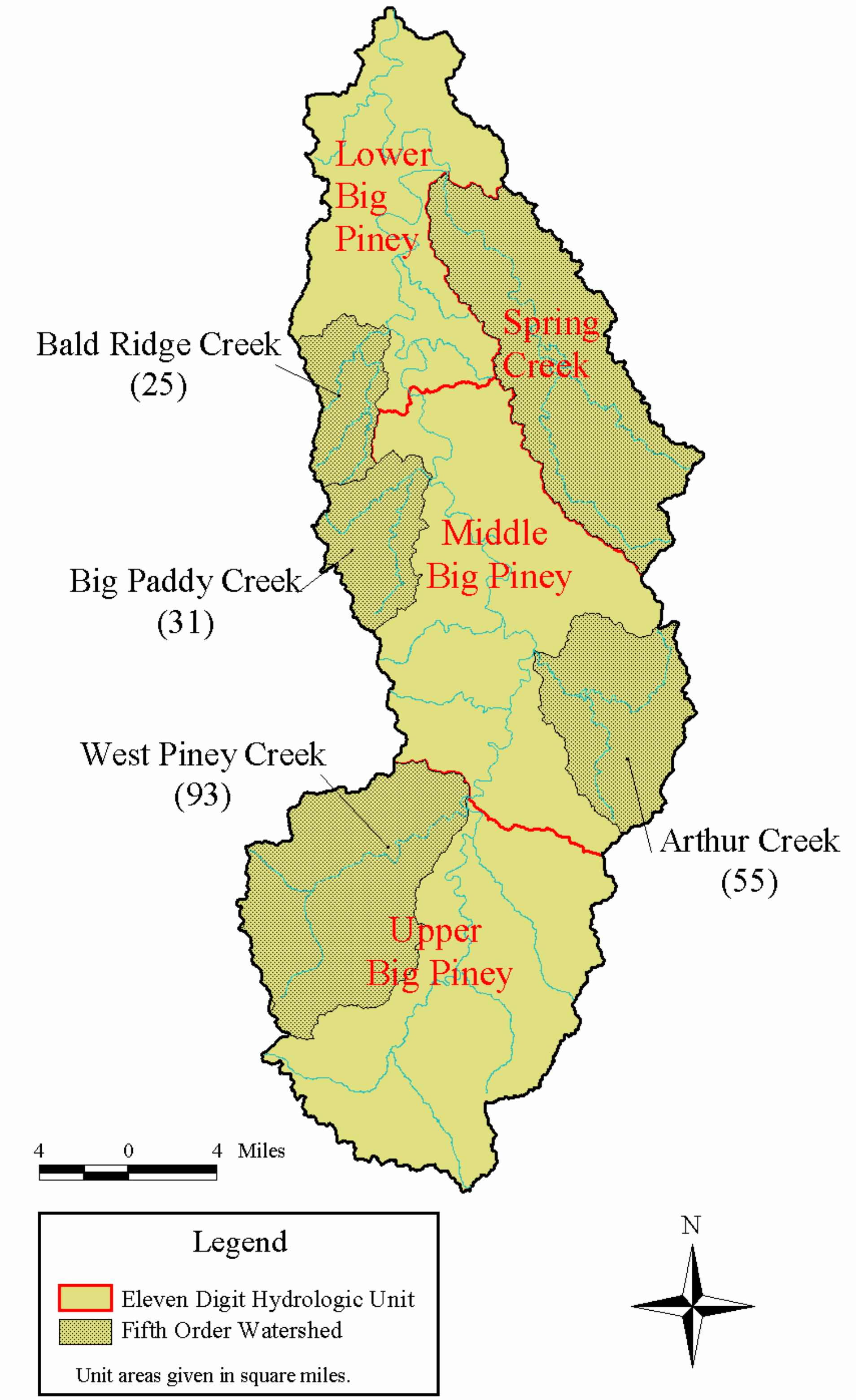


Figure Ge07.

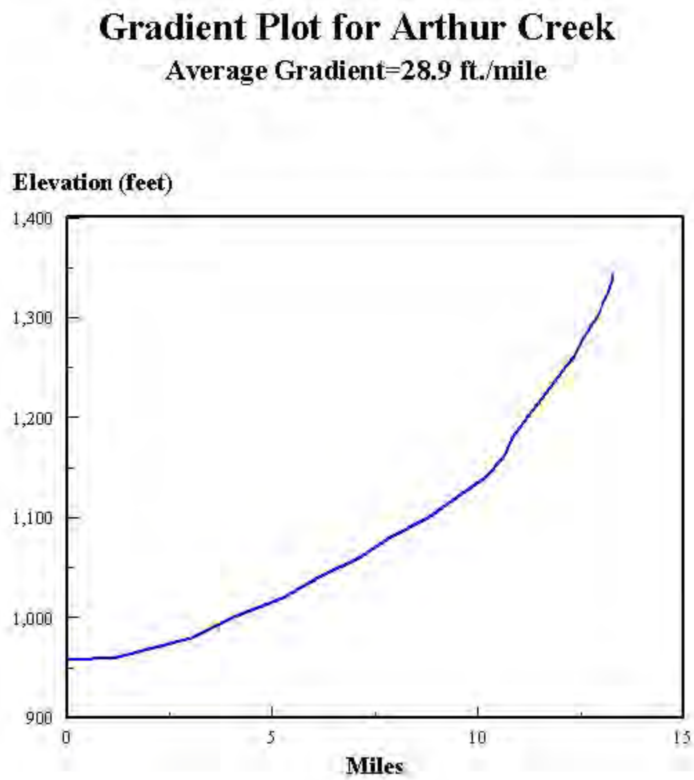


Figure Ge08.

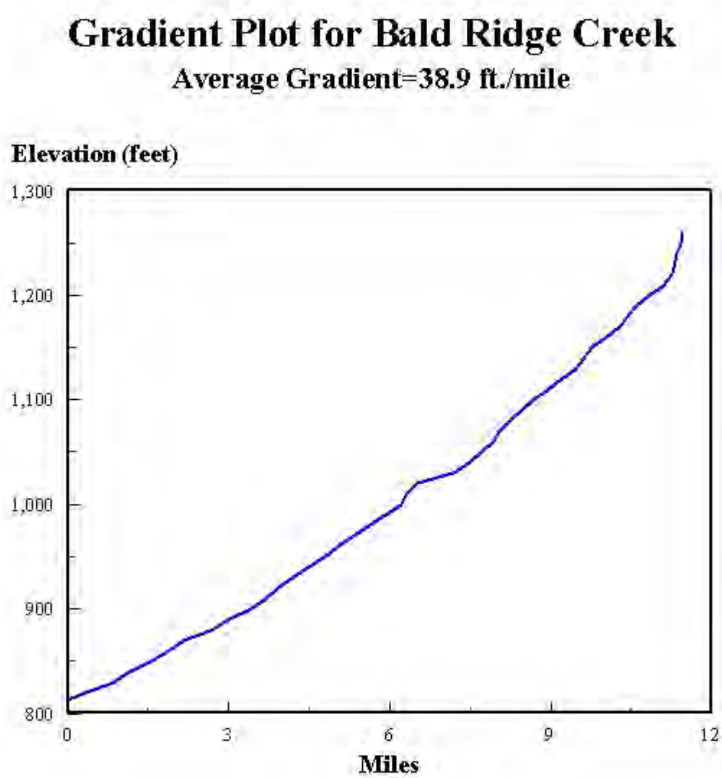


Figure Ge09.

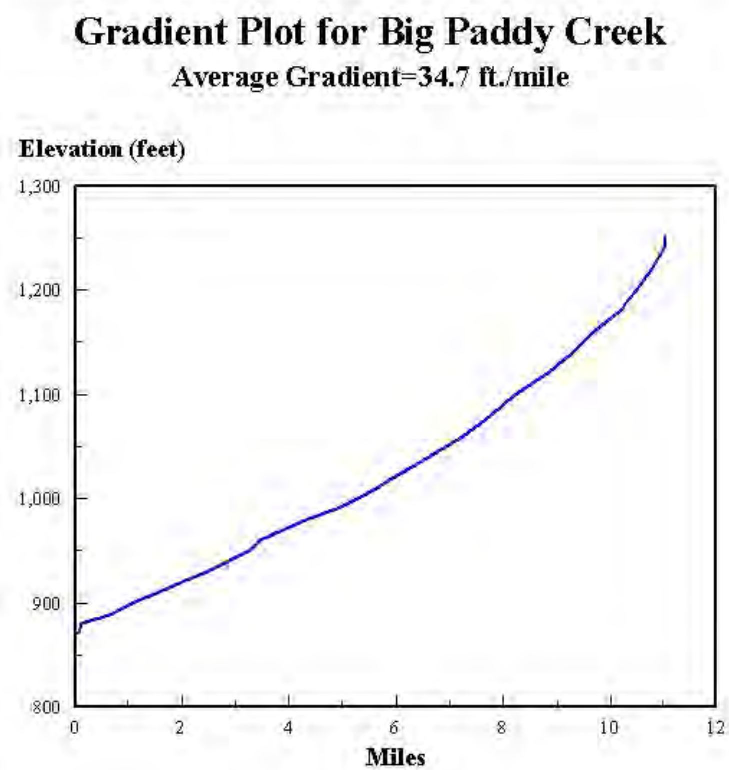


Figure Ge10

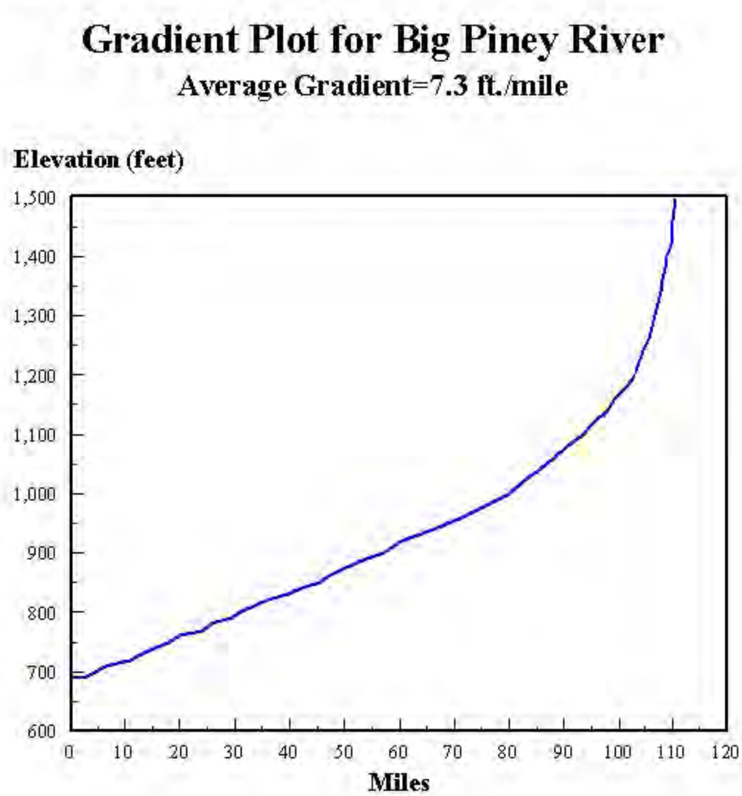


Figure Ge11

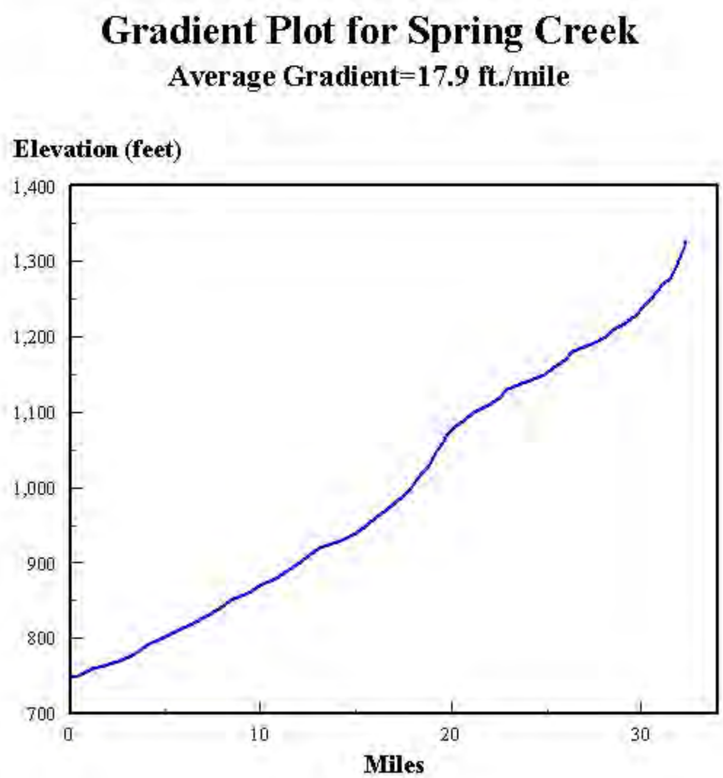
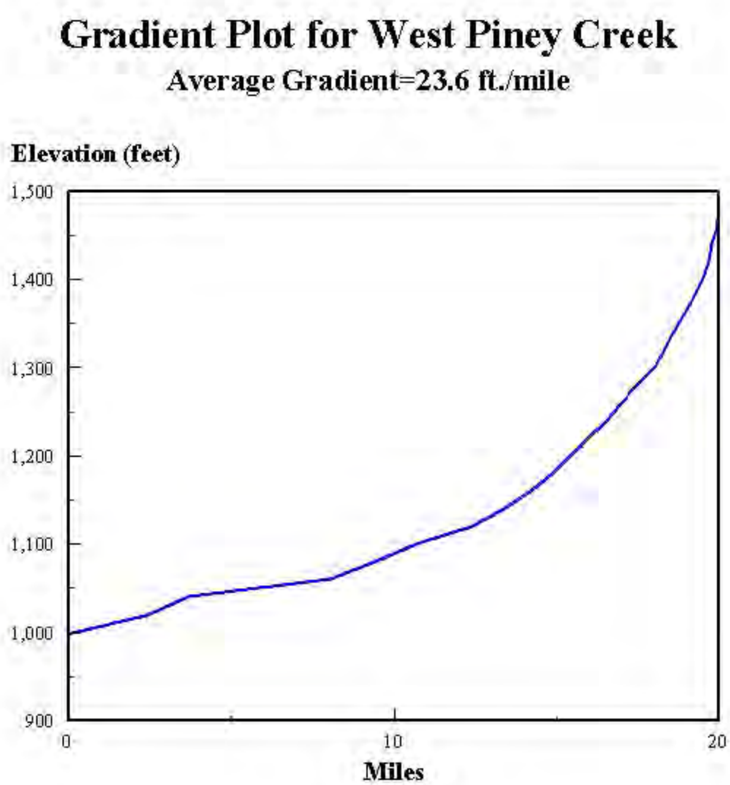


Figure Ge12



Land Cover/Land Use

Historic Land Cover/Land Use

Historical land cover within the uplands of the upper Big Piney Watershed probably consisted of open woodlands comprised of post oak and black oak with an understory of shrubs and grasses such as bluestem (MDC 1997a). Occasional savanna openings were also probably common. The more dissected areas of the uplands most likely consisted of mixed oak woodland and forest.

In the more central portion of the watershed, pine and oak-pine woodlands probably occurred on the uplands underlain by sandstones of the Roubidoux Formation, while oak and oak-pine forest probably dominated the lower slopes as well as more dissected portions of this area (MDC 1997a). In valley bottoms having rich alluvial soils, a forest of mixed hardwoods likely existed.

The land cover blanketing the rugged topography of the lower Big Piney watershed is believed to have consisted of oak and mixed hardwood forest open woodlands and scattered glades on exposed ridges and side slopes with occasional fens in narrow valleys (MDC 1998c).

The Ozark region was first discovered by Native American hunting parties (Rafferty 1980) (Jacobson and Primm 1994). Archeological evidence suggests that these early hunters initially concentrated their efforts on the Ozark fringe along the Missouri and Mississippi Rivers (Rafferty 1980). Initially, Native American peoples inhabiting the Ozarks subsisted as hunters, living in small, transient camps (Jacobson and Primm 1994). As Native American cultures on the fringes of the Ozarks gradually made the transition to a more settled agrarian existence in larger villages, inhabitants in Ozark Highlands, as reference by Chapman (1975 and 1980), probably continued existing as hunters/foragers; although it is suggested that the latter began living in larger, more permanent camps from which hunting and foraging activities were conducted. The limited degree of cultural change by groups in the Ozarks interior may have been the result of geographic isolation within the rugged topography of the Ozarks and/or the lack of suitable agricultural land in the interior, among other factors (Rafferty, 1980). While inhabitants of the Ozarks Fringe may have had occasional contact with isolated groups of interior inhabitants during hunting and gathering expeditions, local ecological factors were probably more influential on interior inhabitants (Chapman 1980).

Prior to the beginnings of European Settlement in the early 1700s, the larger agriculture-based villages in the central Mississippi valley on the Ozarks fringe had been abandoned. It is believed that a climatic shift to cooler, drier summers and the resulting failure of maize crops on which early agriculture was based, may have caused their abandonment (Chapman 1980, Jacobson and Primm 1994). Another contributing factor may have been the occurrence of various epidemics resulting from living in larger crowed villages (Chapman 1980). Whatever the cause(s), remnants of these villages and cultures are believed to have reassembled to form the Osage Tribe which existed throughout much of the Ozarks as European settlement of the area began to occur. (Jacobson and Primm 1994)

Native American use of fire, as well as naturally occurring incidences of fire (i.e. lightening strikes), are believed to have been a large factor in determining the types of vegetation found by Schoolcraft (1821) and others as exploration of the Ozarks interior began to occur after the Louisiana Purchase of 1803. Native Americans are believed to have set fires for many reasons including harassment of enemies as well as an aid in hunting. These fires stimulated warm- season grasses such as bluestem and eliminated woody undergrowth thus creating open woodlands or savannas.

European settlement of the Ozark fringe began in the early 1700's under French and, later, Spanish political control. After the Louisiana Purchase of 1803, American settlers began settling the same areas earlier occupied by the Spanish and French. The Osage, in treaty with the federal government, relinquished claims to much of the Ozarks interior in 1808, although they refused to relinquish their hunting rights in this area (Rafferty 1980). Settlement of the Ozarks Interior increased after the war of

1812 (Jacobson and Primm 1994). Many of the early settlers came from states such as Indiana, Illinois, Kentucky, Virginia, and Tennessee (Rafferty 1983). Most of these states were previously considered the frontier prior to the Louisiana Purchase, thus many settlers brought along skills they had learned for survival in frontier territory. Early settlers subsisted by hunting and fishing as well as maintaining gardens in the small bottomland areas which they cleared. In addition, early settlers raised livestock which grazed on the open range of the slopes and uplands in the summer. In the winter livestock were fed from forage crops cultivated and harvested from the bottom lands (Jacobson and Primm 1994). The annual practice of burning was continued by early settlers in order to enhance the livestock forage of the uplands. In addition to the influx of settlers of European origin which occurred after the war of 1812, Native American tribes such as the Cherokee, Shawnee, and Delaware, which had been displaced from the East, began moving through the region (Jacobson and Primm 1994). As the population of the area increased, more settlers were forced to settle the uplands (Ryan and Smith 1991). Fenced pasture began to replace the practice of open range. These two factors reduced the use of fire on the uplands, thus decreasing the grassland and savanna type land cover (Ryan and Smith 1991; Jacobson and Primm 1994). This region was only sparsely settled until the late 1800's, when the economic values of the vast timber resources were discovered.

Much of the virgin forest of the Ozarks remained relatively undisturbed by logging until the late 1800s (Cunningham and Hauser 1989). Within the Big Piney Watershed however, logging of the pines began as early as 1816 with sawmills being constructed along the Big Piney River during the preceding years (Ryan and Smith 1991; Jacobson and Primm 1994). By 1820, the Big Piney was being used to transport a large number of logs, as well as processed lumber products, which eventually made their way to St. Louis via the Gasconade and Missouri Rivers (Ryan and Smith 1991; Jacobson and Primm 1994). Williams (1904) gives insight into the exploitation of the pine forests in Texas County by the turn of the century when he states that pine was "formerly scattered throughout the county, but became predominant only in Jackson and Current townships bordering the southwest corner of Dent county. It is valued at $5.00 to $7.50 an acre making a total resource of approximately $100, 000; rapidly being converted into money".

As the pines began to be depleted and the importance of railroad transportation grew, logging of hardwoods for railroad ties, barrel staves, tool handles and other products increased. Williams (1904) stated that in Pulaski County, "railroad ties are a leading source of income to all farmers living within hauling distance of the railroad or rivers". Portable mills became common. In regard to the extent of timber exploitation in the Pulaski county, Williams (1904) states that by 1904, "two thirds of the timbered lands have been cut over and bordering the railroad and creeks, practically all merchantable size trees have been made into railroad ties and rough board lumber".

As the timber resource began to play out in the area, residents turned increasingly toward farming the rugged cut-over land in an attempt to eke out a means of survival. Initially row crop farming on an increased scale was attempted. This is exemplified by a sharp increase occurring between 1880 and 1900 in the acres of corn and wheat harvested within the counties of the Big Piney Watershed as shown in Figure Lu01. This type of land use would have undoubtedly contributed to erosion and thus sedimentation and an increased gravel load in the streams of the area. Over time, much of the area was found to be unsuitable for large scale row-cropping.

Figure Lu01 shows the relatively rapid decline of acres harvested of corn and wheat in the counties of the area after 1900. In many counties of the Ozarks, livestock populations experienced sharp increases as row cropping declined. Cattle populations within the counties of the Big Piney Watershed shared this trend, while hog populations experienced a relatively steady decline (Figure Lu02). The increase in cattle led to an increased need for pastureland and thus seasonal burning became commonplace once again to help increase and maintain open pasture. Hay also became an important crop. The number of acres of hay harvested in the watershed experienced a sharp increase after 1880, leveling off somewhat in 1910 and then experiencing a sharp spike in 1950. Between 1960 and 1996, the acres of hay harvested continued to increase. While it might be assumed initially that acres of hay harvested would be a direct reflection of the increase in cattle, the patterns don't appear to necessarily reflect each other perhaps owing to the possibility that counties of the watershed probably exported hay to other areas.

The era of modern natural resource management began in the Big Piney Watershed in the 1930s as the state and federal government began buying up the tired land. The largest purchaser of land within the watershed was the USFS. Initially, a large portion of natural resource rehabilitation

on USFS land was accomplished by the Civilian Conservation Corps (CCC); a work program of the Great Depression. In the Ozarks, CCC camps were established in various places to provide lodging for workers of the CCC. One such camp was established near St. Roberts Missouri (Sternberg et al. 1998). This camp would later become Fort Leonard Wood. The MDC, the state agency responsible for the management of the state's fish, forest, and wildlife, became established in 1937 and would be responsible for state natural resource management efforts in the watershed. Natural resource managers initiated reforestation programs, natural resource education, and fire suppression to name a few.

In an effort to determine the effects of land use changes on stream disturbance in the Ozark Region, Jacobson and Primm (1994) evaluated recent (1993) conditions of Ozark streams, pre- settlement period historical descriptions, stratigraphic observations, and accounts of oral- history responses on river changes during the last 90 years for the Jacks Fork River and Little Piney Creek Watersheds. This led Jacobson and Primm (1994) to the conclusion that Ozark streams are disturbed from their natural conditions. Jacobson and Primm (1994) state that this "disturbance has been characterized by accelerated aggradation of gravel, especially in formerly

deep pools, accelerated channel migration and avulsion, and growth of gravel point bars". Jacobson and Primm (1994) also suggest that "land use changes have disturbed parts of the hydrologic or sediment budgets or both".

As part of the effort to determine the effects Jacobson and Primm (1994) summarized the land use changes from pre-settlement conditions to the 1970's in the Little Piney Creek Watershed (Table Lu01) and summarized the following in regard to the Ozark landscape:

> *"Different types of land use have taken place on different parts of the landscape, and at different times, resulting in a complex series of potential disturbances. Uplands have been subjected to suppression of a natural regime of wildfire, followed by logging, annual burning to support open range, patchy and transient attempts at cropping, a second wave of timber cutting, and most recently, increased grazing intensity. Valley side slopes have been subjected to logging, annual burning, and a second wave of logging. Valley bottoms were the first areas to be settled, cleared, and farmed; removal of riparian vegetation decreased the erosional resistance of the bottom lands. More recently, some areas of bottomland have been allowed to grow back into forest. The net effects of this complex series of land- use changes are difficult to determine and separate from natural variability."*

Jacobson and Primm (1994) offer the following observations which summarize the probable, qualitative changes to runoff, soil erosion, and riparian erosional resistance on parts of the Ozarks landscape relative to man's impact (Table Lu02):

- Initial settlement of the Ozarks may have initiated moderate channel disturbance because of decreased erosional resistance of cleared bottom lands. This trend would have been countered by decreased annual runoff and storm runoff that accompanied fire suppression in the uplands.
- Because of low-impact skidding methods and selective cutting during initial logging for pine during the Timber-boom period, logging would have had minimal effects on runoff and soil erosion. Low- impact methods and selective cutting continued to be the norm in timber

harvesting of hardwoods until the late 1940's, when mechanization and diversified markets for wood products promoted more intensive cutting. Locally, log and tie jams, tie slides, and logging debris may have added to channel instability by diverting flow, but because aggradation and instability also occurred on streams not used for floating timber, these factors were not necessary to create channel disturbance.

- Significant channel disturbance probably began in the Timber-boom period because of continued clearing of bottom land forests and road building in the riparian zone. This hypothesis is supported by evidence that significant stream disturbance began before the peak of upland destabilization in the post-timber- boom period. Extreme floods during 1895 to 1915 may have combined with lowered erosional thresholds on bottom lands to produce the initial channel disturbance.
- The regional practice of annual burning to maintain open range had the most potential to increase annual and storm runoff and soil erosion because of its considerable areal extent and repeated occurrence. Burning would have been most effective in increasing runoff and erosion on the steep slopes that had been recently cut over during the timber boom. Generally, accelerated soil erosion was not observed after burning, and relict gullies presently (1993) are not apparent on valley-side slopes and uplands. These observations support the hypothesis that burning did not produce substantial quantities of sediment.
- The greatest potential for soil erosion on valley slopes and upland areas occurred during the post-timber-boom period when marginal upland areas were cultivated for crops. Accelerated erosion of plowed fields was observed and noted by oral- history respondents and by soil scientists working in the Ozarks during the post- timber-boom period.
- Valley bottoms have the longest history of disturbance from their natural condition because they were the first to be settled, cleared, and farmed. The lowered resistance to stream erosion that results from removing or thinning riparian woodland would have been a significant factor, especially on small to medium sized streams for which bank stability and roughness provided by trees are not overwhelmed by discharge. Disturbance of bottom land riparian forest increased as free-range grazing, crop production, and use of valley bottoms for transportation expanded and reached a peak in the post-timber-boom period. Headward extension of the channel network because of loss of riparian vegetation may have increased conveyance of the channel network (and hence flood peaks downstream) and removed gravel from storage in first and second order valleys at accelerated rates. This hypothesis is supported by a lack of other source areas for gravel and by observations that gravel came from small stream valleys, not off the slopes.
- During present (1993) conditions, channel instability seems somewhat decreased in areas where the riparian woodland has recovered, but stability is hampered by high sedimentation rates because of large quantities of gravel already in transport and effects of instability in upstream reaches that lack a riparian corridor.
- Land use statistics indicate that the present trend in the rural Ozarks is toward increased populations of cattle and increased grazing density. This trend has the potential to continue the historical stream-channel disturbance by increasing storm runoff and sediment supply and thus remobilization of sediment already in transit.

The combined human populations of the counties (Phelps, Pulaski, and Texas) of the Big Piney River Watershed experienced net growth between 1900 and 1990 of approximately 110% (Figure Lu03) (OSEDA 1998). Statistics for the individual counties indicate that while Texas County experienced a net decline in population of 3%, the counties of Phelps and Pulaski experienced increases of 148% and 297% respectively. The dramatic increase in population in

Pulaski County, as well as the combined population increase in the counties of the Big Piney Watershed overall, is undoubtedly largely due to the reactivation of FLW in 1950 and the associated influx of military as well as civilian personnel associated directly and indirectly with the activity and business generated by Fort Leonard Wood.

The 2000 human population within the Big Piney Watershed was estimated to be 31, 144 persons (Blodgett J. and CIESIN 1996). This is a 1.8% decrease from the estimated 1990 population.

Population density in 2000 was approximately 41.3 persons per square mile as compared to the overall population density for Missouri which was approximately 80.3 persons per square mile (Figure Lu04). Of course, one must take into account the effect of the state's urban centers on this estimate.

Projections of human population increase of Missouri counties have been calculated by the Missouri Office of Administration (MOA), Division of Budget and Planning for three different projection scenarios in a report entitled "Projections of the Population of Missouri Counties By Age, Gender, and Race: 1990 to 2020" (MOA 1999). Combined population estimates for Phelps, Pulaski, and Texas Counties from 2000-2020 have been used to calculate percent increase in population for three scenarios. The difference in scenarios is based on calculated long-term, recent, and zero migration. The scenarios project a combined population increase of 20.0%, 25.8%, and 20.7% respectively by the year 2020.

Ecological Classification

The Ecological Classification System (ECS) is a management tool which provides a means of "describing distribution of current and potential natural resources in a manner that considers land capability upfront" using a knowledge of landform, geology, soils, and vegetation patterns (MDC 1997a). There are several levels of classification within the ECS. For purposes of this document the three lowest levels are dealt with. These levels are, in descending order, section, subsection, and land type association (LTA). The Big Piney Watershed intersects 1 sections, 2 subsections and 11 LTAs.

The Ozark Highlands Section is the only ecological section intersected by the Big Piney Watershed. This section consists of very old and highly weathered plateaus which, coupled with its physiographic diversity and central geographic location relative to the continent, has created a region of unique ecosystems harboring many endemic species (MDC 1997a).

The subsections intersected by Big Piney Watershed include the Gasconade River Hills and the Central Plateau (Figure Lu05).

The Gasconade River Hills Subsection

The Gasconade River Hills Subsection "intersects a substantial portion of the Ozark Region on the north. This subsection is associated with the hilly and dissected lands flanking the Big and Little Piney Rivers and the Gasconade River and its tributaries. These streams cut from the Jefferson City-Cotter formation, through the Roubidoux into the Gasconade formation. They also have mainly deep, cherty heavily leached soils which support oak and oak-pine woodland and forest." (MDC 1997b).

The Central Plateau Subsection

The Central Plateau Subsection "represents the high, flat to gently rolling plains that are the least eroded remnant of the Salem Plateau. Underlain primarily by Jefferson City-Cotter dolomites or Roubidoux sandstone/dolomite, the plains are often mantled in a thin layer of loess and have droughty soils. Streams are mainly intermittent, low gradient headwater streams that are often losing. Savannas and woodlands were originally the dominant vegetation types" (MDC 1997a).

Land Type Associations (LTAs) represent the smallest level of the three levels previously mentioned (Figure Lu05). LTAs intersecting the Big Piney Watershed include the Following:

- Middle Gasconade River Oak Woodland/Forest Breaks (13.4%)
- Little Piney Oak Woodland Dissected Plain (1.2%)
- Upper Gasconade Oak Woodland Dissected Plain (37.7%)
- Big Piney Hills Oak Woodland Dissected Plain (4.4%)

- Licking Oak Savanna/Woodland Plain (6.4%)
- Ft. Wood Oak Savanna/Woodland Plain (0.7%)
- Big Piney Oak Woodland Dissected Plain (5.8%)
- Big Piney River Oak-Pine Woodland/Forest Hills (18.7%)
- Big Piney Pine-Oak Woodland Dissected Plains (4.0%)
- Cabool - Mt. Grove Oak Savanna/Woodland Plain (0.4%)
- North Fork River Oak-Pine Woodland/Forest Hills (0.1%)

Table Lu03 gives descriptions of LTAs within the watershed.

The ECS could prove to be a useful tool for planning and implementing management activities by providing an indication of what natural resource management options will be more adapted to specific areas thus increasing the success of management decisions as well as helping to ensure that management decisions are ecologically enhancing.

Current Land Cover

Approximately 62.7% of the Big Piney Watershed is forested based on analysis of MoRAP (1999) Missouri Land Cover data. Grassland is the second most prevalent land cover accounting for about 36.6% of the total watershed area. The categories of cropland and urban account for approximately 0.1% and 0.6% of the total watershed area respectively, while the land cover category of water accounts for approximately 0.1% of the watershed area (Table Lu04, Figures Lu06 and Lu07). Forest cover is the most dominant land cover type in all eleven digit hydrologic units within the watershed except the Upper Big Piney. The Lower Big Piney unit has the highest percentage of forest cover at 80.8%, while the Upper Big Piney unit has the lowest at 44.9%. This unit also has, by far, the largest percentage of grassland at 54.7%.

Soil and Water Conservation Projects

There are no Agricultural Nonpoint Source Special Area Land Treatment (**AgNPS-SALT**), EARTH, or **PL-566** projects within the Big Piney Watershed. A Special Area Land Treatment (**SALT**) project was conducted in a large portion (42, 880 acres) of the West Piney Watershed between 1995 and 1999 (MDNR 2003). Within this area, 8, 157 acres were identified as needing treatment and 6, 724 acres received treatment. Goals of the project included "Control soil erosion on woodland and pastures using no-till, livestock exclusion, streambank stabilization and good forage and woodland management".

Public Land

Knowledge of land ownership within a watershed is an important key to understanding various characteristics of a watershed as well as addressing watershed related issues and concerns.

Within the Big Piney Watershed, approximately 24% (114, 972 acres) of land is under public ownership (Table Lu05 and Figure Lu08). The USFS holds the largest amount of publicly owned land totaling 88, 942 acres. This is followed by the Department of Defense (FLW 24, 133 acres) and the Missouri Department of Conservation (1, 896 acres). The public land within the watershed includes approximately 109 miles of permanent stream and 14 stream accesses.

Analysis of land ownership percentages within eleven digit hydrologic units reveals that the Upper Big Piney Unit has the smallest percentage of public land at 3.4%, all of which is managed by the MDC (Table Lu06 and Figure Lu09). The Lower Big Piney Unit has the highest percentage of public land at 69.0%. The majority of this land is managed by the Department of Defense (as part of FLW) and the USFS.

Table Lu01. Land cover/ land use change from pre -settlement period conditions (1820's) to the 1970's in the Little Piney Watershed, Missouri (Jacobson and Primm 1994).

1820’s Category	1970’s Category	Area sq. miles	% Change From 1820’s
Shrub and brush rangeland	Urban/developed	0.9	0
	Reservoirs	0	0
	Pasture/cropland	36.4	22
	Deciduous forest	123.4	76
	Evergreen Forest Land	2.4	1
	Mixed Forest Land	<0.1	0
Deciduous forest	Urban/developed	4.3	2
	Reservoirs	0.4	0
	Pasture/cropland	82.8	25
	Deciduous forest	151.0	75
	Evergreen forest land	0.1	0
	Mixed forest land	0.4	0
	Barrens	0.4	0
Mixed forest	Deciduous forest	1.6	100
Barrens	Urban/developed	0	0
	Pasture/cropland	7.6	39
	Deciduous forest	11.9	61

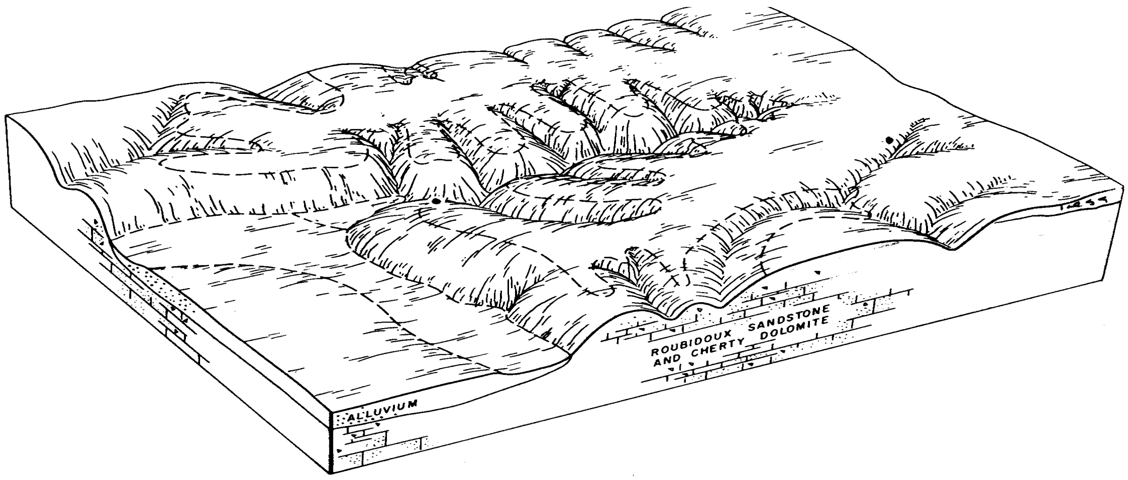
Table Lu02. Summary of probable qualitative changes to runoff, soil erosion, and riparian erosional resistance on parts of the Ozarks landscape relative to pre -settlement period conditions. Reproduced in whole from Jacobson and Primm (1994).

Period	Uplands	Valley Slopes	Valley Bottoms
Pre-settlement	Baseline	Baseline	Baseline
Early Settlement			
Annual Runoff	Decrease	Slight Increase	N/A
Storm Runoff	Decrease	Slight Increase	N/A
Upland Sediment Yield	Decrease	Slight Increase	N/A
Riparian Erosional Resistance	N/A	N/A	Moderate Decrease
Timber-Boom			
Annual Runoff	Slight Increase	Slight Increase	N/A
Storm Runoff	Slight Increase	Moderate Increase	N/A
Upland Sediment Yield	Slight Increase	Moderate Increase	N/A
Riparian Erosional Resistance	N/A	N/A	Decrease
Post-Timber-Boom			
Annual Runoff	Moderate Increase	Increase	N/A
Storm Runoff	Moderate Increase	Increase	N/A
Upland Sediment Yield	Moderate Increase	Increase	N/A
Riparian Erosional Resistance	N/A	N/A	Substantial Decrease
Recent			
Annual Runoff	Slight Increase	Slight Increase	N/A
Storm Runoff	Slight Increase	Moderate Increase	N/A
Upland Sediment Yield	Slight Increase	Slight Increase	N/A
Riparian Erosional Resistance	**N/A**	**N/A**	Decrease

N/A=Not Applicable

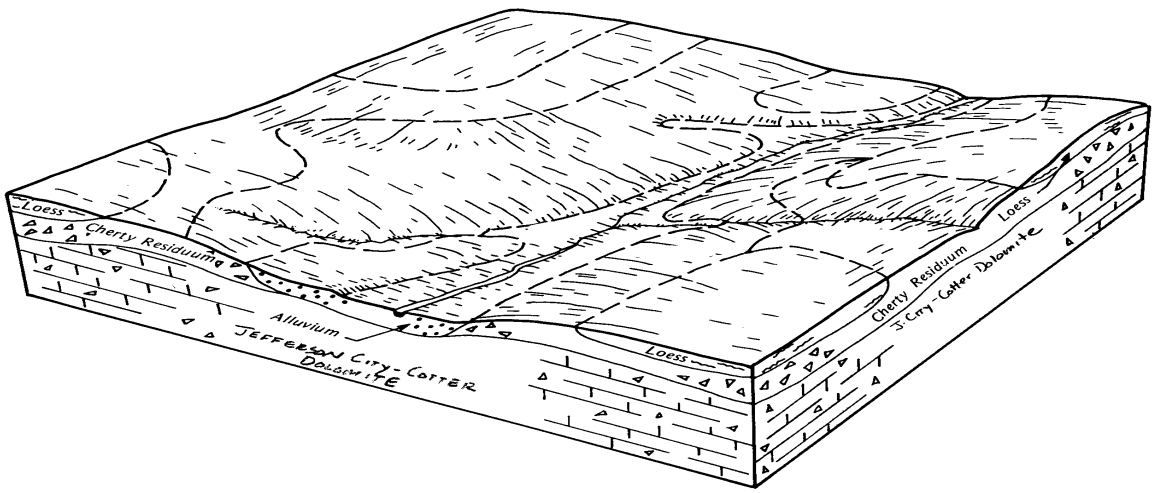
Table Lu03. Descriptions of land type association (LTAs) groups as well as a condensed description of the 11 LTAs (underlined in bold with percentage of watershed in parenthesis) within the Big Piney Watershed. Descriptions and figures taken in part or whole from MDC (1997a, 1998b, and 1998c).

Pine-Oak Woodland Dissected Plains



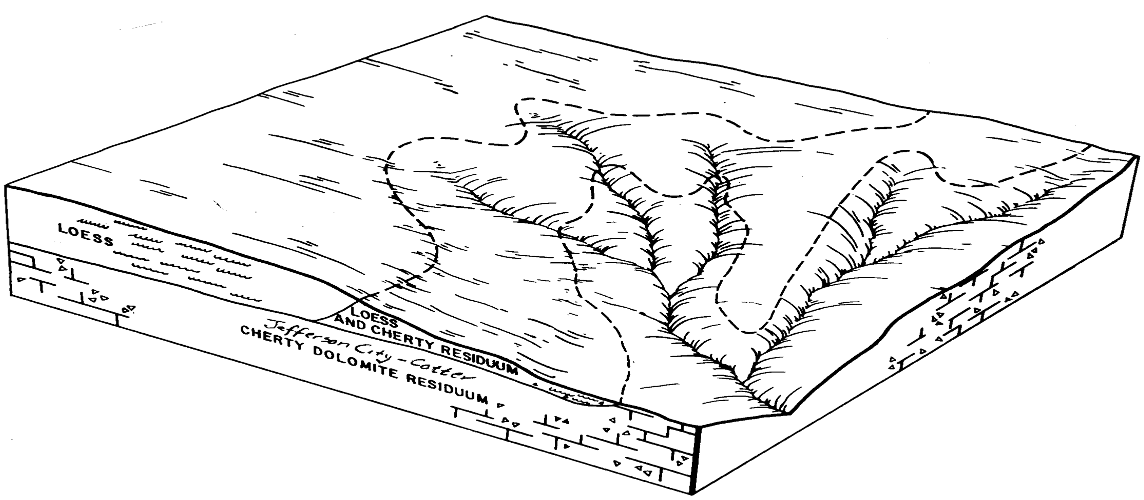
- **Landform:** Broad, flat to gently rolling plains which give way to moderately dissected and sloping lands associated with the headwaters of major drainages. Valleys are broad and local relief 100-150 feet. Clusters of karst sinkholes are common. Streams are mainly headwater streams with flashy, intermittent flow.
- **Geology:** Underlain by cherty sandstone and dolomite of the Roubidoux Formation with frequent loess deposits on the flatter uplands.
- **Soils:** Soils are formed principally in cherty sandstone and dolomite residuum from the Roubidoux Formation. Soils are mainly deep, cherty, and highly weathered, low base soils. However occasional fragipans and shallow to bedrock soils do occur. Most soils are extremely well drained and droughty.
- **Historic Vegetation:** Originally covered in woodlands of shortleaf pine and mixed pine oak with an open understory of dense grass and shrub ground cover. Post oak woodlands occupied occasional loess covered flats. Unique sinkhole ponds dotted the landscape.
- **Current Conditions:** Over 75% of this group are currently forested in dense, even-age oak and oak-pine forest. Only 20% of these forests have a strong pine component. However, the proportion of forests containing shortleaf pine is the highest in this group. Dense stands of near even age scarlet, black, and post oak occur in the place of pine. Understories are dense, woodland ground flora sparse, and oak die-back common. A substantial component of these forested lands are publicly owned. Approximately 20% of this group is currently pasture, which often occupies the broad valley bottoms or karst plains. Most sinkhole ponds have been drained, dozed or severely overgrazed. Headwater streams are subject to grazing and bank erosion.

Oak Woodland Dissected Plains and Hills Group



- **Landform:** Distinguished by rolling to moderately dissected topography. Local relief is 75-150 feet. Very broad, flat ridges give way to gentle side slopes and broad stream valleys. Karst plains with frequent shallow sinkhole depressions are common. Broad stream valleys most often occupied by losing streams, however occasional seeps do occur and can spread across substantial portions of a valley.
- **Geology:** Commonly underlain by Jefferson City-Cotter dolomites with a common loess cap. Some minor areas underlain by Roubidoux sandtones.
- **Soils:** Soils are variable, ranging from shallow to bedrock and fragipan soils, to deep, cherty and well-drained loams. Tree root growth is often restricted by bedrock, pans or clay mineralogy, especially high in the landscape.
- **Historic Vegetation:** Open woodlands with occasional prairie and savanna openings was the principal vegetation type. Post oak and black oak were the principal woodland tree species. Historic fire likely played an important role in maintaining an open canopy, sparse understory and a dense herbaceous ground flora. More dissected lands likely contained mixed oak woodland and forest. Unique sinkhole ponds, wet prairies and seeps were scattered in the broad valleys and depressions.

Oak Savanna/Woodland Plains Group

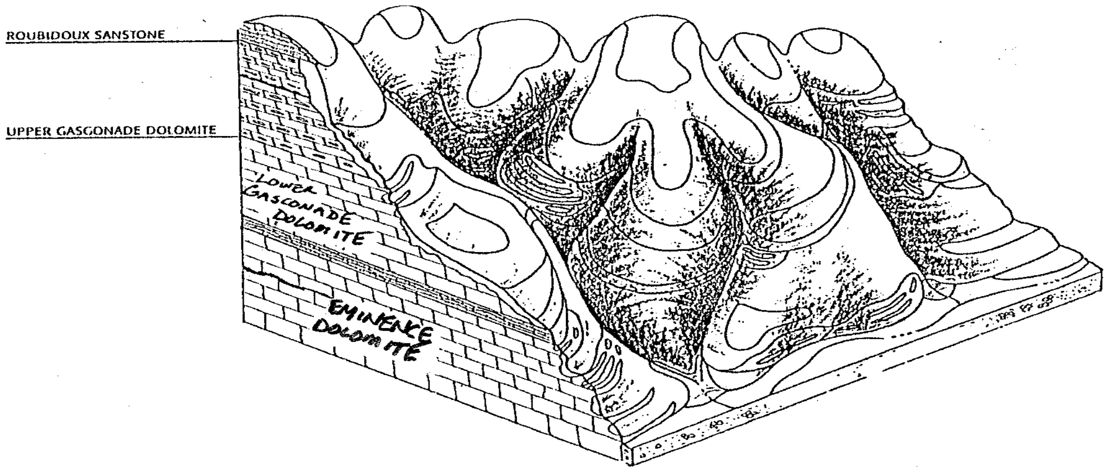


- **Geology:** Underlain mainly by Jefferson City-Cotter dolomites with a common loess cap.

Minor areas of the Roubidoux formation occur. Headwater streams are nearly all losing.

- **Soils:** Fragipan soils or soils with shallow restrictive clays or bedrock are common, inhibiting tree root growth.
- **Historic Vegetation:** Oak savannas and woodlands with common prairie openings were the predominant historic vegetation. While few prairies were named by original land surveyors, early descriptions portray an open, "oak prairie" landscape. Fire likely played a principal role in maintaining a grassland-open woodland structure. Some sinkhole depressions would have had unique ponds and seeps.
- **Current Conditions:** The largest blocks and greatest acres of grassland (45-65% cover) are currently associated with these LTAs; grasslands are mainly fescue pasture. Less than 40% of these LTAs are timbered, mainly in dense, second growth oak forest (post and black oaks) with common grazing pressure. Very few quality native prairies, savannas, woodlands, sinkhole ponds or seeps are known. Many of the regions roads, towns, and businesses are associated with these LTAs.
- **Licking Oak Savanna/Woodland Plain: (6.4%)**: Long, linear flat divide between Big Piney on the west and Current/ Meramec drainages on the east.
- **Ft. Wood Oak Savanna /Woodland Plain: (0.7%)**: Small, flat upland between Big Piney and Roubidoux creek.
- **Cabool-Mt. Grove Oak Savanna/Woodland Plains: (0.4%)**: Two narrow, high, flat divides between Gasconade and North Fork drainages.

Ozark Oak Forest Breaks

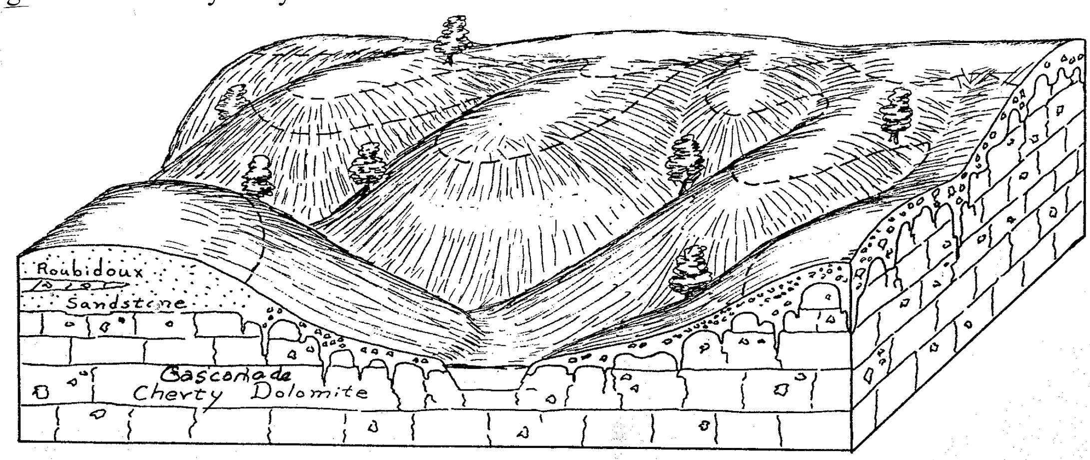


- **Landform:** These LTAs are distinguished by local relief over 300 feet, narrow ridges, steep side slopes and mainly narrow, sinuous valleys. Cliffs, caves and springs are common. These LTAs represent the most rugged and certainly some of the most scenic landscapes in the region.
- **Geology:** The Current and Meramec Breaks differ from the Gasconade by having only a thin layer of Roubidox sandstone on the highest ridges, but cut deeply through the Gasconade formation into the Eminence dolomite, consequently exposing the Gunter sandstone. Consequently, unique benches occur on the Gunter sandstone, and extensive areas of more productive, higher base soils with oak and mixed hardwood forest communities occur here. The breaks along the Gasconade have a thick cap of Roubidoux sandstone on ridges and upper slopes, give way abruptly from the Plains, and only cut into the Lower Gasconade dolomite.

- **Soils:** Areas of shallow soils are frequent with deeper cherty loam soils above and below them.
- **Historic Vegetation:** Historic accounts indicate that these LTAs were originally forested in Oak and Mixed Hardwood Forest Types. Scattered glades and open woodlands would have occurred on exposed slopes and ridges, especially in areas of shallow soil. Relatively small fen openings occasionally filled narrow tributary valleys.
- **Current Conditions:** Because of the steep topography, these LTAs are still mainly forested (65- 85%) in second growth oak and mixed hardwood timber. Open areas are confined to valleys, and bottomland forest is in shorter supply than historically. Dolomite glades are largely overgrown with eastern red cedar, and many of the fens have been drained or heavily grazed. Numerous rare or endangered species, some restricted to these LTAs, are associated with the streams, springs, caves, cliffs and fens in these landscapes. The rivers have been recognized as natural treasures and are an important recreational resource to the entire region.
- **Middle Gasconade River Oak Woodland/Forest Breaks: (13.4%)**: Very steep lands in middle of valley with abrupt fall from adjacent Plains; Roubidox sandstone ridges/upper slopes and Gasconade side slopes/valley bottom.

Oak-Pine Woodland Forest Hills Group

- **Landform:** Mainly broad ridges, moderately sloping (<25%) side slopes, and relatively broad entrenched valleys with local relief between 150-250 feet. Steeper, more dissected areas occur locally near larger stream valleys. Sinkhole depressions are common on broader ridges. Stream valleys vary some



what from broad and rather shallow, to more deeply entrenched, narrow, and meandering. Many losing streams occur in valleys distant from the main rivers. Cliffs, caves and springs are commonly associated with larger, perennial stream valleys.
- **Geology:** Roubidoux cherty sandstones and dolomites occupy most ridges and upper side slopes, while lower side slopes, especially near major streams are in cherty upper Gasconade dolomite materials.
- **Soils:** Soils are mainly deep, highly weathered and very cherty silt loams with clays at varying depth. Broad ridges may have a loess cap with occasional fragipans, and shallow soils with dolomite bedrock near the surface occur frequently on steeper, exposed slopes.
- **Historic Vegetation:** Pine and mixed oak-pine woodland originally dominated the more gently sloping upland surface associated with the Roubidoux Formation. Early descriptions portray an open, grassy and shrubby understory in these woodlands, a condition related to the

prevalence of fire in the historic landscape. Oak and oak-pine forest occupied lower slopes and more dissected, hilly parts of these landscapes, as well as the wider and more well-drained bottom.
Bottoms with richer alluvial soils and more abundant water likely were forested in mixed hardwood timber. Dolomite glade and open savanna/woodland complexes were common on exposed slopes with shallow soils. Sinkhole ponds and fens were dotted occasionally throughout.

- **Current Conditions:** Mainly forested in second growth oak and oak-pine forests; forest cover ranges from sixty to over 80%. Most forests are rather dense, near even-age second growth, with very little woodland ground flora. The occurrence of shortleaf pine in these forests has diminished from its original extent, today having only 20-30% of the forest cover containing a substantial component (>25%) of pine. Even age stands dominated by scarlet, black, and white oak are common, oak die back is a common problem. Much of the existing timber land is associated with public land ownership. Cleared pasture lands occupy many of the broad stream valleys and highest, flattest ridges. Many glades and woodlands suffer from woody encroachment, and sinkhole ponds and fens have been drained or severely overgrazed. An exceptional proportion of state-listed species sites are associated with the streams, springs, caves, cliffs, fens, and sinkhole ponds in this group.
- **Big Piney River Oak-Pine Woodland/Forest Hills (18.7%)**: Includes most of upper valley; exceptional pine component and cleared bottoms.
- **North Fork River Oak-Pine Woodland/Forest Hills (0.1%)**: Includes most of valley; exceptional pine component and USFS ownership.

Table Lu04. Percent land cover for eleven digit hydrologic units within the Big Piney Watershed. Data is based on analysis of MoRAP Missouri Land Cover Data (1999).

Unit Name	FOR	WET	GRAS	CRP	URB	WAT
Upper Big Piney	44.9	0.0	54.7	0.1	0.2	0.0
Middle Big Piney	69.7	0.0	29.8	0.0	0.3	0.1
Spring Creek	63.9	0.0	35.9	0.0	0.1	0.0
Lower Big Piney	80.8	0.0	16.6	0.3	2.0	0.3
Big Piney Watershed	*62.7*	*0.0*	*36.6*	*0.1*	*0.6*	*0.1*

FOR =Forest, **WET**=Wetland, **GRS**=Grassland, **CRP**=Cropland, **URB**=Urban, **WAT**=Water

Table Lu05. Public lands within the Big Piney Watershed. Acreage and permanent stream mile estimates are approximate.

Area Name	Owner/ Leasee	Acres	Permanent Stream Miles
Baptist Camp Access	MDC	6.2	0.80
P. F. Barnes Conservation Area	MDC	118.0	
L. A. Boesl Outdoor Education Area	MDC	8.7	
Boiling Spring Access	MDC	9.5	0.25
Cabool Towersite	MDC	16.0	
Dog's Bluff Access	MDC	2.9	0.20
Dripping Springs Natural Area	MDC*	5.4	0.21
Peter A. Eck Conservation Area	MDC	380.9	0.75
Ft. Leonard Wood Towersite	MDC	60.3	
Horseshoe Bend Natural Area	MDC*	220.3	2.19
Houston Forestry Office	MDC	1.9	
Houston Towersite	MDC	12.5	
Mason Bridge Access	MDC	8.9	0.10
Mineral Springs Access	MDC	6.0	0.25
Piney River Narrows Natural Area	MDC*	248.5	2.05
Ross Access	MDC	3.1	0.05
Ryden Cave Conservation Area	MDC	29.7	
Simmons Ford Access	MDC*	3.3	0.10
George O.White State Forest Nursery	MDC	754.2	
Missouri Dept. of Conservation Total		1, 896.1	6.95

Area Name	Owner/ Leasee	Acres	Permanent Stream Miles
Mark Twain National Forest (Houston-Rolla Dist.)	USFS	88, 942.3	87.90
Fort Leonard Wood Military Reservation	USDOD	24, 133.8	14.16
Big Piney Watershed Total		**114, 972.2**	109.01

Note: This table is not a final authority. Data subject to change.

Owner/Leasee*:

MDC=Missouri Department ofConservation

USFS=United States Forest Service

USDOD= United States Department of Defence

Table Lu06. Percentages of public land ownership within eleven digit hydrologic units of the Big Piney Watershed.

Unit Name	MDC	USFS	DOD	Total
Upper Big Piney	0.3	0.0	0.0	0.3
Middle Big Piney	0.4	20.9	0.0	21.3
Spring Creek	1.1	25.0	0.0	26.1
Lower Big Piney	0.1	41.9	27.0	69.0
Watershed	0.4	18.4	5.0	23.8

MDC=Missouri Department of Conservation

USFS=United States Forest Service

DOD= Department of Defense

Figure Lu01. Historical acreage estimates of selected crops harvested in Phelps, Pulaski, and Texas Counties combined (MASS 1999).

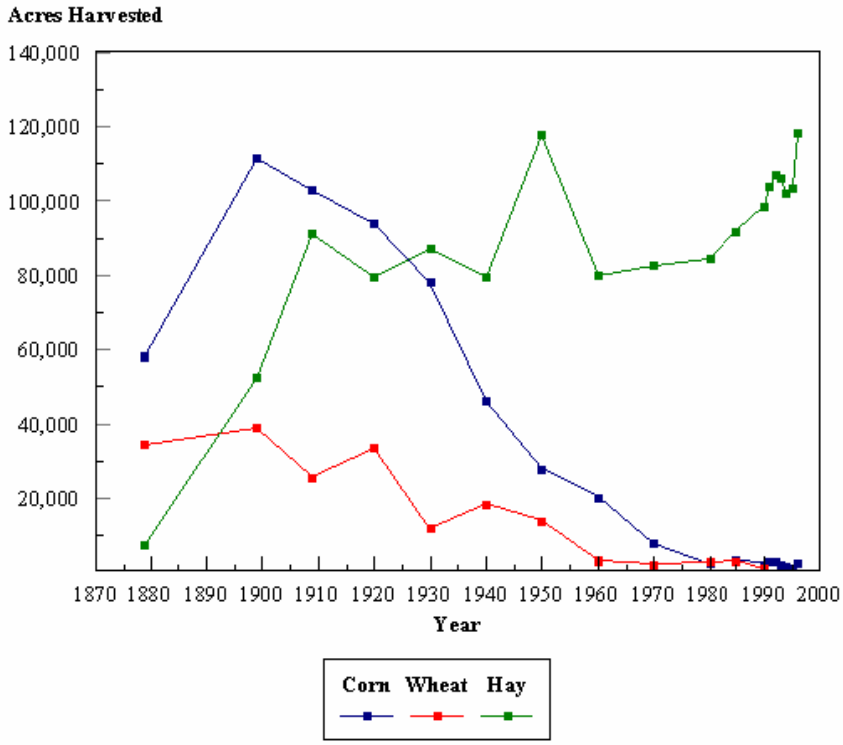
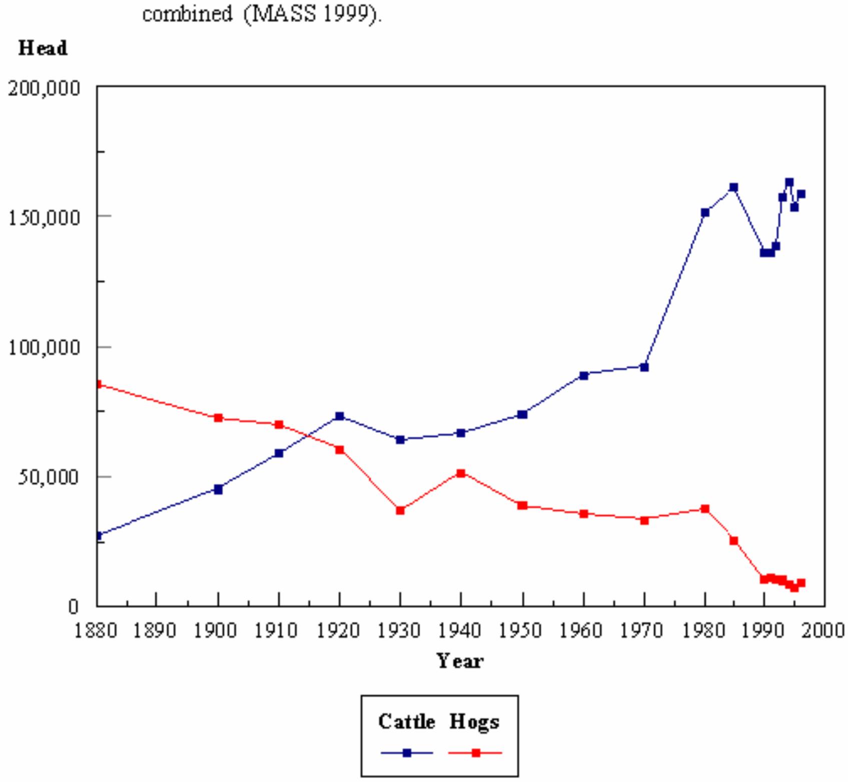


Figure Lu02. Cattle and hog population trends for Phelps, Pulaski, and Texas Counties combined (MASS 1999).



FigureLu03 Human population trends for Phelps, Pulaski, and Texas Counties (OSEDA 1998).

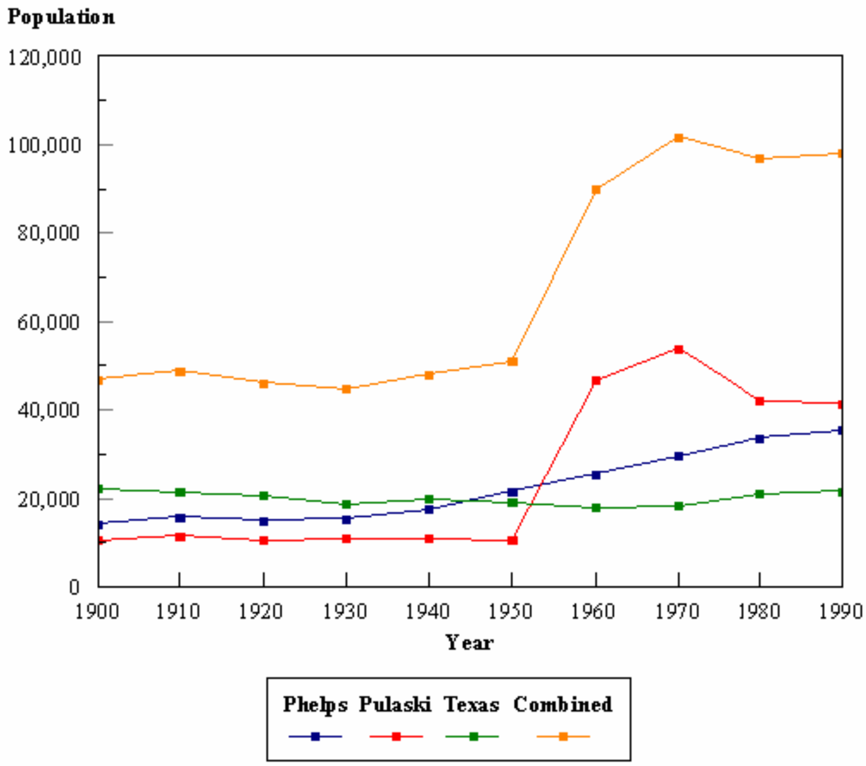
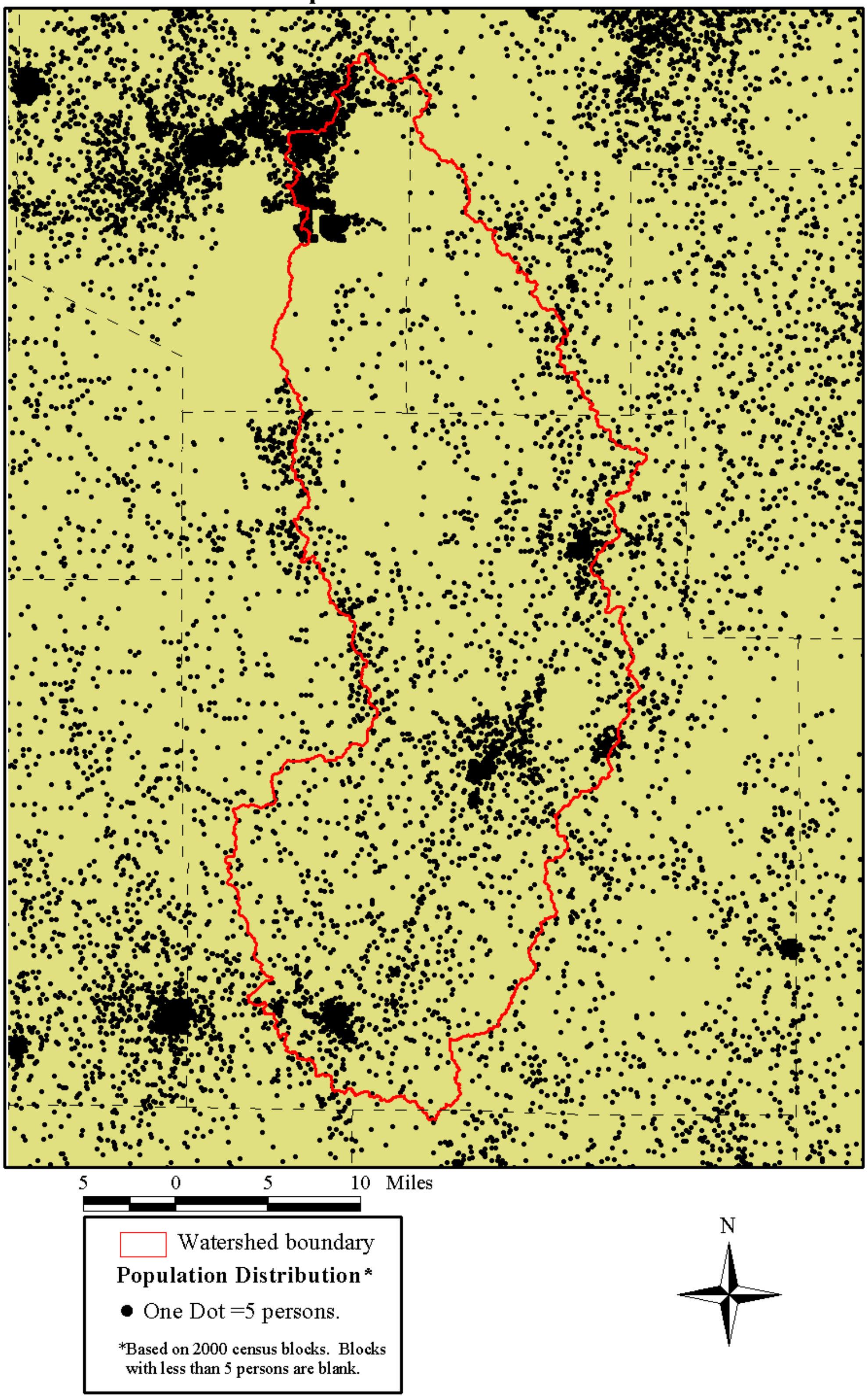


Figure Lu04.

Big Piney Watershed

Population Distribution



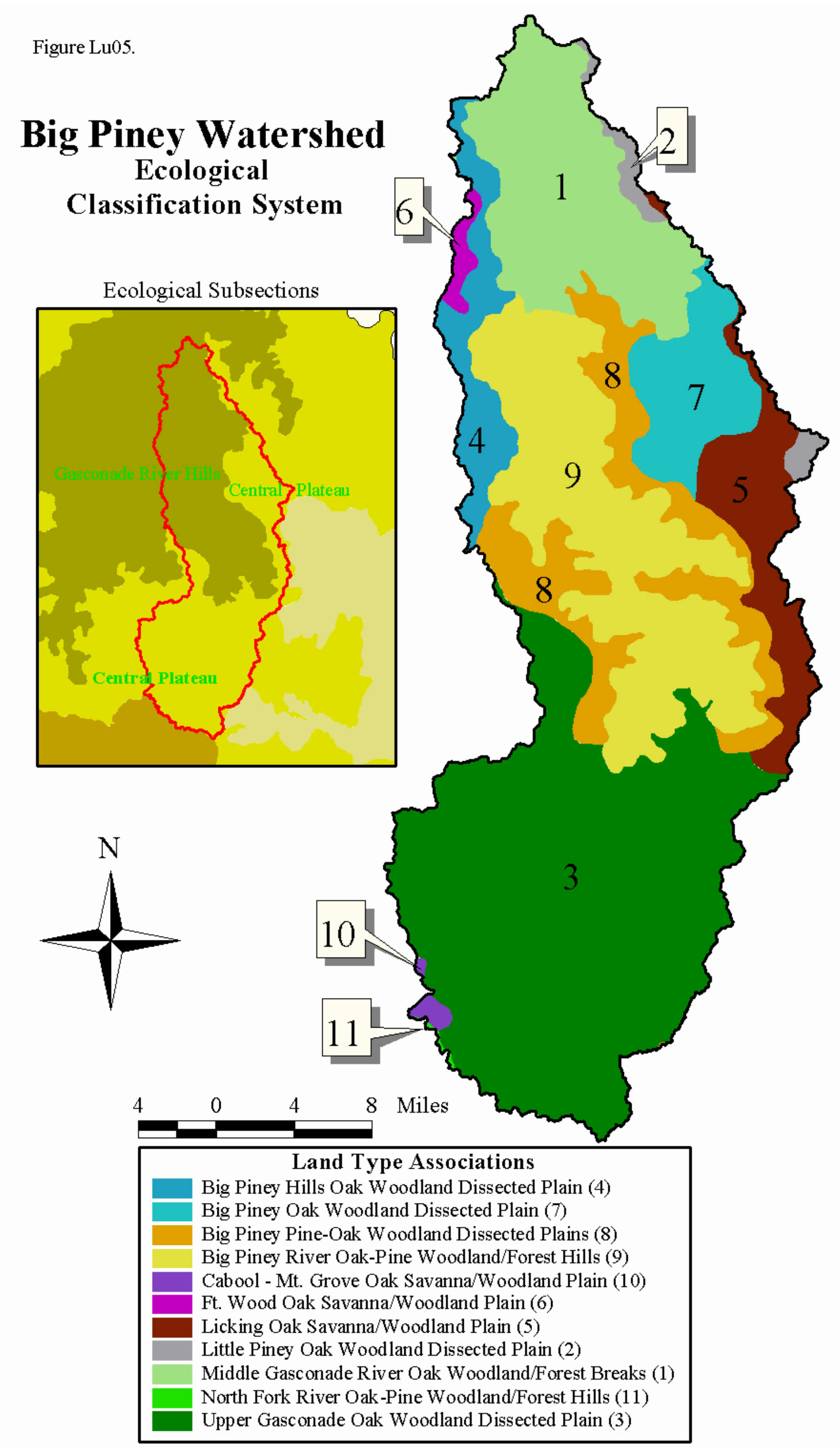


Figure Lu05.
Big Piney Watershed
Ecological
Classification System
Ecological Subsections
Gasconade River Hills
Central Plateau
Central Plateau
N
1
2
3
4
5
6
7
8
8
9
10
11
4 0 4 8 Miles
Land Type Associations
Big Piney Hills Oak Woodland Dissected Plain (4)
Big Piney Oak Woodland Dissected Plain (7)
Big Piney Pine-Oak Woodland Dissected Plains (8)
Big Piney River Oak-Pine Woodland/Forest Hills (9)
Cabool - Mt. Grove Oak Savanna/Woodland Plain (10)
Ft. Wood Oak Savanna/Woodland Plain (6)
Licking Oak Savanna/Woodland Plain (5)
Little Piney Oak Woodland Dissected Plain (2)
Middle Gasconade River Oak Woodland/Forest Breaks (1)
North Fork River Oak-Pine Woodland/Forest Hills (11)
Upper Gasconade Oak Woodland Dissected Plain (3)

Figure Lu06.

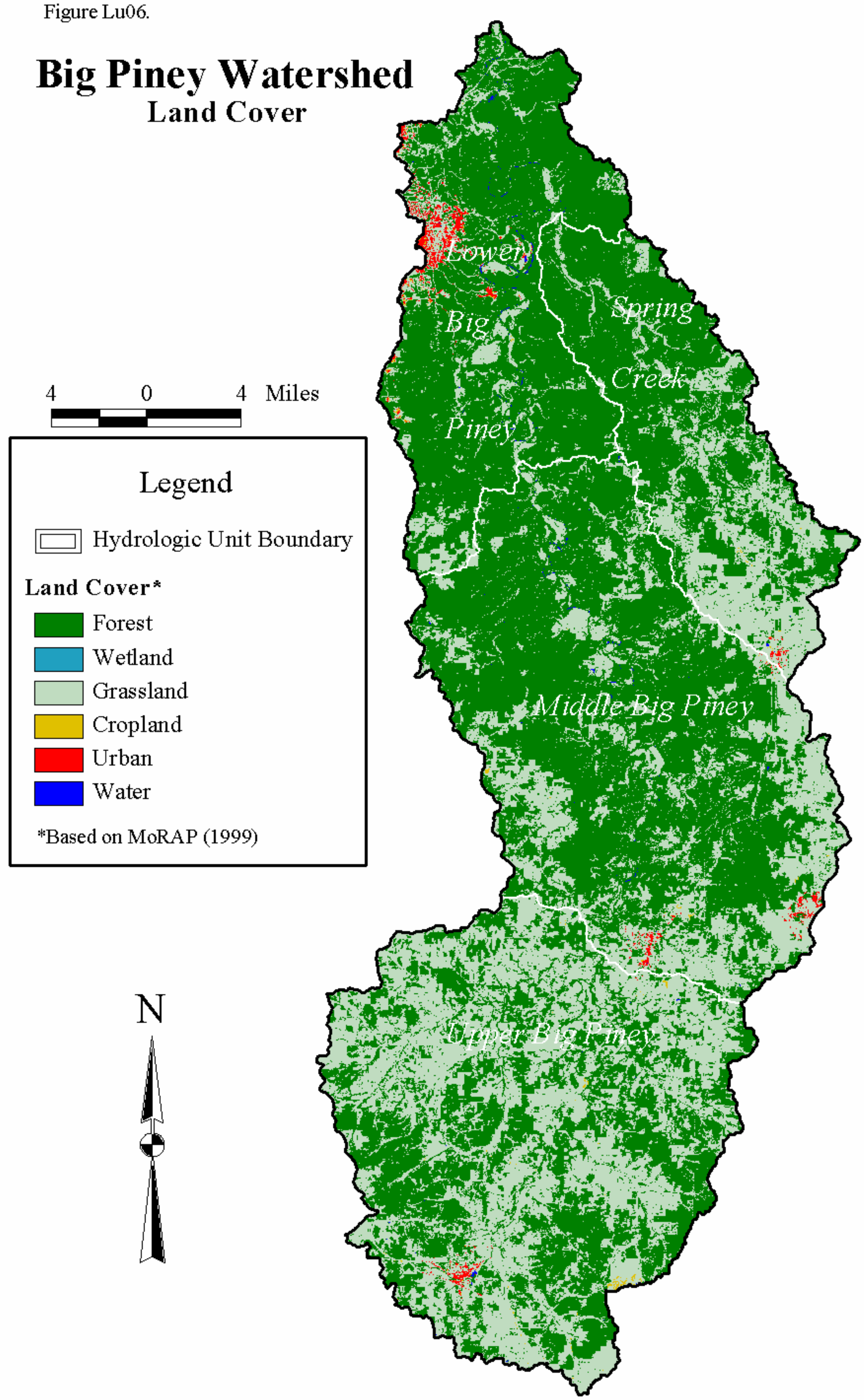

Big Piney Watershed
Land Cover
4 0 4 Miles
Legend
Hydrologic Unit Boundary
Land Cover*
Forest
Wetland
Grassland
Cropland
Urban
Water
*Based on MoRAP (1999)
N
Lower Big Piney
Spring Creek
Middle Big Piney
Upper Big Piney

Figure Lu07.

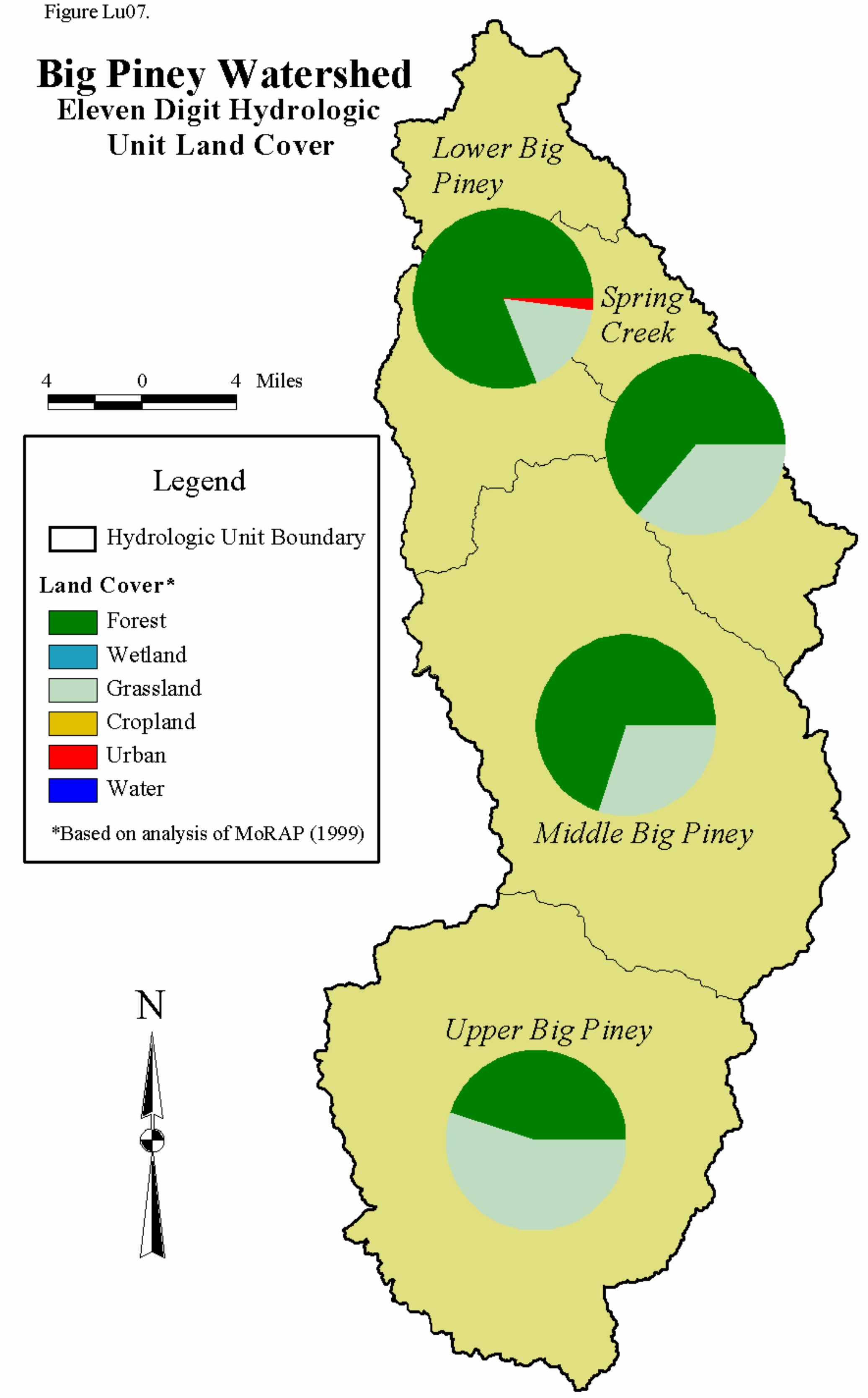
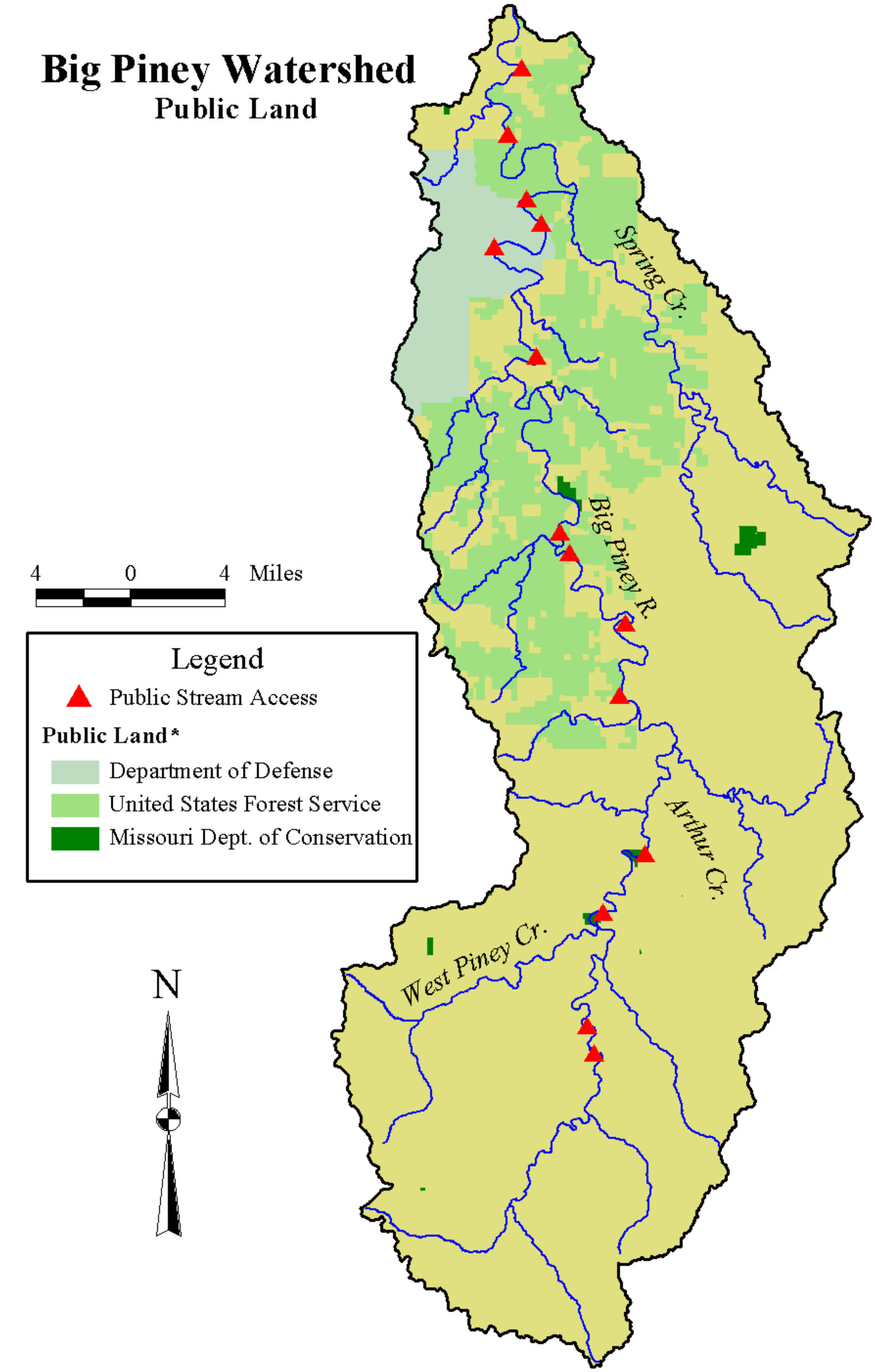
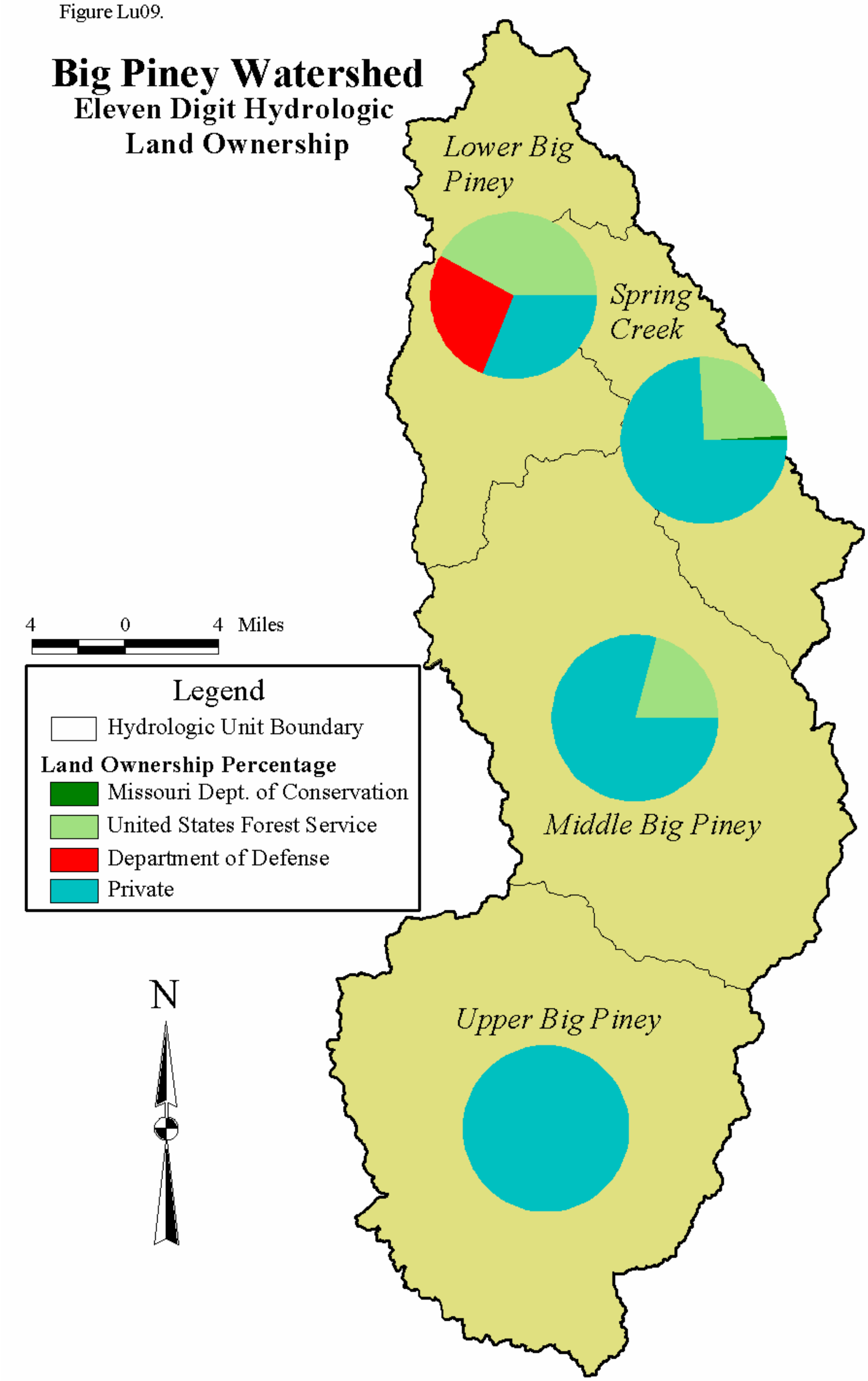

Big Piney Watershed
Eleven Digit Hydrologic
Unit Land Cover
Lower Big
Piney
Spring
Creek
Middle Big Piney
Upper Big Piney
4
0
4
Miles
Legend
Hydrologic Unit Boundary
Land Cover*
Forest
Wetland
Grassland
Cropland
Urban
Water
*Based on analysis of MoRAP (1999)
N

Figure Lu08.



Big Piney Watershed
Public Land
Spring Cr.
Big Piney R.
Arthur Cr.
West Piney Cr.
4 0 4 Miles
Legend
Public Stream Access
Public Land*
Department of Defense
United States Forest Service
Missouri Dept. of Conservation
N

Figure Lu09.


Big Piney Watershed
Eleven Digit Hydrologic
Land Ownership
Lower Big Piney
Spring Creek
Middle Big Piney
Upper Big Piney
4 0 4 Miles
Legend
Hydrologic Unit Boundary
Land Ownership Percentage
Missouri Dept. of Conservation
United States Forest Service
Department of Defense
Private
N

Hydrology

Precipitation

The Big Piney Watershed is situated in one of the wetter parts of Missouri which receives from 32 inches of precipitation in the Northwest to 48 inches in the Southeast portion of the state (Figure Hy01) (MDNR 1986). Analysis of precipitation data based on Easterling et al. (1995) indicates that the Big Piney Watershed receives an average of approximately 41.5 inches of precipitation annually. Analysis of individual annual precipitation amounts for the period 1923 to 1994 indicates a trend toward increased annual precipitation amounts within the watershed (Figure Hy02a). Mean monthly precipitation data for the period indicates that the combined months of April, May, and June receive the most precipitation at 13.39 inches. The combined months of December, January, and February receive the least amount of precipitation at 7.32 inches. May receives the highest mean precipitation amount at 4.91 inches, while January receives the lowest at 2.18 inches (Figure Hy02b).

United States Geological Survey Gaging Stations

The USGS has, as of 2002, two active surface discharge gage stations within the Big Piney Watershed (Table Hy01 and Figure Hy01) (USGS 2002a and USGS 2003). Station 06930000 (Big Piney River Near Big Piney, Mo.) is located on the Big Piney River 14.8 miles upstream from Spring Creek and 3.0 miles east of Big Piney, Missouri (USGS 2000a). The datum of the gage is 800.99 ft above mean sea level (msl). Station 06930000 has been recording daily discharge data periodically since October 1921. Station 06930060 (Big Piney Below Ft. Leonard Wood, Mo.) is located on the Big Piney River at the Highway J/FLW East Gate Road crossing approximately 2.8 miles upstream from Spring Creek. Station 06930060 has been recording daily discharge data since December 1999.

In addition to the previously mentioned active stations, historical daily discharge and/or peak flow records exist for 3 additional surface discharge stations within the watershed with various records available from 1950 to 1997 (Table Hy01).

Daily Mean Discharge Statistics

While discharge data exists for 5 sites within the Big Piney Watershed, Station 06930000 (Big Piney River Near Big Piney, Mo.) provides the most long-term comprehensive dataset available. At this site, discharge data was collected continuously from 1921 to 1982, 1988 to 1996, and 1999 to present. Although some limitations are presented by gaps in this dataset as well as the fact that it is not a record of discharge for the entire watershed, it has been used for analysis because of its extensiveness relative to the remaining stations.

The annual mean discharge of the Big Piney River near Big Piney, Missouri is 542 cubic feet per second (cfs) (USGS 2003a). The highest daily mean discharge at this station is 22, 900 cfs which occurred on September 26, 1993. The lowest daily mean discharge is 60cfs which occurred on September 7, 2001. Table Hy02 lists annual, highest daily, and lowest daily mean discharges as well as the median daily discharge for four analyzed stations. The gap in data between and 1981 and 1989 makes it difficult to accurately determine a single trend in annual mean daily discharge for Big Piney River near Big Piney. For the period of 1923-1981, a trend of decreasing annual mean discharge is indicated; while discharge for the period 1989-1994 shows an increasing trend (Figure Hy03). Annual precipitation trends for these periods appear reflective of these discharge trends even if somewhat more moderate; however, the precipitation for the entire period of 1923- 1994 shows increasing precipitation amounts. This would seem to indicate that the missing discharge data perhaps hides an increasing trend in discharge for the entire period. Analysis of all available discharge data for the Big Piney River near Big Piney reveals that daily mean discharge has been lowest during the months of August, September, and October and highest during March, April, and May (Figure Hy03). The same relative differences are exhibited by daily median discharge as well (Figure Hy03).

As alluded to previously, the drainage area contributing runoff to Station 06930000 is only 74% of the ent ire Big Piney Watershed. The runoff from the largest 5th order subwatershed in the watershed is excluded from the drainage area of this station. Currently, no daily stream discharge data is available for the Big Piney River downstream of Spring Creek.

Flow Duration

Flow duration curves are useful for determining the variability or flashiness of stream flow as well as how the discharge of a stream is sustained over time. These factors are determined by many variables including climate, watershed land cover/land use, soil type, and topography. A daily flow duration curve has been plotted for Station 06930000 (Big Piney River near Big Piney) (Figure Hy04) using data from whole calendar years only for the period of record 1922- 1994. Analysis of this data results in a flow duration curve which is similar to those exhibited by other Ozark streams. The slope above the 10 percentile range, within the higher discharge range, is relatively steep indicating that flood type discharges are infrequent or not sustained for long periods of time. In the 10 to 90 percentile range, the slope is moderate indicating well sustained stream discharges over extended periods of time. This is at least partially attributable to the storage and transport capacity of the karst topography within the watershed and surrounding area.

10:90 Ratio

The 10:90 ratio is used as an indicator of discharge variability. It is the ratio of the discharge which is equaled or exceeded 10% of the time to the discharge which is equaled or exceeded 90% of the time. It is useful for determining summer carrying capacity in streams as well as for interbasin comparisons. The lower the 10:90 ratio, the lower the variability of flow. The 10:90 ratio for the Big Piney near Big Piney is 8.3 (Skelton 1976). This is a low value relative to 10:90 values of drainages of similar size in areas outside the Ozark region of the state (Skelton 1976). This value is similar to 10:90 values from surrounding watersheds with the exception of the remainder of the Upper Gasconade which exhibits 10:90 ratios over twice that of the Big Piney (Table Hy03). The relatively low 10:90 ratios of the Big Piney and surrounding watersheds are due in large part to the water storage and release characteristics of the karst geology, a feature shared by many Ozark watersheds. It is important to note, however, that many streams within the Ozarks (many of which do not have discharge records) are “losing” in nature and thus will typically exhibit higher 10:90 ratios. An example of this is the Eleven Point River near Thomasville (Station 07070500) which has a drainage area similar in size to that of the Jacks Fork at Eminence, but which has a high concentration of losing streams and a 10:90 ratio of 22.9 as compared to 6.9 for the Jacks Fork.

Instantaneous Discharge

On the Big Piney River, the highest instantaneous peak flow of 43, 400 cfs was recorded in 2002 below FLW. The record instantaneous low flow at this site was 103 cfs in 2001. Table Hy02 lists the highest and lowest instantaneous discharge rates that have occurred at selected stations within the Big Piney Watershed.

7-day Q2, Q10, Q20 Low Flow and Slope Index

Q2, Q10, and Q20 seven day low flows refer to the lowest 7 day discharges that have a recurrence interval, on average, of 2, 10, and 20 years respectively. Some of the issues which low flow statistics help answer include the relative permanency of a stream and thus the streams ability to support aquatic life, the influence of groundwater in a particular watershed, as well as issues related to effluent discharge. The Big

Piney station near Big Piney has seven day Q2, Q10, and Q20 low flow values of approximately 115, 82, and 75 cfs, respectively (Skelton 1976 and MDNR 1997). Table Hy04 lists low flow values for additional sites within the Big Piney Watershed. When analyzed relative to drainage area, these values are many times higher than those of north and west Missouri prairie streams and relatively similar to other Ozark streams which, as a basic rule, tend to have the highest sustained low flows in Missouri (Skelton 1976). The slope index (SI, ratio of the seven day Q2 to Q20) is 1.5 for the Big Piney River at Big Piney for discharge data between 1922 and 1972. This is a low slope index, an indication of low variability in annual low flows. Slope index values for additional gage stations are given in Table Hy04.

Flood Frequency

Magnitudes and frequencies of flooding for the Big Piney near Big Piney range from 12, 600 cfs with a frequency of 2 years to 52, 800 cfs for a 100 year frequency (Alexander and Wilson 1995). Table Hy05 lists additional flood frequency estimates.

Table Hy01. USGS continuous surface discharge gage stations within the Big Piney River Watershed (USGS 2003a and 2003b). Active stations (as of 2004) are in bold. Period of record for peak flow measurements is given in parenthesis.

Station #	Station Name	Drainage Area (mi2)	Period of Record
06928700	Beeler Branch Near Cabool Mo.	7.78	1967-1976 (1967-1979)
06929000	Coyle Branch At Houston, Mo.	1.10	(1950-1979)
06929315	Paddy Cr. Ab. Slabtown Spring, Mo.	34.2	1993-1997 (1993-1997)
06930000	Big Piney River Near Big Piney, Mo.	560.00	1921-Present (1922-Present)
06930060	Big Piney Below Ft. Leonard Wood, Mo.	593.00	1999-Present (2001-Present)

Table Hy02. Discharge statistics for selected United States Geological Survey Discharge Gage Stations within the Big Piney Watershed (USGS 1998b, 2003a, and 2003c).

Station #	Station Name	Median	Mean	Instant Peak Flow	Max	Instant Low Flow	Min
06928700	Beeler Branch Near Cabool Mo.	1.7	7.1	4, 700 10/26/70 4/15/72	545 1/29/69	N/A	0.0 (m)
06929315	Paddy Cr. Above Slabtown Spring, Mo.	4.6	24.3	8, 610 11/14/93	2, 320 11/14/93	0.22 9/19/93	0.41 8/17/96
06930000	Big Piney River Near Big Piney, Mo.	257	542	38, 300 5/9/02	22, 900 9/26/93	58 9/7, 8/01	60 9/7/01
06930060	**Big Piney River Below Ft. Leonard Wood, Mo.**	221	543	43, 400 5/9/02	32, 300 5/9/02	103 9/6/01	103 9/6/01

(m)=Multiple measurements at this value.

Table Hy03. Comparison of 10:90 ratios from the Big Piney (in bold) and surrounding watersheds (Skelton 1976).

Station #	Name	Watershed	Drainage Area	10:90
07066000	Jacks Fork at Eminence	Jacks Fork	398	6.8
07057500	North Fork River near Tecumseh	North Fork	561	4.6
07058000	Bryant Creek near Tecumseh	North Fork	570	6.9
07066500	Current River near Eminence	Current	1, 272	5.5
07067000	Current River at Van Buren	Current	1, 667	5.0
07068000	Current River at Doniphan	Current	2, 038	4.1
06928000	Gasconade River at Hazelgreen	Gascoande	1, 250	25.0
06928500	Gasconade River near Waynesville	Gasconade	1, 680	20.7
06930000	Big Piney River near Big Piney	Big Piney	560	8.3
06932000	Little Piney Creek at Newburg	Gasconade	200	6.1
07013000	Meramec River near Steelville	Meramec	781	8

Table Hy04. Low flow calculations for selected USGS stations within the Big Piney Watershed (Skelton 1976 and MDNR 1997).

Station #	Station Name	Drainage Area (mi^2)	Q2	Q10	Q20	Slope Index
06928700	Beeler Branch near Cabool	7.78	0.2	-	-	**NC**
06928900	Big Piney River near Houston	N/A	24.0	17.0	15.0	**1.6**
06929310	Hazleton Spring at Hazleton	N/A	5.0	3.9	-	**NC**
06929320	Slabtown Spring near Licking	N/A	11.0	9.5	-	**NC**
06930000	Big Piney near Big Piney	560	115.0	82.0	75.0	**1.5**
06930030	Stone Mill Spring near Spring Creek	N/A	20.0	16.0	-	**NC**
06930100	Spring Creek at Spring Creek	N/A	21.0	15.0	9.5	**2.2**
06930400	Shanghai Spring near Waynesvile	N/A	9.4	7.2	-	NC

NC=Not Calculable

Table Hy05. Two to 100 year flood discharges (cubic feet per second) for selected USGS Gage Stations within the Big Piney Watershed (Alexander and Wilson 1995).

Station	Recurrence Interval (years) (Discharge in cubic feet per second)					
	2	5	10	25	50	100
06929000 (Coyle Branch at Houston, Mo.)	216	424	601	869	1, 100	1, 360
06930000 (Big Piney near Big Piney, Mo)	12, 600	21, 800	28, 700	38, 000	45, 300	52, 800

Figure Hy01.

Big Piney Watershed
Hydrologic Stations

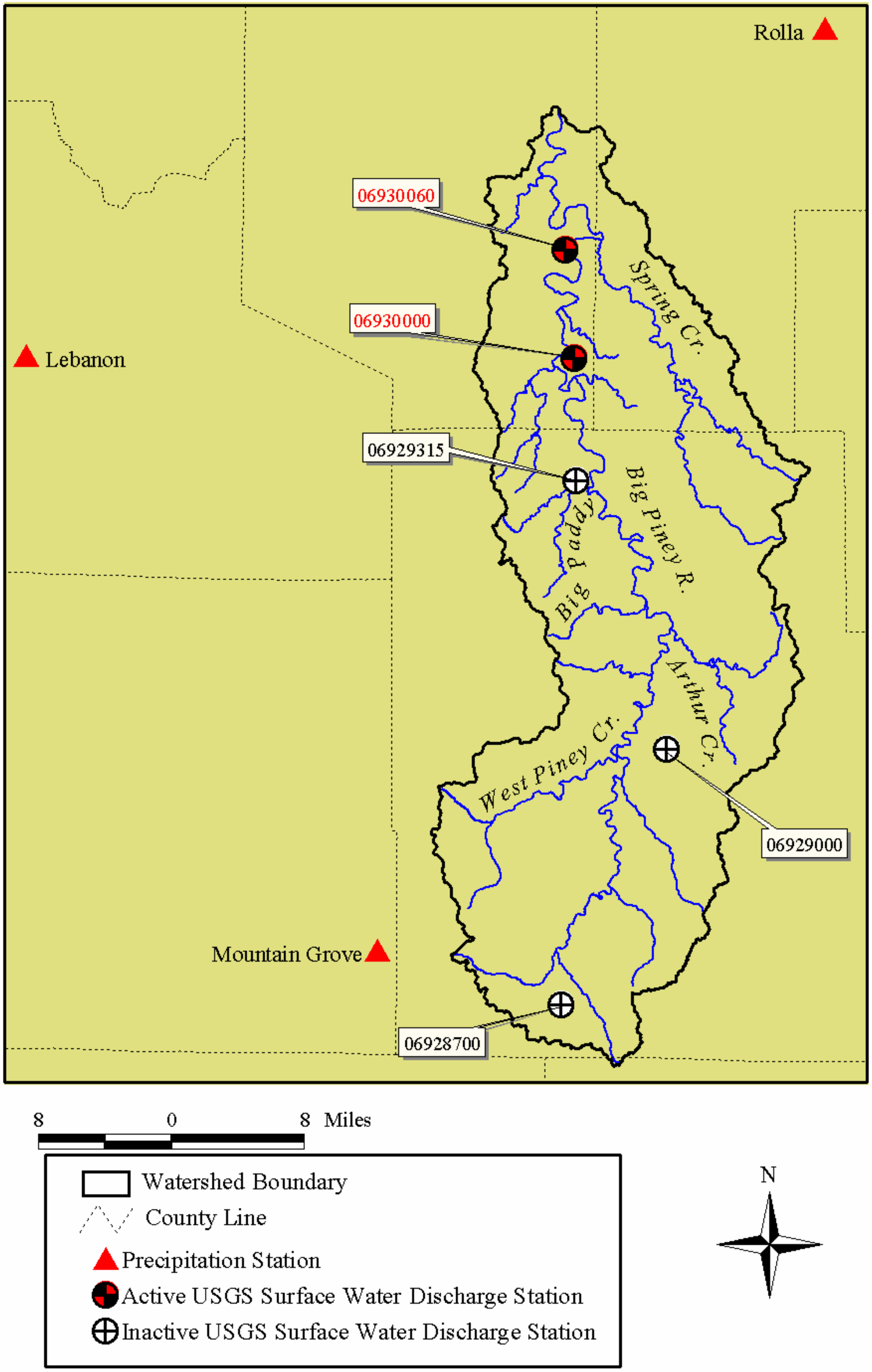


Figure Hy02. (a) Estimated mean annual precipitation amounts and (b) mean monthly precipitation amounts in the Big Piney Basin for years 1923-1994 based on analysis of Easterling et al. (1995).

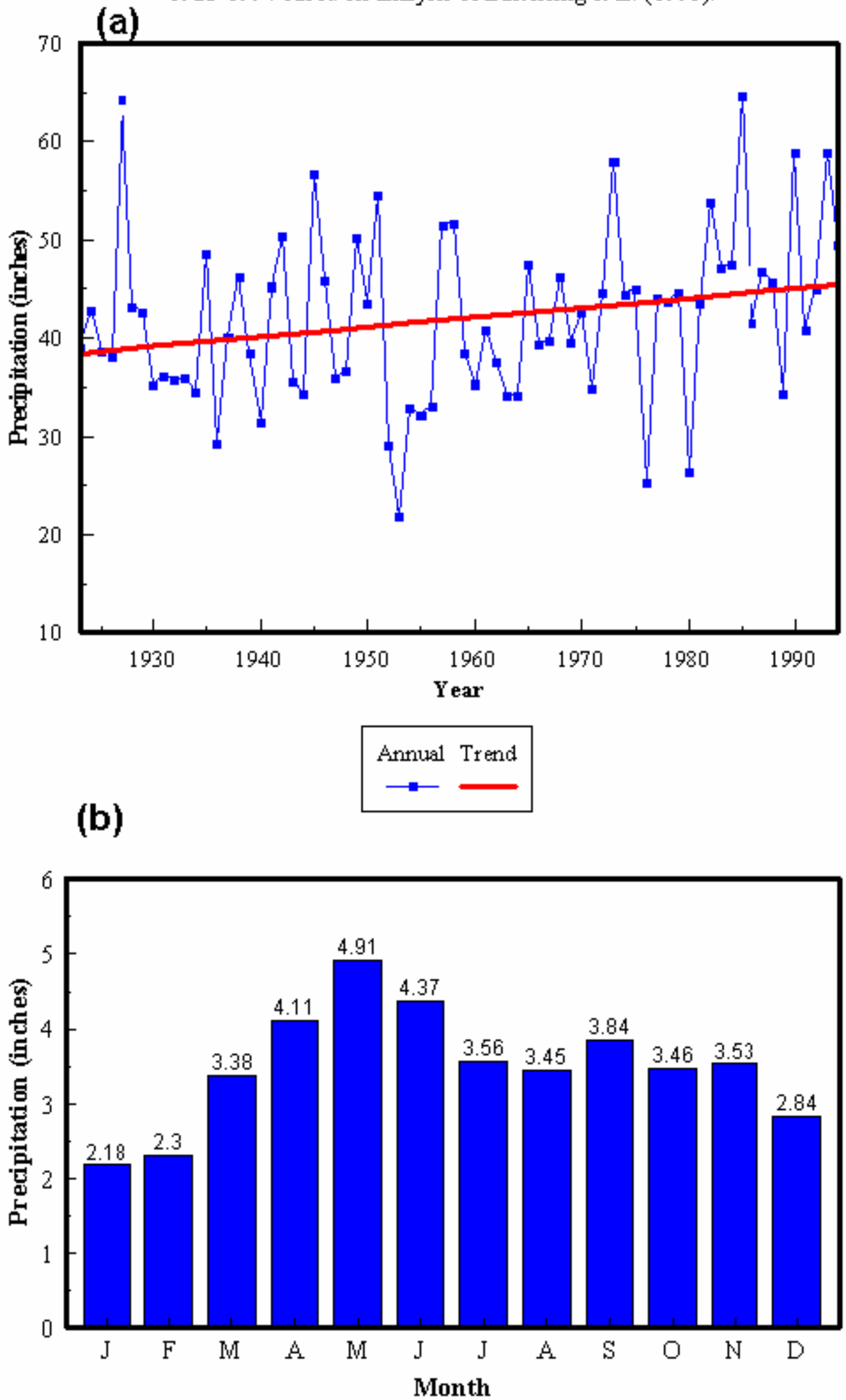
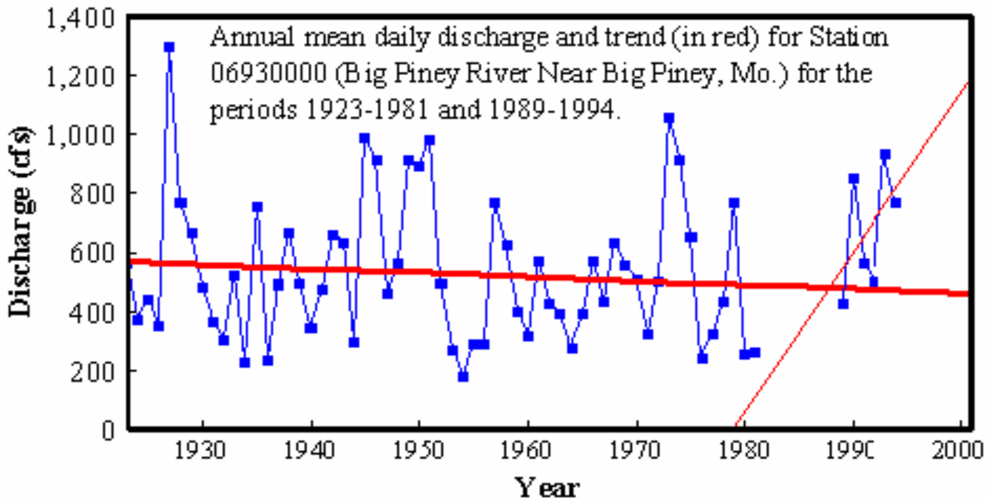
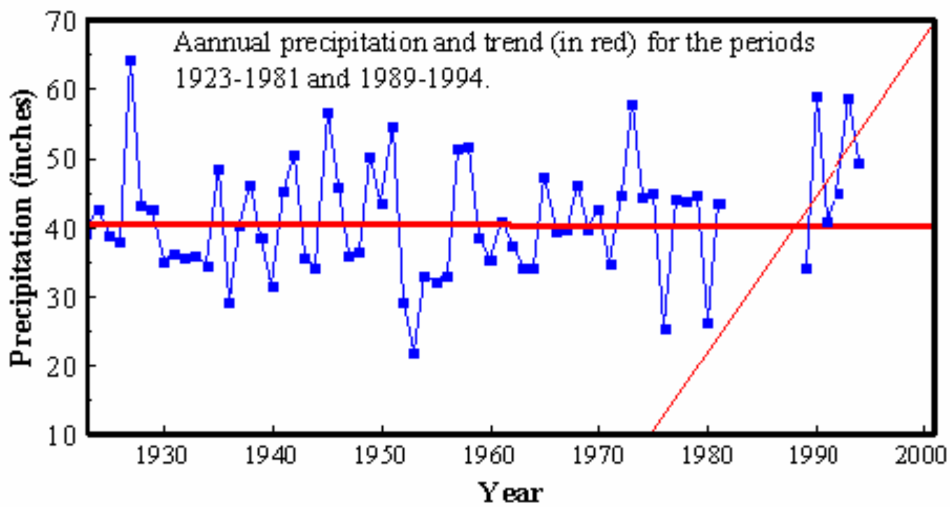


Figure Hy03.


Annual mean daily discharge and trend (in red) for Station 06930000 (Big Piney River Near Big Piney, Mo.) for the periods 1923-1981 and 1989-1994.
Discharge (cfs)
1,400
1,200
1,000
800
600
400
200
0
1930
1940
1950
1960
1970
1980
1990
2000
Year


Aannual precipitation and trend (in red) for the periods 1923-1981 and 1989-1994.
Precipitation (inches)
70
60
50
40
30
20
10
1930
1940
1950
1960
1970
1980
1990
2000
Year

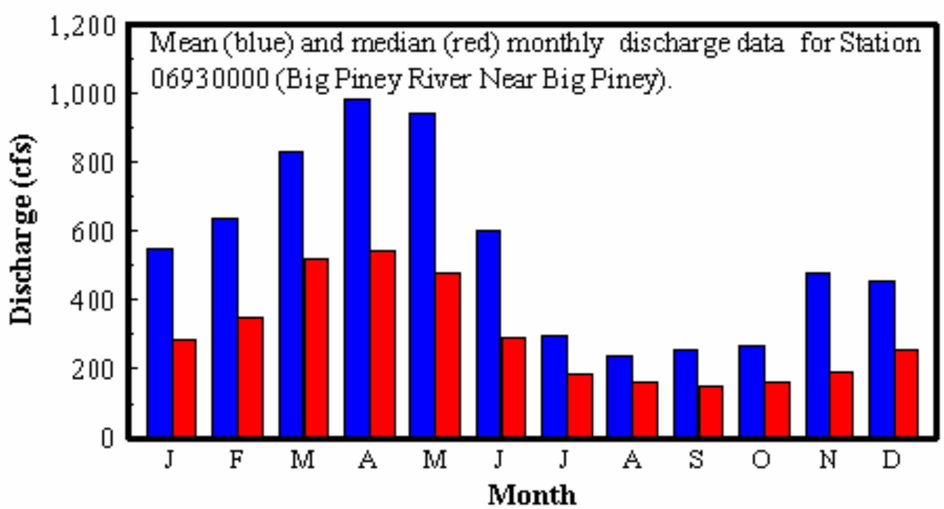
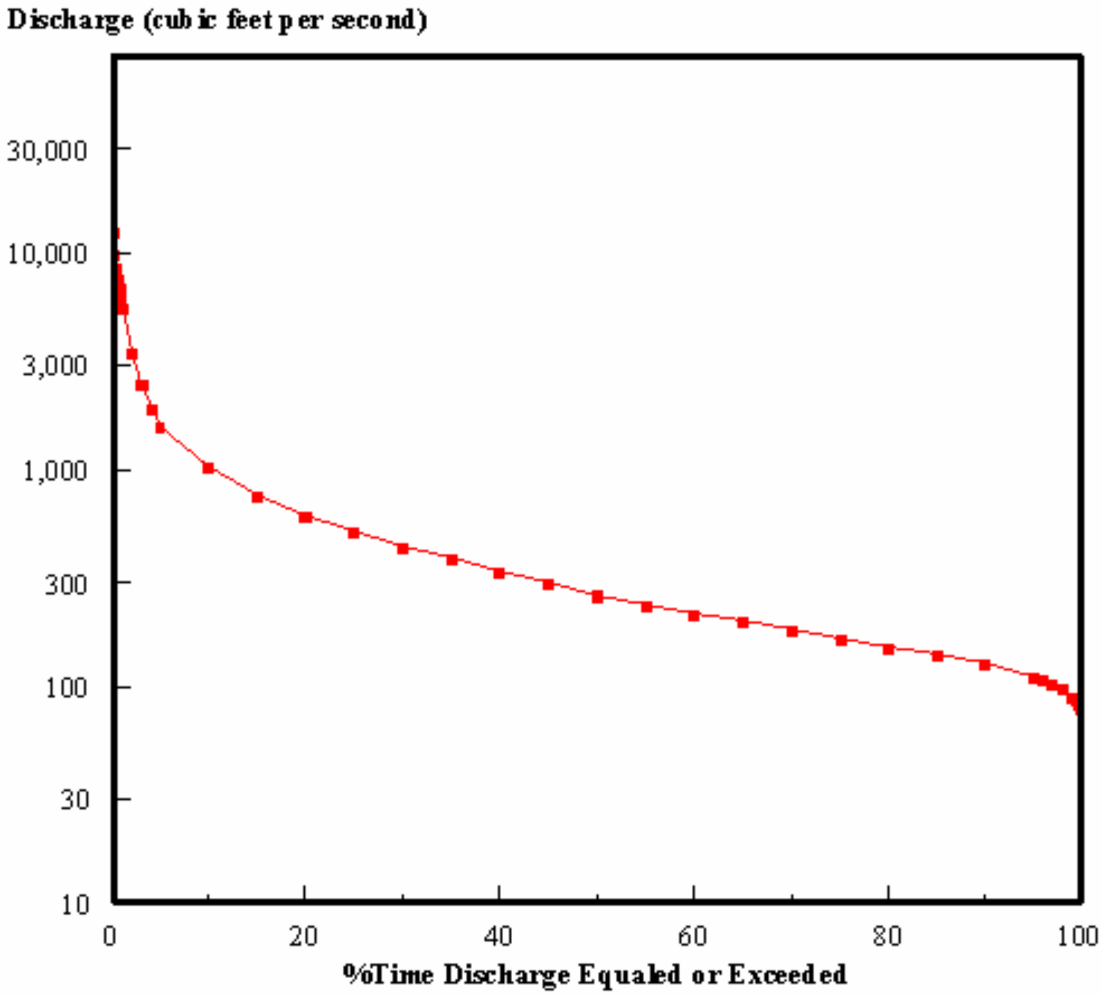

Mean (blue) and median (red) monthly discharge data for Station 06930000 (Big Piney River Near Big Piney).
Discharge (cfs)
1,200
1,000
800
600
400
200
0
J
F
M
A
M
J
J
A
S
O
N
D
Month

Figure Hy04. Flow duration curve for Station 06930000 (Big Piney River Near Big Piney, Mo.)



Water Quality and Use

Beneficial Use Attainment

Approximately 264 stream miles and 10 impoundment acres within the Big Piney Watershed are classified and have designated beneficial uses as presented in Tables G and H of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality (Table Wq01) (MDNR 2001). These waters must meet or exceed established criteria as defined in Table A of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality for those beneficial uses (MDNR 2003b). All watershed streams and impoundments listed in Tables G and H are designated for livestock/wildlife watering as well as protection of aquatic life. In addition, Roby Lake, the single classified impoundment within the watershed is also designated for whole body contact recreation and boating. Approximately 99 miles of the Big Piney River, from its mouth to Township (T) 29N, Range (R) 10W, Section (S) 16, are designated for irrigation, livestock and wildlife watering, protection of aquatic life, cool water fishery, whole body contact recreation, boating, and drinking water supply. Another 8 miles of the Big Piney River, from T29N, R10W, S16 to T28N, R11W, S12, are designated for livestock and wildlife watering, protection of aquatic life, whole body contact recreation, boating, and drinking water supply. Three other streams within the watershed also have additional designated beneficial uses. These streams include Bald Ridge Creek, Hog Creek, and Spring Creek. In addition to the aforementioned designated uses, 6.5 miles of Spring Creek (USFS) has been designated as “Outstanding State Resource Waters” (MDNR 2001).

Section 303(d) of the Federal Clean Water Act requires that states identify impaired waters (MDNR 2003b). This is accomplished by comparing data from those waters with water quality criteria established for designated beneficial uses of those waters. Waters that do not meet their criteria are then included in the 303(d) list (MDNR 2003b). The state must then conduct Total Maximum Daily Load (TMDL) studies on those waters in order to determine what pollution control measures are required and then insure those measures are implemented. Currently, a 0.2 mile segment of Brushy Creek is included in the 1998 303(d) listing. This segment is listed due to impairment by non- filterable residues from the Houston Sewage Treatment Plant.

The Clean Water Act requires that the 303(d) list be updated every four years (MDNR 2003b). At the time of this writing (2003), the 2002 303d list is currently open for public comment and therefore has not been finalized. The draft 2002 303d list for Missouri does include changes from the 1998 listing. More Information can be found regarding the Draft Missouri 2002 303d list on the EPA’s Region 7 TMDL website.

Water Quality

Data regarding surface and ground water quality within the Big Piney Watershed has been collected by several different entities since the 1960s. Government agencies which are or have funded or conducted water quality sampling within the watershed include the Environmental Protection Agency (EPA), FLW, MDC, Missouri Department of Natural Resources Clean Water Commission, USFS, and the USGS. In addition, some water quality data has been collected by Stream Team organizations. The extensive amount of water quality data available for various parameters and varying time periods within the Big Piney Watershed makes an adequate summary of water quality data within this document impractical.

In order to avoid going beyond the scope of this document by attempting to provide a comprehensive summary of all water quality data by all agencies for all available years, six USGS stations within the Big Piney Watershed were selected in order to provide a glimpse of selected water quality values within the watershed (Figure Wq01). These included 2 stations on the Big Piney River, one station on Big Paddy Creek, and one station at Shanghai, Miller, and Sandstone Springs. Water quality was analyzed using data available for the latest five years of operation for a specific station. Water quality parameters selected for analysis (where available) included temperature, pH, dissolved oxygen, fecal coliform, total ammonia nitrogen, phosphorous, sulfate, chloride, and nitrate. These values were compared with state standards (when available) and the number of exceedances were noted (Table Wq02).

Analysis of water quality from selected USGS stations within the watershed reveals that water quality at these stations consistently met water quality standards for the selected parameters during the years examined with the exception of fecal coliform bacteria. Three out of the six stations examined experienced levels of fecal coliform that exceeded state standards for whole body contact recreation. These stations included the Big Piney River near Big Piney, the Big Piney River at Devil's Elbow, and Shanghai Spring.

Although there currently is no state standard regarding total phosphorous, 3 stations experienced levels which periodically exceeded the standard for phosphorous recommend by the EPA. These stations included the Big Piney River near Big Piney, Miller Spring, and Shanghai Spring.

Readers should note that due to the limited number of parameters, as well as the limited spatial, and temporal scope of the aforementioned analysis, this summary can in no way be viewed as a comprehensive examination of water quality within the Big Piney Watershed.

A relatively extensive FLW- funded study of water quality as well as geohydrology in the FLW area was conducted by the USGS in 1994 and 1995 (Imes et al. 1996). The study area included portions of both the Big Piney and Roubidoux watersheds. Ground water, spring, and surface water quality were all examined as part of this study.

Sampling was conducted at ten surface water quality sites within the Big Piney Watershed as part of the aforementioned water quality and geohydrology study. While no detectable concentrations of volatile, semi- volatile organic compounds or explosives were found to be present in any surface water samples, five pesticide compounds were found to be present. These included tebuthiuron, atrazine, deethylatrazine, and p, p'-DDE (a degradation product of DDT) (Imes et al. 1996).

The presence of karst features within and around the Big Piney Watershed such as Spring Creek, Dry Creek, and Big Paddy Creek (losing streams), increases the risk of ground water contamination from point and non-point sources of pollution located on the surface. In addition,

portions of the permanent flow within the watershed are enhanced by springs such as Stone Mill and Boiling Springs. Thus, any contaminant which affects ground water quality is likely to affect surface water quality. There are several ways in which contaminants can enter the groundwater system. These include losing streams, sinkholes, and abandoned wells. As indicated by dye traces performed within the watershed, ground water movement is not always restricted by surface watershed boundaries. Examples of this are the detections of groundwater movement from the Upper Little Piney Creek to Relfe Spring as well as groundwater movement to Shanghai Spring from two points outside the surface watershed (Figure Ge02).

As part of the aforementioned USGS study, water quality sampling was conducted at 3 springs within the Big Piney watershed including Shanghai, Miller, and Pumping Station Springs. Imes et al. (1996) states that both Shanghai and Pumping Station Springs "exhibit probable effects of septic contamination". In addition, the pesticides prometon and simazine were detected in high- base flow samples from both springs. Water quality samples from Shanghai Spring also contained detectable concentrations of trichloromethane and tetrachloroethene as well as higher than background concentrations of dissolved and total sodium, dissolved chloride, total nitrite plus nitrate as nitrogen, total phosphorous, and dissolved and total boron. In addition, the high- base flow sample contained higher than background concentrations of dissolved sulfate and ammonia, while the low-base flow sample contained higher than background dissolved potassium and specific conductance values (Imes et al. 1996).

Imes et al. (1996) indicates that the source for the higher than background levels of the various aforementioned constituents may possibly be a sewage treatment plant located on Dry Creek, a losing stream on FLW known to contribute to the recharge of Shanghai Spring. The high-base flow sample from

Pumping Station Spring contained higher than background levels of total organic carbon while higher than background levels of dissolved and total sodium, dissolved chloride, and total nitrite plus nitrate as nitrogen were noted in the low-base flow sample (Imes et al. 1996).

Ground water quality of the study area examined in Imes et al. (1996) was determined to be similar to the "regional water quality of the Ozark Aquifer". Thirteen groundwater samples in the study area contained elevated zinc or total zinc levels of between 68 and 760 micrograms per liter. Imes et al. (1996) indicates the elevated zinc levels were likely the result of the corrosion of galvanized pipes used in many public and private water supply wells. Small concentrations of trihalomethane compounds, possibly resulting from the chlorination of wells or sample contamination, were detected in samples from six wells. In addition, two samples contained the fuel additive methyltertiarybutylether (MTBE) in concentrations of 0.3 and 0.6 microgram per liter. An additional single sample contained total xylenes concentration of 0.3 microgram per liter. Tentative identification of one or more "non-target" volatile organic compounds was also noted in samples from three wells. There were no detections of compounds associated with explosives or semivolatile organic compounds in any groundwater samples. Samples from four wells in the study area resulted in detections in one or more pesticide compounds at each site. These compounds included diazinon, p, p'-DDE, and tebuthiuron.

As stated previously, a large amount of water quality data for a variety of parameters is available for the Big Piney Watershed. Water quality data is available for additional parameters from the USGS Historical Water Quality Data Website and the annual USGS Water Resources Data Reports as well as the EPA Storage and Retrieval (STORET) Database. Volunteer water quality monitoring data is available from the Missouri Stream Team online database. In addition, extensive water quality data continues to be collected in the FLW area as part of monitoring programs and studies the FLW is funding or otherwise associated with. For additional information regarding this data, contact the FLW Directorate of Public Works, Environmental Division, 320 MANSCEN Loop STE 120, Fort Leonard Wood, Missouri 65473-8929.

Additional State Water Quality Standards are available in the most current document of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7- Water Quality.

USGS Pesticides National Synthesis Project

The USGS conducted water quality samples within the Big Piney Watershed from 1993-1995 as part of the Pesticides National Synthesis Project in an effort to determine the spatial and temporal distribution of contamination by pesticides in the water resources of the United States (USGS 1999b). The watershed was part of the Ozark Plateau Study Unit of the National Water Quality Assessment Program. Two surface water sampling sites and one ground water sampling site were selected within the watershed (Figure Wq01) (USGS 1998c and 1998d). A single sample was taken at the ground water sampling site in 1993. Five samples were collected at a single surface water sites between 1994 and 1995, while two samples were taken at a second site during the same period (USGS 1998c and 2000a).

A total of five pesticide or pesticide related compounds were detected from samples collected within the watershed (Table Wq03). These compounds included Atrazine, Deethyl Atrazine, Diazinon, Metolachlor, and Thiobencarb. Pesticide compounds were detected at both surface sample sites. Site 2 had the most detections of pesticide compounds with four of the five previously mentioned compounds present. These included Thiobencarb, Metolachlor, Atrazine, and Deethyl Atrazine. Site 1 had detections of three of the previously mentioned compounds including Thiobencarb, Metolachlor, Diazinon. No pesticide compounds were detected in the single sample collected from the ground water site. For comparison; 39 of 43 surface water sites within the Ozark Plateau Study Unit had detections of pesticides with 18 sites having samples with six or more pesticide detections (Bell et al. 1997). In addition, 73 of 215 ground water sample sites within the Ozark Plateau Study Unit had pesticide detections with a maximum of 5 pesticides detected in any one sample (Adamski 1996). It is important to note that the number of samples at individual sites varied. It is also important to note that analysis for specific pesticide compounds varied from site to site and/or sample to sample.

Point Source Pollution

Table Wq04 lists 20 municipal and non-municipal waste water and water treatment facilities within the Big Piney Watershed (Figure Wq02) (MDNR 1998b, 2000c). There are 6 municipal waste water facilities within the watershed. These serve the cities/towns of Cabool, Houston, Licking, and Raymondville. Discharges from these facilities have a combined flow of approximately 2.59 million gallons per day (mgd). Two public sewer district facilities also exist in the watershed. These have a combined flow of 0.04 mgd. In addition, two facilities serving the FLW Military Reservation also exist within the watershed. These two facilities, one a waste water facility and the other which is a water treatment facility, have a combined flow of 5.80 mgd. Dry Creek, a losing stream which has been shown to contribute to the recharge of Shanghai Spring, has been known to be negatively impacted by discharge from one of the FLW facilities in the past. Table Wq04 lists individual flows for public/municipal facilities.

The MDNR "Incidents of Mines Occurrences, and Prospects" (IMOP) Database contains data on 15 mines listed as "producer" and 44 mines listed as "past producer" within the Big Piney Watershed (MDNR 2001b). All mines listed as producers are sand and gravel removal operations with the exception of 3 limestone quarries. Improper gravel mining techniques and unsuitable site locations have the potential to threaten water quality as well as aquatic and riparian habitats within the watershed. The negative impacts of improper gravel mining have been shown to include channel incision, sedimentation of downstream habitats, accelerated bank erosion, the formation of a wider and shallower channel, the lowering of the flood plain water table, and channel shift (Roell 1999). The majority of past mining activity is relatively evenly divided between iron, limestone, and gravel mining. Other less significant mining activity within the watershed has been directed at lead, clay, and barium (MDNR 2001b). Nearly all past producers within the watershed are surface mines. When these occur as open pits they have the potential to act as a direct link to the ground water system and thus pose a threat to ground water quality if pollutants are allowed to enter. This can affect wells from which the watersheds population receives its water.

Non-point Source Pollution

Perhaps one of the more difficult challenges to address within any watershed is non-point source pollution. Whereas point source pollution can be traced to a single discharge point or area such as a waste water treatment plant discharge, non-point source pollution, such as sheet erosion of topsoil, runoff of nutrients from pastures, or pesticide or fertilizer runoff from fields, is much more difficult to detect as well as remedy. It takes the cooperation of the landowners within a watershed to minimize non-point source pollution and its impacts. While currently there appear to be no substantial non-point source pollution problems within the watershed, prevention of potential problems will be an important component in ensuring the quality of surface and ground water within the watershed.

Land disruption from road and bridge construction and maintenance as well as urban expansion often results in increased sediment loads to receiving water systems. Bridge construction can also result in stream channel modification, which affects stream flow both up and downstream from the bridge. Within the Big Piney Watershed, there are approximately 1, 737 miles of highways, streets, and county and private roads based on analysis of transportation route geographical information system (GIS) data of the U.S. Bureau of the Census (1997). This is approximately 2.3 miles of road per square mile of watershed area. Approximately 60-70 percent of these roads are probably unpaved. This is based on the assumption that most county and private roads not intersecting a municipality are unpaved. According to the Missouri Department of Transportation Highway and Bridge Construction Schedule, there are currently (2003) no state highway projects which involve drainage and/or bridge construction or maintenance scheduled within the watershed from 2004-2008 (MDT 2003).

It is estimated that approximately 57% of the human population within the Big Piney Watershed lives within municipalities or otherwise urban type areas and thus are serviced by a public waste water treatment facility. The remaining 43% likely rely on on-site waste treatment systems such as septic systems. The potential for contamination of groundwater by septic systems has been shown by Aley (1972 and 1974) to be increased in areas of soluble bedrock (MDNR 1984).

Aley and Aley (1987) state that according to a 1972 Missouri Clean Water Commission publication, sewage production is approximately 100 gallons per person per day. Using this information and assuming that nearly all of the populations of the municipalities within the watershed are served by municipal waste water treatment facilities, it can be estimated that 1, 772, 800 gallons of septic system effluent is generated per day within the Big Piney Watershed. Both Shanghai and Pumping Station Springs are believed to "exhibit probable effects of septic contamination" Imes et al. (1996). It is important to stress that proper septic system installation and maintenance remains important to the protection of both surface and ground water systems.

As with many other watersheds in the state, livestock, and in particular cattle populations, can potentially adversely affect water quality within the Big Piney Watershed. This is especially true when livestock are allowed to linger in riparian zones. Estimated animal unit density (animal units/acre) for the Big Piney Watershed, based on the 1992 Census of Agriculture, was 0.130 (MUWASC 1998). An animal unit is equal to "roughly one beef cow or 1000 pounds live weight" (MUWASC 1998). Much of the livestock population data currently available is based on county estimates. Analysis of United States Department of Agriculture-National Agriculture Statistics Service (USDA-NASS 2000) data indicates that in 2001, counties intersecting the Big Piney Watershed had an average of 9.1 head of hogs per square mile and 56.9 head of cattle per square mile. For comparison, the average for counties statewide was 23.2 head of hogs per square mile and 60.9 head of cattle per square mile. The majority of livestock within the watershed are probably pastured. This makes the presence of nutrient filtering timbered stream corridors and limited livestock access to streams important tools landowners can use to minimize the impacts of livestock on water quality.

Five permitted concentrated animal feeding operations (CAFOs) existed in the watershed between 1988 and 1998 (Figure Wq02) (MDNR 1999). All were related to dairy operations and all were classified as non-point operations with between 86 and 214 animal units.

The Big Piney Watershed is unique to many other watersheds in Missouri in that a large military installation, at least in part, is located within its boundaries. The presence of FLW presents unique water quality concerns which are not applicable to many other watersheds. Since 1982, several studies have been conducted regarding the presence of contaminants on the installation and the potential effects on ground water and surface water quality as well as soil (USAEC 2003). In 1985, the Installation and Restoration Program (IRP) was initiated at FLW. The IRP is "a comprehensive program to identify, investigate, and cleanup contamination from hazardous substances and wastes resulting from past DoD activities on active installations and formerly- used DoD lands" (USDOD 1998). As part of this program, 68 (42 within the Big Piney Watershed) sites have been identified in association with FLW as "having the possibility to cause contamination" (USAEC 2003). Contaminants of concern which have been noted at these sites include metals, solvents, pesticides, petroleum (oils and lubricants), explosives, PCP (pentachlorophenol), and PCE (a type of chlorinated solvent). Remediation or interim remediation activities have been conducted at 11 sites (9 within the Big Piney Watershed). A total of 56 sites (33 within the Big Piney Watershed) are listed as "response completed" sites, while 12 sites (9 within the Big Piney Watershed) "have been identified for further investigation and/or remediation" or are otherwise considered active sites (USAEC 2003). Currently, all remediation activities are on track to be completed by 2009, with the installation's IRP program scheduled to be completed in 2017.

As part of the FLW Stormwater Runoff Monitoring Program, water quality data has been routinely collected at 7 sites within the Big Piney Watershed since 1995. This program is funded by FLW and conducted by the USGS. Additional information regarding this program may be obtained by contacting the FLW Directorate of Public Works, Environmental Division, 320 MANSCEN Loop STE 120, Fort

Leonard Wood, Missouri 65473-8929.

An increased awareness by the public will be important to the protection of both surface and ground water quality from non-point sources of pollution within the Big Piney Watershed.

Water Pollution and Fish Kill Investigations

Sixteen water pollution, potential water pollution, and fish kill incidents have been investigated in the Big Piney Watershed since 1990 (Table Wq05) (MDC 2003). The stream impacts associated with these incidents ranged from less than one eighth of a mile to 14 miles, with the impacts of two incidents unknown. Three fish kills were observed in relation to the aforementioned incidents. One fish kill on Brushy Creek was attributed to sewage. Another fish kill on a tributary to Elk Creek was alleged to be the result of cattle manure from a feedlot within the drainage. The remaining fish kill which occurred on the Big Piney River, was attributed to the natural occurrence of "summer kill".

Fish Consumption Advisories

Currently (2004), all waters within the Big Piney Watershed are included in a statewide fish consumption advisory for largemouth bass. Women who are pregnant, who may become pregnant, nursing mothers and children twelve (12) years of age and younger should not eat any Largemouth Bass over twelve (12) inches in length from anywhere in Missouri due to elevated levels of mercury (MDHSS 2003 and EPA 2004). Additional information regarding fish consumption advisories may be found on the EPA's National Listing of Fish and Wildlife Advisories website, or by contacting the Missouri Department of Health and Senior Services at (866)628-9891.

Water Use

Water use data for the Big Piney Watershed obtained from the USGS National Water Use Database (1998c) indicate that total water withdrawn from the Big Piney Watershed in 1995 was 4.72 million gallons per day (mgd) (Table Wq06). Most of the water withdrawn from the watershed was from the groundwater system. Groundwater withdrawn from the watershed was 2.66 mgd while surface water withdrawn was 2.06 mgd.

Estimated water withdrawal for domestic purposes (self-supplied and public supply delivered) was the most prevalent use within the Big Piney Watershed in 1995, with 1.3 mgd in public deliveries and 0.58 mgd being self-supplied (USGS 1998c). Livestock use was the second most prevalent within the Big Piney Watershed with 0.78 mgd withdrawn, of which 0.58 was from surface water supplies.

Major water use information for the Big Piney Watershed was obtained from the MDNR, Division of Geology and Land Survey. The MDNR maintains records of "major" (those facilities capable of withdrawing 100, 000 gallons/day or more) surface and ground water users throughout the state. Recent records (2001) indicate there were a total of 12 major water users withdrawing nearly 2 billion gallons of water from 27 groundwater and surface water wells and/or intakes combined in 2001 (Table Wq07) (MDNR 2003c). The majority of water (55.6%) was acquired from surface water withdrawal from the Big Piney River with the remaining 44.4% coming from ground water. Withdrawals by government entities accounted for nearly 89% of water pumped in the watershed, with the United States Army Maneuver Support Center FLW accounting for the largest amount of water withdrawn.

Recreational Use

In 1982, the Big Piney River was ranked with 36 other major watersheds in Missouri according to recreational value (MDC and MDNR 1982). Results were obtained by surveying professional staff from six state and federal agencies. The Big Piney River was ranked 13th in mean recreational value within the state. Its recreational worth was expected to remain unchanged in the future.

Angler surveys are useful for evaluating angler use, species preference, and satisfaction. Angler surveys can also be used to identify changes or trends in angler responses over time. These surveys provide the information necessary for managers to meet angler needs, as well as improve and validate decisions to change or maintain regulations. Results from statewide annual angler surveys which were conducted by the MDC from 1983 to 1988, estimate that on an annual basis, an average of 29, 780 total days were spent angling on the Big Piney and its tributaries (Weithman 1991).

Results from a narrower seasonal probability angler survey conducted by the MDC on 17.1 miles of the Big Piney from the Highway 17 bridge to Boiling Spring Bridge during the period of April 1-October 31 indicate that an estimated average of 6, 800 angler hours were spent on this section of river during the years of 1995-1998 (MDC 1999).

Angler surveys have been conducted by FLW staff for the past four years. It is estimated that an average of 4, 330 angler trips were made annually to the 0.3 miles of Stone Mill Spring trout fishery (Zurbrick, Personal Communication). In addition, it is estimated that an average of 1, 250 angler trips were made annually to five impoundments on FLW within the Big Piney Watershed.

In addition to angling, the Big Piney River and its tributaries provide a variety of recreational opportunities such as canoeing and tubing. Fourteen stream accesses exist within the watershed and at least 5 outfitters offer float trips on the Big Piney.

Table Wq01. Missouri Department of Natural Resources use designations for selected streams and impoundments within the Big Piney Watershed (MDNR 2001). Locations are given in section, township, range format.

Stream Name	Class[1]	Miles Acres*	From	To	Designated Use[2]
Roby Lake	L3	10	3, 32n, 11w		lww, aql, wbc, btg
Anderson Cr.	C	1.9	Mouth	31, 33n, 09w	lww, aql
Arthur Cr.	P	4.5	Mouth	14, 31n, 9w	lww, aql
Arthur Cr.	C	2.5	14, 31n, 9w	26, 31n, 9w	lww, aql
Bald Ridge Cr.	C	10.0	Mouth	13, 33n, 11w	lww, aql, wbc
Bear Cr.	C	2.0	Mouth	25, 29n, 10w	lww, aql
Beeler Br.	P	1.5	Mouth	7, 28n, 10w	lww, aql
Beeler Br.	C	1.0	7, 28n, 10w	18, 28n, 10w	lww, aql
Bender Cr.	P	3.0	Mouth	13, 31n, 9w	lww, aql
Bender Cr.	C	3.0	13, 31n, 9w	8, 31n, 8w	lww, aql
Big Paddy Cr.	C	4.0	Mouth	32, 33n, 10w	lww, aql
Big Piney R.	P	99.0	Mouth	16, 29n, 10w	irr, lww, aql, clf, wbc, bgt, dws
Big Piney R.	P	8.0	16, 29n, 10w	12, 28n, 11w	lww, aql, wbc, btg, dws
Boiling Spring	P	0.1	Mouth	24, 32n, 10w	lww, aql
Boone Cr.	P	3.0	Mouth	16, 32n, 9w	lww, aql
Boone Cr.	C	3.0	16, 32n, 9w	15, 32n, 9w	lww, aql
Brushy Cr.	P	3.0	Mouth	Hwy. 63	lww, aql
Brushy Cr.	C	4.0	Hwy. 63	14, 30n, 09w	lww, aql
Burton Br.	C	2.0	Mouth	13, 31n, 10w	lww, aql
Camp Br.	C	3.5	Mouth	35, 29n, 10w	lww, aql
Cathcart Hol.	C	1.6	Mouth	20, 31n, 09w	lww, aql
Elk Cr.	P	3.0	Mouth	24, 29n, 10w	lww, aql
Elk Cr.	C	2.0	24, 29n, 10w	30, 29n, 9w	lww, aql

Stream Name	Class[1]	Miles Acres*	From	To	Designated Use[2]
Emery Hol.	C	3.9	Mouth	28, 31n, 10w	lww, aql
Hamilton Cr.	P	4.5	Mouth	5, 29n, 10w	lww, aql
Hamilton Cr.	C	2.0	5, 29n, 10w	7, 29n, 10w	lww, aql
Hazelton Spring	P	0.1	Mouth	34, 33n, 10w	lww, aql
Hog Cr.	P	4.5	Mouth	06, 29n, 9w	lww, aql, clf
Hog Cr.	C	5.1	06, 29n, 9w	16, 29n, 09w	lww, aql
Indian Cr.	P	4.0	Mouth	30, 30n, 9w	lww, aql
Indian Cr.	C	3.0	30, 30n, 9w	27, 30n, 9w	lww, aql
Jacktar Hol.	C	5.1	Mouth	22, 32n, 10w	lww, aql
Johnson Br.	C	1.0	Mouth	29, 30n, 9w	lww, aql
L. Paddy Cr.	C	3.5	Mouth	36, 33n, 11w	lww, aql
L. Pine Cr.	C	1.5	Mouth	12, 33n, 12w	lww, aql
Mineral Spring Hol.	C	0.8	Mouth	30, 31n, 09w	lww, aql
Mooney Br.	C	2.0	Mouth	3, 33n, 10w	lww, aql
Opossum Cr.	C	2.0	Mouth	36, 30n, 11w	lww, aql
Potters Cr.	P	4.0	Mouth	16, 28n, 10w	lww, aql
Potters Cr.	C	2.0	16, 28n, 10w	22, 28n, 10w	lww, aql
Roaring Springs	P	0.1	Mouth	35, 33n, 10w	lww, aql
Rock Br.	C	1.6	Mouth	10, 32n, 10w	lww, aql
Sand Hol.	C	0.3	Mouth	24, 31n, 10w	lww, aql
Schoolhouse Hol.	C	0.3	Mouth	19, 31n, 09w	lww, aql
Slabtown Br.	C	3.3	Mouth	23, 33n, 10w	lww, aql
Spring Cr.	P	6.5	Mouth	31, 35n, 9w	irr, lww, aql, cdf, wbc, btg
Spring Cr.	P	11.5	31, 35n, 9w	16, 33n, 9w	lww, aql
Spring Cr.	C	3.5	16, 33n, 9w	26, 33n, 9w	lww, aql
Trib. to	C	0.7	Mouth	26, 35n, 10w	lww, aql

Stream Name	Class[1]	Miles Acres*	From	To	Designated Use[2]
Spring Cr.					
Spurlock Hol.	C	2.7	Mouth	15, 30n, 11w	lww, aql
Stream Mill Hol.	P	3.0	Mouth	27, 32n, 10w	lww, aql
Stream Mill Hol.	C	2.0	27, 32n, 10w	28, 32n, 10w	lww, aql
Trib. to Beeler Br.	C	1.0	Mouth	20, 28n, 10w	lww, aql
W. Piney Cr.	P	11.0	Mouth	33, 30n, 11w	lww, aql
W. Piney Cr.	C	2.0	33, 30n, 11w	5, 29n, 11w	lww, aql

Note: This table is not presented as a final authority.

[1] **L1**- Lakes used primarily for public drinking water supply.

L2- Major reservoirs.

L3 -Other lakes which are waters of the state. For effluent regulation purposes, publicly owned lakes are those for which a substantial portion of the surrounding lands are publicly owned or managed.

P - Streams that maintain permanent flow even in drought periods.

C - Streams that may cease flow in dry periods but maintain permanent pools which support aquatic life.

[2] **lww**- livestock & wildlife watering

clf-cool water fishery

aql-protection of warm water aquatic life**wbc**-whole body contact and human health-fish consumption. recreation

cdf-cold water fishery

btg-boating & canoeing

irr-Irrigation

*Acres given for Impoundments.

Table Wq02. Water quality data for selected stations and parameters within the Big Piney Watershed (MDNR 2001, USGS 2003c). Applicable of state standards used for comparison of values at each site are in italics and may include one or more of the following: AQL Protection of aquatic life, CLF cool water fishery, CDF cold water fishery, DWS Drinking Water Supply, IRR Irrigation, LWW Livestock and Wildlife Watering, WBC Whole-body-contact recreation, and BTG Boating.

Parameter	AQL	IRR	CLF	CDF	DWS	LWW	BTG	WBC	Min Max	Exceed
Station 06929315 (Paddy Creek above Slabtown Spring)										
Temperature (oF) (warm water fishery)	90.0 Max		84	68					35.6-75.9	**0/41**
pH	6.5-9.0								7.1-8.4	**0/41**
Oxygen, dissolved (mg/l) (warm water fishery)	5.0 Min		5.0	6.0					5.6-13.5	**0/41**
Coliform, fecal (colonies / 100 ml)								200	1-4500	**N/A**
Nitrogen, Total Ammonia (mg/l as N)	0.1-2.5		0.2-3.9	0.1-2.8					0.01-0.08	**0/41**
Phosophorus, Total3 (mg/l as P)									0.01-0.1	**0/41**
Sulfate (mg/l)					250				2.4-5.3	**0/41**
Chloride (mg/l)	230/360				250				0.7-2.6	**0**
Nitrate (mg/l)					10				0.0-0.56	**0**
Station 06930000 (Big Piney River near Big Piney)										
Temperature (oF) (warm water fishery)	90.0 Max		84	68					46.4-79.3	**0/7**
pH	6.5-9.0								7.2-8.3	**0/7**
Oxygen, dissolved (mg/l) (warm water fishery)	5.0 Min		5.0	6.0					6.8-10.9	**0/7**
Coliform, fecal (colonies / 100								200	32-230	**1/4**

Parameter	AQL	IRR	CLF	CDF	DWS	LWW	BTG	WBC	Min Max	Exceed
ml)										
Nitrogen, Total Ammonia (mg/l as N)	0.1-2.5		0.2-3.9	0.1-2.8					0.012-<0.048 E	**0/6**
Phosophorus, Total3 (mg/l as P)									0.01-0.12<	**1/6**
Sulfate (mg/l)					250				3.6-5.1	**0/5**
Chloride (mg/l)	230/360				250				2.9-4.7	**0/5**
Nitrate (mg/l)					10				N/O	
Station 06930450 (Big Piney River at Devils Elbow)										
Temperature (oF) (warm water fishery)	90.0 Max		84	68					36.5-80.4	**0/28**
pH	6.5-9.0								7.3-8.4	**0/28**
Oxygen, dissolved (mg/l) (warm water fishery)	5.0 Min		5.0	6.0					6.2-13.5	**0/28**
Coliform, fecal (colonies / 100 ml)								200	2e-650	**2/28**
Nitrogen, Total Ammonia (mg/l as N)	0.1-2.5		0.2-3.9						<0.024 - 0.06e	**0/27**
Phosophorus, Total3 (mg/l as P)									0.03-<0.06e	**0/23**
Sulfate (mg/l)					250				4.1-6.7	**0/9**
Chloride(mg/l)	230/360				250				3.1-6.9	**0/9**
Nitrate (mg/l)					10				N/A	
Station 374749092051901 (Shanghai Spring)										
Temperature (oF)	90.0 Max		84	68					56.3-65.1	**0/45**

Parameter	AQL	IRR	CLF	CDF	DWS	LWW	BTG	WBC	Min Max	Exceed
(warm water fishery)										
pH	6.5-9.0								6.9-7.6	**0/13**
Oxygen, dissolved (mg/l) (warm water fishery)	5.0 Min		5.0	6.0					3.0-9.0	**0/9**
Coliform, fecal (colonies / 100 ml)								200	200e	**1/1**
Nitrogen, Total Ammonia (mg/l as N)	0.1-2.5		0.2-3.9	0.1 -2.8					0.0024 - <0.018	**0/5**
Phosophorus, Total3 (mg/l as P)									0.06-0.59e	**13/35**
Sulfate (mg/l)					250				6.8-10.4E	**0/42**
Chloride (mg/l)	230/360				250				4.4-24.8	**0/42**
Nitrate (mg/l)					10				N/O	
374203092041601 (Miller Spring)										
Temperature (oF) (warm water fishery)	90.0 Max		84	68					56.3-57.6	**0/3**
pH	6.5-9.0								6.9-7.6	**0/3**
Oxygen, dissolved (mg/l) (warm water fishery)	5.0 Min		5.0	6.0					2.2-8.3	**0/2**
Coliform, fecal (colonies / 100 ml)										
Nitrogen, Total Ammonia (mg/l as N)	0.1-2.5		0.2-3.9	0.1-2.8					0.019-0.006	**0/2**

Parameter	AQL	IRR	CLF	CDF	DWS	LWW	BTG	WBC	Min Max	Exceed
Phosophoru, Total3 mg/l as P)									0.008-0.190	
Chloride(mg/l)	230/360				250				1.7-2.5	**0/2**
Nitrate (mg/l)					10				N/O	
374418092045101 (Sandstone Spring)										
Temperat re (oF) (warm water fishery)			**84**	**68**					**55.2-64.6**	**0/8**

N/O No observations

k Non-ideal count of colonies (too large a sample, colonies merg

e Range includes laboratory estimated value.

<Range includes measurement(s) in which actual value is known to be lower than value shown. [1] Based on maximum chronic and acute standards for cold-water fishery. Levels are pH and temperature dependent. For specific criteria at varying pH and temperatures consult Table B of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.

[2] Based on maximum chronic and acute standards for general warm- water fishery. Levels are pH and temperature dependent. For specific criteria at varying pH and temperatures consult Table B of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.

[3] State standards for phosphorus is currently unavailable. The Environmental Protection Agency currently recommends a maximum of 0.1mg/L for rivers (Christensen and Pope 1997).

[4] Based on maximum chronic and acute standards for all waters. Levels are hardness dependent. For specific criteria at varying hardness consult Table A of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.

[5] Based on maximum chronic and acute standards for cold water fishery. Levels are hardness dependent. For specific criteria at varying hardness consult Table A of the Rules of the Department of Natural Resources Division 20-Clean Water Commission Chapter 7-Water Quality.

Table Wq03. Results of Pesticides National Synthesis Project water quality sampling for pesticide compounds within the Big Piney Watershed (USGS 1998b and 2000a).

Station	Name	Type	Pesticide Compound Detected
1	Big Piney River nr. Big Piney	S	**Thiobencarb, Metolachlor, Diazinon**
2	Paddy Creek above Slabtown Spring	S	**Thiobencarb, Metolachlor, Atrazine, Deethyl Atrazine**
3	**N/A**	**GW**	**Non-Detection**

Type: S-Surface **GW-**Ground Water

Pesticide Compound	Pesticide Type
Atrazine	**Herbicide**
Diazinon	**Insecticide**
Deethyl Atrazine	**Degradation Product (Atrazine)**
Metolachlor	**Herbicide**
Thiobencarb	**Herbicide**

Table Wq04. Public/municipal and non-municipal waste water and water treatment facilities within the Big Piney Watershed (MDNR 1998b, 2000d, 2000e).

Facility Name	County	Facility1 Type	Receiving Stream	Flow* (mgd)
Cabool WWTF	Texas	POTW	Big Piney River	**1.70**
Houston-Brushy Creek	Texas	POTW	Brushy Creek	**0.40**
Licking Northwest WWTP	Texas	POTW	Br. Of Spring Creek	**0.43**
Pcsd #1-Wyndridge Es.	Pulaski	SEWDI	Big Piney River	**0.02**
Pcsd-Thousand Hills	Pulaski	SEWDI	Trib Dry Creek	**0.02**
Raymondville WWTP	Texas	POTW	Arthur Creek	**0.06**
Usa-Ft Leonard Wood WWTP	Pulaski	BASE	Dry Fork	**5.54**
Willard-St. Robert Quarry	Pulaski	LIM Q	Dry Branch	
Interstate Ready-Mix Inc.	Pulaski	LIM Q	Trib Big Piney River	
Grandview Courts	Pulaski	MHP	Trib Big Piney River	
Chastain Trailer Court	Pulaski	MHP	Trib. Dry Cr	
Waynesville Super 8 Motel	Pulaski	MOTEL	Trib Week Hollow	
Bluffview Apartments	Pulaski	SUBD	Trib. Big Piney	
Country Oaks Est Subd	Pulaski	SUBD	Trib. Dry Creek	
Usa-Ft Leonard Wood WTP	Pulaski	WATER	Trib. To Big Piney River	**0.26**
Matherly Concrete-Cabool	Texas	LIM Q	Big Piney River	
Country Aire MHP	Texas	MHP	Ditch Big Piney River	

Facility Name	County	Facility1 Type	Receiving Stream	Flow* (mgd)
Houston Redi-Mix	Texas	CONCR	Brushy Creek	
Texas Co Residential Care	Texas	HEAL	Trib. Indian Creek	
El Rancho Truck Stop	**Texas**	**TRU S**	**Trib. To Beeler Creek**	

Note: Table is not a final authority. Data subject to change.

*Only Flows of public/municipal waste water facilities are given (millions of gallons a day).

1 Facility Type:

BASE-Military Base

CONCR-Concrete Products **HEAL-**Health Care (Private) **LIM Q-**Limestone Quarry **MHP-**Mobile Home Park **MOTEL-**Motel & Hotel

POTW-Publicly Owned Treatment Works

SEWDI-Public Sewer District

SUBD-Public Subdivision,

TRU S-Truck Stop.

WATER-Public Water Treatment Plant

Table Wq05. Water pollution incidents and potential water pollution incidents and fish kills investigated within the Big Piney Watershed from 1990-2002 (MDC 2003).

Year	County	Stream	Cause	Fish kill	Damage
1990	Texas	Big Piney River	Oak tree pollen	No	**<1/4 mile**
1991	Texas	Big Piney River	Treated sewage and process water	No	**<1/4 mile**
1992	Pulaski	Dry Creek	Sewage and biological sludge	No	**4 miles**
1993	Texas	Brushy Creek	Sewage sludge.	No	**200 yards.**
1993	Texas	Big Piney River	Excessive algal bloom	No	**14 miles**
1993	Texas	Big Piney River	Summerkill	Yes	**3 miles**
1993	Texas	Big Piney River	Sewage.	No	
1993	Texas	Tributary to Bender Creek	Gasoline	No	**<1/8 mile**
1994	Texas	Arthur Creek	Diesel	No	**1 to 3 miles.**
1994	Texas	Big Piney River	Hog feed suppliment (whey)	No	**<1/8 mile**
1996	Texas	Tributary to Elk Creek	Cattle manure (alledged)	Yes	**<1/4 mile**
1996	Texas	Big Piney River	Milk product (undetermine)	No	**<1/8 mile**
1997	Texas	Beeler Branch/ Big Piney River	Milk	No	**1 & 10+ miles**
1997	Pulaski	Hooker Hollow	Trash	No	**1/4 mile**
1997	Texas	Branch of Spring Creek	Stormwater	No	**unknown**
2001	**Texas**	**Brushy Creek**	**Sewage**	**Yes**	**1 Mile**

Table Wq06. Water withdrawals in millions of gallons per day by use category within the Big Piney Watershed in 1995 (USGS 1998c).

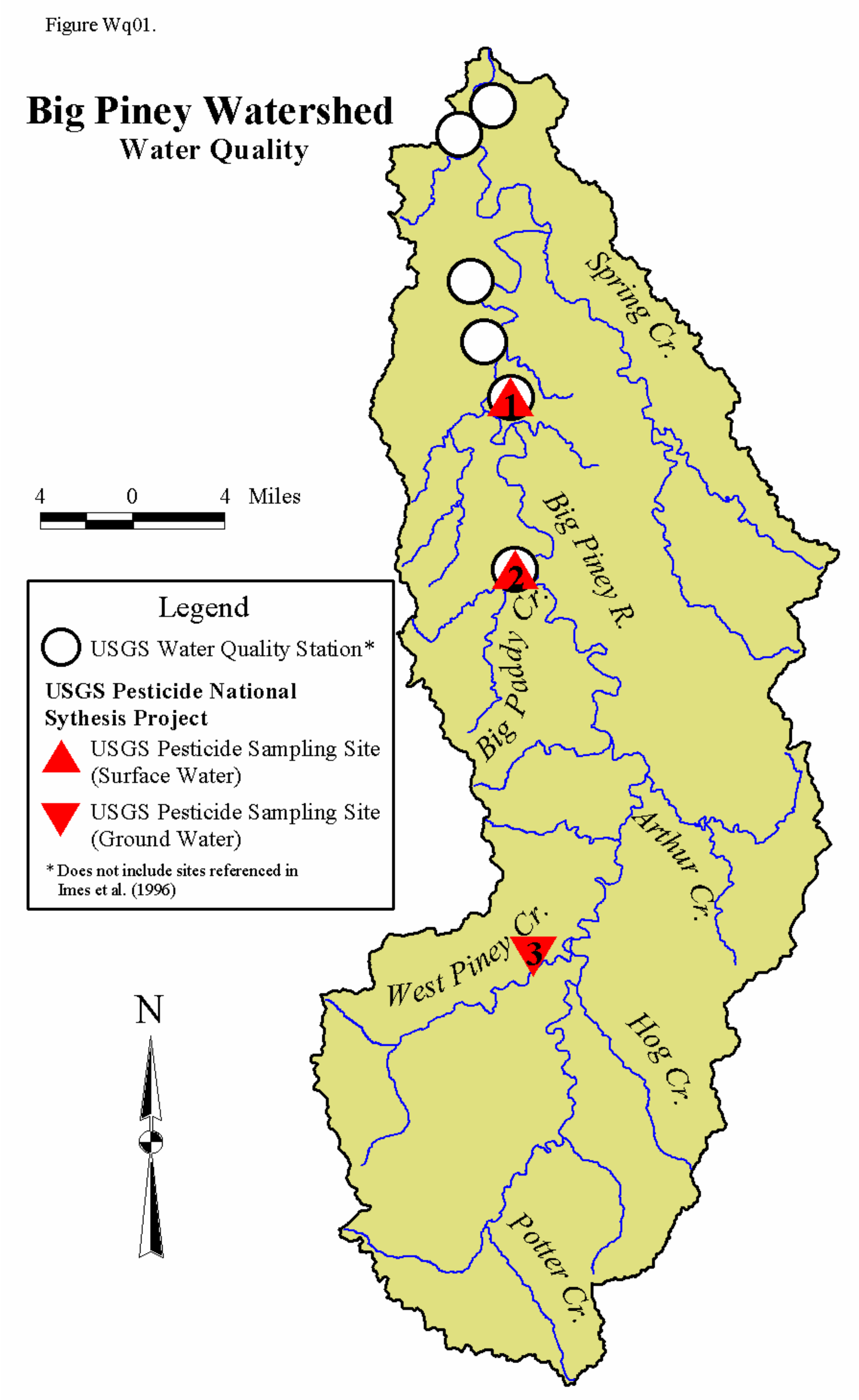
Use	Ground Water	Surface Water	Total
Public Supply Total	1.45	0.83	2.28
Domestic (delivered)			1.3
Commercial (delivered)			0.25
Industrial (delivered)			0.04
Self Supplied (total)	1.21	1.23	2.44
Domestic	0.58	0.00	0.58
Commercial	0.01	0.00	0.01
Industrial	0.37	0.00	0.37
Livestock	0.20	0.58	0.78
Irrigation	0.05	0.65	0.70
Watershed Total	2.66	2.06	4.72

Table Wq07. Major water users within the Big Piney Watershed (MDNR 2003c).

Owner	Total Gallons Pumped in 2001	Acres
City Of Cabool	39,951,230	
City Of Cabool	41,335,122	
City Of Cabool	49,657,000	
City Of Houston	30,179,600	
City Of Houston	43,136,800	
City Of Houston	30,385,000	
City Of Licking	58,259,000	
City Of Licking	26,133,000	
City Of Licking	20,280,000	
City Of St. Robert	19,595,000	
City Of St. Robert	74,298,100	
Dairy Farmers Of America Inc.	3,412,800	
Dairy Farmers Of America Inc.	98,352 000	
Dairy Farmers Of America Inc.	116,376,480	
Missouri Dept. Of Conservation George O. White State Forest Nursery	6,115,000	
Missouri Dept. Of Conservation George O. White State Forest Nursery	12,500,000	
Missour i Dept. Of Conservation George O. White State Forest Nursery	12,500,000	
Public Water Supply Dist. #4	22,603,700	
Pulaski County Pwsd #2	70,784,100	
Texas County P.W.S.D. #1	0	
Texas County P.W.S.D. #1	20,401 676	
Texas County P.W.S.D. #1	22,450,531	
Texas County P.W.S.D. #1	40,649,354	
Texas County P.W.S.D. #2	14,127,000	
Texas County P.W.S.D. #2	21,027, 00	
Us Army Maneuver Support Center Fort Leonard Wood	1,082,615,123	20.0

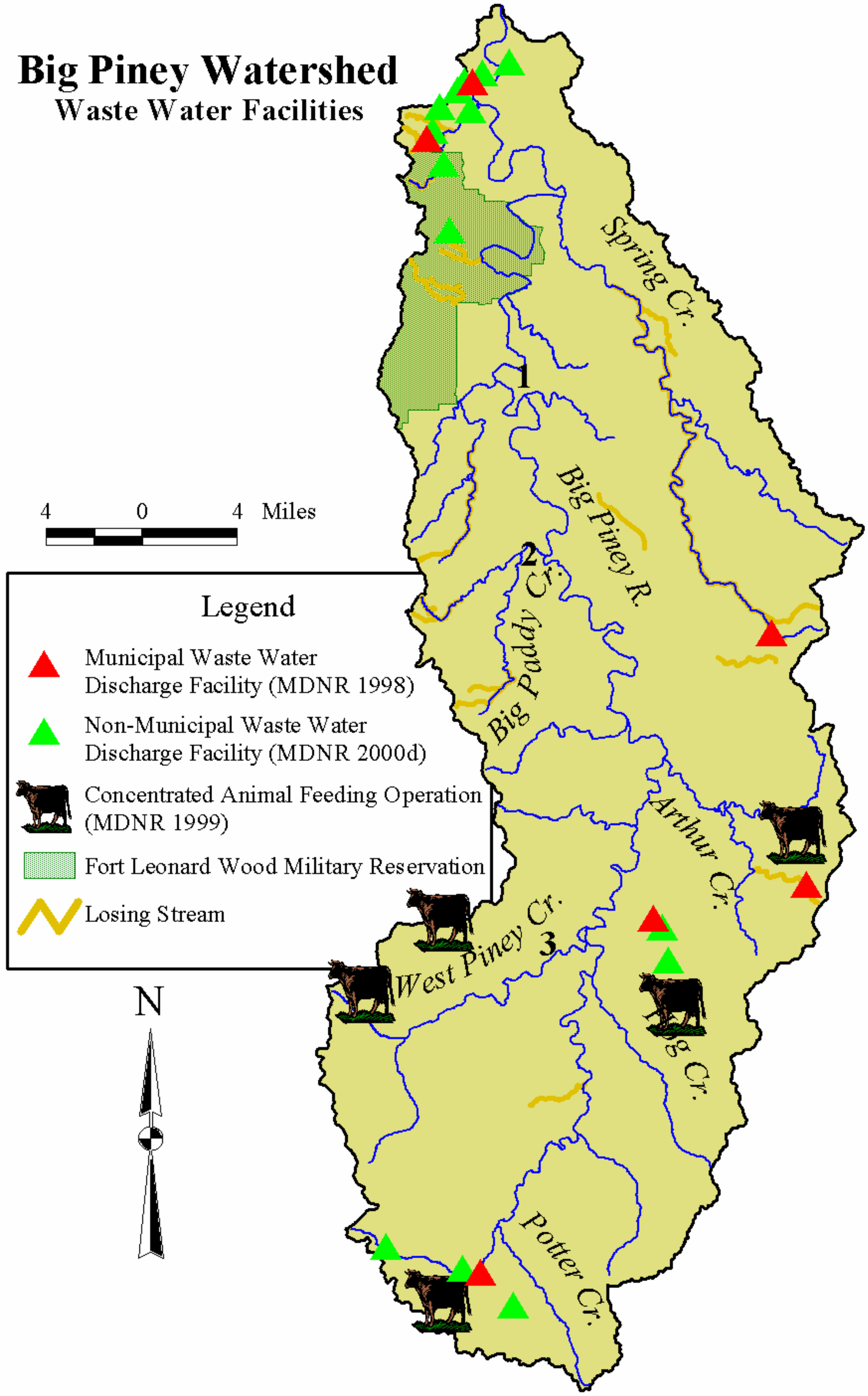
Owner	Total Gallons Pumped in 2001	Acres
Village Of Raymondville	10,158,740	
Total	1,947,333,026	20.0

Figure Wq01.



Big Piney Watershed
Water Quality
4
0
4
Miles
Legend
USGS Water Quality Station*
USGS Pesticide National Sythesis Project
USGS Pesticide Sampling Site (Surface Water)
USGS Pesticide Sampling Site (Ground Water)
* Does not include sites referenced in Imes et al. (1996)
N
1
2
3
Spring Cr.
Big Piney R.
Big Paddy Cr.
Arthur Cr.
West Piney Cr.
Hog Cr.
Potter Cr.

Figure Wq02.


Big Piney Watershed
Waste Water Facilities
4 0 4 Miles
Legend
Municipal Waste Water Discharge Facility (MDNR 1998)
Non-Municipal Waste Water Discharge Facility (MDNR 2000d)
Concentrated Animal Feeding Operation (MDNR 1999)
Fort Leonard Wood Military Reservation
Losing Stream
N
Spring Cr.
Big Piney R.
Big Paddy Cr.
Arthur Cr.
West Piney Cr.
Potter Cr.
1
2
3

Habitat Conditions

Dam and Hydropower Influences

Section 236.400 of the Missouri Revised Statutes defines a dam as "any artificial or manmade barrier which does or may impound water, and which impoundment has or may have a surface area of fifteen or more acres of water at the water storage elevation, or which is thirty- five feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or dam, if it is not across a streambed or watercourse, together with appurtenant works." (MGA 2000a).

The Dam Safety Law of 1979 established a "Dam and Reservoir Safety Council" associated with the MDNR (MDNR 2000e and MGA 2000a). The responsibility of this council is to "...carry out a state program of inspection of dams and reservoirs in accordance with regulations adopted by the council" (MGA 2000b). The MDNR Dam and Reservoir Safety Program operates under the guidance of the council. The program is responsible for regulating all new and existing non- federal, non-agricultural dams which have a height of 35 feet or greater in order to ensure that these structures meet minimum safety standards. In order to facilitate this, the program maintains a database on over 4, 000 dams within the state to be used by private owners, professional engineers, mining companies, emergency management officials, educational institutions, other government agencies as well as private individuals (MDNR 2000f). This database includes permitted dams as well as some dams which don't require a permit.

Within the Big Piney Watershed there are currently 6 dams which have records within the Dam and Reservoir Safety Program Database (Figure Hc01) (MDNR 2000g). All are reinforced earth structures with heights ranging from 12 to 27 feet. Impoundment areas range from 4 to 45 acres. Two additional dams located on the lower Big Piney River are mentioned in MDC 2003f. One is a low rock structure located upstream from the FLW golf course. The other is a concrete structure approximately 4.3 miles downstream of the aforementioned structure. The latter structure backs up the Big Piney River for approximately one mile upstream (MDC 2003f).

In an effort to further determine the presence of significant dam and reservoir structures within the watershed, analysis was performed on National Wetlands Inventory (NWI) GIS data for the watershed. Data was analyzed based on all diked/impounded waters within 100 feet of third order (Strahler) and larger stream segments. This method yielded 14 potentially significant diked/impounded sites. The largest of these sites was 2.0 acres; with the smallest being less than 1 acre. It is estimated that 2 of these structures are in-stream, based on analysis of their spatial relationship to the 1: 24, 000 hydrography layer.

Channel Alterations

Alterations of stream channels by human activity can take several forms including channelization, channel constriction through bridge construction, raising of the base level of the stream by improper construction of low-water bridges sand and gravel removal, etc. All of these activities can adversely affect stream habitat as well as water quality and thus the health of riparian and aquatic communities.

Channelization of a stream involves the straightening, deepening, and/or widening of the stream channel. Frequently, stream channels, in their natural states, have a complex morphology composed of meanders, riffles, and pools. The meanders of a stream help to dissipate the streams energy. A meandering stream also allows surface and ground water within a drainage to be released gradually relative to a straight stream thus allowing for better maintained base flows during dry periods. Channelizing can have several direct and indirect negative effects. These include shortening of the stream, increasing channel gradient of the channelized segment, loss of well defined riffles and pools, increased erosion including headcutting upstream of the channelized segment, increased deposition and flooding downstream of the channelized segment, lowering of the flood plain water table, and a loss of habitat diversity to name a few (Bolton and

Shellberg 2001). These impacts can spread to other streams within the respective watershed as well. The aforementioned impacts not only negatively affect aquatic habitats and biotic communities, but can also be damaging to property both up and downstream due to the potential for increased erosion and flooding in these areas respectively. Estimates based on analysis of National Wetlands Inventory data indicate that only about 3 miles of channelized stream exist within the Big Piney Watershed (Figure Hc01). All channelization within the watershed appears to be relatively small and localized. It is possible that smaller unknown channelization projects have probably occurred on private property and also from road and bridge construction elsewhere in the watershed.

Improper bridge design which alters the normal flow pattern of a stream can also negatively impact a stream. Bridges can restrict stream flow especially at high flows, reducing flow velocities upstream of the bridge, thus increasing sedimentation. They can also increase velocities downstream of the bridge, thus increasing scour/erosion. Improperly designed low- water bridges can alter the base level (that level below which a stream cannot erode) of a stream, thus altering the stream gradient. They can also act as a dam, backing up water behind them and increasing sedimentation on the upstream side. Improperly constructed low-water bridges can also act as a barrier to fish movement. According to the U.S. Corps of Engineers Regulatory Program Database, no permits were issued for culvert construction, bridge construction, bridge removal, or bridge replacement in the Big Piney Watershed between January 2003 and September 2003 (USACOE 2003). According to the Missouri Department of Transportation Highway and Bridge Construction Schedule, there are currently (2003) no state highway projects which involve drainage and/or bridge construction or maintenance scheduled within the watershed from 2004-2008 (MDT 2003).

Gravel mining can also directly and indirectly contribute to channel alterations as well as water quality problems. The negative impacts of improper gravel mining have been shown to include channel incision, sedimentation of downstream habitats, accelerated bank erosion, channel shift, the lowering of the flood plain water table, and the formation of a wider and shallower channel which can result in increased temperature extremes (Roell 1999).

Since 1993, there have been 59 permitted instream sand and gravel removal operation sites within the Big Piney Watershed (MDNR 2003e). Figure Hc02 shows the general location and relative level of activity of permitted gravel mining within the watershed. Much of the permitted sand and gravel removal activity has occurred on the Upper Big Piney and its tributaries. Other streams which have experienced activity include Bradford Branch, Elk Creek, Hamilton Creek, Hog Creek, Potters Creek, Spring Creek, and West Piney Creek.

Approximately 63 miles of streams within the Big Piney Watershed have seasonal restrictions placed on sand and gravel mining activities (Figure Hc02). Currently approximately 54 miles of the Big Piney River are closed to sand and gravel mining from March 15 through June 15 (MDC 2000). This closing is based on the following criteria: Sensitive species recovery or maintenance, RTE or sensitive species spawning, outstanding national or state water, specific species management by MDC, and unique community or diversity. In addition, approximately 9 miles of Spring Creek are closed to sand and gravel mining from November 15 through February 15 (MDC 2000). The criteria for listing includes RTE or sensitive species spawning and specific species management by MDC.

Many types of activities such as the filling of wetlands, placement of roadfills, construction of dams and the construction of cable or pipeline crossing, just to name a few, require permitting from the COE when they involve “waters of the United States”. In the period from 1998 to 2002, approximately 29 permits were issued by the COE for activities within the Big Piney Watershed (USACOE 2003b). The most common activity for which permits were issued was gravel removal. Other activities for which permits were issued included road work, structures, bridge work, bank stabilization, and utilities. Additional information regarding the COE Regulatory Program can be found at http://www.nwk.usace.army.mil/regulatory/regulatory.htm.

Natural Features

The MDC inventoried counties within the Big Piney Watershed between 1990 and 1992 for unique natural features (Ryan and Smith 1991 and Ryan 1992). The inventories recognized seven categories of natural features: examples of undisturbed natural communities, habitat of rare or endangered species, habitat of relict species, outstanding geological formations, areas for nature studies, other unique features, and special aquatic areas having good water quality, flora, and fauna.

In tandem with the initial natural features inventories, the Missouri Natural Heritage Database (NHD) was created. The NHD lists many of the features which were included in the Missouri Natural Features Inventory. The database, which is updated frequently, is a dynamic representation of the occurrence of many natural features in Missouri. Currently the database contains 172 features for the Big Piney Watershed (MDC 2003b). These include 33 examples of 15 types of natural communities (Table Hc01). Dolomite glades are the most commonly recorded community of the watershed within the database accounting for 5 records. Dry-Mesic Chert Forest are the second most commonly recorded community with 4 records. Table Hc02 lists 4 inventoried aquatic communities located within the Big Piney Watershed. These include examples of 2 types of aquatic communities including Ozark Creeks and Small Rivers and Ozark Headwater Streams. A detailed description of the previously mentioned terrestrial natural communities can be found in *The Terrestrial Natural Communities of Missouri* by Nelson (1987), while a detailed description of Missouri's aquatic communities can be found in *Aquatic Community Classification System for Missouri* by Pflieger (1989).

Undoubtedly more examples of natural features exist within the watershed. However, due to many circumstances including the limited access to private land and the large land area, many features may be as yet unrecorded. Therefore, the previous listing of features should not be regarded as final or comprehensive. However, this listing does provide a good cross section of the types of communities which can be found within the watershed.

Improvement Projects

Much of the stream improvement activity within the Big Piney watershed has been focused on the coldwater fishery of Spring Creek. Since 1988 several projects have been completed on Spring Creek. These projects include bank stabilization using rock blankets, cedar tree revetments, and willow staking; as well as in-stream habitat improvement utilizing the placement of boulders and rootwads. In addition, a single site on Potters Creek near Cabool has been the site of an ongoing streambank stabilization project since 1990. Stabilization practices which have been used at this site include a cedar tree revetment, rock blankets, rock barbs, and riparian corridor tree planting.

Stream Habitat Assessment

Perhaps one of the more difficult attributes of a watershed to attempt to quantify is stream habitat. This is due to the fact that there are several dynamic characteristics which make up stream habitat. To evaluate all of these characteristics individually and accurately for an entire watershed, is a monumental task and beyond the scope of this document. Thus, the next best thing is to evaluate a characteristic that has the most impact on all aspects of stream habitat. This is, arguably, riparian corridor land cover/land use. Riparian corridor land cover affects many aspects of stream habitat. These include, but are not limited to water temperature, turbidity, nutrient loading, sand/gravel deposition, in-stream cover, flow, channel width, and channel stability. These in turn have effects on still other characteristics of stream habitat such as dissolved oxygen, cover, spawning areas, etc.

Evaluation of riparian corridor land cover within the Big Piney Watershed was accomplished using *Missouri Resource Assessment Partnership Land Cover Data* (morapmd.wpd). A buffer zone 3 pixels (90 meters) wide was created which corresponded to a 1:24, 000 hydrography coverage for the watershed. Percent land cover was then calculated for the area within this buffer based on the land cover categories of forest, wetland, grassland, cropland, urban, and water. Percentages of these categories were calculated for riparian corridors within each drainage unit as well as for the whole watershed.

Results from the Big Piney Watershed indicate that riparian corridor land cover consists of more forest/wetland (68.3%) than grassland/cropland (31.1%). Percentages for the remaining categories of urban and water are 0.2% and 0.4% respectively. Of the 4 eleven digit hydrologic units within the watershed, the Lower Big Piney Unit has the highest combined percentage of forest/wetland corridor land cover at 83.5%. It also ranks as having the lowest combined percentage of grassland/cropland corridor land cover at 14.8%. The Upper Big Piney Unit has the lowest percentage of combined forest/wetland riparian corridor at 49.0% and the highest combined percentage of grassland/cropland at 50.6%. Table Hc03 gives riparian corridor land cover/land use percentages for all eleven digit hydrologic units within the watershed as well as percentages for the total watershed. Figure Hc03 presents a graphic representation of riparian corridor land cover for all units within the watershed.

In addition to analysis of riparian corridor within hydrologic units, riparian corridor land cover was analyzed for all fourth order (Horton) and larger streams within the watershed. A comparison of combined forest/wetland to combined grassland/cropland land cover for fourth order and larger streams indicates that 17 out of 21 streams have corridors with larger combined percentages of forest/wetland than grassland/cropland. The Little Bald Ridge Creek corridor has the highest percentage of forest/wetland at 93.0%, while the Potter Creek corridor has lowest percentage of forest/wetland at 22.6%. The Big Piney River corridor has combined percentages of forest and wetland at 79.5% and combined grassland cropland at 12.6%. Results for the remaining fourth order and larger streams are given in Table Hc04.

An aerial stream survey of the Big Piney Watershed was conducted by the MDC in the spring of 1991. The survey included portions of Big Piney River, as well as major tributaries. Points of interest such as unstable stream and riparian areas as well as other significant landmarks were cataloged and an index of photos taken during the flight was created. Topographic maps were labeled according to the video index time. Information from this survey will be useful for a variety of projects such as future habitat assessment, assisting landowners with problems associated with stream bank erosion and deposition, reviewing gravel mining permits, selection of aquatic biota sampling sites.

Cold Water Habitat

Approximately 7.4 miles of streams within the Big Piney Watershed are designated for cold-water sport fishery (Figure Hc01) (MDNR 2000b). Approximately 6.5 miles of Spring Creek are designated for cold-water sport fishery. Bender Creek and Stone Mill Spring Branch account for another 0.7 and 0.2 miles designated for cold-water sport fishery respectively.

Table Hc01. Inventoried natural communities within the Big Piney Watershed (MDC 2003b).

Community	Number of Records in Watershed
Cave	3
Creeks And Small Rivers (Ozark)	2
Dolomite Glade	5
Dry Limestone/Dolomite Cliff	3
Dry-Mesic Chert Forest	4
Dry-Mesic Chert Woodland	2
Dry-Mesic Sandstone Forest	2
Dry-Mesic Sandstone Woodland	2
Headwater Streams (Ozark)	2
Mesic Limestone/Dolomite Forest	1
Moist Limestone/Dolomite Cliff	2
Moist Sandstone Cliff	1
Ozark Fen	2
Sandstone Glade	1
Upland Flatwoods	1

Table Hc02. Inventoried aquatic natural communities within the Big Piney Watershed (MDC 2003b).

Aquatic Community Type	Name	Significance
Creeks and Small Rivers (Ozark)	Arthur Creek	E
Creeks and Small Rivers (Ozark)	Big Piney River	ND
Headwater Streams (Ozark)	Arthur Creek	E
Headwater Streams (Ozark)	Bender Creek	E

Significance: S=Significant, **E**=Exceptional, **ND**=No Data

Table Hc03. Percent riparian corridor land cover for eleven digit hydrologic units within the Big Piney Watershed. Data is based analysis of MoRAP Missouri Land Cover Data (1999).

Unit Name	Forest	Wetland	Grassland	Cropland	Urban	Water
Upper Big Piney	49.0	0.0	50.6	0.1	0.2	0.1
Middle Big Piney	78.9	0.0	20.4	0.0	0.2	0.4
Spring Creek	64.8	0.0	35.1	0.1	0.0	0.0
Lower Big Piney	83.5	0.0	14.7	0.1	0.5	1.2
Big Piney Watershed	68.3	0.0	31.0	0.1	0.2	0.4

Table Hc04. Percent riparian corridor land cover for fourth order and larger streams within the Big Piney Watershed. Streams having combined percentages of grassland and cropland exceeding combined percentages of forest and wetland are in *bold italics*. Data is based on analysis of Missouri Land Cover Data (MoRAP 1999) and Kansas land cover data (KARS 1993).

Stream Name	Forest	Wetland	Grassland	Cropland	Urban	Water
Arthur Creek	78.9	0.0	21.1	0.0	0.0	0.0
BPW023	39.8	0.0	60.2	0.0	0.0	0.0
Bald Ridge Creek	75.2	0.0	24.6	0.0	0.0	0.2
Bender Creek	64.0	0.0	35.9	0.0	0.0	0.1
Berry Branch	59.7	0.0	40.3	0.0	0.0	0.0
Big Paddy Creek	88.3	0.0	11.3	0.0	0.0	0.4
Big Piney River	79.5	0.0	12.6	0.0	0.4	7.5
Burton Branch	67.4	0.0	32.6	0.0	0.0	0.0
Crossing Hollow	88.2	0.0	11.8	0.0	0.0	0.0
Dry Creek	60.1	0.0	36.1	0.1	3.7	0.0
Elk Creek	33.7	0.0	66.3	0.0	0.0	0.0
Hog Creek	55.4	0.0	44.6	0.0	0.0	0.1
Little Bald Ridge Creek	93.0	0.0	7.0	0.0	0.0	0.0
Little Paddy Creek	91.5	0.0	6.1	0.0	0.0	2.5
Long Hollow	59.1	0.0	40.9	0.0	0.0	0.0
Potter Creek	22.6	0.0	77.4	0.0	0.0	0.0
Sherrill Creek	62.5	0.0	37.5	0.0	0.0	0.0
Spring Creek	47.4	0.0	52.2	0.1	0.3	0.0
Steam Mill Hollow	73.0	0.0	27.0	0.0	0.0	0.0
Watts Hollow	84.7	0.0	14.8	0.0	0.0	0.4
West Piney Creek	65.5	0.0	34.4	0.1	0.0	0.0

Figure Hc01.

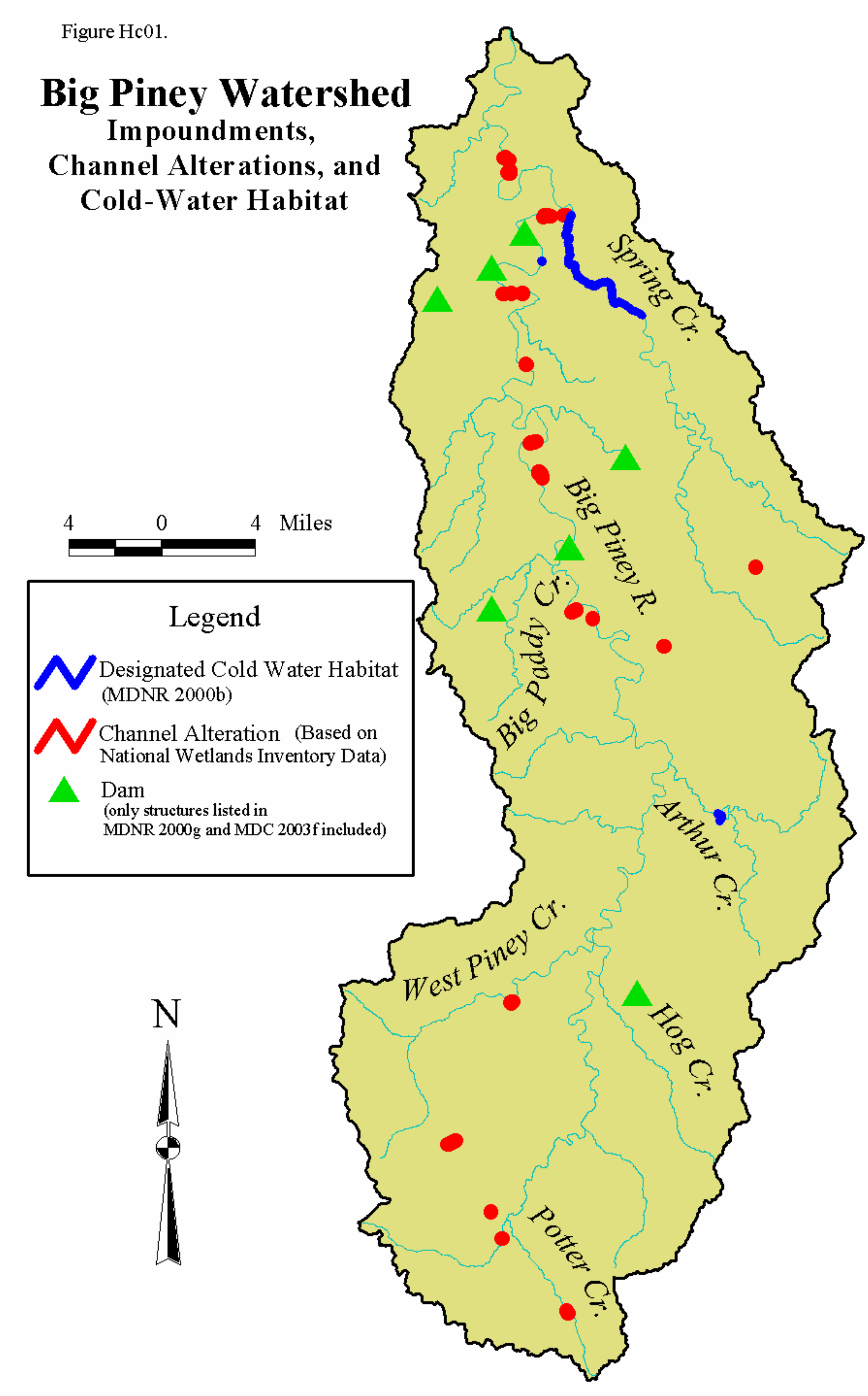

Big Piney Watershed
Impoundments,
Channel Alterations, and
Cold-Water Habitat
4 0 4 Miles
Legend
Designated Cold Water Habitat
(MDNR 2000b)
Channel Alteration (Based on
National Wetlands Inventory Data)
Dam
(only structures listed in
MDNR 2000g and MDC 2003f included)
N
Spring Cr.
Big Piney R.
Big Paddy Cr.
Arthur Cr.
West Piney Cr.
Hog Cr.
Potter Cr.

Figure Hc02.

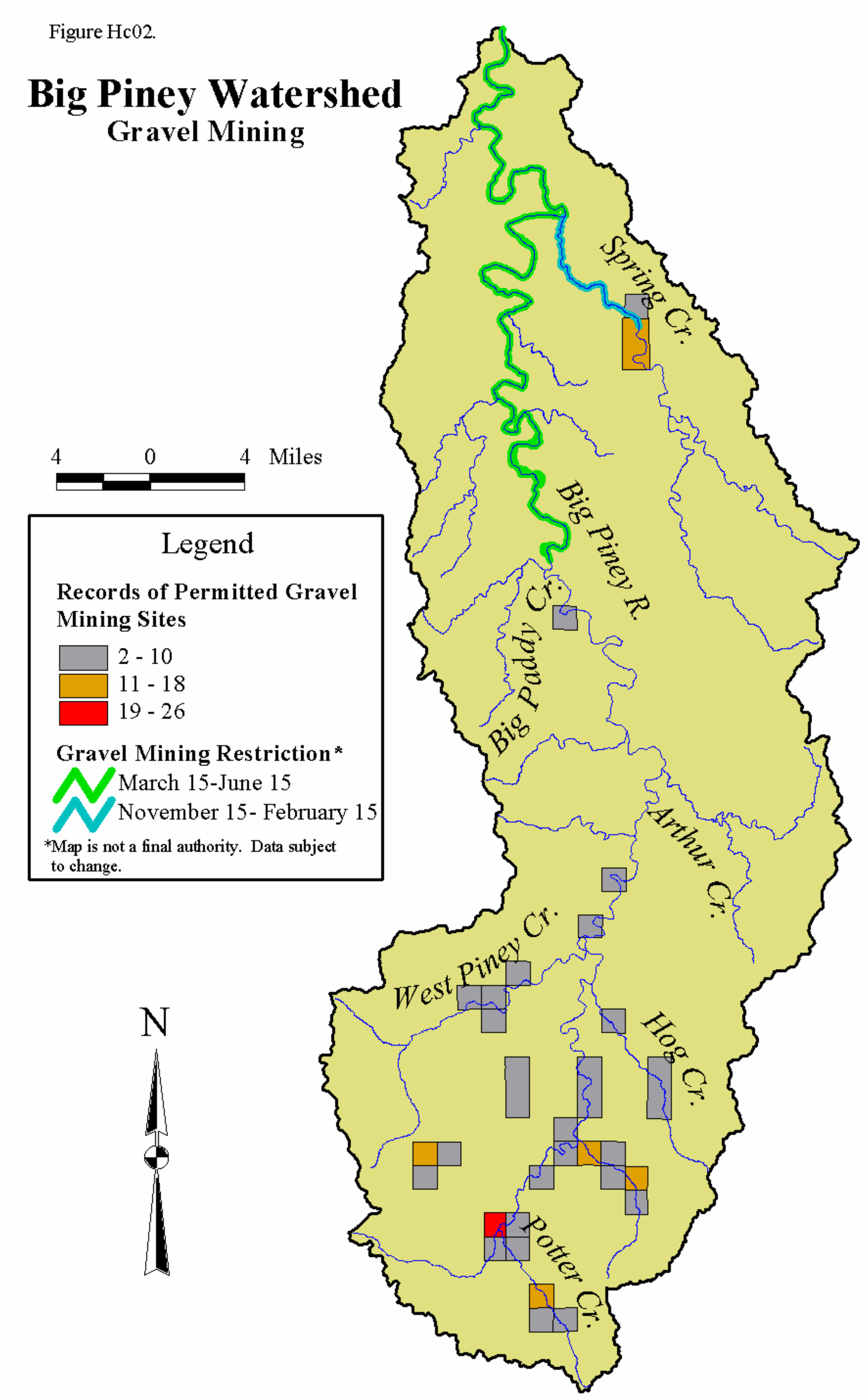
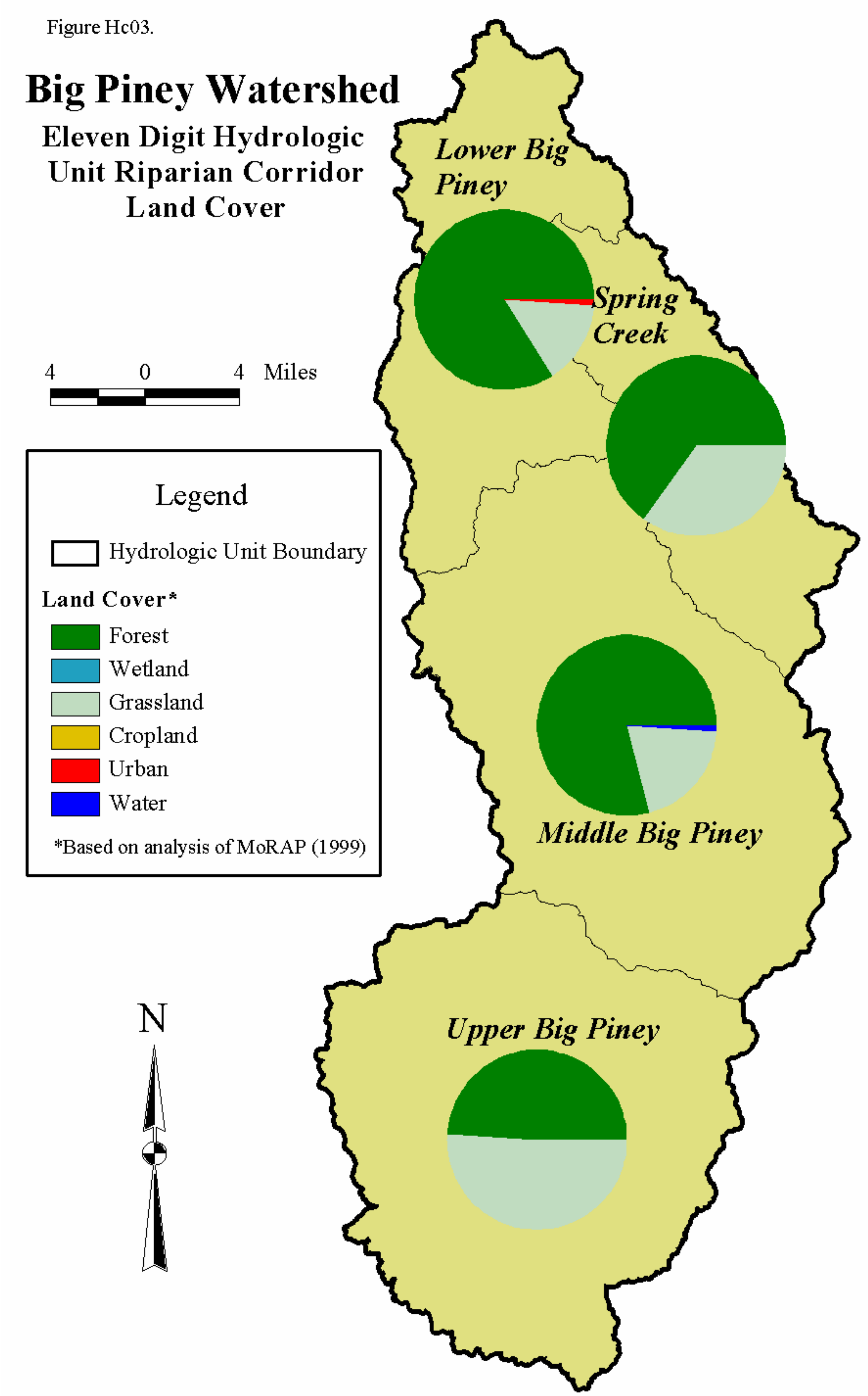

Big Piney Watershed
Gravel Mining
4 0 4 Miles
Legend
Records of Permitted Gravel Mining Sites
2 - 10
11 - 18
19 - 26
Gravel Mining Restriction*
March 15-June 15
November 15- February 15
*Map is not a final authority. Data subject to change.
N
Spring Cr.
Big Piney R.
Big Paddy Cr.
Arthur Cr.
West Piney Cr.
Hog Cr.
Potter Cr.

Figure Hc03.


Big Piney Watershed
Eleven Digit Hydrologic Unit Riparian Corridor Land Cover
4 0 4 Miles
Legend
Hydrologic Unit Boundary
Land Cover*
Forest
Wetland
Grassland
Cropland
Urban
Water
*Based on analysis of MoRAP (1999)
N
Lower Big Piney
Spring Creek
Middle Big Piney
Upper Big Piney

Biotic Community

Stream Fish Distribution and Abundance

Historical records of fish community collections within the Big Piney Watershed date back to 1930 (MDC 1998a and MoRAP 2003a). From 1930 to 2002, 73 fish species (not including hybrids or larval lamprey) in 24 families have been collected within the watershed (Table Bc01) (MDC Ozark Regional Fish Community Collections and Sport Fish Sample Files; MDC 1998a; Sternberg et al. 1998; MoRAP 2003a). Fish community sampling sites are presented in Figure Bc01.

Analysis of temporal distribution of species within the watershed was accomplished by dividing the examined Period of record for fish community collections into three periods: Period One (1930- 1954), Period Two (1955-1979), and Period Three (1980-2002). This analysis revealed that 68 fish species were sampled within the watershed in Period One, while 60 species each were sampled in Periods Two and Three (MDC Ozark Regional Fish Community Collections, Sport Fish Sample Files, and Creel Survey Files; MDC 1998a; and MoRAP 2003a). Three species found within the watershed in Period Three had not been found in previous periods. These species include mottled sculpin (Cottus bairdi), western mosquitofish (*Gambusia affinis),* and striped shiner *(Luxilis chrysocephalus)*.

Thirteen fish species found within the watershed in Periods One and /or Two were not found in Period Three. These include Goldfish (*Carassius auratus),* river carpsucker (*Carpoides carpio)* quillback (*Carpoides cyprinus),* highfin carpsucker (*Carpoides velifer)*, northern brook lamprey *(Ichthyomyzon fossor)*, smallmouth buffalo *(Ictiobus bubalus)*, shortnose gar *(Lepisosteus platostomus)*, orangespotted sunfish *(Lepomis humilis)*, silver redhorse *(Moxostoma anisurum),* river redhorse *(Moxostoma carinatum)*, shorthead redhorse *(Moxostoma macrolepidotum)*, slenderhead darter *(Percina phoxocephala)*, and walleye *(Stizostedion vitreum*). Six species, including river carpsucker, highfin carpsucker, smallmouth buffalo, shortnose gar, slenderhead darter, and walleye do not appear to have solid records of being common to the watershed. This is illustrated by the fact that only a maximum of 8 individuals per species are recorded as having been found in the watershed. In addition, each species was found only at a single site within the watershed with no additional individuals observed after Period One.

Two species absent from Period Three collections, the quillback and the northern brook lamprey, each had 6 individuals recorded from 2 locations and 4 locations respectively during the previous time period(s). However, due to the combining of collections from two locations with samples spanning Periods One and Two, it is difficult to determine if these species were present in one or both periods.

Three species which appear to have been relatively well established within the watershed during Periods One and Two are absent from Period Three collections. The shorthead redhorse was previously reported from 5 sites within the watershed with 208 individuals recorded. The river redhorse was previously reported from 6 sites within the watershed with 50 individuals recorded. Over 11 individuals of the orange spotted sunfish were also reported during Periods One and Two from 6 sites.

Two species of fish have been collected in fish community samples of Period Three which were not recorded in fish community collections from the previous two periods within the watershed. These include the striped shiner, and western mosquitofish. Prior to 1995, the striped shiner had not been recorded in the Big Piney Watershed since before 1905. Since 1995, this species has been recorded from 9 sites within the watershed. Pflieger (1997) notes the historic decline and reappearance of the striped shiner within the Gasconade River System (which includes the Big Piney Watershed) and states that the "reestablishment of the striped shiner in the Gasconade system suggests an undocumented reintroduction of the species into the Gasconade headwaters".

The western mosquitofish had not been observed within the watershed prior to 1980. Since 1980, the western mosquitofish has been recorded at 10 sites within the watershed. A survey in the 1940s indicated that its distribution in Missouri included the "Lowland Faunal Re gion and northward along the

Mississippi River to Ramsey Creek in Pike County" (Pflieger 1997). Today the mosquito fish can be found in all of the faunal regions of the state.

Many variables, including differences in sampling methodology and effort could be an explanation for the absence from recent collections of some species which were previously known to occur in the watershed. For other previously recorded species, the limited distribution as well as the absence of substantial numbers of individuals suggests that some species have never been common in the watershed. The exact cause or causes of the appearance of some species and apparent disappearance of others in the watershed is difficult to ascertain given the many different variables one might need to take into account among these of which are differences in sampling effort and gear between the three time periods. Such an analysis not only goes beyond the scope of this document but could comprise a fairly lengthy report by itself.

Game Fish

The Big Piney River and its tributaries offer a variety of angling opportunities. A total of 8 species of gamefish (as defined in MDC 2004a) are known to occur within the watershed (MDC Ozark Regional Fish Collection Files; MoRAP 2003a; MDC 1998a). Smallmouth bass, largemouth bass and rock bass are common. At the time of this writing, the Big Piney River from Slabtown Access to Ross Access is a Smallmouth Bass Special Management Area (MDC 2003d). In this area, "all smallmouth bass less than fifteen inches in total length must be returned to the water unharmed immediately after being caught" and the "daily limit may include no more than one smallmouth bass" (MDC 2004a). In addition, the Big Piney River, from highway 17 to the Gasconade River, has an eight inch minimum length limit for Rock Bass. In this area, "all rock bass less than eight inches in total length must be returned to the water unharmed immediately after being caught" (MDC 2004a).

Other game fish species found in the watershed include channel catfish (probably more common in farm ponds of the watershed than streams), rainbow trout, white crappie, black crappie, and flathead catfish. Walleye are known to have been found in a few pre-1955 fish community samples, however they have not been found in samples since.

Two significant rainbow trout fisheries occur within the watershed. These are located on Spring Creek in Phelps County and Stone Mill Spring Branch in Pulaski County. Spring Creek, from

Relfe Spring to its junction with the Big Piney River (6.2 miles) is currently managed as a Wild Trout Management Area; while the entire Stone Mill Spring Branch (0.3 miles), is currently managed as a Trout Management Area. Special regulations apply for both areas. For additional information please refer to current copy of the Missouri Wildlife Code. It should also be noted that in addition to a Missouri fishing license, an FLW sportsmen's permit and stamp is required to fish in the Stone Mill Spring Trout Management Area (MDC 2004b).

Regulations governing hunting and fishing activities are subject to change. Before engaging in these activities, one should consult the most current copy of the Missouri Wildlife Code.

One potential concern regarding the game fish population of the headwaters of the Big Piney Watershed, as well as many other Ozark headwater streams, is the success of MDCs river otter reintroduction program. Since the successful reintroduction of the otter, complaints from private land owners and sportsman's groups regarding otter impacts to pond and stream fisheries have been received by the MDC. Efforts have been undertaken by the MDC to determine the otter's role in the decline of game fish populations in headwater streams. Changes in otter trapping regulations have been implemented in order to address problems associated with high otter densities in areas where damage is believed to be the most severe. As a result, many Ozark streams, including the Big Piney and its tributaries, are located in a management zone which has an extended otter trapping season (relative to other zones) and a liberal bag limit (MDC 2003e).

Detailed studies and monitoring of stream gamefish populations have been conducted by the MDC within the watershed. Due to the large amount of information available, a comprehensive summary of these efforts is not practical within the pages of this document. Additional information regarding the gamefish populations within the watershed may be obtained by contacting the Fisheries staff at the Missouri Department of Conservation, West Plains, Missouri 65775; Phone (417)256-7161

Fish Stocking

Fish stocking efforts within the Big Piney Watershed have included the stocking of both cold and warm-water species. Some of the earliest fish stocking known to have occur red in the watershed involved the introduction of Salmonid species. It is speculated that trout may have been stocked as early as 1880 with fish from Brown Spring Station Hatchery at St. Joseph Missouri (Tryon 1990). Also during this time, "California Salmon" were introduced to tributaries of the Missouri River (which may well have included the Gasconade) via the Frisco Railroad which ran from St. Louis to Southwest Missouri (Turner 1979). Several later stockings of other species were also carried out utilizing the rail line. While this rail line did not cross streams of the Big Piney, it did cross the Gasconade downstream of the Big Piney. Whether or not these fish ever made it into the streams of the Big Piney watershed is, for the most part, left to speculation. In 1902, grayling were stocked in Spring Creek (Tryon 1990). The first official record of trout introduction into spring creek is in 1908 with the stocking of brook trout. In 1910, the first official recorded introduction of rainbow trout occurs. Periodic stockings of both brown trout and rainbow trout (including at least one documented case of the stocking of Australian rainbow trout) occurred until 1982 when Spring Creek became managed as a self-sustaining rainbow trout fishery (Turner 1988 and Tryon 1990).

Today spring creek continues to have a self-sustaining rainbow trout population and currently receives no stocking.

Stone Mill Spring Branch is another stream which has been stocked with trout. Stone Mill Spring Branch, located east of Fort Leonard Wood Military Reservation, has been managed by Fort Leonard Wood as a "put-and-take" rainbow trout fishery since 1965. This fishery is stocked regularly throughout the year.

Limited availability of historic stocking records for warm water species, the potential of "bait bucket" introductions and the availability of fish from commercial dealers, makes it difficult to address the entire scope of warm water stocking which has or may have occurred in the Big Piney Watershed. However, examination of various sources reveals some past stocking efforts within the watershed. The common carp, a species native to Asia, was widely stocked in Missouri by the Missouri Fish Commission between 1879 and 1895 at which time the program was discontinued (Pflieger 1997). Earliest observations of common carp from MDC fish community collection files are from 1947 (MDC 1998a). While common carp are a component of the commercial fishing industry in Missouri (Barnes and Riggert 2000), common carp can also be a nuisance species.

They take space in rivers, streams, and lakes away from native species. They can increase stream and lake turbidity, destroy spawning habitat, while eating the eggs of native species of fish (Barnes and Riggert 2000). MDC annual reports (1937-1942 and 1946-1992) indicate that, historically, warm-water fish stocked or "rescued" (removing fish from intermittent pools of water and redistributing to areas deemed more suitable) by the MDC in the watershed included largemouth bass, smallmouth bass, crappie, bluegill, green sunfish, catfish, shadow bass, and "minnows". The practice of "fish rescue" has been discontinued.

Roby Lake, a USFS impoundment, currently receives supplemental stockings of channel catfish on a semi-annual basis (MDC 2000c). In addition, 5 impoundments on FLW are stocked with channel catfish annually by FLW. Some of these impoundments have also received stockings of hybrid sunfish and bluegill within the last 5 years (Zurbrick, Personal Communication). Undoubtedly, farm ponds within the watershed have been stocked with largemouth bass, bluegill, and channel catfish by private individuals who obtained fish from the MDC, commercial dealers, and/or other water bodies. The availability of grass carp from commercial fish dealers also increases the probability of this species having been stocked in water bodies within the watershed. The potential of these fish being washed into streams exists during major precipitation events.

A lack of historical records, plus the occurrence of undocumented introductions makes it difficult to determine, with any reliability, all species which may have been introduced into the watershed. Effects of introductions vary. While the introduction of species already present in the watershed may have minimal to no effect, the introduction of exotic (non-native) species can, in many instances, have disastrous consequences.

Mussels

A total of 32 species and subspecies of mussels are known to occur within the Big Piney Watershed (Table Bc02 and Figure Bc02) (MDC 1998d, MDC 1998f, Sternberg 1998 et al. 1998, MoRAP 2003b, MNHP 2003b, and). Of these, 1 species, the pink mucket (*Lampsilis abrupta*) is listed as a state and federal endangered species (MNHP 2003a). In addition, the elephant ear (*Elliptio crassidens*) is a state endangered species. Three additional species within the watershed are considered species of conservation concern. These include the elktoe (*Alasmidonta marginata*),

spectaclecase (*Cumberlandia monodonta*), and the Ouachita kidneyshell (*Ptychobranchus occidentalis*). The Asian clam (*Corbicula flumina*) is an exotic (non-native) species of mussel which occurs in the watershed. This mollusk is a native of southern and eastern Asia. The Asian clam can alter lake and stream substrates, compete with native mussels for food and space, and cause biofouling problems in irrigation systems, power plants, and other industrial water systems (USGS 2002b).

Snails

Six species of snails have been identified within the Big Piney Watershed (Wu etal. 1997). These include the highland campeloma (*Campeloma subsolidum*), pyramid elimia (*Elimia potosiensis*), pygmy fossaria (*Lymnaea [Fossaria] parva*), Goodrich's physa (*Physa [Physella] goodrichi*), tadpole physa (*Physa [Physella] gyrina*), and sharp hornsnail (*Pleurocera acuta*).

Crayfish

Three species of crayfish are known to occur within the Big Piney Watershed (MDC 1998e, Sternberg et al. 1998, and MoRAP 2003c). These include the golden crayfish (*Orconectes luteus*), Salem cave crayfish (*Cambarus hubrichti*), and spothanded crayfish (*Orconectes punctimanus*).

The Salem cave crayfish, currently (2003) a species of conservation concern, has been found at a single site in the watershed; while the golden crayfish and spothanded crayfish appear to be fairly wide spread within the watershed. It is important to note that it appears no crayfish sampling has been conducted on the Lower Big Piney or its tributaries with the exception of Spring Creek.

Crayfish community sampling sites are presented in Figure Bc03.

Benthic Invertebrates

One hundred and ninety-one taxa of aquatic invertebrates (not including mussels and crayfish) have been collected within the Big Piney Watershed and have records within the MDC Benthic Invertebrate Database (MDC 1998f) (Table Bc03). Two species are listed as Missouri species of conservation concern (MDNHP 2003a). These include the Ozark clubtail (*Gomphus ozarkensis*) and westfall's snaketail (*Ophiogomphus westfalli*). MDC (1998f) benthic invertebrate sampling sites are presented in Figure Bc04.

Species of Conservation Concern

Within the Big Piney Watershed, 40 species of conservation concern have been identified (Table Bc04) (MNHP 2003b). These include 15 species of plants (flowering plants, ferns, fern allies, and mosses); 2

species of insects; 1 species of crayfish; 4 species of mussels; 4 species of fish; 2 species of amphibians, 6 species of birds; and 5 species of mammals. Four species within the watershed are federally and state listed as endangered. These include the gray bat, Indiana bat, pink mucket, and running buffalo clover. An additional species, the Bald Eagle, is federally listed as threatened and state listed as endangered. In addition to the aforementioned species, the eastern hellbender is currently proposed for state listing as endangered.

Table Bc01. Fish species (and subspecies) whose distributions range includes the Big Piney Watershed in Missouri (MDC Ozark Regional Fish Community and Sport Fish Sample Files; Pflieger 1997; MDC 1998a; MNHP 2003b; MoRap 2003a).

Scientific Name	Common Name	Period 1	Period 2	Period 3
Ambloplites rupestris	Rock Bass	X	X	X
Ameiurus melas	Black Bullhead	X	X	X
Ameiurus natalis	Yellow Bullhead	X	X	X
Anguilla rostrata	American Eel	X	X	X
Aplodinotus grunniens	Freshwater Drum	X		X
Campostoma oligolepis	Largescale Stoneroller	X	X	X
Campostoma pullum	Central Stoneroller	X	X	X
Carassius auratus	Goldfish		X	
Carpiodes carpio	River Carpsucker	X		
Carpiodes cyprinus	Quillback	X	X	
Carpiodes velifer	Highfin Carpsucker	X		
Catostomus commersonni	White Sucker	X	X	X
Cottus bairdi	Mottled Sculpin			X
Cottus carolinae	Banded Sculpin	X	X	X
Cottus hypselurus	Ozark Sculpin	X	X	X
Cyprinella spiloptera	Spotfin Shiner	X	X	X
Cyprinus carpio	Common Carp	X	X	X
Dorosoma cepedianum	Gizzard Shad	X	X	X
Erimystax x -punctatus	Gravel Chub	X	X	X
Etheostoma blennioides	Greenside Darter	X	X	X
Etheostoma caeruleum	Rainbow Darter	X	X	X
Etheostoma f. lineolatum	Striped Fantail	X	X	X
Etheostoma punctulatum	Stippled Darter	X	X	X
Etheostoma s. spectabile	Northern Orangethroat Darter	X	X	X
Etheostoma tetrazonum	Missouri Saddled Darter	X	X	X
Etheostoma zonale	Banded Darter	X	X	X
Fundulus catenatus	Northern Studfish	X	X	X

Scientific Name	Common Name	Period 1	Period 2	Period 3
Fundulus olivaceous	Blackspotted Topminnow	X	X	X
Fundulus sciadicus	Plains Topminnow	X	X	X
Gambusia affinis	Western Mosquitofish			X
Hiodon tergisus	Mooneye	X		X
Hypentelium nigricans	Northern Hog Sucker	X	X	X
Ichthyomyzon fossor	Northern Brook Lamprey	X	X	
Ictalurus punctatus	Channel Catfish	X		X
Ictiobus bubalus	Smallmouth Buffalo	X		
Labidesthes sicculus	Brook Silverside	X	X	X
Lepisosteus osseus	Longnose Gar	X	X	X
Lepisosteus platostomus	Shortnose Gar	X		
Scientific Name	Common Name	Period 1	Period 2	Period 3
Lepomis cyanellus	Green Sunfish	X	X	X
Lepomis humilis	Orangespotted Sunfish	X	X	
Lepomis macrochirus	Bluegill	X	X	X
Lepomis megalotis	Longear Sunfish	X	X	X
Luxilus chrysocephalus	Striped Shiner			X
Luxilus zonatus	Bleeding Shiner	X	X	X
Lythrurus U. Umbratilis	Western Redfin Shiner	X	X	X
Micropterus dolomieu	Smallmouth Bass	X	X	X
Micropterus salmoides	Largemouth Bass	X	X	X
Moxostoma anisurum	Silver Redhorse	X	X	
Moxostoma carinatum	River Redhorse	X	X	
Moxostoma duquesnei	Black Redhorse	X	X	X
Moxostoma erythrurum	Golden Redhorse	X	X	X
Moxostoma macrolepidotum	Shorthead Redhorse	X	X	
Nocomis biguttatus	Hornyhead Chub	X	X	X
Notemigonus crysoleucas	Golden Shiner	X	X	X
Notropis boops	Bigeye Shiner		X	X

Scientific Name	Common Name	Period 1	Period 2	Period 3
Notropis greenei	Wedgespot Shiner	X	X	X
Notropis heterolepis	Blacknose Shiner	X	X	X
Notropis nubilus	Ozark Minnow	X	X	X
Notropis rubellus	Rosyface Shiner	X	X	X
Noturus exilis	Slender Madtom	X	X	X
Noturus flavus	Stonecat	X	X	X
Oncorhynchus mykiss	Rainbow Trout	X		X
Percina C. Fulvitaenia	Ozark Logperch	X	X	X
Percina cymatotaenia	Bluestripe Darter	X	X	X
Percina evides	Gilt Darter	X	X	X
Percina phoxocephala	Slenderhead Darter	X		
Phoxinus erythrogaster	Southern Redbelly Dace	X	X	X
Pimephales notatus	Bluntnose Minnow	X	X	X
Pomoxis annularis	White Crappie	X	X	X
Pomoxis nigromaculatus	Black Crappie	X		X
Pylodictis olivaris	Flathead Catfish	X	X	X
Semotilus atromaculatus	Creek Chub	X	X	X
Stizostedion vitreum	Walleye	X		

Period 1 = collected 1930 to 1954; **Period 2** = collected 1955 to 1979; **Period 3** = collected 1980-2002

Table Bc02. Mussel species found historically within the Big Piney Watershed. (MDC 1998d, MDC 1998f, Sternberg et al. 1998, MoRAP 2003b, MNHP 2003a, and MNHP 2003b)

*Species of Conservation Concern

Scientific Name	Common Name	State Status	Federal Status
Actinonaias ligamentina	Mucket		
Alasmidonta marginata*	Elktoe*		
Alasmidonta viridis	Slippershell mussel		
Amblema plicata	Threeridge		
Corbicula fluminea (I)	Asiatic Clam (I)		
Cumberlandia monodonta*	Spectaclecase*		
Cyclonaias tuberculata	Purple Wartyback		
Elliptio crassidens*	Elephant Ear*	Endangered	
Elliptio dilatata	Spike		
Fusconaia flava	Wabash Pigtoe		
Fusconaia ozarkensis	Ozark Pigtoe		
Lampsilis abrupta*	Pink Mucket*	Endangered	Endangered
Lampsilis cardium	Plain Pocketbook		
Lampsilis r. brevicula	Ozark Broken-ray		
Lampsilis r. brittsi	Northern Broken-ray		
Lampsilis siliquoidea	Fatmucket		
Lampsilis teres	Yellow Sandshell		
Lasmigona costata	Fluted Shell		
Leptodea fragilis	Fragile Papershell		
Ligumia recta*	Black Sandshell*		
Ligumia subrostrata	Pond Mussel		
Pleurobema sintoxia	Round Pigtoe		
Ptychobranchus occidentalis*	Ouachita Kidneyshell*		
Potamilus alatus	Pink Heelsplitter		
Pyganodon grandis	Giant Floater		

Scientific Name	Common Name	State Status	Federal Status
grandis			
Quadrula metanevra	Monkeyface		
Quadrula pustulosa	Pimpleback		
Strophitus undulates	Creeper		
Utterbackia imbecillis	Paper Pondshell		
Tritogonia verrucosa	Pistolgrip		
Venustaconcha ellipsiformis	Ellipse		
Venustaconcha pleasi	Bleedingtooth Mussel		

Table Bc03. Benthic invertebrate taxa of the Big Piney Watershed (MDC 1998f and MNHP 2003b). List does not include mussels or crayfish.

Order	Family	Species
Amphipoda	Crangonyctidae	Crangonyx minor (Bousfield)
Amphipoda	Gammaridae	Gammarus pseudolimnaeus (Bousfield)
Amphipoda	Talitridae	Hyalella azteca (Saussure)
Coleoptera	Curculionidae	Onyc hylis sp.
Coleoptera	Dryopidae	
Coleoptera	Dryopidae	Helichus lithophilus (Germar)
Coleoptera	Dytiscidae	
Coleoptera	Dytiscidae	Copelatus glyphicus (Say)
Coleoptera	Dytiscidae	Cybister fimbriolatus (Say)
Coleoptera	Dytiscidae	Cybister sp.
Coleoptera	Dytiscidae	Dytiscus sp.
Coleoptera	Dytiscidae	Hydroporus undulatus (Say)
Coleoptera	Dytiscidae	Laccophilus fasciatus (Aube)
Coleoptera	Elmidae	Ancyronyx variegata (Germar)
Coleoptera	Elmidae	Dubiraphia sp.
Coleoptera	Elmidae	Macronychus glabratus (Say)
Coleoptera	Elmidae	Microcylloepus pusillus pusillus (LeConte)
Coleoptera	Elmidae	Optioservus sandersoni (Collier)
Coleoptera	Elmidae	Stenelmis sp.
Coleoptera	Gyrinidae	Dineutus sp.
Coleoptera	Haliplidae	
Coleoptera	Haliplidae	Haliplus sp.
Coleoptera	Haliplidae	Peltodytes edentulus (LeConte)
Coleoptera	Haliplidae	Peltodytes tortulosus (Roberts)
Coleoptera	Hydrophilidae	
Coleoptera	Hydrophilidae	Berosus sp.
Coleoptera	Hydrophilidae	Enochrus sp.
Coleoptera	Hydrophilidae	Tropisternus sp.

Order	Family	Species
Coleoptera	Limnicidae	Lutrochus laticeps (Casey)
Coleoptera	Psephinidae	Ectopria nervosa (Melsheimer)
Coleoptera	Psephinidae	Psephenus herricki (DeKay)
Coleoptera	Ptilodactylidae	
Diptera	Athericidae	Atherix lantha (Webb)
Diptera	Ceratopogonidae	
Diptera	Ceratopogonidae	Alluaudomyia sp.
Diptera	Ceratopogonidae	Atrichopogon sp.
Diptera	Ceratopogonidae	Bezzia/Probezzia...
Diptera	Ceratopogonidae	Forcipomyia sp.
Diptera	Chaoboridae	
Diptera	Chironomidae	
Diptera	Culicidae	
Diptera	Culicidae	Aedes sp.
Diptera	Culicidae	Anopheles sp.
Diptera	Empididae	
Diptera	Ephydridae	
Diptera	Muscidae	
Diptera	Psychodidae	Pericoma sp.
Diptera	Psychodidae	Psychoda sp.
Diptera	Simuliidae	
Diptera	Stratiomyidae	
Diptera	Stratiomyidae	Odontomyia sp.
Diptera	Syrphidae	Chrysogaster sp.
Diptera	Tabanidae	
Diptera	Tanyderidae	Protoplasa fitchii (Osten-Sacken)
Diptera	Tipulidae	Antocha sp.
Diptera	Tipulidae	Erioptera sp.
Diptera	Tipulidae	Hexatoma sp.

Order	Family	Species
Diptera	Tipulidae	Tipula sp.
Ephemeroptera	Baetidae	
Ephemeroptera	Baetidae	Acentrella sp.
Ephemeroptera	Baetidae	Baetis tricaudatus (Dodds)
Ephemeroptera	Baetidae	Callibaetis sp.
Ephemeroptera	Baetidae	Diphetor sp.
Ephemeroptera	Baetiscidae	Baetisca lacustris (McDunnough)
Ephemeroptera	Caenidae	Caenis sp.
Ephemeroptera	Ephemerellidae	Ephemerella (invaria grp.)
Ephemeroptera	Ephemerellidae	Ephemerella sp.
Ephemeroptera	Ephemerellidae	Eurylophella (bicolor grp.)
Ephemeroptera	Ephemerellidae	Serratella deficiens (Morgan)
Ephemeroptera	Ephemeridae	Ephemera simulans (Walker)
Ephemeroptera	Ephemeridae	Hexagenia limbata (Serville)
Ephemeroptera	Heptageniidae	Epeorus namatus (Burks)
Ephemeroptera	Heptageniidae	Heptagenia sp.
Ephemeroptera	Heptageniidae	Rhithrogena pellucida (Daggy)
Ephemeroptera	Heptageniidae	Stenacron (interpunctatum grp.)
Ephemeroptera	Heptageniidae	Stenacron gildersleevei (Traver)
Ephemeroptera	Heptageniidae	Stenonema femoratum (Say)
Ephemeroptera	Heptageniidae	Stenonema mediopunctatum (McDunnough)
Ephemeroptera	Heptageniidae	Stenonema pulchellum (Walsh)
Ephemeroptera	Isonychiidae	Isonychia sp.
Ephemeroptera	Leptophlebiidae	
Ephemeroptera	Leptophlebiidae	Choroterpes basalis (Banks)
Ephemeroptera	Leptophlebiidae	Leptophlebia cupida (Say)
Ephemeroptera	Leptophlebiidae	Paraleptophlebia moerens (McDunnough)
Ephemeroptera	Polymitarcyidae	Ephoron album (Say)
Ephemeroptera	Potamanthidae	Anthopotamus sp.

Order	Family	Species
Ephemeroptera	Siphlonuridae	Siphlonurus sp.
Ephemeroptera	Tricorythidae	Tricorythodes sp.
Gordiida		
Hemiptera	Corixidae	
Hemiptera	Gerridae	
Hemiptera	Gerridae	Trepobates sp.
Hemiptera	Notonectidae	Buenoa sp.
Hemiptera	Veliidae	
Hemiptera	Veliidae	Rhagovelia sp.
Hirudinea2		
Hirundinea2	Branchiobdellidae1	
Hydracarina	Acari	
Isopoda		
Isopoda	Asellidae	Caecidotea sp.
Isopoda	Asellidae	Lirceus sp.
Lepidoptera	Pyralidae	Nymphula sp.
Lepidoptera	Pyralidae	Petrophila sp.
Lymnophila	Ancylidae	
Lymnophila	Ancylidae	Ferrissia fragilis (Tryon)
Lymnophila	Lymnaeidae	
Lymnophila	Physidae	
Lymnophila	Planorbidae	
Megagastropoda	Pleuroceridae	Elimia sp.
Megagastropoda	Viviparidae	
Megaloptera	Corydalidae	Corydalus cornutus (Linnaeus)
Megaloptera	Corydalidae	Nigronia serricornis (Say)
Megaloptera	Sialidae	Sialis sp.
Nemata3		
Neuroptera	Sisyridae	Sisyra sp.

Order	Family	Species
Odonata	Aeshnidae	Aeshna sp.
Odonata	Aeshnidae	Epiaeschna heros (Fabricius)
Odonata	Calopterygidae	
Odonata	Calopterygidae	Hetaerina americana (Fabricius)
Odonata	Coenagrionidae	
Odonata	Coenagrionidae	Argia moesta (Hagen)
Odonata	Coenagrionidae	Enallagma praevarum (Hagen)
Odonata	Coenagrionidae	Ischnura sp.
Odonata	Coenagrionidae	Nehalennia gracilis (Morse)
Odonata	Coenagrionidae	Telebasis sp.
Odonata	Corduliidae	Epitheca princeps (Hagen)
Odonata	Gomphidae	
Odonata	Gomphidae	Erpetogomphus designatus (Hagen)
Odonata	Gomphidae	Gomphus ozarkensis
Odonata	Gomphidae	Ophiogomphus westfalli
Odonata	Gomphidae	Stylogomphus albistylus (Hagen)
Odonata	Libellulidae	
Oligochaeta		
Pelecypoda2		
Plecoptera	Capniidae	Allocapnia sp.
Plecoptera	Capniidae	Paracapnia sp.
Plecoptera	Chloroperlidae	
Plecoptera	Leuctridae	Leuctra tenuis (Pictet)
Plecoptera	Nemouridae	
Plecoptera	Nemouridae	Amphinemura delosa (Ricker)
Plecoptera	Perlidae	
Plecoptera	Perlidae	Acroneuria sp.
Plecoptera	Perlidae	Neoperla clymene (Newman)
Plecoptera	Perlidae	Neoperla sp.

Order	Family	Species
Plecoptera	Perlidae	Perlesta placida (Hagen)
Plecoptera	Perlidae	Perlinella drymo (Newman)
Plecoptera	Perlodidae	Hydroperla sp.
Plecoptera	Perlodidae	Isoperla bilineata (Say)
Plecoptera	Perlodidae	Isoperla marlynia (Needham & Claassen)
Plecoptera	Perlodidae	Isoperla mohri (Frison)
Plecoptera	Pteronarcyidae	Pteronarcys pictetii (Hagen)
Plecoptera	Taeniopterygidae	
Plecoptera	Taeniopterygidae	Strophopteryx fasciata (Burmeister)
Plecoptera	Taeniopterygidae	Taeniopteryx metequi (Ricker & Ross)
Plecoptera	unknown	unidentified plecoptera
Trichoptera		
Trichoptera	Brachycentridae	Brachycentrus americanus (Banks)
Trichoptera	Glossosomatidae	Agapetus sp.
Trichoptera	Helicopsychidae	Helicopsyche borealis (Hagen)
Trichoptera	Hydropsychidae	Ceratopsyche (morose grp.)
Trichoptera	Hydropsychidae	Ceratopsyche piatrix (Ross)
Trichoptera	Hydropsychidae	Ceratopsyche slossonae (Banks)
Trichoptera	Hydropsychidae	Cheumatopsyche sp.
Trichoptera	Hydropsychidae	Hydropsyche betteni (Ross)
Trichoptera	Hydropsychidae	Hydropsyche cuanis (Ross)
Trichoptera	Hydropsychidae	Hydropsyche simulans/incommoda
Trichoptera	Hydropsychidae	Hydropsyche sp.
Trichoptera	Hydroptilidae	Agraylea multipunctata (Curtis)
Trichoptera	Hydroptilidae	Hydroptila sp.

[1] Subclass, [2] Class, [3] Phylum

Table Bc04. Species of conservation concern within the Big Piney Watershed in Missouri (MDC 1998f, Sternberg et al. 1998, and MNHP 2003b). Note: Listing does not include records of occurrences listed as historic, destroyed, or introduced (exotic); or records with a location precision that is “General” (mappable to within a 5 mile radius) or unmappable.

Scientific Name	Common Name	F	M	GRank	SRank	Date
			Amphibians			
Ambystoma annulatum	Ringed Salamander			G4	S3	1975
Cryptobranchus alleganiensis Alleganiensis	Eastern Hellbender		E*	G3G4T3T4	S1	1998
			Birds			
Accipiter cooperii	Cooper's Hawk			G5	S3	1986
Accipiter striatus	Sharp-Shinned Hawk			G5	S2	1986
Buteo lineatus	Red-Shouldered Hawk			G5	S3	1995
Dendroica cerulean	Cerulean Warbler			G4	S2S3	1995
Haliaeetus leucocephalus	Bald Eagle	T	E	G4	S2	2000
Vireo bellii	Bell's Vireo			G5	S3	1995
			Fish			
Fundulus sciadicus	Plains Topminnow			G4	S3	1995
Hiodon tergisus	Mooneye			G5	S3	1995
Notropis heterolepis	Blacknose Shiner			G4	S2	1980
Percina cymatotaenia	Bluestripe Darter			G2	S2	1994
			Mammals			
Mustela	Long-Tailed			G5	S2	1992

Scientific Name	Common Name	F	M	GRank	SRank	Date
frenata	Weasel					
Myotis grisescens	Gray Bat	E	E	G3	S3	1997
Myotis septentrional is	Northern Myotis			G4	S3	1997
Myotis sodalist	Indiana Bat	E	E	G2	S1	1994
Ochrotomys nuttalli	Golden Mouse			G5	S3?	1990
Crayfish						
Cambarus hubrichti	Salem Cave Crayfish			G2	S3	1980
Insects						
Gomphus ozarkensis	Ozark Clubtail			G4	S3	2000
Ophiogomph us westfalli	Westfall's Snaketail			G3	S3	1976
Mussels						
Alasmidonta marginata	Elktoe			G4	S2?	1998
Cumberlandi a monodonta	Spectaclecase			G2G3	S3	1998
Elliptio crassidens	Elephant Ear		E	G5	S1	1976
Lampsilis abrupta	Pink Mucket	E	E	G2	S2	1976
Ligumia recta	Black Sandshell			G5	S1S2	1993-1995
Ptychobranc hus occidentalis	Ouachita Kidneyshell			G3G4	S2S3	1993
Non-Vascular Plants						
Aneura pinguis	A Liverwort			G5	SU	2002

Scientific Name	Common Name	F	M	GRank	SRank	Date
Flavoparmelia rutidota	A Lichen			G?	S?	1986
			Vascular Plants			
Aster furcatus	Forked Aster			G3	S2	1990
Heuchera parviflora var. parviflora	Little Leaved Alum Root			G4T4	S1	1992
Pueraria lobata	Kudzu			G?	SE	2001
Sullivantia sullivantii	Sullivantia			G4	S2	1994
Trifolium stoloniferum	Running Buffalo Clover	E	E	G3	S1	1997
Calamagrostis porteri ssp. insperata	Oferhollow Reed Grass			G4T3	S3	1994
Carex comosa	Bristly Sedge			G5	S2	1991
Carex molestiformis	A Sedge			G?	S2	1991
Glyceria acutiflora	Sharp-Scaled Manna Grass			G5	S3	1991
Najas gracillima	Thread-Like Naiad			G5?	S2	1994
Potamogeton pusillus var. pusillus	Slender Pondweed			G5T5	S1	1991
Zannichellia palustris var. major	Horned Pondweed			G5T?	S3?	1994
Dryopteris goldiana	**Goldie's Fern**			**G4**	**S2**	1994

Year=Last year observed in watershed.

F=Federal Status

M=Missouri Status, E=Endangered T=Threatened

= Former category-2 candidate (In December of 1996, the USFWS discontinued the practice of maintaining a list of species regarded as “category-2 candidates”. MDC continues to distinguish these species for information and planning purposes.

SRrank

S1=Critically imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state. (typically, 5 or fewer occurrences or very few remaining individuals)

S2=Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state. (6 to 20 occurrences or few remaining individuals or acres)

S3=Rare and uncommon in the state. (21 to 100 occurrences)

S4=Widespread, abundant, and apparently secure in state, with many occurrences, but the species is of long-term concern. (usually more than 100 occurrences)

S5=Demonstrably widespread, abundant, and secure in the state, and essentially ineradicable under present conditions.

SU=Unrankable: Possibly in peril in the state, but status uncertain; need more information. SE=Exotic: An exotic established in the state; may be native in nearby regions.

SH=Historical: Element occurred historically in the state (with expectation that it may be rediscovered). Perhaps having not been verified in the past 20 years, and suspected to be still extant.

SX=Extirpated: Element is believed to be extirpated from the state. S?=Unranked: Species is not yet ranked in the state.

Qualifier: ? =Inexact or uncertain: for numeric ranks, denotes inexactness. (The ? qualifies the character immediately preceding it in Srank)

GRank

G1=Critically imperiled globally because of extreme rarity or because of some factor(s) making it especially vulnerable to extinction. (typically, 5 or fewer occurrences or very few remaining individuals or acres)

G2=Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction throughout its range. (6 to 20 occurrences or few remaining individuals or acres) G3=Either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single western state, a physiographic region in the East) or because of other factors making it vulnerable to extinction throughout its range. (21 to 100 occurrences)

G4=Widespread, abundant, and apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery. Thus, the element is of long-term concern. (usually more than 100 occurrences)

G5=Demonstrably Widespread, abundant, and secure globally, though it may be quite rare in parts of its range, especially at the periphery.

Subrank:

T=Taxonomic subdivision: rank applies to subspecies or variety.

Qualifier: ? =Inexact: denotes inexact numeric rank.

Q=Questionable taxonomy: taxonomic status is questionable; numeric rank may change with taxonomy.

Note: Data in table subject to revision. This table is not a final authority.

Figure Bc01..

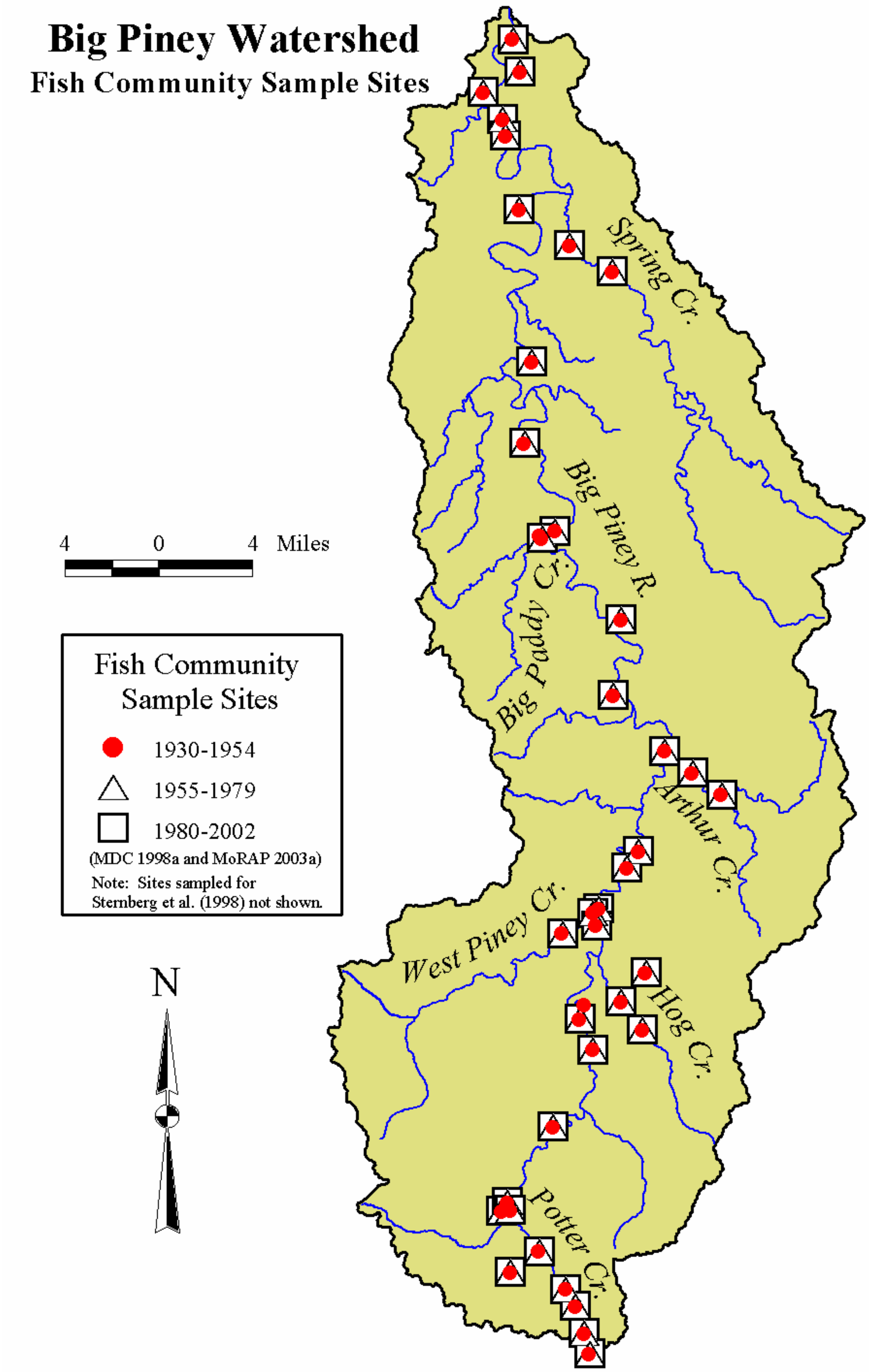

Big Piney Watershed
Fish Community Sample Sites
4 0 4 Miles
Fish Community Sample Sites
1930-1954
1955-1979
1980-2002
(MDC 1998a and MoRAP 2003a)
Note: Sites sampled for Sternberg et al. (1998) not shown.
N
Spring Cr.
Big Piney R.
Big Paddy Cr.
Arthur Cr.
West Piney Cr.
Hog Cr.
Potter Cr.

Figure Bc02.

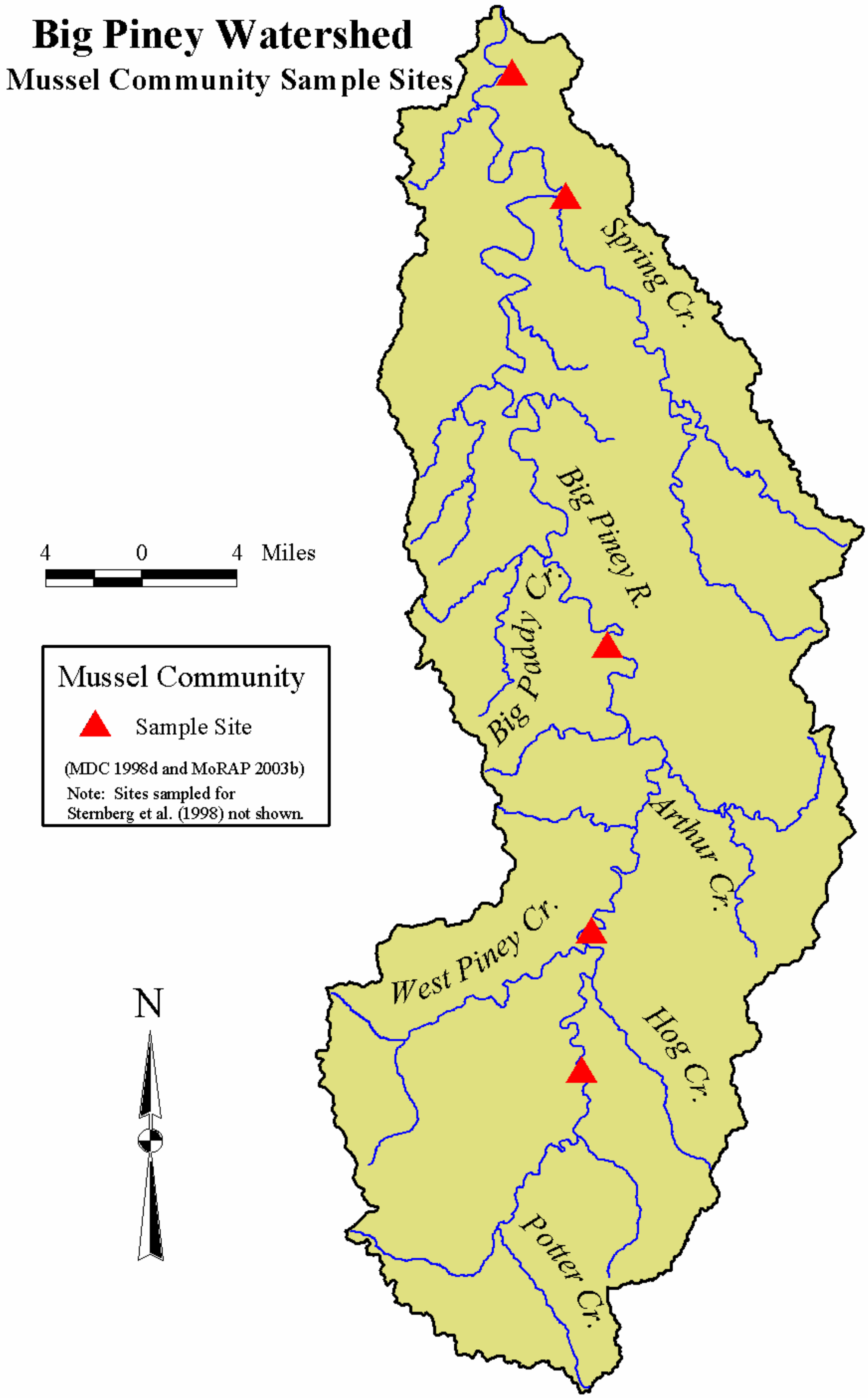
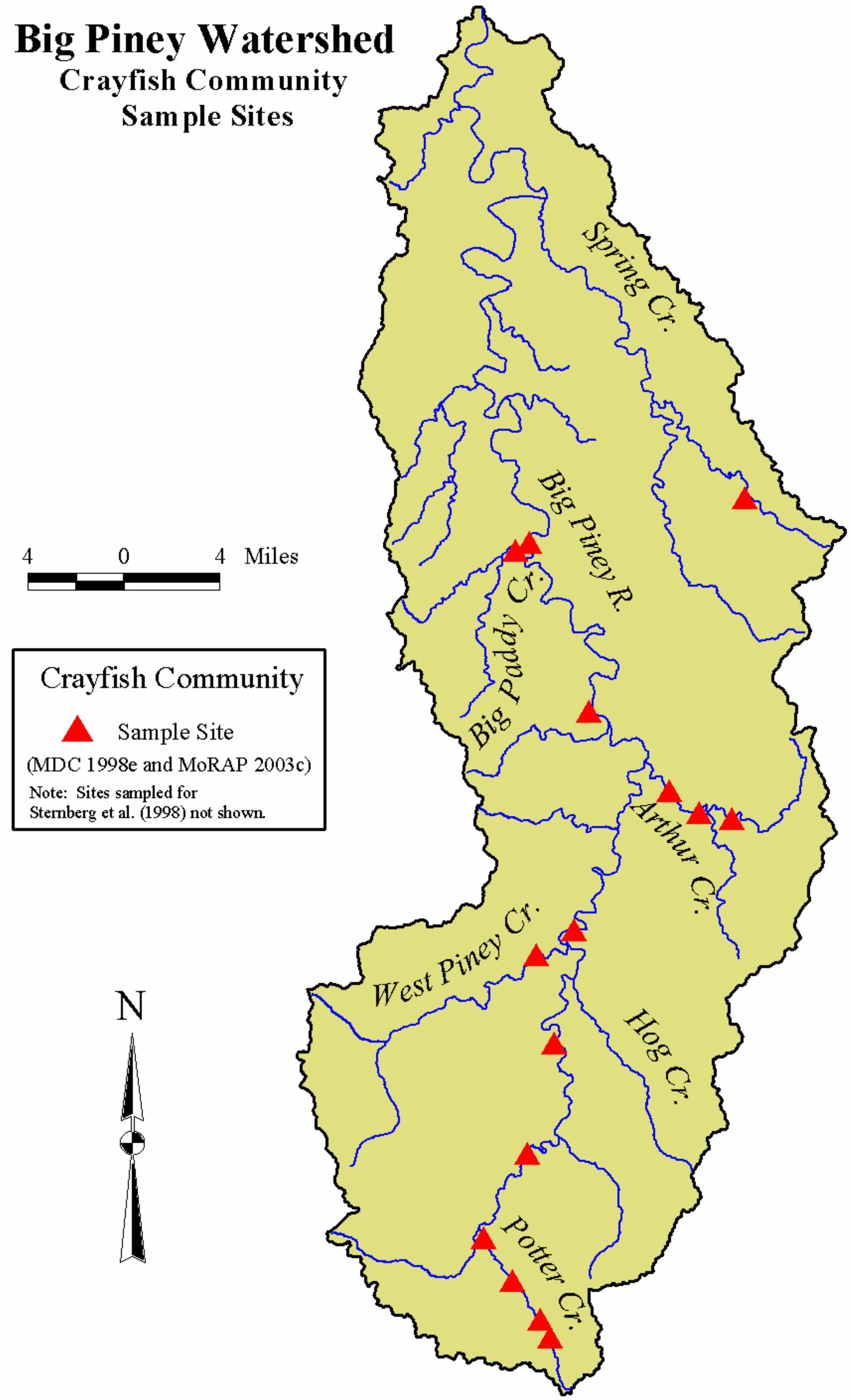

Big Piney Watershed
Mussel Community Sample Sites
4 0 4 Miles
Mussel Community
Sample Site
(MDC 1998d and MoRAP 2003b)
Note: Sites sampled for
Sternberg et al. (1998) not shown.
N
Spring Cr.
Big Piney R.
Big Paddy Cr.
Arthur Cr.
West Piney Cr.
Hog Cr.
Potter Cr.

Figure Bc03.



Big Piney Watershed
Crayfish Community
Sample Sites
Spring Cr.
Big Piney R.
Big Paddy Cr.
Arthur Cr.
West Piney Cr.
Hog Cr.
Potter Cr.
4
0
4
Miles
Crayfish Community
Sample Site
(MDC 1998e and MoRAP 2003c)
Note: Sites sampled for
Sternberg et al. (1998) not shown.
N

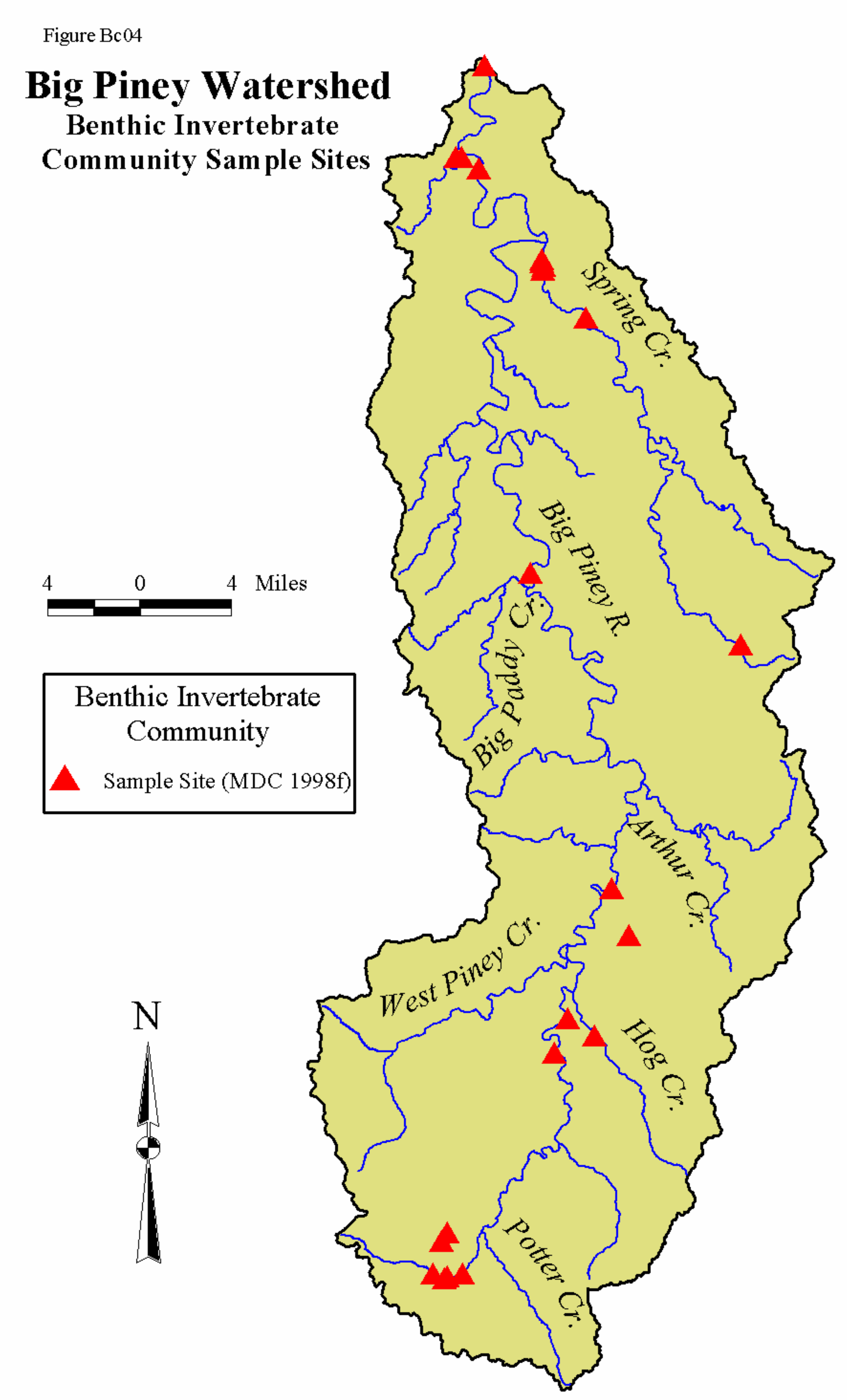


Figure Bc04
Big Piney Watershed
Benthic Invertebrate
Community Sample Sites
Spring Cr.
Big Piney R.
Big Paddy Cr.
Arthur Cr.
West Piney Cr.
Hog Cr.
Potter Cr.
4 0 4 Miles
Benthic Invertebrate
Community
Sample Site (MDC 1998f)
N

Management Challenges and Opportunities

The management goals, objectives, and strategies for the Big Piney Watershed were developed using information collected from the Big Piney Watershed Inventory and Assessment (WIA) and direction provided by the Ozark Regional Management Guidelines (1998), Missouri Department of Conservation (MDC) Strategic Plan, and the Fisheries Division Five Year Strategic Plan.

Objectives and strategies were written for instream and riparian habitat, water quality, aquatic biota, recreational use, and hydrography. All goals are of equal importance, with objectives listed in prioritized order whenever possible. This plan includes only those activities and results that can reasonably be expected to be achieved or influenced during the next 25 years.

Completion of these objectives will depend upon their status in overall regional and division priorities and the availability of human resources and funds.

Goal I: Protect and improve riparian and aquatic habitats in the Big Piney Watershed

Status: Many streams in various portions of the watershed lack sufficient riparian corridors. Streams within the Upper Big Piney Hydrologic Unit have the least percentage of forested riparian corridors. In addition, grave l mining has been very prevalent in the Upper Big Piney as well as, to a lesser extent, in the Middle Big Piney and Spring Creek Hydrologic Units.

Objective 1.1: With the assistance of willing landowners, over a 25-year period, increase by 25% the proportion of streams with a sufficient forested corridor as defined in NRCS (2000).

Strategy: Referencing the priority ranking for eleven digit units of the Big Piney Watershed presented in Figure Mc01 (developed through evaluations of riparian forest cover absence, losing streams, unit size, and presence of sensitive species), direct appropriate riparian corridor improvement efforts towards the following ranked drainage units: High = Upper Big Piney; Medium = Middle Big Piney; Low = Lower Big Piney and Spring Creek.

- Using satellite imagery, aerial photography, aerial stream survey documentation, and/or field investigations, document the conditions of riparian corridors and stream banks once every 10 years. Future projects such as the Missouri Resource Assessment Partnership Land Cover Classification should be encouraged in order to ensure that adequate data is available to allow efficient analysis of riparian corridor conditions over time.
- Ensure all MDC Areas represent examples of proper riparian corridor stewardship by following established best management practices for riparian restoration/protection.
- In cooperation with regional Private Land Services Division personnel, provide appropriate agencies such as Natural Resources Conservation Service (NRCS)
- and Soil and Water Conservation Districts (SWCDs) as well as willing agricultural-oriented businesses such as farm centers, agricultural chemical dealers, etc. with free brochures dealing with riparian corridor issues in order to facilitate increased awareness and dissemination of this information to landowners.
- Facilitate a riparian corridor workshop in the Upper Big Piney Drainage Unit.
- Facilitate riparian corridor restoration/protection by willing landowners in accordance with applicable guidelines through the use of available funding and/or technical assistance.

Objective 1.2: Limit the negative impacts of sand and gravel removal within the watershed.

Strategy: Education of sand and gravel operators regarding limiting the potential negative impacts associated with sand and gravel removal, dynamic documentation of permitted sand and gravel removal sites, assisting with continued research regarding gravel removal, and encouragement of the efficient enforcement of violations associated with sand and gravel removal will be important in limiting the potential negative impacts of gravel removal.

- Work with MDC Resource Science Division, Outreach and Education Division, and appropriate agencies such as MDNR in the development of an educational video illustrating proper and improper sand and gravel removal methods, proper site selection, and the consequences of improper sand and gravel removal operations.
- Work with gravel removal operators, willing landowners, and regulating agencies to create a geographic information system (GIS) database of appropriate potential sand and gravel removal sites (to be updated as needed).
- Continue to assist appropriate state and federal agencies in the enforcement of existing water quality laws in regard to sand and gravel removal.
- Assist with additional research efforts regarding the effects of instream sand and gravel removal in order to develop measures that adequately protect aquatic resources.
- Work with stakeholder groups such as landowners and governmental and non- governmental organizations to ensure appropriate gravel mining regulations exist to prevent damage to stream resources as well as property within the watershed due to improper gravel removal.

Goal II: Protect surface and ground water quality in the Big Piney Watershed.

Status: Currently (2004), all waters within the Big Piney Watershed are included in a statewide fish consumption advisory for largemouth bass due to elevated levels of mercury. While a limited analysis of water quality data does not appear to indicate any additional specific wide spread water quality problems within the Big Piney Watershed, some site specific concerns are noted. Within the watershed there is a 0.2 mile segment of Brushy Creek included in the 1998 303d list due to impairment by non- filterable residues from the Houston Sewage Treatment Plant. In addition, periodically elevated fecal coliform levels have been observed at Shanghai Spring, the Big Piney River near Big Piney, and the Big Piney River at Devil's Elbow. It has been noted that Shanghai Spring and Pumping Station Spring "exhibit probable effects of septic contamination" (Imes et al. 1996). Potential contaminant sites have been inventoried on the Fort Leonard Wood Military Reservation and measures have been, or are being, taken to address these concerns. In addition, extensive water quality data continues to be collected in the FLW area as part of monitoring programs and studies the FLW is funding or otherwise associated with. Other items which always have the potential to cause water quality problems in this watershed, as in any other, include large numbers of livestock in riparian areas for extended periods of time, private septic system failure, increased nutrients from municipal sewage treatment facilities, improper sand and gravel removal and poor land use practices such as indiscriminate land clearing. These can result in periodic high fecal coliform levels, nutrient loading, and/or increased sediment and gravel deposition.

Objective 1.1: Ensure that watershed streams meet or exceed state standards for water quality.

Strategy: Due to the connection between the surface water and ground water systems in the watershed, protection of surface waters, both permanent and intermittent, can greatly contribute to the enhancement of ground water quality. MDC lands should be managed to provide good examples of water quality protection and form the basis for MDC efforts to promote water quality protection on both public and private land. Education of the citizenry and land owners on water quality issues and land stewardship is the best hope for improving water quality. Protecting riparian corridors will help to reduce and filter surface runoff as well as provide stream bank and channel stability. Ensuring that additional water quality monitoring (including bio-monitoring), particularly in those areas that have exhibited some water quality concerns in the recent past, is conducted in order to better delineate the degree of and solution to those problems will also be important. Encouragement of appropriate agencies to enforce existing water quality laws will also be required to obtain satisfactory water quality.

- In cooperation with field personnel from all divisions, ensure management activities on public land, as well as MDC sponsored projects on private land, follow best management practices that protect water quality.
- Encourage the establishment of a long-term monitoring project by the MDC Science Division in order to determine the impacts of MDC land management activities on water quality.
- Through media contacts, personal contacts, literature development, and speaking engagements to groups such as area Stream Teams and land owners, inform the public of water quality issues and problems (e.g. karst topography, excessive siltation, animal waste runoff, gravel dredging, septic system failure etc.) and best management practices to address these problems.
- In cooperation with regional private lands services personnel, encourage limiting livestock access in riparian areas and through education and/or incentive programs for private landowners.
- Ensure that sites of water quality concern continue to be monitored and assist in developing solutions to any current problems which may still exist.
- Encourage and assist, as needed, with additional dye tracing studies within the watershed in order to further determine intrawatershed and interwatershed ground water movement as well as recharge area of selected springs within the watershed with an emphasis on publicly owned spring outlets and, specifically, spring outlets on lands managed by the MDC.
- Encourage and assist with enforcement of existing water quality laws by reviewing 404 permits, cooperating with other state and federal agencies to investigate pollution and fish kill reports, collecting water quality related data, and recommending measures to protect aquatic communities.
- Encourage the incorporation of water quality data such as fish kills and water pollution investigation and MDNR designated uses into GIS by appropriate MDC and MDNR staff in order to facilitate effective data updating and analysis.
- Encourage better stormwater management in urban and other developing areas.

Goal III: Maintain the abundance, diversity, and distribution of aquatic biota at or above current levels while improving the quality of the game fishery in the Big Piney River.

Status: Since 1930, an assemblage of 73 fish species, 32 mussel species and subspecies, 6 species of snails, 3 crayfish species, and 191 taxa of benthic macro- invertebrates (not including mussels and crayfish) have been identified throughout the Big Piney Watershed. A total of 41 species and subspecies of conservation concern are known to occur in the watershed. This list includes 4 fish species, 5 species of mussels, 2 species of amphibians, 1 species of crayfish, and 2 species of insects. The most common game fish species within the watershed include smallmouth bass, rock bass, and largemouth bass. In addition, two significant rainbow trout fisheries occur within the watershed, with a large amount of habitat enhancement work being done within the trout fishery of Spring Creek. Sucker species provide an alternative consumptive recreational opportunity within the watershed. Invasive exotic aquatic species within the watershed include the Asian clam and the common carp.

Objective 1.1: Maintain the diversity, abundance, and distribution of native non-sport fish, and aquatic invertebrate communities at or above current levels.

Strategy: High priority should be placed on protecting species of conservation concern and unique aquatic community assemblages. Focusing enhancement and protective efforts on a few species can be effective in helping other species that share the same habitat. Detecting changes in aquatic community species composition can be accomplished by conducting routine surveys of fish and invertebrate communities. In cases where significant changes in diversity, abundance, and/or distribution are noted, efforts to determine factors influencing the changes should be developed through cooperation with MDC Resource Science Division as well as other appropriate agencies and institutions. Cooperation between state and federal natural resource agencies, private land owners, and, in some instances, citizen groups will be necessary to adequately address challenges to aquatic community health.

- Assist with recovery efforts for species of conservation concern within the watershed.
- Survey fish communities in the watershed every 10 years at historical sampling sites using standardized sampling techniques. Initial emphasis should be placed on historic sites known in the past to harbor "species of conservation concern". Establish additional sampling sites as necessary with high priority given to MDC areas. Incorporate data into GIS in order to facilitate documentation of changes in species diversity, abundance, and/or distribution.
- Using GIS, document locations and identify unique fish assemblages associated with natural features and special habitats such as spring branches for inclusion in the Natural Heritage Database.
- Develop a prioritized list of stream reaches on MDC areas needing instream habitat restoration using the following criteria: presence of listed species, extent of forested stream corridor, size of stream, land use, soils, presence of permanent water, presence of sport fish, natural features and critical habitat.
- As appropriate, recommend research projects in cooperation with MDC Resource Science staff to investigate reasons for significant changes in faunal abundance and distribution. Recommend management changes ifneeded.
- Coordinate with MDC Resource Science staff and other groups (i.e. Fort Leonard Wood environmental staff, University of Missouri, etc.) to develop a routine mussel survey schedule for the watershed and ensure that data collected is made available in a comprehensive database.
- Coordinate with MDC Resource Science staff and other groups (i.e. Fort Leonard Wood environmental staff, MDNR, University of Missouri, etc.) to conduct a survey of benthic invertebrates on all fifth order and larger streams and ensure that data collected is made available in a comprehensive database.

Objective 1.2: Maintain or improve populations of sport fish while maintaining a stable and diverse fish community.

Strategy: Proper management of game fish populations will depend on obtaining adequate surveys to determine the status of the fishery and angler attitudes as well as implementing habitat improvement projects, regulation changes, and fish stocking where needed.

- Coordinate with appropriate MDC Staff (i.e. RCT and DCT Team members) to determine future management strategies for the Rock Bass and Black Bass fisheries of the Big Piney River based on the most recent scientific data available.
- Assist in maintaining existing stream habitat enhancement structures within the watershed.

- With approval from appropriate agencies (i.e. Fort Leonard Wood Natural Resources Staff, United States Army Corps of Engineers, USFS, etc.), implement additional instream habitat improvement projects in stream segments of heavy angler pressure which otherwise lack sufficient stream habitat with priority given to public areas.
- Assist in maintaining a quality trout fishery in the Stone Mill Spring Branch Trout Management Area and the Spring Creek WTMA.
- Within the Big Piney Watershed, continue to assist with future MDC efforts to comprehensively determine the extent of cold water resources in the state.

Objective 1.3: Prevent detrimental impacts on native fauna of the Big Piney Watershed from invasive exotic aquatic species.

Strategy: Preventing the introduction of invasive exotic species into the state is the easiest way to prevent detrimental impacts to native fauna. Public education regarding the prevention of invasive exotic species introduction is the key to preventing the potentially ecologically and economically damaging effects of such introductions. Once a detrimental invasive exotic species becomes established, research will be needed to seek ways to contain or eliminate them.

- Educate the public on the potentially damaging effects of 'bait bucket' introductions to lake and stream communities as well as through the development and use of flyers posted at accesses, newspaper articles, and the Internet.
- Continue MDC Fisheries division participation in the Missouri Aquaculture Advisory Council (MAAC) and other organizations and advocate controlling the introduction of invasive exotic fauna into state waters.
- Monitor for invasive exotic species (e.g. zebra mussel, Asian clams, etc.) and their potentially harmful effects. This can be performed during fish community surveys.
- If/when invasive exotic species are found, participate in statewide efforts to eliminate before unacceptable levels are reached.

Goal IV: Increase public awareness and promote wise use of aquatic resources in the Big Piney Watershed

Status: Much of the recreational use within the watershed is associated with the Big Piney River as well as the trout fisheries located on Spring Creek and Stone Mill Spring Branch. A statewide angler survey conducted in the 1980s estimated that total days spent angling on the Big Piney and its tributaries averaged 29, 780 annually between the years 1983 and 1988. Some angler survey data has also been gathered for Stone Mill Spring Branch by Fort Leonard Wood Natural Resource Managers. In addition to angling, other stream oriented recreational activities within the watershed include canoeing and tubing to name a few.

Objective 4.1: Ensure that up to date aquatic oriented recreational data is available to properly manage aquatic resources and their use.

Strategy: In addition to creel surveys conducted by MDC, encourage and assist appropriate agencies such as the USFS as well as Fort Leonard Wood natural resource managers, in the continued monitoring of aquatic oriented recreational activities within the watershed on a regular basis in order to provide data to be used for determining long term trends and problems which may need to be addressed through adjustments in management.

- In cooperation with MDC Resource Science, develop a routine angler survey program for the Big Piney Watershed to be conducted every 10 years.
- Encourage surveys of non-consumptive river use by the United States Forest Service.

- Encourage continued periodic surveys of aquatic resource use on Fort Leonard Wood Military Reservation by FLW natural resource managers.

Objective 4.2: Increase awareness of stream recreational opportunities and appreciation of stream ecology and advocacy to a level that will encourage a widespread and diversified public interest in the Big Piney Watershed.

Strategy: Careful publicity which focuses on species of conservation concern, unique aquatic-oriented communities, as well as abundant recreationally valuable fish populations can promote a continued appreciation of these different types of natural resource elements. Providing opportunities for the public to learn about stream ecology will, hopefully, create stream advocates.

- Continue to assist in providing the MDC annual fishing prospectus as well as the “Missouri Trout Fishing” and “Ozark Smallmouth Bass Fishing” maps for public release in order to describe the specific fisheries and angling opportunities of selected waters.
- Provide updated versions of the “Popular Public Fishing Streams in the Ozark Region” and “Popular Public Fishing Lakes in the Ozark Region” brochures in electronic form (via the MDC public Internet website) and paper form.
- In cooperation with MDC Outreach and Education Division, provide the local and statewide media with timely "How to", "When to" articles and interviews that focus attention on places as well as both consumptive (i.e. gigging, float/wade fishing) and non-consumptive activities (i.e. snorkeling, floating, underwater photography)
- Publicize the acquisition, development and opening of new public access and/or stream frontage sites.
- In cooperation with regional field personnel from all divisions, emphasize stream ecology and good stream stewardship (utilizing brochures, aquaria, and stream tables where applicable) during presentations to school groups, youth organizations, and private landowner contacts.
- Conduct outdoor youth events, such as Ecology Days at stream sites with field activities that demonstrate stream ecology and good stream stewardship.
- Facilitate the development and activity of Stream Teams and other groups interested in adopting or otherwise promoting good stewardship and enjoyment of watershed streams.
- Make public presentations in cooperation with regional field personnel from all divisions that focus on best management practices for private landowners.
- Provide promotional, educational, and technical stream materials to groups, fairs and other special events.
- In cooperation with regional field personnel from all divisions, develop brochure which describes the watershed and promotes best management practices within the watershed.

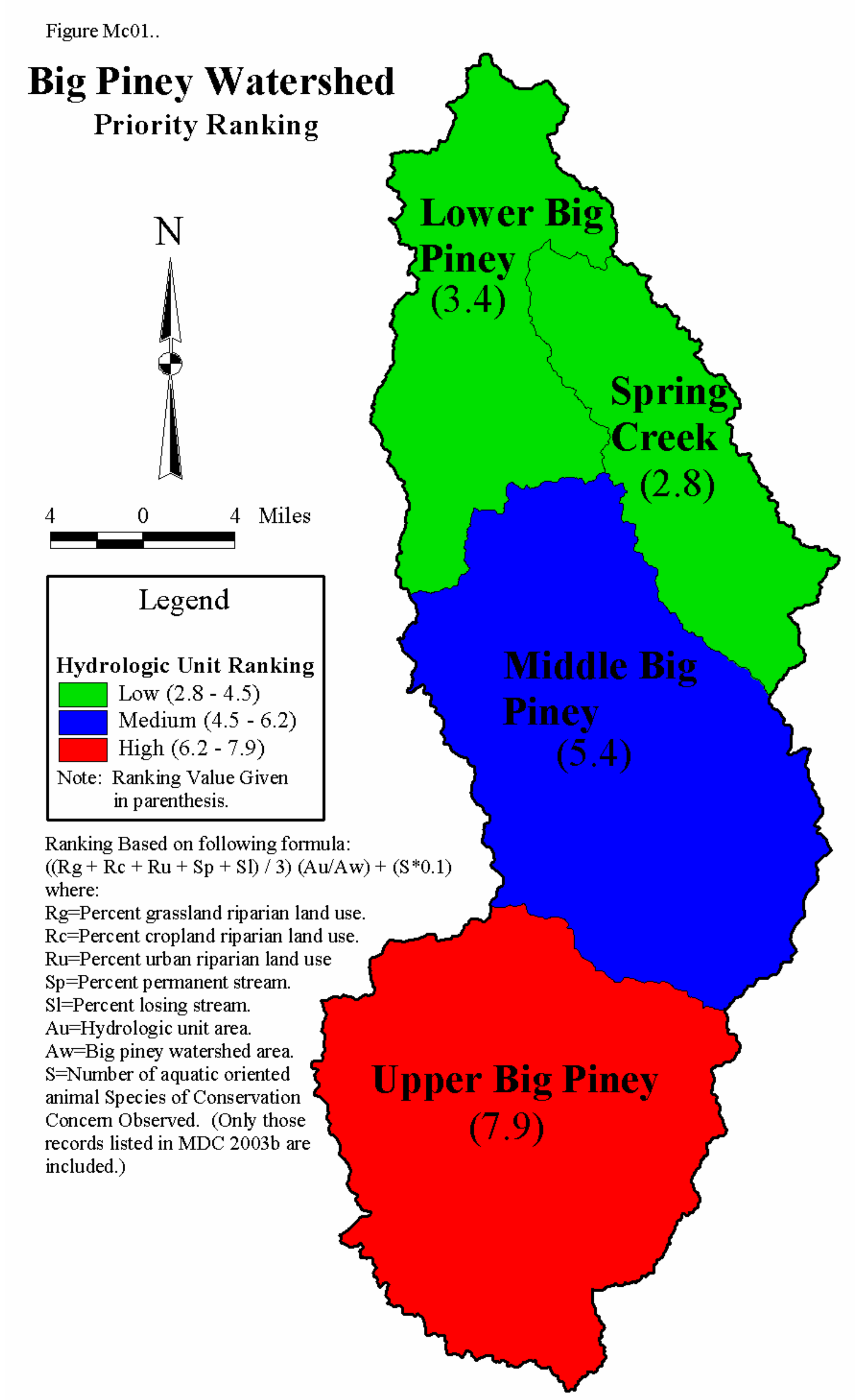


Figure Mc01..
Big Piney Watershed
Priority Ranking
N
4 0 4 Miles
Legend
Hydrologic Unit Ranking
Low (2.8 - 4.5)
Medium (4.5 - 6.2)
High (6.2 - 7.9)
Note: Ranking Value Given in parenthesis.
Ranking Based on following formula:
((Rg + Rc + Ru + Sp + Sl) / 3) (Au/Aw) + (S*0.1)
where:
Rg=Percent grassland riparian land use.
Rc=Percent cropland riparian land use.
Ru=Percent urban riparian land use
Sp=Percent permanent stream.
Sl=Percent losing stream.
Au=Hydrologic unit area.
Aw=Big piney watershed area.
S=Number of aquatic oriented animal Species of Conservation Concern Observed. (Only those records listed in MDC 2003b are included.)
Lower Big Piney (3.4)
Spring Creek (2.8)
Middle Big Piney (5.4)
Upper Big Piney (7.9)

Angler Guide

Big Piney River is a beautiful clear Ozark stream. With headwaters beginning in Texas County, this sixty-mile river flows north and drains into Gasconade River. There are many springs scattered throughout the Big Piney drainage basin. Game fish commonly sought after include rock bass, smallmouth, and largemouth bass. Panfish species such as longear and bluegill are also a good addition to any creel. Many species of suckers are abundant. Fishing methods on Big Piney include pole and line, fly fishing, and gigging. Sucker gigging is a longtime Ozark tradition. The sucker gigging season begins on September 15th and ends on January 31st. Giggers can take a total of 20 suckers, but only five may be hog suckers. There are no length limits on suckers.

Rock bass

Rock bass is one of the most popular sport fish on the Big Piney. Fishing regulations for rock bass on the Big Piney have changed this year. Beginning March 1st, 2005, a new rock bass regulation will go into effect. All rock bass less than eight inches (8") in total length must be immediately returned to the water unharmed after being caught on the Big Piney River and its tributaries, to its confluence with the Gasconade River.

This change reduces the number of small rock bass harvested and allows the remaining fish to achieve a desirable size. Data collected during a 10-year study support the implementation of these regulations. The eight-inch minimum length limit should produce a high quality fishery.

The rock bass is a secretive fish that spends most of the daylight hours around boulders, dense beds of vegetation or submerged logs. Look for them in deep rocky pools just below a riffle. Rock bass coloration will match its surroundings, making it difficult to see. The rock bass diet consists of macro invertebrates, small minnows, and crayfish.

Rock bass are receptive to bait any time of day or night but are most active at dawn or dusk and at night.

Black bass (smallmouth and largemouth bass)

For black bass species: largemouth and smallmouth, the statewide regulation is in effect for most of the Big Piney River, except for a smallmouth bass Special Management Area. The Special Management Area begins at Slabtown Access and ends at the Ross Bridge Access. The statewide regulation is that black bass must be twelve inches (12") in length and the daily limit is six. Black bass can only be possessed from the second Saturday before Memorial Day through February 28th. The Special Management Area allows an angler to keep one smallmouth bass that is fifteen inches (15") or longer per day. Otherwise the statewide regulation is in effect concerning largemouth and spotted bass in the Special Management Area.

Smallmouth bass prefer clear, cool water with woody structure, root wads or boulders. They are found in cover associated with current. Largemouth bass are found in warmer backwater pools where there is dense growth of aquatic plants with little current. The diet of both species changes with the age of the fish. When fish are young, they depend mostly on small aquatic macro invertebrates or crustaceans. As the fish increase in size, their diet will shift to crayfish, minnows, macro invertebrates, frogs or almost any other animal that swims or falls into the water.

By nature, a bass will always expend the least amount of energy for the greatest amount of benefit. For this reason, a bass is considered to be more of an ambush fish than a chaser. During the day, largemouth bass are found in deeper water around logs, drift piles, and other cover. In the evening, bass move into the shallows. A variety of natural or artificial baits can be used to catch bass.

Eastern Hellbender (What about the Ozark Hellbender?)

Eastern Hellbenders are found on the Big Piney River. Hellbenders are the largest aquatic salamander in the state and range in size from 16 to 22 inches in length. The preferred habitat is downstream from cold water springs where they usually hide under flat rocks.

Hellbenders breed during the fall months. During this time, the hellbenders congregate and do not pay attention to predators. There has been a 77% decline in hellbender numbers in Missouri since the 1960's and the animals are currently listed as a state endangered species. Hellbenders are on the decline. Please release hellbenders and report their locations and do not kill them. In the past, many anglers' (giggers and trotline) have killed hellbenders. Hellbenders do not eat game fish.

- Hellbenders are not poisonous; however, they are slimy and will try to bite.
- Hellbenders mainly feed on crayfish (~90%) and occasionally small fish.

It is illegal to possess or kill hellbenders, and if you catch one on hook and line, please release it unharmed by removing the hook or simply cutting the line.

Glossary

Alluvial soil: Soil deposits resulting directly or indirectly from the sediment transport of streams, deposited in river beds, flood plains, and lakes.

Aquifer: An underground layer of porous, water-bearing rock, gravel, or sand.

Benthic: Bottom-dwelling; describes organisms which reside in or on any substrate.

Benthic macroinvertebrate: Bottom-dwelling (benthic) animals without backbones (invertebrate) that are visible with the naked eye (macro).

Biota: The animal and plant life of a region.

Biocriteria monitoring: The use of organisms to assess or monitor environmental conditions.

Channelization: The mechanical alteration of a stream which includes straightening or dredging of the existing channel, or creating a new channel to which the stream is diverted.

Concentrated animal feeding operation (CAFO): Large livestock (ie. cattle, chickens, turkeys, or hogs) production facilities that are considered a point source pollution, larger operations are regulated by the MDNR. Most CAFOs confine animals in large enclosed buildings, or feedlots and store liquid waste in closed lagoons or pits, or store dry manure in sheds. In many cases manure, both wet and dry, is broadcast overland.

Confining rock layer: A geologic layer through which water cannot easily move.

Chert: Hard sedimentary rock composed of microcrystalline quartz, usually light in color, common in the Springfield Plateau in gravel deposits. Resistance to chemical decay enables it to survive rough treatment from streams and other erosive forces.

Cubic feet per second (cfs): A measure of the amount of water (cubic feet) traveling past a known point for a given amount of time (one second), used to determine discharge.

Discharge: Volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic feet per second.

Disjunct: Separated or disjoined populations of organisms. Populations are said to be disjunct when they are geographically isolated from their main range.

Dissolved oxygen: The concentration of oxygen dissolved in water, expressed in milligrams per liter or as percent.

Dolomite: A magnesium rich, carbonate, sedimentary rock consisting mainly (more than 50% by weight) of the mineral dolomite $(CaMg(CO_3)_2)$.

Endangered: In danger of becoming extinct.

Endemic: Found only in, or limited to, a particular geographic region or locality.

Environmental Protection Agency (EPA): A Federal organization, housed under the Executive branch, charged with protecting human health and safeguarding the natural environment — air, water, and land — upon which life depends.

Epilimnion: The upper layer of water in a lake that is characterized by a temperature gradient of less than 1^{o} Celsius per meter of depth.

Eutrophication: The nutrient (nitrogen and phosphorus) enrichment of an aquatic ecosystem that promotes biological productivity.

Extirpated: Exterminated on a local basis, political or geographic portion of the range.

Faunal: The animals of a specified region or time.

Fecal coliform: A type of bacterium occurring in the guts of mammals. The degree of its presence in a lake or stream is used as an index of contamination from human or livestock waste.

Flow duration curve: A graphic representation of the number of times given quantities of flow are equaled or exceeded during a certain period of record.

Fragipans: A natural subsurface soil horizon seemingly cemented when dry, but when moist showing moderate to weak brittleness, usually low in organic matter, and very slow to permeate water.

Gage stations: The site on a stream or lake where hydrologic data is collected.

Gradient plots: A graph representing the gradient of a specified reach of stream. Elevation is represented on the Y-axis and length of channel is represented on the X- axis.

Hydropeaking: Rapid and frequent fluctuations in flow resulting from power generation by a hydroelectric dam's need to meet peak electrical demands.

Hydrologic unit (HUC): A subdivision of watersheds, generally 40, 000-50, 000 acres or less, created by the USGS. Hydrologic units do not represent true subwatersheds.

Hypolimnion: The region of a body of water that extends from the thermocline to the bottom and is essentially removed from major surface influences during periods of thermal stratification.

Incised: Deep, well defined channel with narrow width to depth ration, and limited or no lateral movement. Often newly formed, and as a result of rapid down-cutting in the substrate

Intermittent stream: One that has intervals of flow interspersed with intervals of no flow. A stream that ceases to flow for a time.

Karst topography: An area of limestone formations marked by sinkholes, caves, springs, and underground streams.

Loess: Loamy soils deposited by wind, often quite erodible.

Low flow: The lowest discharge recorded over a specified period of time.

Missouri Department of Conservation (MDC): Missouri agency charged with: protecting and managing the fish, forest, and wildlife resources of the state; serving the public and facilitating their participation in resource management activities; and providing opportunity for all citizens to use, enjoy, and learn about fish, forest, and wildlife resources.

Missouri Department of Natural Resources (MDNR): Missouri agency charged with preserving and protecting the state's natural, cultural, and energy resources and inspiring their enjoyment and responsible use for present and future generations.

Mean monthly flow: Arithmetic mean of the individual daily mean discharge of a stream for the given month.

Mean sea level (MSL): A measure of the surface of the Earth, usually represented in feet above mean sea level. MSL for conservation pool at Pomme de Terre Lake is 839 ft. MSL and Truman Lake conservation pool is 706 ft. MSL.

Necktonic: Organisms that live in the open water areas (mid and upper) of waterbodies and streams.

Non-point source: Source of pollution in which wastes are not released at a specific, identifiable point, but from numerous points that are spread out and difficult to identify and control, as compared to point sources.

National Pollution Discharge Elimination System (NPDES): Permits required under The Federal Clean Water Act authorizing point source discharges into waters of the United States in an effort to protect public health and the nation's waters.

Nutrification: Increased inputs, viewed as a pollutant, such as phosphorous or nitrogen, that fuel abnormally high organic growth in aquatic systems.

Optimal flow: Flow regime designed to maximize fishery potential.

Perennial streams: Streams fed continuously by a shallow water table an flowing year-round.

pH : Numeric value that describes the intensity of the acid or basic (alkaline) conditions of a solution. The pH scale is from 0 to 14, with the neutral point at 7.0. Values lower than 7 indicate the presence of acids and greater than 7.0 the presence of alkalis (bases).

Point source: Source of pollution that involves discharge of wastes from an identifiable point, such as a smokestack or sewage treatment plant.

Recurrence interval: The inverse probability that a certain flow will occur. It represents a mean time interval based on the distribution of flows over a period of record. A 2-year recurrence interval means that the flow event is expected, on average, once every two years.

Residuum: Unconsolidated and partially weathered mineral materials accumulated by disintegration of consolidated rock in place.

Riparian: Pertaining to, situated, or dwelling on the margin of a river or other body of water.

Riparian corridor: The parcel of land that includes the channel and an adjoining strip of the floodplain, generally considered to be 100 feet on each side of the channel.

7-day $Q^{10:}$: Lowest 7-day flow that occurs an average of every ten years.

7-day Q^{2}: Lowest 7-day flow that occurs an average of every two years.

Solum: The upper and most weathered portion of the soil profile.

Special Area Land Treatment project (SALT): Small, state funded watershed programs overseen by MDNR and administered by local Soil and Water Conservation Districts. Salt projects are implemented in an attempt to slow or stop soil erosion.

Stream Habitat Annotation Device (SHAD): Qualitative method of describing stream corridor and instream habitat using a set of selected parameters and descriptors.

Stream gradient: The change of a stream in vertical elevation per unit of horizontal distance.

Stream order: A hierarchical ordering of streams based on the degree of branching. A first order stream is an unbranched or unforked stream. Two first order streams flow together to make a second order stream; two second order streams combine to make a third order stream. Stream order is often determined from 7.5 minute topographic maps.

Substrate: The mineral and/or organic material forming the bottom of a waterway or waterbody.

Thermocline: The plane or surface of maximum rate of decrease of temperature with respect to depth in a waterbody.

Threatened: A species likely to become endangered within the foreseeable future if certain conditions continue to deteriorate.

United States Army Corps of Engineers (USCOE) and now (USACE): Federal agency under control of the Army, responsible for certain regulation of water courses, some dams, wetlands, and flood control projects.

United States Geological Survey (USGS): Federal agency charged with providing reliable information to: describe and understand the Earth; minimize loss of life and property from natural disasters; manage water, biological, energy, and mineral resources; and enhance and protect the quality of life.

Watershed: The total land area that water runs over or under when draining to a stream, river, pond, or lake.

Waste water treatment facility (WWTF): Facilities that store and process municipal sewage, before release. These facilities are under the regulation of the Missouri Department of Natural Resources.

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