The Ozarks Environmental and Water Resources Institute (OEWRI)
Missouri State University (MSU)

National Water Quality Initiative (NWQI)
Watershed Assessment for:

Little Hunting Slough-Black River Watershed (HUC- 110100070805)

FINAL REPORT

Deliverable # 4 – Inventory of the Watershed
Deliverable # 5 – Resource Analysis of the Watershed
Deliverable # 6 –Identification of Conservation Needs on Susceptible Acres

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SCOPE AND OBJECTIVES

In 2012, the U.S. Department of Agriculture through the National Resources Conservation Service (NRCS) implemented the National Water Quality Initiative (NWQI) aimed at reducing nutrients and sediment in the nation's rivers and streams. The goal of the NWQI program is for the NRCS and its partners to work with landowners to implement voluntary conservation practices that improve water quality in high-priority watersheds while maintaining agricultural productivity. While high-priority watersheds have been selected around the country, typically watershed-scale evaluations identifying specific pollution sources and the conservation practices needed to improve water quality are not available to field office staff responsible for working with landowners. Therefore, a comprehensive planning effort aimed at prioritizing specific landscapes, crop types, and the conservation practices available is needed to help NRCS field staff implement the NWQI program where it will be the most effective considering limited available resources.

The Missouri State Office of the NRCS contracted the Ozarks Environmental and Water Resources Institute (OEWRI) at Missouri State University (MSU) to perform a watershed assessment study for the Little Hunting Slough-Black River watershed located in Butler County in southeast Missouri. The project area is a 12-digit hydrologic unit code (HUC-12 #110100070805) watershed that is within the larger Upper Black River watershed. The watershed lies within the Mississippi River Alluvial Plain lowlands that were once a combination of swampy, bottomland forest and low sandy hills (Nigh and Schroeder 2002). After the timber was harvested in the early 1900s, the wetlands were drained and converted into highly productive cropland through the widespread construction of ditches and canals to move water off of the landscape (Marsden 1930, Graves 1983). With the exception of the protected publicly owned land and a few remnant wetlands, the majority of the land is cultivated for production of soybeans, rice, and corn (Nigh and Schroeder 2002, USDA 2016). While the lowland ditches in the Little Hunting Slough watershed are generally stable, they are considered poor aquatic habitat and typically lack an adequate riparian corridor (Cieslewicz 2004). The biggest water quality concern for the area is potential contamination of the shallow aquifer susceptible to agricultural chemicals, pesticides, and fertilizers that can pollute public and private water supplies (Miller and Vandike 1997). The purpose of this assessment is to provide NRCS field staff with the necessary information to identify locations within the Little Hunting Slough HUC-12 watershed where soil, slope, and land use practices have the highest pollution potential and to describe conservation practices that can be the most beneficial to improve water quality. The specific objectives of this assessment are to:

(1) Complete a comprehensive inventory of existing data in the watershed including information related to geology, soils, hydrology, climate, land use, and any existing biological or chemical monitoring data available;
(2) Perform a resource assessment of the watershed that includes analysis of the data gathered in the watershed inventory that includes identification of nonpoint source pollutants, water quality impairments, rainfall-runoff characteristics, and a field-based stream bank conditions assessment;
(3) Provide NRCS staff with information on the resource concerns within the watershed, specific field conditions that contribute the most to the water quality impairment, and what conservation practices should be implemented for the existing conditions to get the most water quality benefit.

DESCRIPTION OF THE WATERSHED

Location

Little Hunting Slough is located in southeast Missouri and is a tributary of the Black River within the Upper Black River watershed (HUC-8 #11010007) (Figure 1). The Little Hunting Slough-Black River watershed (HUC-12 #110100070805) is one of five 12-digit HUC watersheds within the Big Hunting Slough-Black River watershed (HUC-10 #1101000708). The headwaters of Little Hunting Slough begin in central Butler County and flow south towards the confluence with the Black River near the Arkansas state line. The upper portion of the Little Hunting Slough watershed (54,084 acres) is along the eastern edge of Poplar Bluff and lies west of Qulin and east of Neelyville, Missouri (Figure 2).

Climate

Missouri has a humid, continental climate with the highest annual precipitation occurring in the southeast part of the state (Vandike 1995). Over the 30-year period from 1989–2018, the annual rainfall at the closest weather station in Poplar Bluff, Missouri showed relatively variable from year-to-year. Annual rainfall totals ranged from 33.7 to 75.4 inches, with an average of 50.3 inches per year (Table 1). The highest monthly rainfall totals (>5”) occur in April and May with generally less precipitation (<4”) in the winter and late summer (Figure 3A). The average annual temperature was fairly consistent ranging from 56.8-62.2°F with an average of 59.0°F between 1989-2018 (Table 1). Average monthly temperatures range from 35.4°F in January to 80.5°F in July (Figure 3B). Looking at the long-term trend, the five-year annual rainfall total has increased over the last decade. From 1989-2008 the five-year moving average was less than 50 inches per year (Figure 4A). However, since 2008 the five-year moving average has been greater than 50 inches of rainfall per year. The five-year average annual temperature has increased steadily from 1989 to 2018 (Figure 4B). Between 1989-2011 the five-year moving average of annual average temperature reached, or was below 59.0°F. Since 2011, the five-year moving average has remained above 59.0°F.

Solar radiation and evaporation trends are similar to the monthly temperature and precipitation trends in southeast Missouri. The average daily solar radiation by month ranged from 6.7 MJ/m^2 in December to 22.6 MJ/m^2 in June with an average of 15.1 MJ/m^2 from 2000-2018 at Glennonville, Missouri in Dunklin County (Figure 5A). Monthly estimated average daily evaporation ranged from 0.038 inches in January to 0.218 inches in June with an average 0.115 inches from 2017-2018 at Senath, Missouri in Dunklin County (Figure 5B).

Geology, Topography, and Geomorphology

The Little Hunting Slough-Black River watershed is located along the boundary of the Ozark escarpment but lies mostly within the Mississippi Alluvial Plain draining the Black River which begins in the unglaciated, dissected Ozark Highlands (USDA 2006). The underlying geology consists of Ordovician age dolomite bedrock along the Ozarks escarpment with more recent deposits of alluvium from streams flowing out of the Ozarks overlying the older alluvium of the Mississippi River floodplain downstream along the flat to gently sloping alluvial plain portion of the watershed (Graves 1983, Nigh and Schroeder 2002, Starbuck 2017). Elevation within the watershed range from around 436 ft along the escarpment to about 291 ft near the Arkansas line (Figure 6). The Ash Hill Low Sand Hills and Terraces located in the southern part of the watershed are well drained and are about 10-20 ft higher in elevation than the surrounding land (Nigh and Schroeder 2002). Slopes derived from digital elevation models show the majority of the watershed has slopes less than 3% with the exception of the small portion of the watershed located along the Ozarks escarpment with slopes greater that 7% (Figure 7).

Large-scale drainage projects that effectively moved water off of the landscape were accomplished by the construction of a series of connected channelized ditches (Graves 1983). It is well known that channelized streams adjust to higher slopes and increased stream power by incision and channel widening processes (Simon and Rinaldi 2000). However, over time, aggradation starts to occur, and the streams begins to meander within the constructed banks to create low, bankfull benches where vegetation can start to establish and help stabilize the channel (Figure 8). The exception is the Black River, which originates in the Ozarks highlands and flows onto the alluvial lowlands (USDA 2006). The portion of the Black River in the lowlands is low gradient, meandering streams in fine grain alluvium (Nigh and Schroeder 2002). However, the Black River is hydrologically controlled upstream by Clearwater Reservoir and levees have been constructed on both sides of the river to contain floods (Nigh and Schroeder 2002, MDC 2018).

Landscape and Soils

The majority of the Little Hunting Slough-Black River watershed is within the Southern Mississippi River Alluvium Major Land Resource Area (MRLA) with a very small portion of the upper watershed within the Ozark Highlands. The Southern Mississippi River Alluvium section of the Mississippi Delta Cotton and Grains Region consists of a nearly level, to gently sloping landscape within the old floodplain of the Mississippi River south of the Ohio River (USDA 2006). The northern half of the Little Hunting Slough-Black River watershed is within Black River Silty Lowland and the southern half lies within the Ash Hill Low Sand Hills and Terraces of the Black River Alluvial Plain subsection of the Mississippi River Alluvial Basin (Nigh and Schroeder 2002). Soils within the watershed are mostly alfisols (76.9%) and inceptisols (15.7%) (Table 2, Figure 9). The majority (about 72%) of the soils in the watershed have moderate to high runoff potential being classified as hydrologic soil groups C, C/D, or D (Table 2, Figure 10) (USDA 2009). Land Capability Classifications are used to determine the suitability of a soil to grow common field or pasture crops (USDA 2018). Land capability classes within the watershed mainly ranged from class 2-4 with limitations to growing crops mostly due to (w) wetness (90.2%) with only minor limitations due to (e) erosion and (s) shallow soil (Table 2, Figure 11). The dominate subclasses within this watershed are 3w and 4w, which reduces the choice of plants, or requires conservation practices, or require very careful management due to susceptibility to wetness (USDA 2018). The majority of the soils within the watershed have a K-factor of >0.20 and ≤0.4 (Table 2, Figure 12). A complete list of soil series found within the watershed is available in Appendix A.

Hydrology and Drainage Network

The Black River is the major stream within the HUC-12 watershed and flows from the northern portion of the watershed south toward the Arkansas line (Figure 1). Major tributaries including the Little Hunting Slough, Big Hunting Slough, Caney Slough, Cross Slough, and the Den River have all been rerouted and hydrologically altered by a network of engineered ditches designed to move water to and from converted cropland (Marsden 1930, Graves 1983) (Figure 2). With the exception of the Black River, the only other remaining natural hydrological features are the human-created “oxbow” wetlands that appear to be isolated remnants of old stream channels (Nigh and Schroeder 2002). There are three, large main ditches constructed within the watershed that generally flow north to south including Ackerman Ditch, Black River Ditch, and Stillcamp Ditch. Crop fields and the remnant “oxbow” wetlands are connected to these main ditches by a series of smaller drainage ditches and road ditches that move water around field borders. There is a total of 251 miles of mapped streams within the watershed (Table 3). According to the National Hydrological Dataset (NHD), around 191 miles are natural while only 60 miles are channelized. However, after delineating the stream network from recent LiDAR data, there appears to be more channelized streams than the NHD files indicate. LiDAR analysis reveals about 184 miles (73%) of the streams in the watershed are channelized and only 67 miles of natural channels are present, with the majority of the natural channels classified along the Black River. There are only around 65 acres of ponds and lakes within the NHD database. A total of 16 major water users reporting groundwater usage within the watershed have been identified with all but one using groundwater for irrigation (Table 4).

Land Use and Land Cover

The Little Hunting Slough-Black River watershed is dominated by cropland. Land uses for the watershed were determined using the National Agricultural Statistics Service (NASS) Crop Database from 2014-2018. In 2018, cropland made up the majority of the land use within the watersheds at 74.2%, followed by wetlands (15.8%) and urban development (6.3%) (Table 5, Figure 13). Over the last five years these percentages have been very consistent. The main crops grown in the watershed are soybeans, rice, and corn. Between 2014-2018, soybean and rice production increase by almost 1,300 acres while there was a decrease in corn (-498 acres) and grass/pasture land (-335 acres) (Table 6). However, forest and wetlands have remained fairly steady over that time. This suggests that there has been at least some conversion of grassland to cropland within the watershed over the last five years, but generally the only annual changes in land cover seem to be the type of crop grown from year to year.

Previous Work and Other Available Data

<u>TMDLs and Management Plans</u>

There are currently no TMDLs or watershed management plans for Little Hunting Slough-Black River HUC-12 watershed. However, approximately 47 miles of the Black River within the watershed are listed on the 303(d) list of impaired waters for mercury in fish tissue from atmospheric deposition and toxic sources (MDNR 2018). The Missouri Department of Conservation has a Fifteen-Year Area Management Plan for the Coon Island Conservation Area. Most of Coon Island lies between the levees of the Black River in the southern portion of the watershed and the plan emphasizes the challenges of maintaining habitat and infrastructure within the publicly held land (MDC 2018). However, one of the goals stated in the plan was to work with local landowners to improve riparian habitat and connectedness to some of the last bottomland forest in Butler County.

<u>Surface and Groundwater Monitoring Stations</u>

There is a United States Geological Survey (USGS) gaging station located on the Black River at Poplar Bluff, MO (USGS Gaging Station #07063000) that has been in continuous operation since 1939 that is within the Little Hunting Slough-Black River watershed (USGS 2019). Furthermore, there is station on the Black River approximately 59 miles downstream near Corning, AR (USGS

Gaging Station #07064000). However, there are no stations located within the tributaries to the Black River within the study watershed. To be able to predict discharge within the study watershed, 31 nearby USGS gaging stations were used to complete drainage area-based regression equations to be able to estimate discharge from different size watersheds within the study area (Figure 14). A list of the USGS gaging stations used for this analysis can be found in Appendix B. Additionally, there are no ground water monitoring stations within the study watershed. The closest ground water monitoring site is located approximately 6 miles to the east of the watershed in Qulin (Site Number: 363551090152801) on the southeast side of the Black River that has been in operation since 2000. Data from this station shows that the water table can fluctuate 15-20 feet annually (Figure 15). If resources became available to install continuous monitoring stations within the watershed, it might be beneficial to install a groundwater monitoring station in the lowlands on the northwest side of the Black River that includes a continuous soil moisture sensor. Public land might be the easiest place to install the monitoring station. For instance, Coon Island Conservation Area operated by the Missouri Department of Conservation has land that is located outside the Black River Ditch off County Road 251 (UTM Zone15N meters, N:4,046,755.522, E: 736,129.031). Other possible locations are Big Cane Conservation Area and Allred Lake Natural Area.

Water Quality Sampling Data

There are only two water quality monitoring sites within the Little Hunting Slough-Black River watershed that collected nutrients and sediment samples. One site (2769/41.0) is located at the USGS gaging station on the Black River at Poplar Bluff and the other is on the Palmer Slough (2769/36.9) (Table 7, Figure 16). Site 2769/41.0 was sampled fairly frequently between 1969 and 1987. Site 2769/36.9 was sampled more recently in 2008, but only 7 samples were collected. However, downstream of the study watershed about 150 water quality samples have been collected at the Black River near Corning, AR since 1993. As a comparison, samples from 10 sites were included in the table from the Main Ditch just west of the Little Hunting Slough-Black River watershed. This waterway also drains Poplar Bluff and there is a waste water treatment plant located within this watershed. Additionally, there are only two permitted point source outfalls within the watershed. One is land application site and the other is for stormwater (Table 8). There are no waste water treatment facilities within the study watershed. Finally, there are no confined animal feeding operations (CAFOs) in the watershed.

Biological Monitoring Data

Limited biological monitoring has been conducted within the Little Hunting Slough-Black River watershed for macroinvertebrates, fish, and crayfish communities. In 2002, sites on the Black River within the lowlands were sampled to help develop biological criteria for streams within the Mississippi Alluvial Plain Ecological Drainage Unit (EDU) (Sarver et al. 2002). Results indicate that at the time of sampling biological metrics were similar among all the sites in the Mississippi Alluvial Plain EDU including the reference streams. In 2007, Palmer Slough Ditch at County Road 606 was sampled, and the site was rated as "Partially Biologically Supporting" according to the Missouri Stream Condition Index (MSCI) (Sarver et al. 2002). Fish and crayfish community surveys have been collected within the lowlands of the Black River watershed going back to 1941. Repeat surveys show that the lowlands have a high diversity of aquatic species, but the area has seen a decline that is likely due to the modifications to the natural streams in the area (Cieslewicz 2004). Cieslewicz (2004) goes on to say unstable stream beds, loss of deep-water habitat, and poor riparian corridors are the major threats to aquatic organisms.

Summary

This report was compiled to provide necessary information to describe the study area for the National Water Quality Initiative (NWQI) Watershed Assessment for the Little Hunting Slough-Black River watershed (HUC-12 #1110100070805). The Little Hunting Slough-Black River watershed is heavily agricultural with approximately 73% of the land area in crops, mainly soybeans, rice, and corn. The hydrology of the area has been substantially modified by the construction of a series of ditches that drained the natural wetlands. As a result, this area has some of the most productive agricultural land in the state. Limited available data indicate surface water quality is fairly good in the area, however there is a potential for shallow groundwater pollution by nonpoint agricultural sources. Unstable stream beds, loss of deep-water habitat, and poor riparian corridors are also major threats to aquatic communities. The purpose of this watershed assessment is to provide necessary information to the NRCS field staff to identify localities where slope, soil, and land use practices have the highest potential for pollution and to describe conservation practices that would benefit the watershed's water quality. This first phase of the project provides a general description of the watershed and accessible data that will be utilized in subsequent phases of the project. Information gathered for the first phase of the project provides geographical, physical, hydrological, and water quality attributes along with documentation of available data sources (Table 9).

RESOURCE ANALYSIS OF THE WATERSHED

The resource analysis of the watershed will include evaluation of water quality data within the watershed, observed channel conditions from both historical aerial photography and an on-site visual assessment, and water quality modeling results. Ultimately these results will help establish what land uses are producing the most pollution and what practices would be the most useful in reducing nutrient and sediment loads within the watershed.

Water Quality Analysis

Summary statistics for all nutrient and sediment samples were used to evaluate water quality by looking at both the range of mean concentrations and variability among sites. All water quality data was downloaded from the MDNR Water Quality Assessment System website. Data was only available at two sites within the Little Hunting Slough watershed with both located on the main stem of the Black River. An additional site downstream of the study watershed on the Black River in Arkansas also had data available. Furthermore, data was also recovered from the watershed just west of Little Hunting Slough. However, this site is influenced by a wastewater treatment plant and those sites will not be evaluated. For the three remaining sites along the Black River, average concentrations of total phosphorus (TP) ranged from 0.062-0.096 mg/L, mean concentrations of total nitrogen (TN) ranged from 0.29-0.80 mg/L, and average total suspended sediment (TSS) concentrations ranged from 21.6-34.9 mg/L (Table 10). The site at 2769/41.0 is located in the upper portion of the watershed and has the lowest concentrations of nutrients and sediment of the three sites. Downstream at 2769/36.9, concentrations of nutrients and sediment increase 1.5-3 times. However, concentrations of nutrients and sediment downstream of Little Hunting Slough at 2769/AR are slightly lower. While the number and distribution of samples available in this watershed are limited, these data suggest runoff from Little Hunting Slough may be at least partially responsible for the increase of nutrients and sediment in the Black River.

Total phosphorus concentrations within the Little Hunting Slough watershed are lower than the established reference concentration for the ecoregion, but nitrogen concentrations are slightly above the reference condition. Ambient water quality criteria suggested reference conditions for these streams is 0.71 mg/L TN and 0.125 mg/L TP based on the 25th percentile value for streams within the Mississippi Alluvial Plain region (Table 11, USEPA 2001). The limited sample set shows that Little Hunting Slough has mean total phosphorus concentrations <0.1 mg/L. However, average total nitrogen concentrations at the middle Black River site is 0.80 mg/L. These data suggest conservation practices that can reduce nitrogen in runoff can be important component in improving and protecting water quality in these watersheds.

Channel Stability and Riparian Corridor Assessment

<u>Aerial Photo Methods</u>

Aerial photographs from 1996 and 2015 were obtained from the Missouri Spatial Data Information Service (MSDIS) online data server pre-rectified (Table 12). Differences between the two photos due to transformation errors was quantified using point-to-point error analysis. A total of 10 locations on both sets of aerials were evaluated within the HUC-12 watershed boundary. Point-to-point errors ranged from 3.1-11.6 ft for a mean of 7.7 ft (Table 13). Streams channels for each year were digitized to identify and measure changes over time. Both bank lines were digitized for the main stem and larger tributaries. However, since many of the tributary channels were small and the channel bank was obstructed by vegetation in some places, the channel centerline was digitized where it could clearly be seen at a scale of 1:1,500 (Martin and Pavlowsky 2011). Digitized lines representing the channel position from each year were then compared to identify areas of change and to quantify lateral migration rates.

Channel Classification

Tributary channels and the main stem of the Black River within the Little Hunting Slough watershed were further classified by identifying historical channel changes by interpretation of the 1996 and 2015 aerial photos. Channels were first characterized as modified or natural. Modified channels were further classified as either “channelized” or “ponded”. Natural channels were then classified as either “stable” or “active”. Active channels were identified by assessing planform changes since 1996 by overlay analysis of the digitized channel using an error buffer which is based off the 7.7 ft mean point-to-point error to account for biases attributed to rectification (Martin and Pavlowsky 2011). Active reaches were identified as areas where the buffers between the two sets of digitized lines did not overlap for at least 100 ft to account for rectification errors. If the channel was obstructed by vegetation or not visible in both aerials, it was classified as “not visible”. A flow chart was developed to assist in channel classification during aerial photo interpretation (Figure 17).

Channel classification results show the majority of the tributaries were channelized and directed into the larger main ditches to drain the land to allow for crop production (Figure 19). Of the 290.8 miles of evaluated channels within the watershed using this method, 205.9 (70.8%) miles were classified as channelized, 41.1 (14.1%) miles were not visible, 23.9 (8.2%) miles were active, 16.7 (5.8%) miles were stable, and 3.2 (1.1%) miles were ponds/dams (Table 14). The Black River, which is constrained by levees, has the majority of the active areas within the watershed. Outside of the Black River, the majority of the channels that were not classified as channelized are classified as “not visible”. The areas of the channel that were classified as not visible was mainly due to the obstruction of vegetation in the aerial photographs. While most of the active channel sections are located along the Black River, the 2015 aerial photograph appears to have been taken during high flow that may overestimate the severity of bank erosion along the Black River. However, due to high sinuosity and low slope, bank erosion is likely prevalent along the outside banks of the river.

Riparian Corridor Analysis

The presence of a healthy riparian corridor can provide resistance to erosion during floods and filter runoff water moving from the uplands to the stream (Rosgen 1996, Montgomery and MacDonald 2002, USDA 2003). Riparian corridors for the Little Hunting Slough watershed were evaluated by creating a buffer around the 2015 digitized stream layer and overlaying that layer on the 2015 aerial photo. A 50 ft buffer was used on first and second order streams and a 100 ft buffer was placed around streams third order and larger (USDA 2014). The area within the buffer was classified into the following: Good, Moderate, and Poor. A Good classification represents portions of streams in which adequate riparian tree coverage extends the width of the buffer on both sides of the stream. A Moderate class signifies one side of the stream buffer meets the good classification, but the other side does not. Alternatively, the Moderate classification can also indicate a situation where riparian coverage reaches the extent of the buffer, but the tree coverage is sparse. Finally, the Poor classification is assigned to portions of the stream where the riparian corridor does not extend to the limits of the buffer on either side of the stream.

The majority of the riparian corridors along streams in the Little Hunting Slough watershed classified as poor or moderate were located along the channelized tributaries to the Black River. Within the Little Hunting Slough watershed, 87 mi (29.9%) of the total 291 mi of the streams were classified as having a good riparian corridor that is mostly located along the Black River corridor and the few remaining wetland remnants that can still be found in the watershed (Table 15, Figure 20). In contrast, poor (48.8%) and moderate (21.3%) corridors are found along the main ditches and channelized sections of the tributaries in the mostly cropped areas of the watershed. Due to the artificial drainage patterns in this watershed, water typically drains off crop fields at a single point via a pipe or other stable outlet. Therefore, the filtering capacity of the typical riparian corridor in this watershed is generally not utilized. However, vegetation growing along the banks of the channelized reaches appear to be providing some erosion protection and roughness during higher flows.

Visual Stream Survey Results

A modified rapid visual stream survey was conducted upstream and downstream of all public road crossings within the watershed following an established NRCS protocol (USDA 1998). The protocol was modified by only focusing on five physical stream channel indicators, riparian corridor evaluation, and the presence of manure indicating livestock access to the stream (Appendix C). Based on the assessment, each site receives an overall score between 1 and 10, with <6.0 considered poor, 6.0 – 7.4 fair, 7.5 – 8.9 good, and >9.0 excellent.

Streams within the Little Hunting Slough watershed have been extensively modified and VSA scores indicate the majority of these streams are classified in poor condition. A total of 204 sites were evaluated using the modified visual stream assessment protocol. Of these 204 sites, 75% are rated as poor, 3.9% as fair, 21.1% as good, and 0% as excellent (Table 16, Figure 21). Since the drainage patterns of the Little Hunting Slough watershed have been extensively modified by channelization, sites were classified into five categories which all had similar VSA scores. These categories are the Black River, main ditches, secondary ditches, road ditches, and wetland remnants. Black River sites were located along the main stem of the Black River and were classified in the "fair" category. While the Black River has not been channelized, levees do constrict the floodplain. Also, sites on the Black River have good riparian corridors but show evidence of bank erosion. Main ditch, secondary ditch, and road ditch sites have all been channelized, show at least some evidence of incision, and are all classified in the poor category. Main and secondary ditch sites generally have some riparian corridor but also generally show more evidence of bank erosion. Finally, wetland remnant sites appear to be isolated areas between the ditches that have not been channelized and score in the good category in VSA protocol. While there may be some modifications that may be hidden by vegetation, these areas are not straightened or show any evidence of incision or bank erosion. They generally have good riparian corridors with wetland species present. Overall, poor ratings are exclusively due to channelization, incision, and poor riparian conditions. Unmodified streams tend to be in much better condition, but there are few of these sites remaining in the watershed. Examples of sites evaluated for the Little Hunting Slough watershed can be found in Appendix D.

Rainfall–Runoff Relationship

Annual and monthly runoff rates for the Little Hunting Slough watershed were estimated using equations developed from 31 USGS gaging stations in the region. Monthly runoff rates are important for understanding the seasonal variability and how rainfall-runoff relationships correspond to land management and annual runoff rates will be used to help validate the STEPL model hydrology results. A list of the equations used for the analysis of monthly mean discharge values can be found in Appendix E. Mean annual discharge for the Little Hunting Slough watershed is 106.4 ft^3/s and total runoff volume was 77,054 ac-ft (Figure 22). Average monthly discharge peaks in the month of April and is the lowest in September. Monthly mean runoff as a percentage of rainfall is highest in the spring and lowest in the summer ranging from 10% in July to nearly 60% in April. Average annual runoff as a percentage of rainfall is 34.0%. The remainder of the rainfall is either lost to evapotranspiration or moved through the soil into groundwater storage through infiltration (USDA, 2009b). These estimates are comparable with existing literature that state evapotranspiration rates for Missouri range from 60–70% (Sanford and Selnick 2013).

Water Quality Modeling

STEPL Model

Existing water quality loads in the watershed were estimated using a predictive model (STEPL). The Spreadsheet Tool for Estimating Pollutant Load (STEPL) uses simple algorithms to calculate nutrient and sediment loads from different land uses and load reductions from implementation of conservation practices (Tetra Tech, Inc 2017). Annual nutrient loading was calculated based on the annual runoff volume and established land use specific pollutant concentrations. The annual sediment load from sheet and rill erosion was calculated based on the Universal Soil Loss Equation (USLE) and the sediment delivery ratio. Accuracy is primarily limited by the wide variability in event mean concentrations (EMCs) across watersheds since EMCs are used to calculate annual pollutant loadings.

For this study, the watershed was modeled with inputs following methods outlined in the STEPL user's guide. Model inputs include drainage area, soil hydrologic group, land use, animal numbers, and estimates on septic systems within the watershed. Land use was derived from the 2018 USDA Crop database. Animal numbers were calculated per acre of pasture within the watershed using animal number ratio of one animal per 2.5 acres of pastureland based on input from local staff. The number of septic systems within each watershed was based an area ratio of the low intensity developed land use and provided by the STEPL online database. Details about the inputs for each watershed can be found in Appendix F.

Lateral stream bank erosion was accounted for by calculating length of actively eroding banks, migration rates from historical aerial photo analysis, and bank heights from a LiDAR digital elevation model (DEM) datasets identified earlier in this report. Annual migration rates were estimated by overlaying the bank lines from each aerial photo year. The areas between the 1996 and 2015 photos that do not overlap were considered the bank erosion polygons. Additionally, a 7.7 ft error buffer was used to account for the difference in photos. The area of bank erosion was then divided by the length to calculate a mean width. The mean width was then divided by the number of years between photos to establish an average annual migration rate for each bank erosion polygon. This method identified a total of 86 eroding stream banks in the Little Hunting Slough watershed (Appendix G). Total eroding bank length for the Little Hunting Slough watershed is 37,515 ft, average volume weighted bank height is 6.0 ft, and average volume weighted migration rate is 1.5 ft/yr.

Model results estimated average yields for the Little Hunting Slough watershed were 7.02 lb/ac/yr for nitrogen, 1.33 lb/ac/yr phosphorus, and 0.47 T/ac/yr of sediment (Table 17). Runoff rates were 1.34 ac-ft/ac/yr and the percentage of rainfall as runoff was 34.3% for the watershed. Modeled percent runoff is relatively close to the estimated percentage of rainfall as runoff from the USGS gaging station equation estimate, which was 36.4% for the watershed. The relative agreement of these two methods adds confidence to the STEPL modelled runoff results.

When assessing model results by sources for the Little Hunting Slough watershed, the majority of the nutrient load is from cropland, but the highest sediment source is from bank erosion. Model results show crop land accounts for 83.3% of the nitrogen and 79.4% of the phosphorus load, but only 39.7% of the sediment load (Table 18). Bank erosion was the highest contributor of sediment to the watershed, accounting for 56.9% of the load. Urban land use and bank erosion account for most of the remaining nutrient load. There is so little pasture and forest land in the watershed that the contribution from these land uses are negligible. These results suggest any effort to reduce nutrients from leaving the watersheds with conservation practices should solely be focused on crop land agriculture.

Summary

The purpose of this section of the report is to provide results of the resource analysis of the watershed (Deliverable #5) for the Mississippi River Basin Healthy Watersheds Initiative (MRBI) Watershed Assessment for the Little Hunting Slough Watershed (HUC-110100070805). Available water quality data was limited in the Little Hunting Slough watershed but indicates phosphorus concentrations meet the regional ambient water quality criteria suggested reference conditions for streams in Mississippi Alluvial Plain region. However, nitrogen concentration in the Black River exceed the reference condition.

Stream channel analysis shows that the channelized streams in the watershed tend to not show excessive erosion, but still score poorly on riparian cover and visual survey criteria. Both historical aerial photos and a visual stream assessment were used to evaluate potential contributions of streambank erosion to water quality problems within the watershed. The majority of these streams have been channelized and detection of actively eroding reaches was mainly limited to the main stem of the Black River. The riparian corridor assessment shows similar results with the majority of the channelized stream having poor riparian corridors. Stream reaches assessed in the visual stream survey showed that channelized reaches were classified in the poor category while unmodified reaches scored in the fair-good category.

Water quality modeling results indicate cropland overwhelmingly produces the majority of the nonpoint source nutrient pollution within the watershed, but stream bank erosion is the highest sediment source. Model results show cropland accounts for 83% of the nitrogen and 79% of the phosphorus load in the watershed. However, streambank erosion is a significant contributor at nearly 57% of the total sediment load in these watersheds. Bank erosion analysis shows that the majority of the stream bank erosion is along the main stem of the Black River.

IDENTIFICATION OF CONSERVATION NEEDS

Load Reduction Analysis

Load reduction for the watershed was modeled with STEPL using established conservation practice efficiencies (Waidler et al. 2009, GSWCC 2013, Tetra Tech 2017). The efficiencies of combined practices were calculated with STEPL's BMP Calculator. A total of twelve cropland conservation practice scenarios were modeled, with seven identified for use with corn/soybeans and five for rice. A description of each combined conservation practice scenario with calculated efficiencies can be found in Appendix H. Load reductions of nitrogen, phosphorus, and sediment were modeled based on the percentage of soybeans/corn and rice grown in the watershed that were treated. The result is a load reduction matrix for the watershed showing the load reduction for the different percentage for all cropland treated in 10% increments. Currently, approximately 70% of the cropland is used for growing corn/soybeans and 30% for rice production.

Soybean/corn practices include installing a drop pipe, 90-day wetland (winter), cover crop, permanent outside berms, and no-till. For rice, conservation practices included in the analysis were installing a drop pipe, 90-day wetland (summer), permanent outside berms, drainage water management, and 180-day wetland (summer/winter). Land retirement was also used as a scenario to show what would happen if cropland was taken out of production. Since the corn/soybeans and rice were modeled separately within the watershed, the combined load reductions can be added together to estimate the combined effect.

Load reduction analysis for the Little Hunting Slough watershed shows that the most beneficial conservation practices for reduction of sediment can be achieved by implementation on corn/soybeans fields. For example, applying cover crop, no-till, drop pipe, permanent outside berm, and a 90-day wetland (winter) to half of the 28,456 acres of corn/soybean acres in the watershed (14,228 acres), the reduction for nitrogen would be 27.6%, phosphorus 30.1%, and sediment 23.2% (Tables 19-21). However, if all of the 11,623 acres of land in rice production had the most intensive practices implemented, which is a drop pipe, permanent outside berm, drainage water management, and a 180-day wetland (summer/winter), load reduction would be 22.2% for nitrogen, 22.9% for phosphorus, and 17.2% for sediment. Again, by combining corn/soybeans and rice practices in this watershed these practices can substantially reduce nutrient and sediment loads in the watershed. For comparison, if all of the cropland in the watershed were taken out of production through land retirement the resulting load reduction would be 78.6% for nitrogen, 73.0% for phosphorus, and 62.8% for sediment.

Resource Priorities

In the Little Hunting Slough watershed, the top resource priority identified by local staff is the reduction of the current sediment load. STEPL modeling results suggest higher sediment loads are coming from cropland within the Little Hunting Slough watershed. There is very little pastureland within the watershed and therefore is considered a low resource priority. Load reduction estimates for sediment suggest implementation of conservation practices on corn/soybean acres should be the focus within the watershed over land in rice production. There is a total of 28,456 acres of corn/soybeans and 11,623 acres of rice within the Little Hunting Slough watershed.

Conservation Planning

One of the main goals of this project is to use this assessment to help guide where conservation practices would be the most beneficial to meet water quality goals. This will be accomplished by using a management unit ranking, a priority acres classification, and a conservation practice rating system.

<u>Management Units</u>

To better plan for locations to implement conservation practices, the watershed was split into 14 smaller sub-watersheds, or management units (MUs) (Figure 23). MUs will allow field staff to evaluate potential projects based on a system that would spatially rank geographic areas within the watershed. STEPL was then used to estimate sediment yields for each MU ranging from about 1,271-6,871 acres (Table 22). MUs 6, 7, and 10 are within the Dan River drainage which has been identified as a particularly sensitive area within the Little Hunting Slough watershed by local staff. Therefore, these MUs are considered the top three for implementation of conservation practices. After that, all MUs are ranked by sediment yield. MUs 12, 13, and 14 cover areas that have relatively low acres of cropland and low sediment yields. MU 12 is mostly urban and MUs 13 and 14 are along the Black River floodplain between the levees.

<u>Susceptible Acres Classification</u>

To identify areas with the most pollution potential within a proposed project, a susceptible acres ranking system was developed to help field staff isolate problem areas and prioritize projects within the same MU. Four risk classes were used to rank the agricultural land based on the resource analysis of the watershed, STEPL modeling, and the VSA. <u>Highest Risk</u> land represents the most critical areas for pollution potential from the landscape and should be prioritized for planning. <u>High Risk</u> are areas that have significant risk as a pollution source, but not as high as the Highest Risk category. The <u>Moderate Risk</u> category could see potential gains from conservation practices but are a lower priority. <u>Low Risk</u> lands have adequate treatment of the landscape. Remaining areas of urban land use and water were classified as “other”. A description of each class type is detailed below and summarized in Table 23.

Highest – For the Little Hunting Slough watershed, land with the highest susceptibility classification for conservation planning was identified on irrigated cropland. Irrigated cropland with soils in Hydrological Soil Groups (HSG) C, C/D, or D, and a K-factor of >0.3 were identified as having the highest susceptibility for potential pollution. Within the Little Hunting Slough watershed, 19,007 acres are classified in the highest priority category, or roughly 35.1% of the watershed area (Figure 24).

High – Irrigated cropland with soils in Hydrological Soil Groups C, C/D, or D, and a K-factor of ≤0.3 were classified in the high susceptibility category for conservation planning. Additionally, irrigated cropland within HSGs A, B, or B/D are also in the high susceptibility category. There is a total of 15,357 acres of high priority acres within the watershed, or about 28.4% of the total drainage area.

Moderate – Non-irrigated cropland with soils in HSGs C, C/D, or D, and a K-factor of >0.3 were identified as having the moderate susceptibility for potential pollution in this watershed. This totals 3,162 acres, or 5.8% of the total area of the watershed.

Low - Low susceptibility acres were defined non-irrigated cropland with soils in HSGs C, C/D, or D, and a K-factor of <0.3 and non-irrigated cropland within HSGs A, B, or B/D. Within the study watershed there are only 2,400 low susceptibility acres, or 4.4% of the total area.

N/A – This category represents all pasture, forest, urban, and land classified as water or wetlands within the study watershed. This represents 14,159 acres, or 26.2% of the total land area.

<u>Conservation Practice Ranking</u>

The final part of the conservation planning portion of this project is to identify the conservation practices that are best suited for reducing sediment within the Little Hunting Slough watershed. For this, each conservation practice, or combination of conservation practices, was ranked based on the highest benefit by percentage of land treated for both corn/soybeans and rice acreage. Rankings suggest implementing conservation practices in acres of corn/soybeans would be the most effective at reducing the sediment load in this watershed. The top six conservation practice rankings are all corn/soybean conservation practices (Table 24). All practices potentially implemented on rice production land rank lower than the corn/soybeans practices for sediment reduction. There is a total of 28,456 acres of corn/soybeans and 11,623 acres of rice within the Little Hunting Slough watershed.

CONCLUSIONS

The purpose of this report is to provide the Missouri State office of the NRCS the results of a watershed assessment study of the HUC-12 watershed Little Hunting Slough-Black River Watershed (110100070805) located in Butler County, Missouri. This assessment supports the National Water Quality Initiative (NWQI) aimed at reducing nutrients and sediment in the nation's rivers and streams. The goal of the NWQI program is for the NRCS and its partners to work with landowners to implement voluntary conservation practices that improve water quality in high-priority watersheds while maintaining agricultural productivity. Ultimately, this watershed assessment provides NRCS field staff with the necessary information to identify locations within the study watershed where soil, slope, and land use practices have the highest pollution potential and to describe conservation practices that can be the most beneficial to improve water quality. The assessment included three phases, 1) resource inventory, 2) resource analysis, and 3) identification of resource needs. There are seven main conclusions from this assessment:

1) While there are no impaired stream segments within the Little Hunting Slough watershed, reducing the sediment loads coming from the landscape was identified by this assessment as the top resource concern to be addressed by implementation of conservation practices aimed at reducing erosion;

2) Available water quality data was limited in the Little Hunting Slough watershed but indicates phosphorus concentrations meet the regional ambient water quality criteria suggested reference conditions for streams in Mississippi Alluvial Plain region. However, nitrogen concentration in the Black River exceed the reference condition;

3) Both historical aerial photos and a visual stream assessment were used to evaluate potential contributions of streambank erosion to water quality problems within the watershed. The majority of these streams have been channelized and detection of actively eroding reaches was mainly limited to the main stem of the Black River;

4) The riparian corridor assessment results show the majority of the channelized streams have poor riparian corridors. Stream reaches assessed in the visual stream survey showed that

channelized reaches were classified in the poor category while unmodified reaches scored in the fair-good category;

5) Water quality modeling results indicate cropland overwhelmingly produces the majority of the nonpoint source nutrient pollution within the watershed, but stream bank erosion is the highest sediment source. However, the majority of the sediment from bank erosion is coming from the main stem of the Black River. Model results show cropland accounts for 83% of the nitrogen and 79% of the phosphorus load in the watershed. Streambank erosion is a significant contributor at nearly 57% of the total sediment load in the watershed;

6) Load reduction analysis suggests and that additional conservation practices on cropland can significantly reduce sediment loads within the watershed. The implementation of cover crops, drop pipes, no-till, permanent outside berms, and a 90-day wetland (winter) on corn/soybeans can reduce sediment loads up to and exceeding 45%. Additionally, implementing drop pipes, permanent outside berms, drainage water management, and 180-day wetlands (summer/winter) to rice acreage can reduce sediment loads an additional 17%; and

7) Management units, susceptible acres, and conservation practice rankings were all created to help field staff prioritize areas and evaluate potential projects. Management units direct conservation practices to specific areas of the watershed. Susceptible acres within management units can be used to evaluate projects within management units. Finally, conservation practices are ranked in order of effectiveness for cropland.

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TABLES

Table 1. Annual rainfall and average annual temperature for Poplar Bluff, Missouri (1989-2018).

Year	Total Rainfall (in)	Average Temperature (˚F)
1989	44.6	58.1
1990	54.8	60.1
1991	42.6	60.9
1992	37.6	58.0
1993	53.6	57.5
1994	47.3	58.3
1995	33.7	60.1
1996	50.2	56.8
1997	49.1	57.3
1998	62.7	60.8
1999	44.6	59.9
2000	38.5	58.0
2001	50.9	59.0
2002	59.4	58.6
2003	45.2	57.6
2004	38.7	58.4
2005	37.4	59.5
2006	67.6	59.3
2007	47.2	60.0
2008	59.1	58.8
2009	59.1	57.4
2010	39.5	59.1
2011	75.4	58.9
2012	35.7	62.2
2013	67.6	58.0
2014	40.4	56.9
2015	68.2	60.4
2016	55.9	60.4
2017	44.0	60.5
2018	59.3	59.0
n	30	30
Min	33.7	66.8
Mean	50.3	69.2
Max	75.4	62.2

data source: http://mrcc.isws.illinois.edu/CLIMATE

Table 2. Watershed soil characteristics summary

Soil Order	%	Hydrologic Soil Group	%	Soil Erosion K-Factor	%	Land Capability Classification	%
Alfisol	76.9	A	3.7	<0.2	3.7	2e	2.8
Inceptisols	15.7	B	5.3	0.2-0.3	34.8	2w	12.6
Ultisols	1.6	B/D	15.0	0.3-0.4	50.5	3e	1.5
Entisol	1.5	C	13.8	>0.4	6.7	3w	34.3
Other	4.3	C/D	38.0	Other	4.3	4s	0.1
		D	19.9			4w	43.3
		Other	4.3			6s	1.1
						Other	4.3

Table 3. Drainage network summary

Water Feature	**NHD 2018[1] Length/Area**	**2015 LiDAR[2] Length**
Streams	251 miles	251 miles
Natural Streams	191 miles	67 miles
Canals/Ditches	60 miles	184 miles
Waterbodies, Lakes, Ponds	65 acres	NA

1. From the National Hydrological Dataset, 2018
2. From 2015 LiDAR Analysis

Table 4. Major water users within the watershed

ID	MWU ID	Prime Use	Usage (millions of gallons) 2013	2014	2015	2016	2017	% Change
1	60308635	Irrigation	57.6	57.6	52.2	57.6	52.2	-9.4
2	60308635	Irrigation	90.7	90.7	23.5	90.7	23.5	-74.1
3	60308635	Irrigation	207.4	207.4	52.2	207.4	52.2	-74.8
4	60308635	Irrigation	54.0	54.0	48.9	54.0	48.9	-9.4
5	60308635	Irrigation	189.2	189.2	46.9	189.2	46.9	-75.2
6	65090436	Irrigation	87.4	8.7	10.9	10.9	10.9	-87.5
7	65090436	Irrigation	27.4	8.7	8.7	8.7	8.7	-68.1
8	65090436	Irrigation	13.1	13.1	13.1	131.1	13.1	0.0
9	65090436	Irrigation	17.5	17.5	17.5	17.5	17.5	0.0
10	65090436	Irrigation	85.3	85.3	32.8	68.5	46.7	-45.2
11	65090436	Irrigation	18.3	18.3	57.5	27.4	17.5	-4.8
12	65090436	Irrigation	8.7	8.7	8.7	13.0	8.7	0.0
13	65090436	Irrigation	3.8	9.8	9.8	44.0	9.8	158.2
14	65090436	Irrigation	27.4	10.9	10.9	48.9	10.9	-60.1
15	44278427	Municipal	853.6	853.6	730.0	800.0	847.6	-0.7
16	57379162	Irrigation	55.0	0.0	0.0	0.0	0.0	-100.0
		Total	1796.4	1633.7	1123.6	1768.9	1215.2	

Table 5. Generalized crop data classification (%) from 2014-2018.

General Land Use/Land Cover	Year					2014-2018 Average
	2014	2015	2016	2017	2018	
Urban	6.3	6.3	6.3	6.3	6.3	6.3
Cropland	73.5	73.9	73.9	73.9	74.2	73.8
Pasture	1.5	0.9	1.0	1.1	0.9	1.1
Forest	1.0	1.2	1.0	1.0	1.0	1.1
Wetlands	1.8	1.7	1.7	1.9	1.8	1.8
Water	15.9	15.9	16.0	15.8	15.8	15.9

Table 6. Selected specific crop acres from 2014-2018 with five-year total change.

Specific Land Use/Land Cover	Year					2014-2018 Change
	2014	2015	2016	2017	2018	
Soybeans	23,177	23,412	23,245	20,871	24,258	1,081
Rice	11,424	9,584	12,210	8,233	11,622	198
Corn	3,996	2,854	3,731	2,680	3,498	-498
Pasture	813	470	555	570	478	-335
Forest	552	649	551	550	547	-5
Wetlands	8,602	8,617	8,642	8,566	8,552	-50

Table 7. Available water quality data

Site ID	Location	TP (n)	TP start date	TP end date	TP Mean (mg/L)	TN (n)	TN start date	TN end date	TN Mean (mg/L)	TSS (n)	TSS start date	TSS end date	TSS Mean (mg/L)
2769/36.9	Palmer Slough	7	8/5/2008	9/15/2008	0.096	7	8/5/2008	9/15/2008	0.80	7	8/5/2008	9/15/2008	35
2769/41.0	Black River at Poplar Bluff	76	11/13/1969	6/3/1987	0.062	5	11/26/1974	7/17/1975	0.29	42	1/4/1984	6/3/1987	22
2769/AR	Black River near Corning, AR	152	6/1/1993	2/10/2009	0.088	78	11/12/1997	6/5/2007	0.60	150	6/1/1993	2/10/2009	22
2815/0.3	Pike Creek	4	9/10/2013	9/12/2013	0.031	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2815/0.9	Pike Creek	13	8/30/2000	8/5/2008	0.048	12	8/30/2000	8/5/2008	0.67	10	7/9/2002	8/5/2008	18
2814/13.5	Main Ditch @ Pike Creek	6	8/12/2008	9/16/2008	0.028	6	8/12/2008	9/16/2008	0.33	6	8/12/2008	9/16/2008	7
2814/12.4	Main Ditch	16	8/30/2000	9/12/2013	1.055	11	8/30/2000	8/7/2002	7.64	9	7/9/2002	5/13/2004	36
2814/11.4	Main Ditch	23	8/30/2000	9/12/2013	0.926	18	8/30/2000	9/16/2008	6.02	15	7/9/2002	9/16/2008	39
2814/10.4	Main Ditch	5	9/10/2013	9/2/2013	0.696	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2814/9.4	Main Ditch	2	8/6/2002	8/7/2002	0.140	2	8/6/2002	8/7/2002	1.14	2	8/6/2002	8/7/2002	19
2814/7.2	Main Ditch	12	8/30/2000	8/7/2002	0.448	12	8/30/2000	8/7/2002	2.65	8	7/9/2002	8/7/2002	43
2814/3.7	Main Ditch	11	8/30/2000	9/16/2008	0.303	11	8/30/2000	9/16/2008	1.69	7	8/5/2008	9/16/2008	15
2814/0.3	Main Ditch	5	11/26/1974	7/17/1975	0.764	5	11/26/1974	7/17/1975	1.44	N/A	N/A	N/A	N/A

Gray rows are sites outside the study watershed

Table 8. Permitted point sources within the watershed.

Site Number	Facility Name	Type	Stream	Waste	Status
1	MO Ark Provision Co	Land Application Site	Trib. to Black River	Nonprocess	Effective
2	Union Pacific Railroad-Poplar Bluff Yard	Outfall	Black River	Stormwater	Effective

Table 9. Data and source summary with web site address

Data Needed	Source	Agency	Within HUC-12 Watershed	Nearby Watershed	Website
HUC 8 Watershed	National Hydrography Dataset	USGS	X		https://nhd.usgs.gov
HUC 10 Watershed	National Hydrography Dataset	USGS	X		https://nhd.usgs.gov
HUC 12 Watershed	National Hydrography Dataset	USGS	X		https://nhd.usgs.gov
Stream Network	National Hydrography Dataset	USGS	X		https://nhd.usgs.gov
Soils (polygons)	NRCS Geospatial Data Gateway	USDA	X		https://datagateway.nrcs.usda.gov
Soils (attributes)	NRCS Web Soil Survey	USDA	X		https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm
Precipitation	Cli-mate	MRCC		X	http://mrcc.isws.illinois.edu/CLIMATE/
Temperature	Cli-mate	MRCC		X	http://mrcc.isws.illinois.edu/CLIMATE/
Solar Radiation	Missouri Climate Center	UMC		X	www.climate.missouri.edu
Evapotranspiration	Missouri Climate Center	UMC		X	www.climate.missouri.edu
Elevation (LiDAR)	MSDIS	UMC	X		http://msdis.missouri.edu/
Geology	MSDIS	UMC	X		http://msdis.missouri.edu/
Land Use/Land Cover	National Agricultural Statistics Service	USDA	X		www.nass.usda.gov
Hydrology	National Water Information System	USGS		X	https://waterdata.usgs.gov/nwis/rt
Groundwater Levels	Groundwater Watch	MDNR		X	https://groundwaterwatch.usgs.gov
Water Quality	MDNR Water Quality Assessment System	MDNR		X	http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do
Biological Monitoring	MDNR Water Quality Assessment System	MDNR		X	http://www.dnr.mo.gov/mocwis_public/wqa/waterbodySearch.do

HUC = Hydrologic Unit Code
WWTF = Waste Water Treatment Facility
NRCS = National Resource Conservation Service
MSDIS = Missouri Spatial Data Information Service
USGS = United States Geological Survey
USDA = United States Department of Agriculture
MRCC = Midwest Regional Climate Center
UMC = University of Missouri-Columbia
MDNR = Missouri Department of Natural Resources

Table 10. Water quality data summary

Site ID	TP (mg/L)						TN (mg/L)						TSS (mg/L)					
	n	min	mean	max	stdev	cv%	n	min	mean	max	stdev	cv%	n	min	mean	max	stdev	cv%
2769/36.9	7	0.070	0.096	0.130	0.022	23.3	7	0.64	0.80	1.09	0.16	19.6	7	14.0	34.9	54.0	13.3	38.2
2769/41.0	76	0.000	0.062	0.600	0.107	171.4	5	0.22	0.29	0.38	0.07	23.7	42	1.0	22.3	103.0	19.3	86.5
2769/AR	152	0.010	0.088	0.437	0.062	71.2	78	0.13	0.60	3.50	0.45	74.0	150	1.0	21.6	168.0	19.6	90.8
2815/0.3	4	0.021	0.031	0.048	0.012	37.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2815/0.9	13	0.030	0.048	0.070	0.012	25.9	12	0.32	0.67	1.10	0.32	46.9	10	7.0	18.0	40.0	10.3	57.4
2814/13.5	6	0.010	0.028	0.040	0.012	41.3	6	0.21	0.33	0.48	0.10	30.0	6	5.0	6.8	9.0	1.6	23.4
2814/12.4	16	0.480	1.055	2.640	0.562	53.2	11	4.00	7.64	21.10	5.11	66.9	9	12.0	35.8	92.0	23.3	65.1
2814/11.4	23	0.500	0.926	1.540	0.312	33.7	18	3.41	6.02	8.70	1.55	25.8	15	15.0	39.1	67.0	15.4	39.5
2814/10.4	5	0.600	0.696	0.830	0.085	12.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
2814/9.4	2	0.100	0.140	0.180	0.057	40.4	2	0.76	1.14	1.52	0.54	47.1	2	13.0	19.0	25.0	8.5	44.7
2814/7.2	12	0.320	0.448	0.590	0.093	20.9	11	1.50	2.85	3.84	0.75	26.4	8	29.0	43.4	74.0	17.5	40.3
2814/3.7	11	0.160	0.303	0.440	0.080	26.5	11	0.90	1.69	2.84	0.59	34.9	7	9.0	14.9	24.0	5.2	35.1
2814/0.3	5	0.370	0.764	1.100	0.298	39.0	5	0.62	1.44	2.90	0.86	59.7	NA	NA	NA	NA	NA	NA

n = sample number

TP = total phosphorus

TN = total nitrogen

TSS = total suspended sediment

Table 11. Ambient water quality criteria recommendations for total nitrogen (TN) and total phosphorus (TP), Ecoregion X (USEPA 2001)

Parameter	25th Percentile	Range
TN (mg/L)	0.71	0.16 – 2.68
TP (mg/L)	0.125	0.005-1.325

Table 12. Aerial photography used for channel change analysis

Photo Year	Source	Type	Resolution (ft)
1996	USGS	Black and White Photo	3.3
2015	USGS	Color High Resolution	0.5

Table 13. Point-to-point (PTP) errors by watershed.

Watershed	Range PTP Error (ft)	Mean PTP Error (ft)
Little Hunting Slough	3.1 – 11.6	7.7

Table 14. Channel classification analysis summary

Watershed	Total Length (mi)	Channelized	Dam/Pond	Stable	Active	Not Visible
Little Hunting Slough	290.8	205.9	3.2	16.7	23.9	41.1
		70.8%	1.1%	5.8%	8.2%	14.1%

Table 15. Riparian corridor analysis summary

Watershed	Total Length (mi)	Good	Moderate	Poor
Little Hunting Slough	291	87	62	142
		29.9%	21.3%	48.8%

Table 16. Visual Stream Assessment survey scores and classification

Site Type	# of Sites	% of Site	VSA Score	VSA Class
Black River	8	3.9	7.2	Fair
Main Ditches	51	25.0	3.4	Poor
Secondary Ditches	46	22.5	3.2	Poor
Road Ditches	56	27.5	3.2	Poor
Wetland Remnant	43	21.1	8.6	Good

Table 17. STEPL model results

Watershed ID	Total Ad (ac)	Runoff (ac-ft)	Runoff Yield (ac-ft/ac)	% Rainfall as runoff	Annual Load			Annual Yield			Mean Concentration		
					N- lb/yr	P- lb/yr	Sed- t/yr	N- lb/ac/yr	P- lb/ac/yr	Sed- t/ac/yr	N- mg/L	P- mg/L	Sed- mg/L
Little Hunting Slough	54,084	72,558	1.34	34.3	379,852	72,084	25,237	7.02	1.33	0.47	1.93	0.365	256

Table 18. STEPL results by sources

Sources	**N Load (lb/yr)**	**%**	**P Load (lb/yr)**	**%**	**Sediment Load (t/yr)**	**%**
Little Hunting Slough						
Urban	34,517	9.1	5,353	7.4	793	3.1
Cropland	316,487	83.3	57,256	79.4	10,023	39.7
Pastureland	5,504	1.4	459	0.6	47	0.2
Forest	317	0.1	150	0.2	25	0.1
Septic	68	<0.1	27	<0.1	0.0	<0.1
Streambank	22,959	6.0	8,839	12.3	14,349	56.9
Total	379,852	100.0	72,084	100.0	25,237	100.0

Table 19. Nitrogen load reduction results for the Little Hunting Slough watershed.

List of Practices in Deliverable	Nitrogen load reduction by % of land treated									
Soybeans and Corn	**7%**	**14%**	**21%**	**28%**	**36%**	**43%**	**50%**	**57%**	**64%**	**71%**
Drop Pipe and 90-Day Wetland (Winter)	4.7	9.3	14.0	18.7	24.0	28.7	33.3	38.0	42.7	47.3
Cover Crop, Drop Pipe, and Permanent Outside Berm	5.0	10.0	15.0	20.1	25.8	30.8	35.8	40.8	45.8	50.9
Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Winter)	4.8	9.7	14.5	19.4	24.9	29.7	34.6	39.4	44.3	49.1
No-till, Drop Pipe, and Permanent Outside Berm	5.1	10.3	15.4	20.6	26.5	31.6	36.8	41.9	47.1	52.2
Cover Crop, No-till, Drop Pipe, and Permanent Outside Berm	5.3	10.7	16.0	21.3	27.4	32.7	38.1	43.4	48.7	54.1
Cover Crop, No-till, Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Winter)	5.4	10.7	16.1	21.5	27.6	33.0	38.4	43.7	49.1	54.5
Land Retirement	5.5	11.0	16.5	22.0	28.3	33.8	39.3	44.8	50.3	55.8
Rice	**3%**	**6%**	**9%**	**12%**	**14%**	**17%**	**20%**	**23%**	**26%**	**29%**
Drop Pipe and 90-Day Wetland (Summer)	2.0	4.0	6.0	8.0	9.3	11.3	13.3	15.3	17.3	19.3
Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Summer)	2.2	4.4	6.6	8.8	10.3	12.5	14.7	16.9	19.1	21.3
Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 90-Day Wetland (Summer)	2.3	4.5	6.8	9.1	10.6	12.9	15.1	17.4	19.7	21.9
Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 180-Day Wetland (Summer)	2.3	4.6	6.9	9.2	10.7	13.0	15.3	17.6	19.9	22.2
Land Retirement	2.4	4.7	7.1	9.4	11.0	13.4	15.7	18.1	20.4	22.8

Table 20. Phosphorus load reduction results for the Little Hunting Slough watershed.

List of Practices in Deliverable	Phosphorus load reduction by % of land treated									
Soybeans and Corn	**7%**	**14%**	**21%**	**28%**	**36%**	**43%**	**50%**	**57%**	**64%**	**71%**
Drop Pipe and 90-Day Wetland (Winter)	4.8	9.7	14.5	19.4	24.9	29.8	34.6	39.5	44.3	49.1
Cover Crop, Drop Pipe, and Permanent Outside Berm	5.1	10.2	15.4	20.5	26.3	31.5	36.6	41.7	46.8	52.0
Drop Pipe , Permanent Outside Berm, and 90-Day Wetland (Winter)	5.2	10.5	15.7	20.9	26.9	32.1	37.4	42.6	47.8	53.1
No-till, Drop Pipe, and Permanent Outside Berm	5.8	11.6	17.3	23.1	29.7	35.5	41.3	47.1	52.9	58.6
Cover Crop, No-till, Drop Pipe, and Permanent Outside Berm	5.8	11.6	17.4	23.2	29.9	35.7	41.5	47.3	53.1	58.9
Cover Crop, No-till, Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Winter)	5.9	11.7	17.6	23.4	30.1	36.0	41.8	47.7	53.6	59.4
Land Retirement	5.1	10.2	15.3	20.4	26.3	31.4	36.5	41.6	46.7	51.8
Rice	**3%**	**6%**	**9%**	**12%**	**14%**	**17%**	**20%**	**23%**	**26%**	**29%**
Drop Pipe and 90-Day Wetland (Summer)	2.1	4.2	6.2	8.3	9.7	11.8	13.8	15.9	18.0	20.1
Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Summer)	2.2	4.4	6.6	8.9	10.3	12.5	14.8	17.0	19.2	21.4
Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 90-Day Wetland (Summer)	2.3	4.7	7.0	9.3	10.9	13.2	15.5	17.9	20.2	22.5
Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 180-Day Wetland (Summer)	2.4	4.7	7.1	9.5	11.1	13.4	15.8	18.2	20.6	22.9
Land Retirement	2.2	4.4	6.6	8.8	10.2	12.4	14.6	16.8	19.0	21.2

Table 21. Sediment load reduction results for the Little Hunting Slough watershed.

List of Practices in Deliverable	Sediment load reduction by % of land treated									
Soybeans and Corn	**7%**	**14%**	**21%**	**28%**	**36%**	**43%**	**50%**	**57%**	**64%**	**71%**
Drop Pipe and 90-Day Wetland (Winter)	3.7	7.4	11.1	14.8	19.0	22.7	26.4	30.1	33.8	37.5
Cover Crop, Drop Pipe, and Permanent Outside Berm	4.0	7.9	11.9	15.8	20.3	24.3	28.2	32.2	36.1	40.1
Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Winter)	4.0	8.0	12.1	16.1	20.7	24.7	28.7	32.8	36.8	40.8
No-till, Drop Pipe, and Permanent Outside Berm	4.5	8.9	13.4	17.8	22.9	27.4	31.8	36.3	40.8	45.2
Cover Crop, No-till, Drop Pipe, and Permanent Outside Berm	4.5	8.9	13.4	17.9	23.0	27.5	31.9	36.4	40.9	45.4
Cover Crop, No-till, Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Winter)	4.5	9.0	13.5	18.0	23.2	27.7	32.2	36.7	41.2	45.7
Land Retirement	4.4	8.8	13.2	17.6	22.6	27.0	31.4	35.8	40.2	44.6
Rice	**3%**	**6%**	**9%**	**12%**	**14%**	**17%**	**20%**	**23%**	**26%**	**29%**
Drop Pipe and 90-Day Wetland (Summer)	1.6	3.2	4.8	6.3	7.4	9.0	10.6	12.2	13.7	15.3
Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Summer)	1.6	3.2	4.9	6.5	7.6	9.2	10.8	12.5	14.1	15.7
Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 90-Day Wetland (Summer)	1.7	3.4	5.2	6.9	8.0	9.8	11.5	13.2	14.9	16.7
Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 180-Day Wetland (Summer)	1.8	3.6	5.4	7.1	8.3	10.1	11.9	13.7	15.5	17.2
Land Retirement	1.9	3.8	5.7	7.5	8.8	10.7	12.6	14.5	16.3	18.2

Table 22. Annual sediment yield and MU ranking.
Watersheds in yellow are draining the Dan River.

Watershed Ranking	Watershed ID	Total Ad (ac)	Crop Acres	Annual Yield Sed-T/ac/yr
1	6	3,863	3,617	0.50
2	7	4,681	4,396	0.44
3	10	6,871	5,972	0.42
4	9	1,969	1,653	0.45
5	2	3,557	3,307	0.43
6	8	4,909	4,739	0.42
7	5	3,550	3,319	0.41
8	11	3,005	1,803	0.37
9	3	6,248	5,659	0.35
10	4	3,284	3,284	0.33
11	1	4,656	2,516	0.32
12	12	1,271	1.8	0.18
13	13	1,744	388	0.14
14	14	4,524	453	0.06

Table 23. Summary of susceptibility classification for the Little Hunting Slough watershed.

Vulnerable Acres Rank	Land Use and Conditions	Total Acres (%)
Highest	Irrigated Cropland; HSG C, C/D, or D; and K-factor >0.3	19,007 (35.1%)
High	Irrigated Cropland and HSG A, B, or B/D; or Irrigated Cropland HSG C, C/D, or D; and K-factor <0.3	15,357 (28.4%)
Moderate	Non-irrigated Cropland; HSG C, C/D, or D; and K-factor >0.3	3,162 (5.8%)
Low	Non-irrigated Cropland and HSG A, B, or B/D; or Non-irrigated Cropland; HSG C, C/D, or D; and K-factor <0.3	2,400 (4.4%)
N/A	Urban, Forest, Pasture, Water, and Wetlands	14,159 (26.2%)
	Total	54,084 (100%)

Table 24. Ranked conservation practices by largest sediment load reduction.

Rank	Practice	Land Use
1	Cover Crop, No-till, Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Winter)	Corn/Soybeans
2	Cover Crop, No-till, Drop Pipe, and Permanent Outside Berm	Corn/Soybeans
3	No-till, Drop Pipe, and Permanent Outside Berm	Corn/Soybeans
4	Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Winter)	Corn/Soybeans
5	Cover Crop, Drop Pipe, and Permanent Outside Berm	Corn/Soybeans
6	Drop Pipe and 90-Day Wetland (Winter)	Corn/Soybeans
7	Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 180-Day Wetland (Summer)	Rice
8	Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 90-Day Wetland (Summer)	Rice
9	Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (Summer)	Rice
10	Drop Pipe and 90-Day Wetland (Summer)	Rice

FIGURES

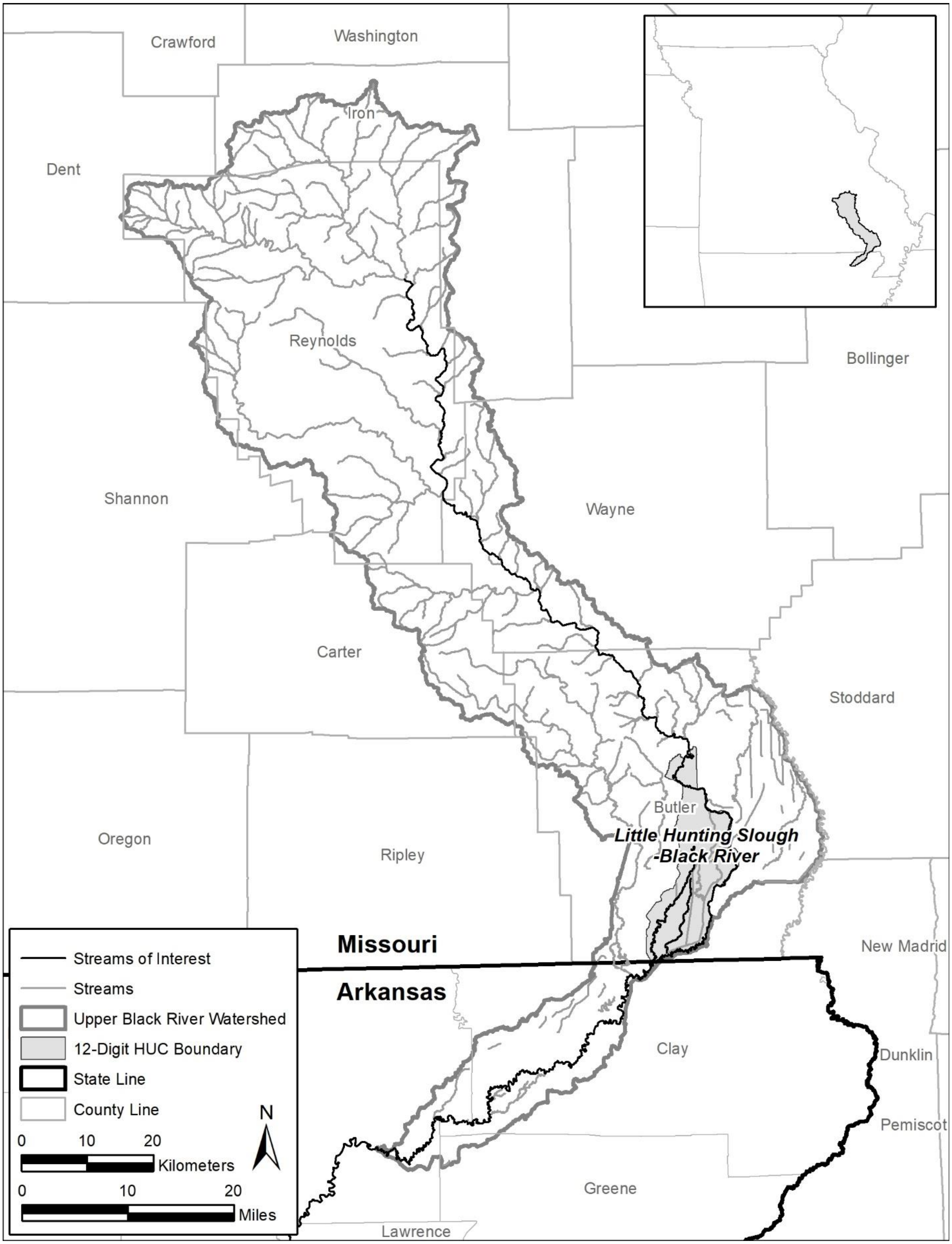

Figure 1. Location of Little Hunting Slough-Black River in the Upper Black River Watershed.

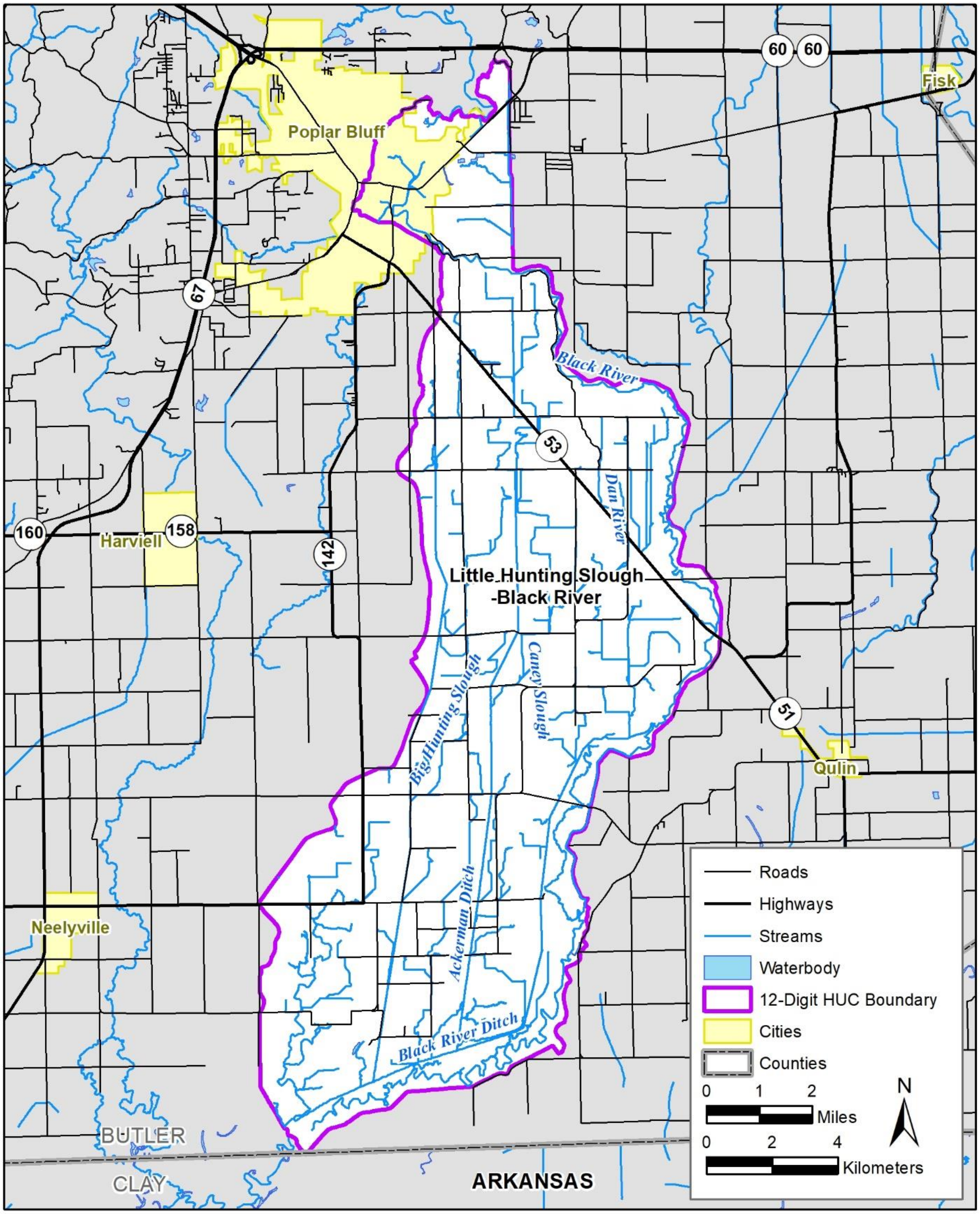

Figure 2. The Little Hunting Slough-Black River watershed.

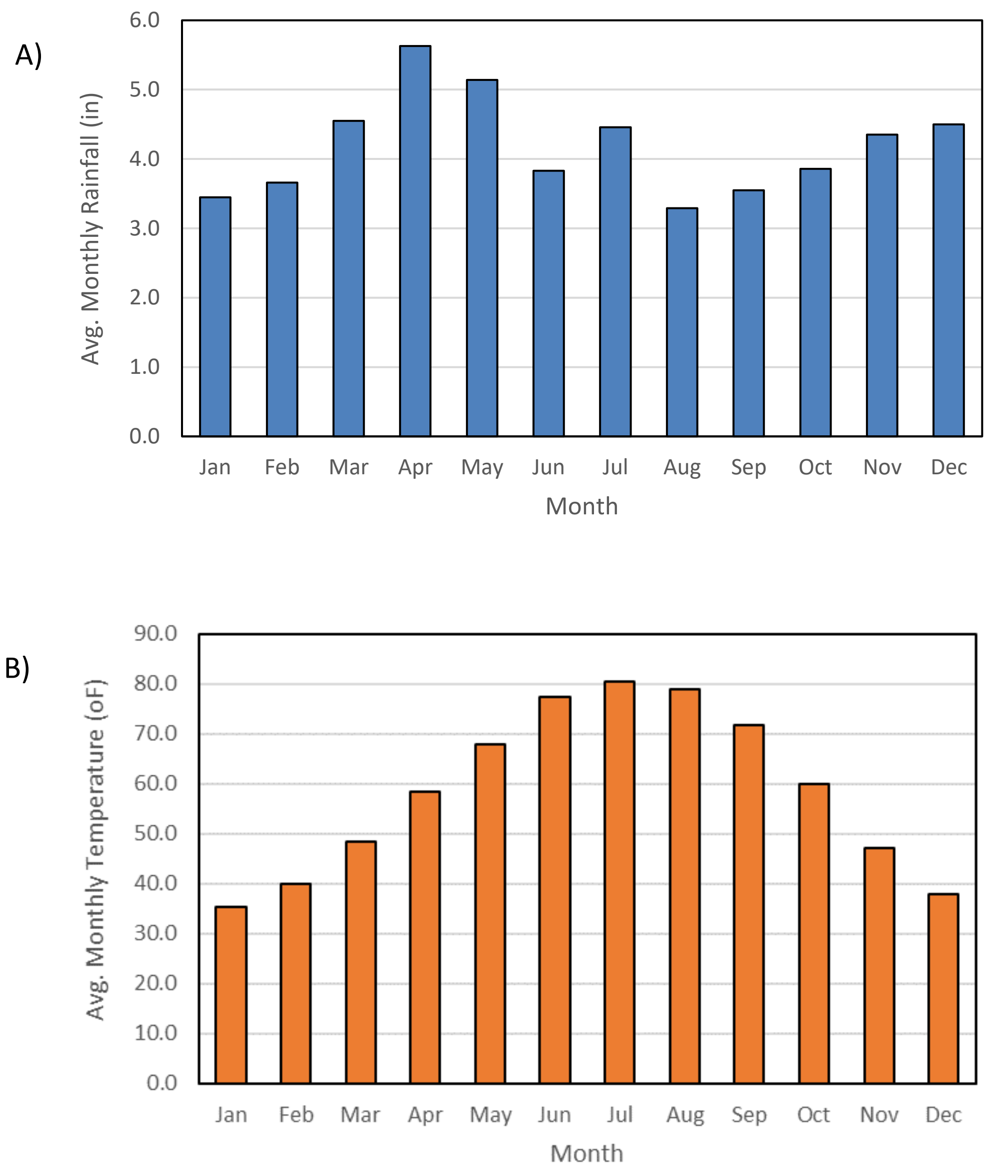

Figure 3. Mean monthly A) rainfall and B) temperature from 1989-2018 for Poplar Bluff, Missouri.

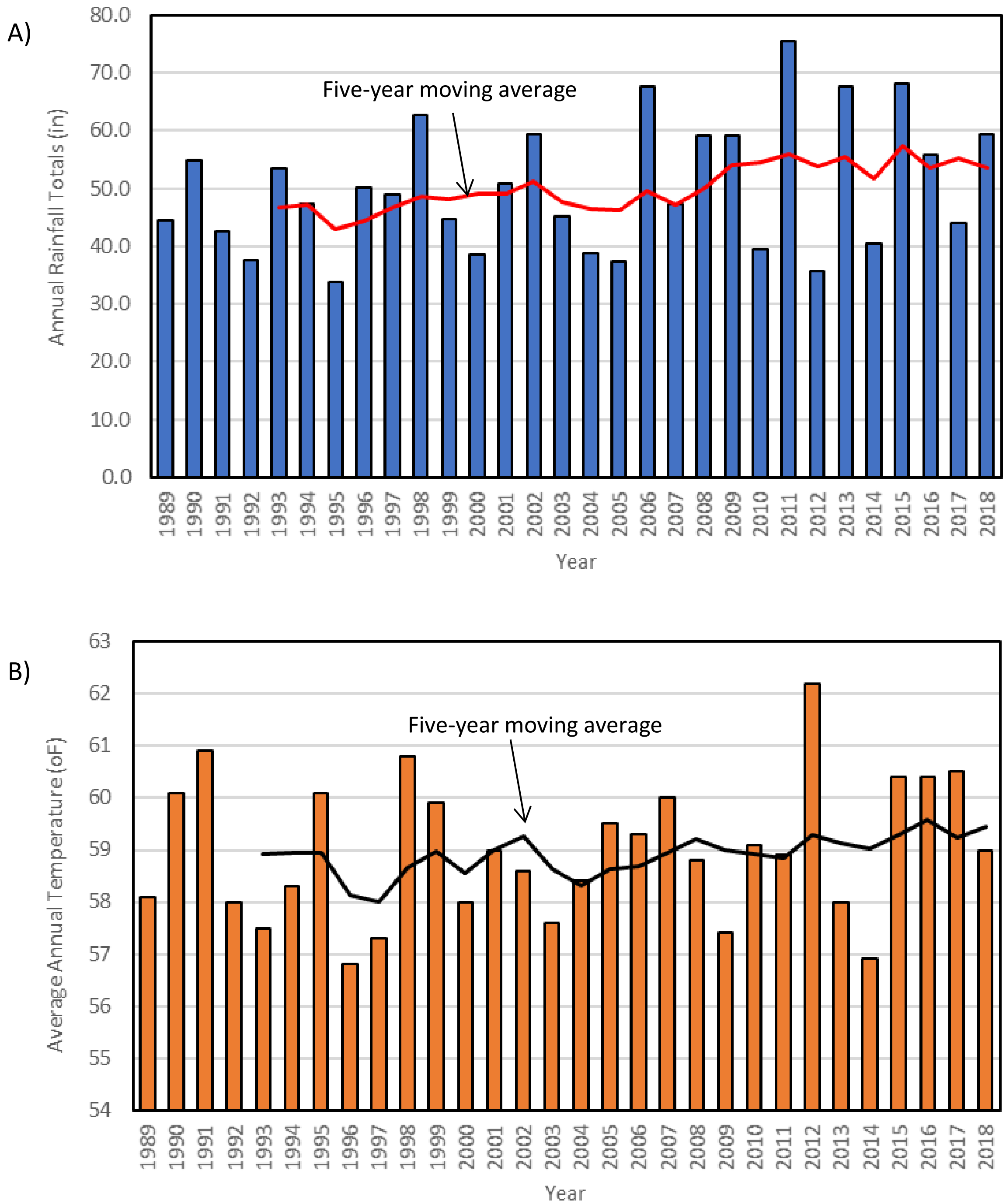

Figure 4. A) Annual total rainfall and B) average annual temperature from 1989-2018 for Poplar Bluff, Missouri.

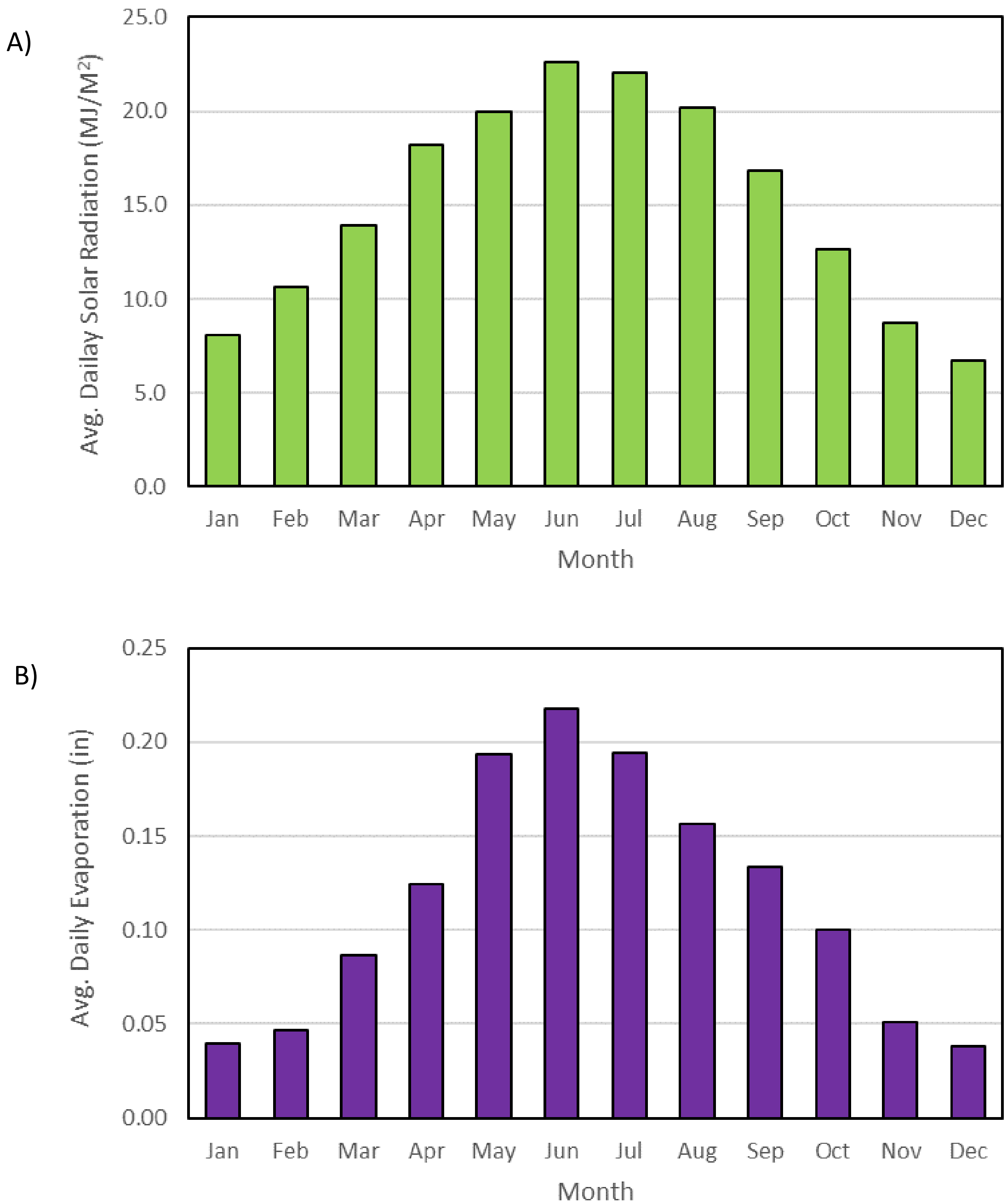

Figure 5. Monthly average daily A) solar radiation (2000-2018) at Glennonville, Missouri and B) estimated evaporation (2017-2018) for Senath, Missouri.

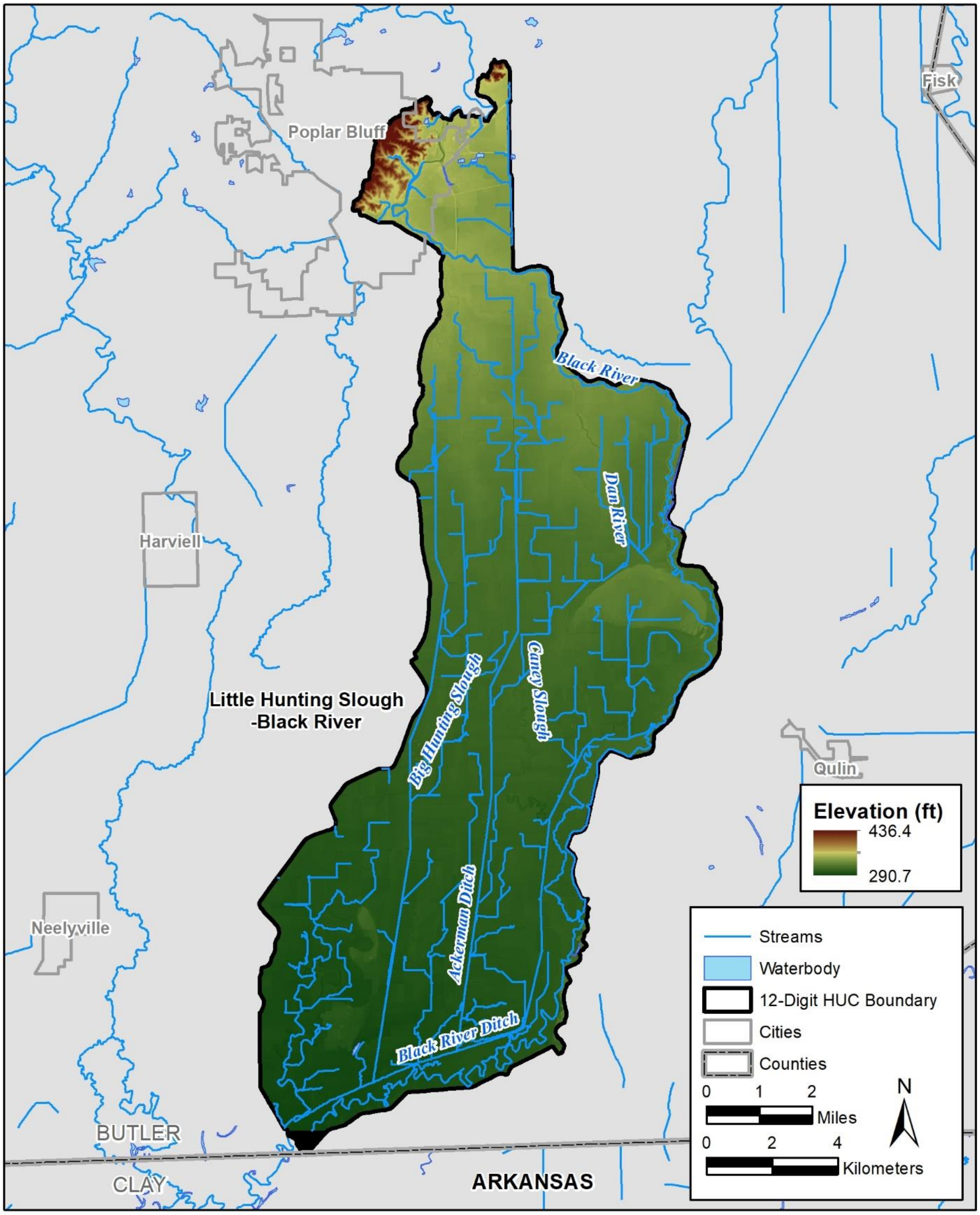

Figure 6. Elevations within the watershed.

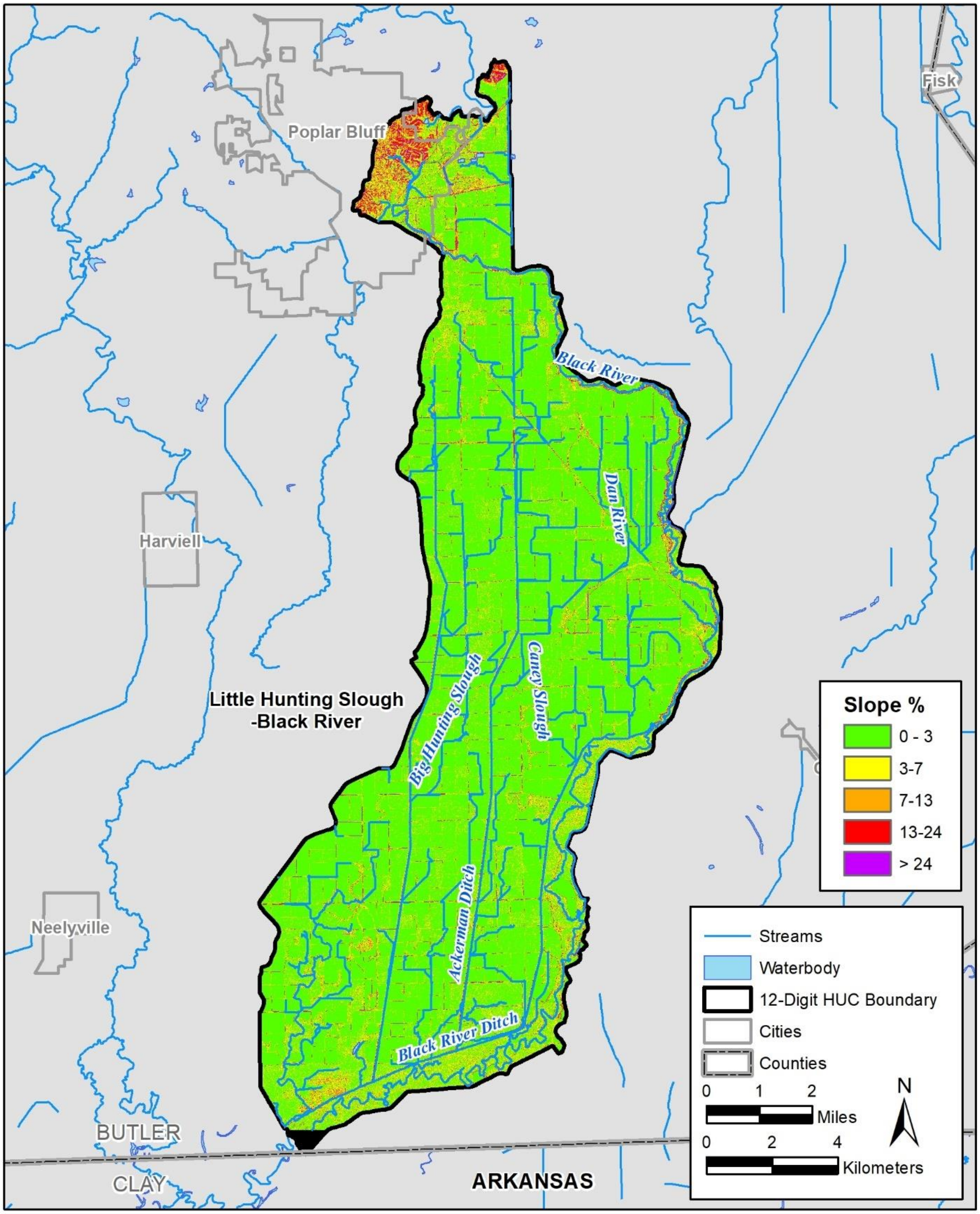

Figure 7. Slope classification across the watershed.

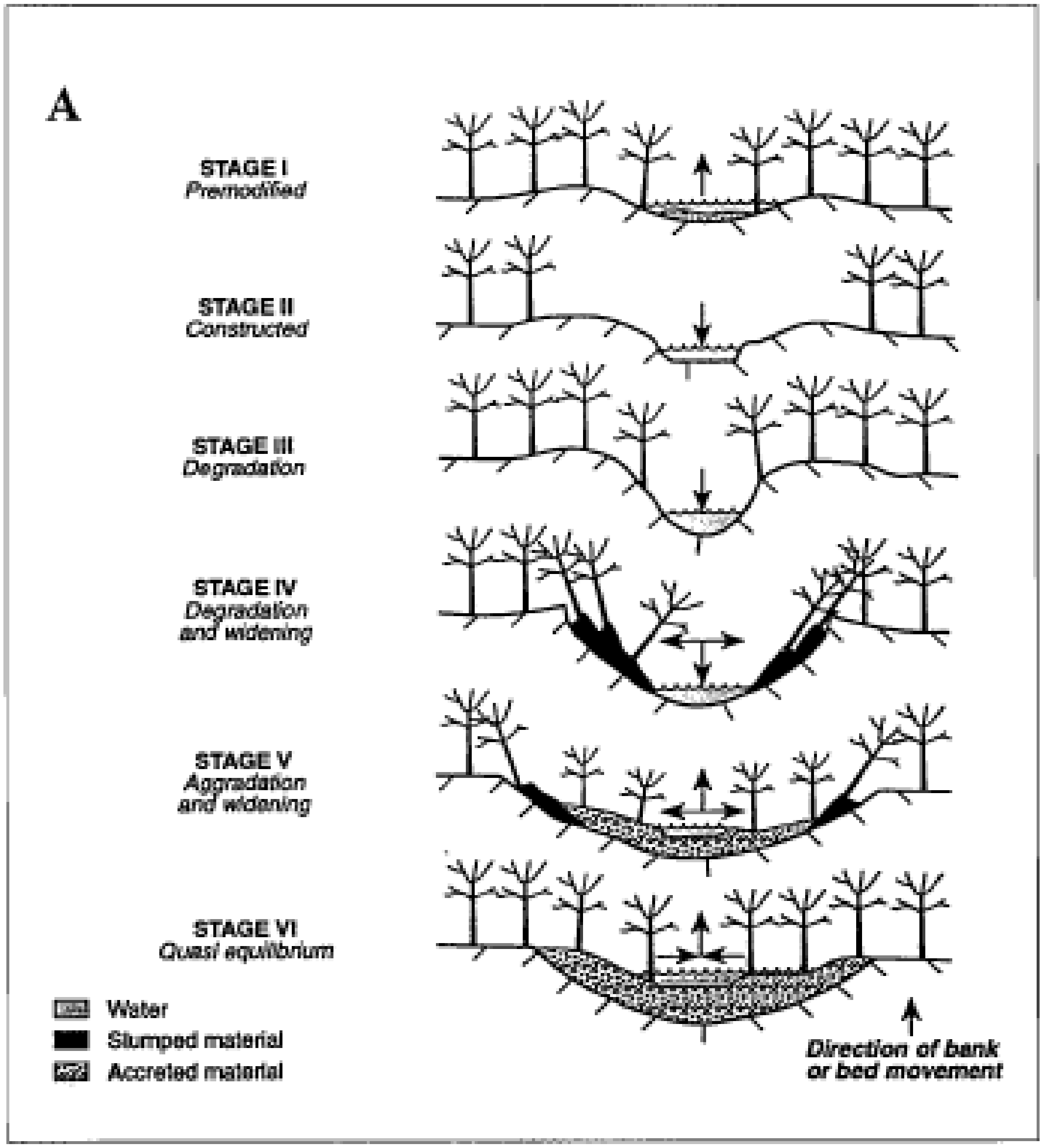

Figure 8. Six Stage Channel Evolution Model for Disturbed Alluvial Channels (Simon and Rinaldi 2000).

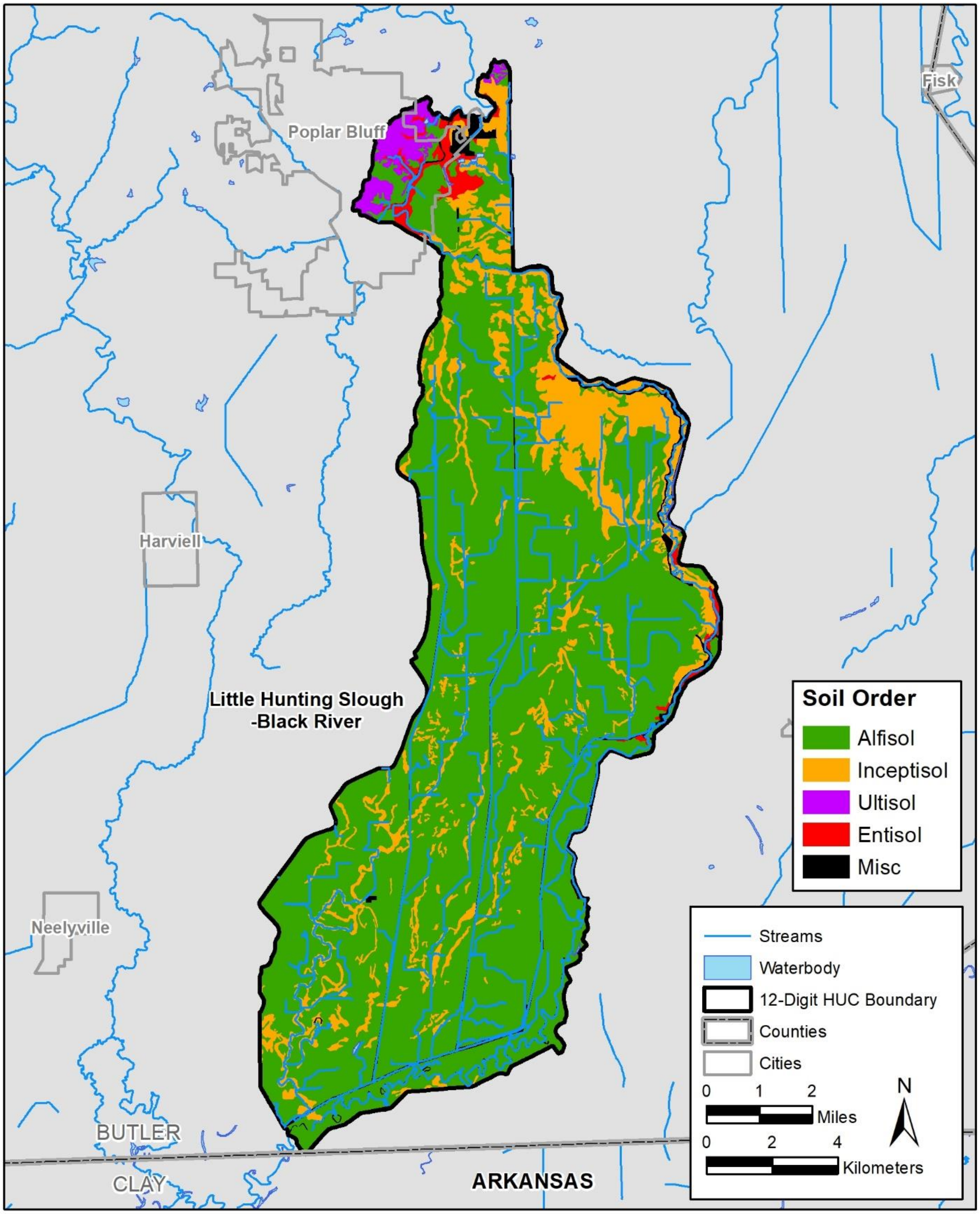

Figure 9. Soil series classified by order.

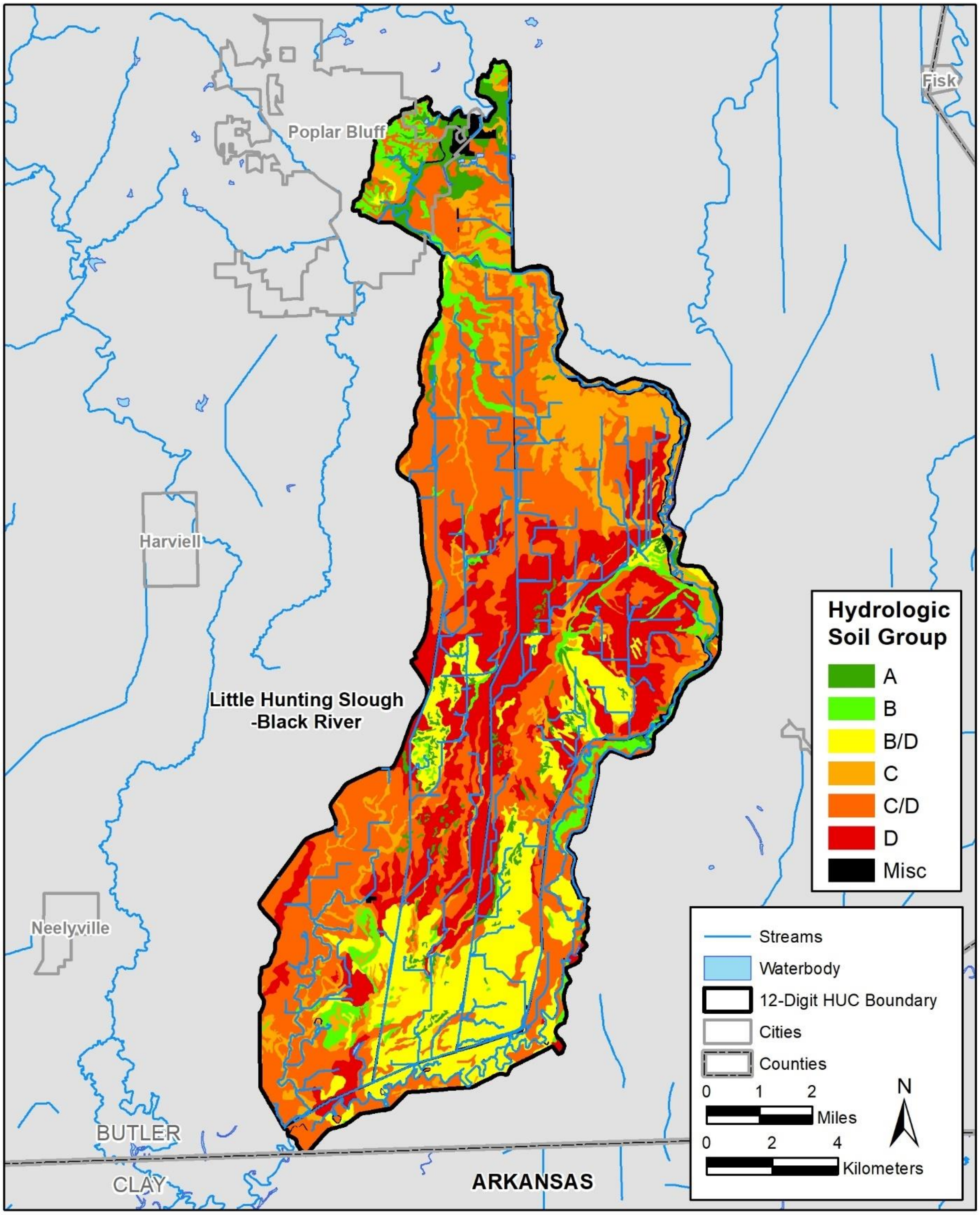

Figure 10. Soil series classified by hydrologic soil group.

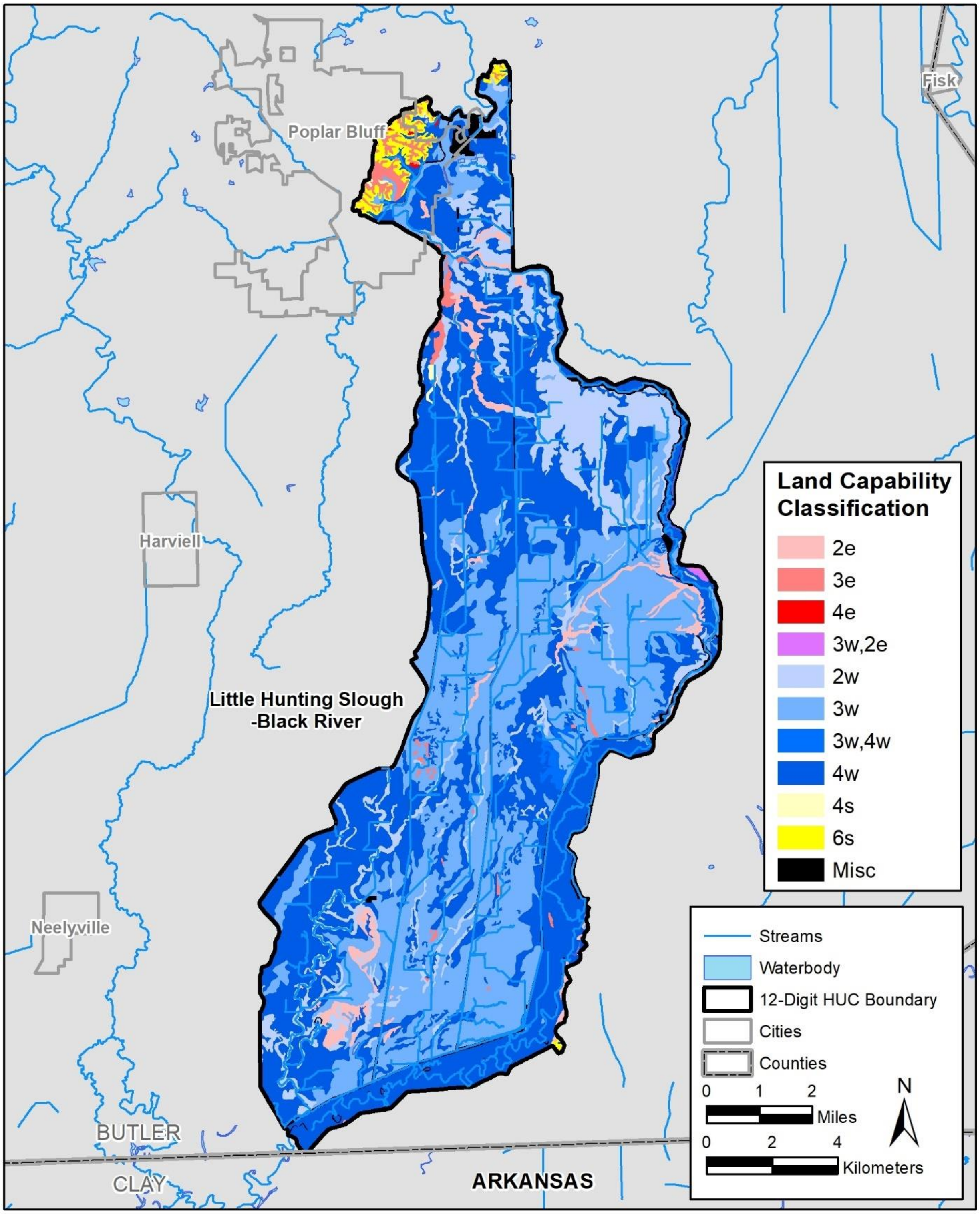

Figure 11. Soil series classified by land capability classification.

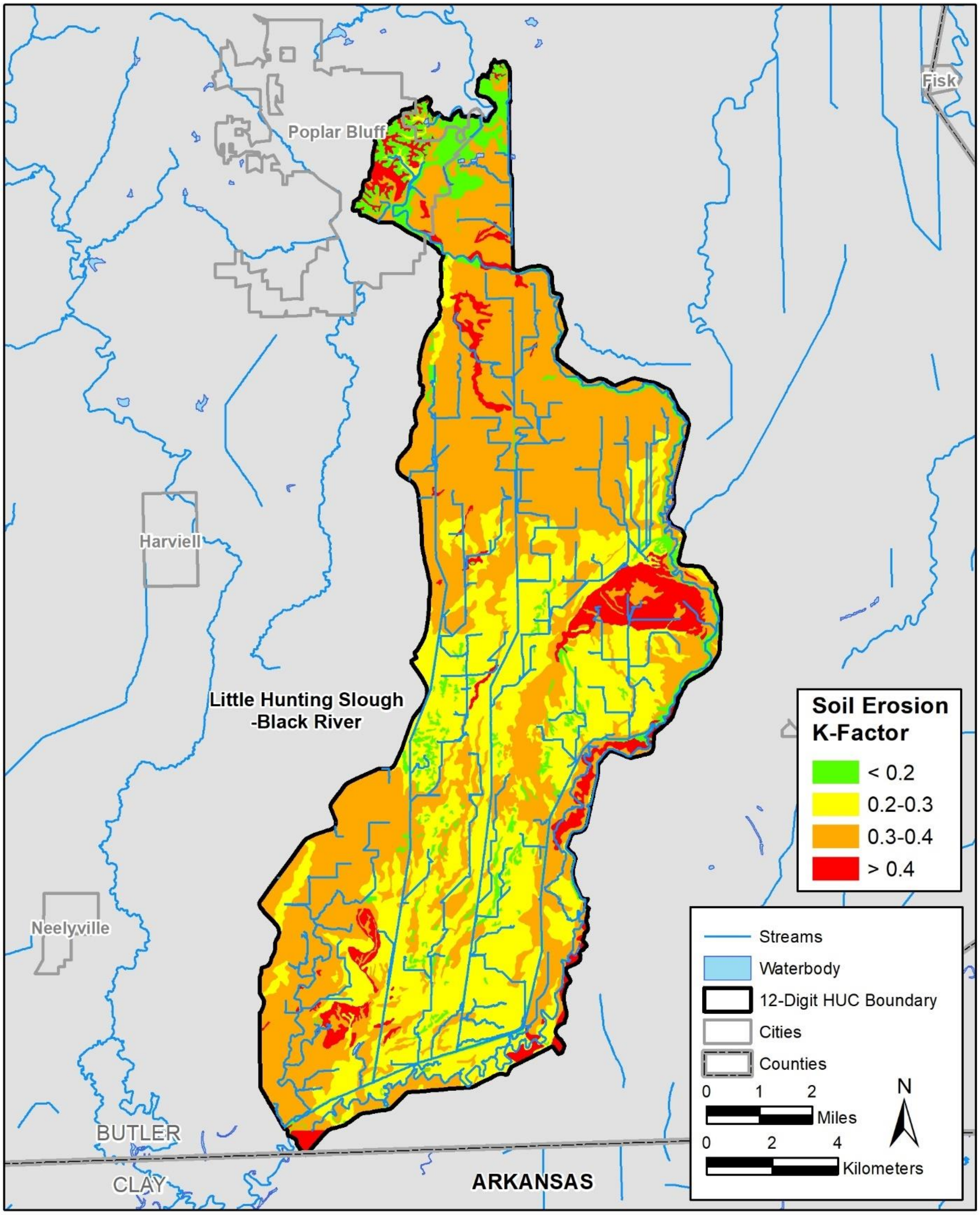

Figure 12. Soil series classified by soil erosion K-factor.

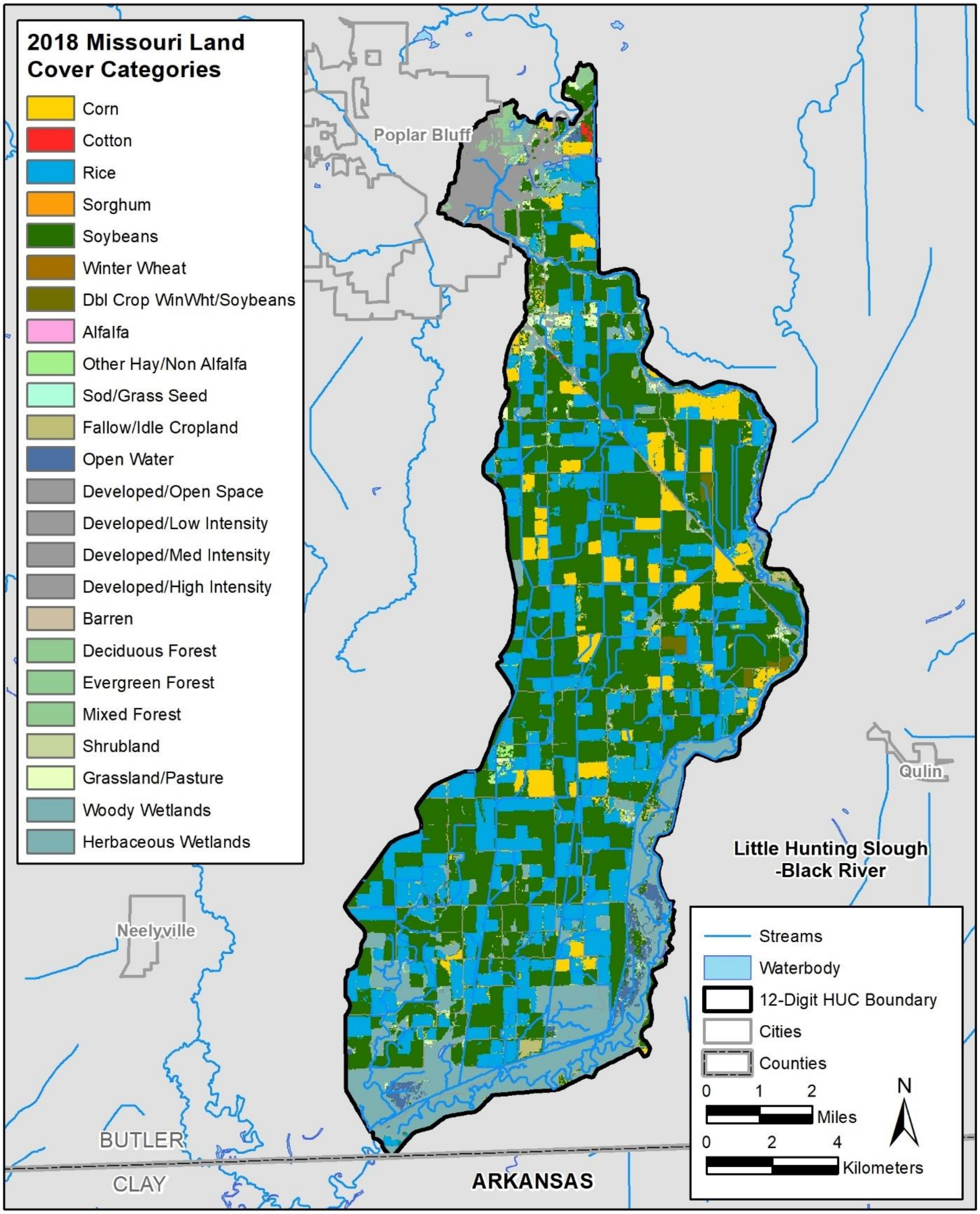

Figure 13. 2018 crop data from the NASS.

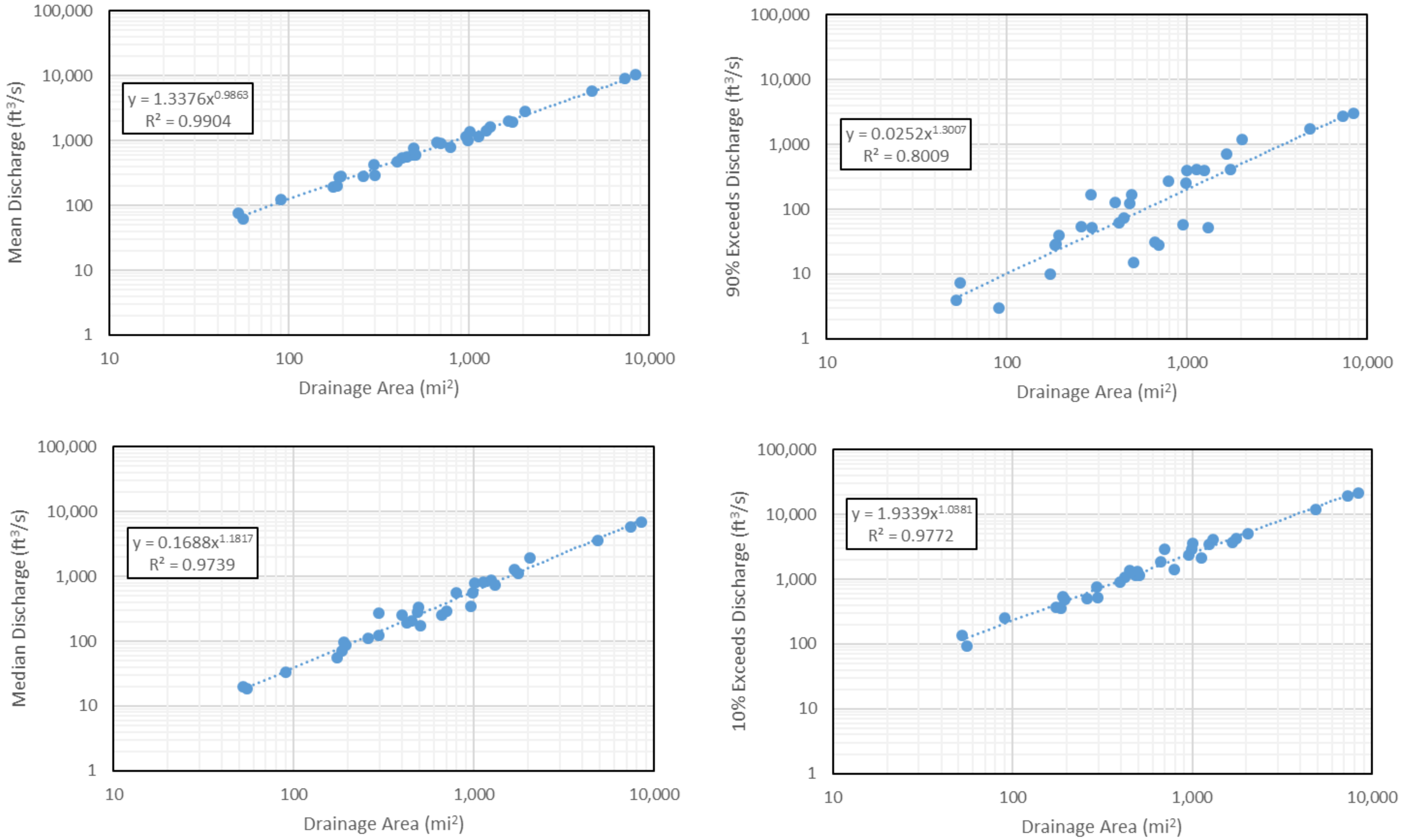

Figure 14. Drainage area and discharge relationships for 31 USGS gaging stations near the study watershed.

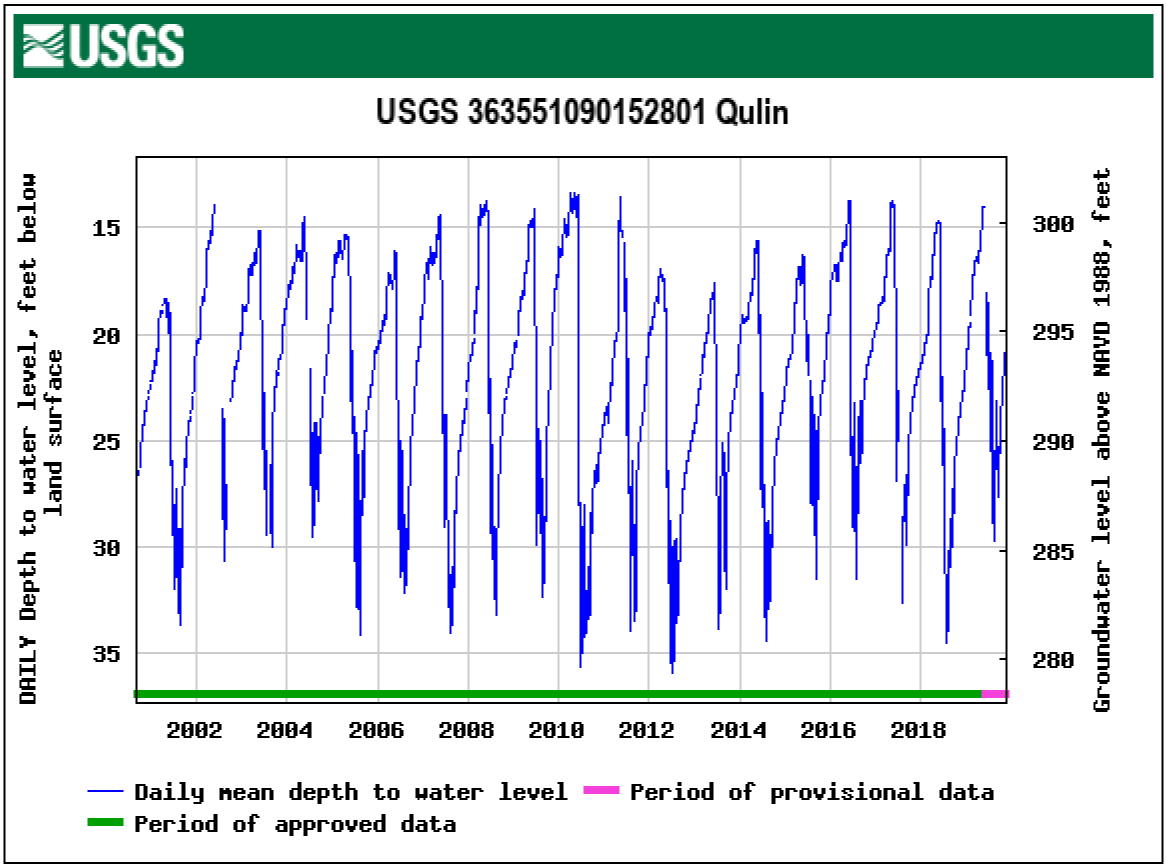

Figure 15. Groundwater level change for Qulin (2000-2019).

https://waterdata.usgs.gov/nwis/dv?cb_72019=on&format=gif_default&site_no=363551090152801&referred_module=sw&period=&begin_date=2000-9-1&end_date=2019-11-20

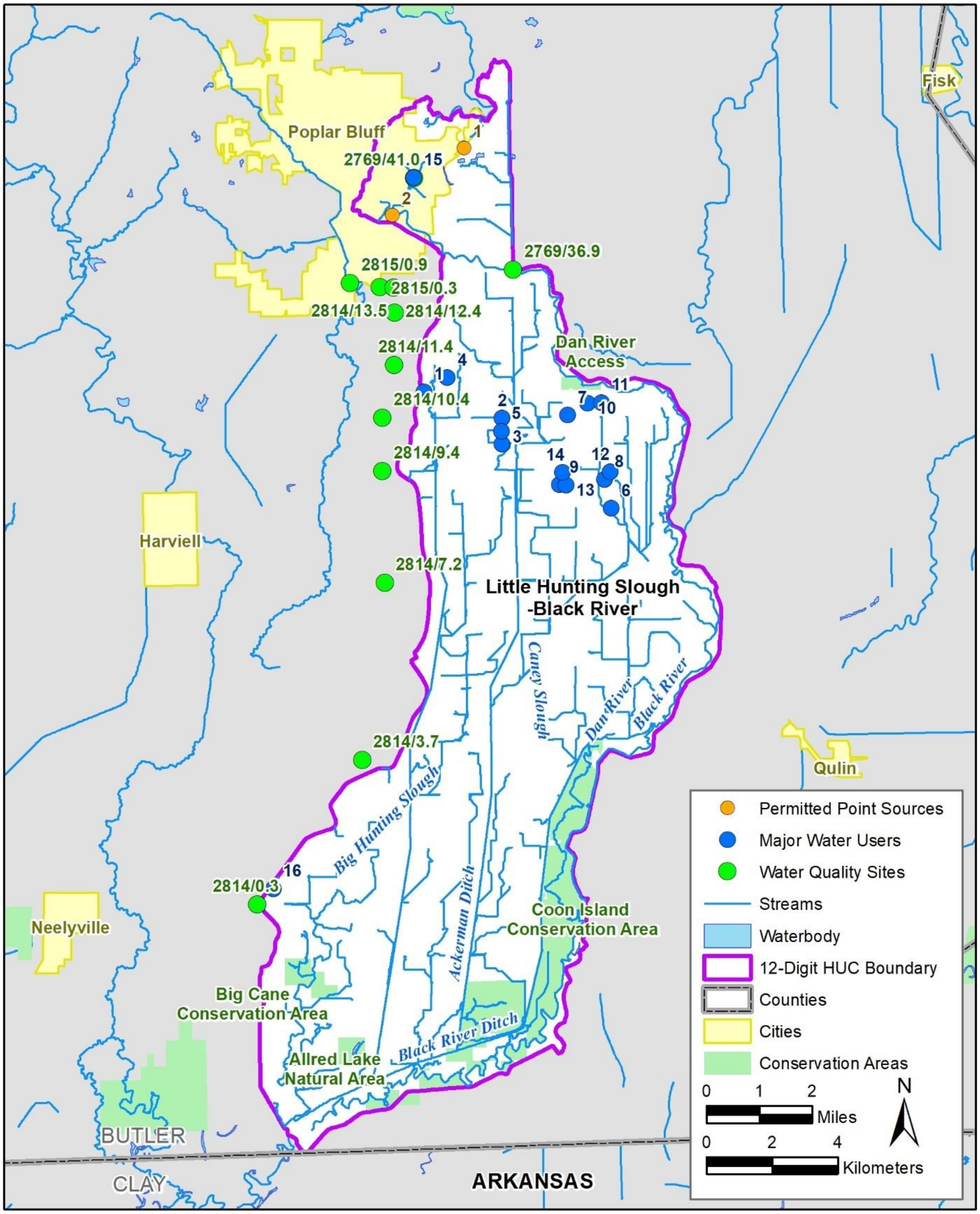

Figure 16. Permitted Point Sources, Water Quality Monitoring Site, and Major Water Users

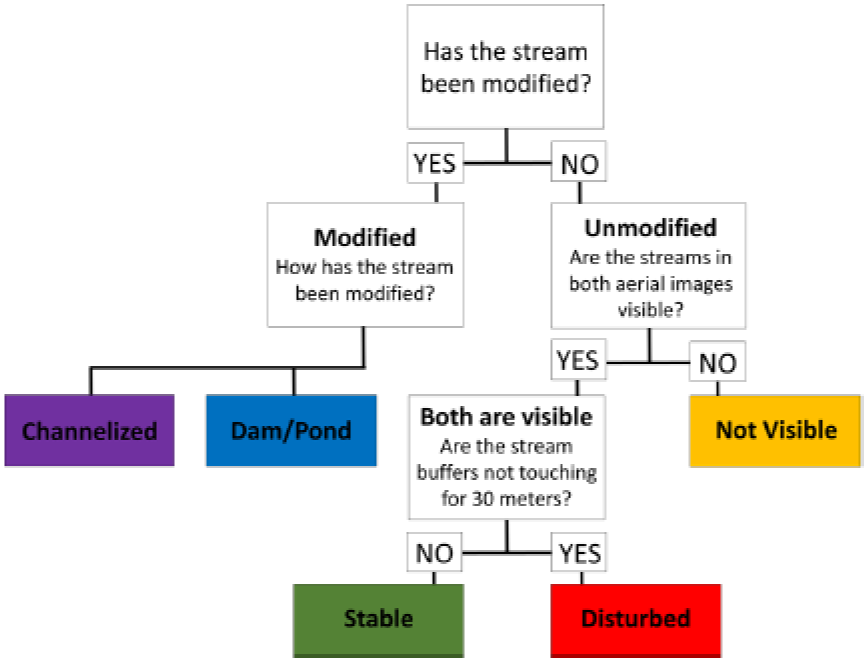

Figure 17. Flow chart showing decision tree for classifying stream channels from aerial photo analysis.

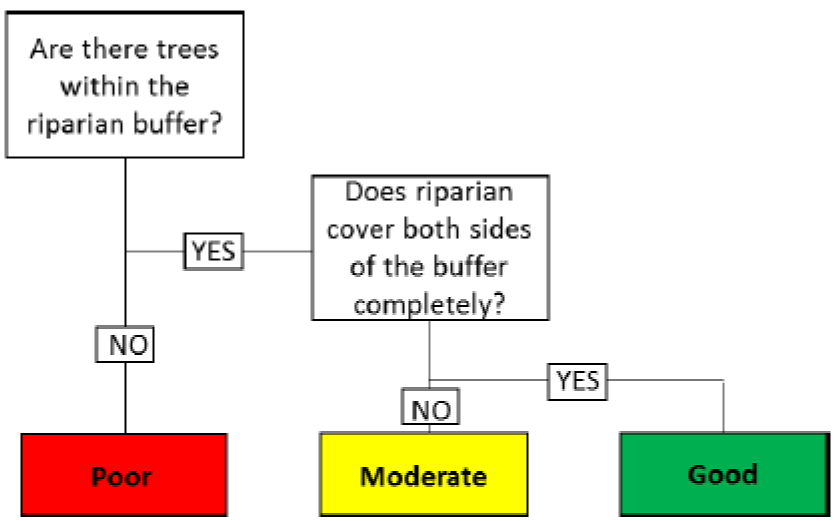

Figure 18. Flow chart showing decision tree for riparian corridor assessment from aerial photo analysis.

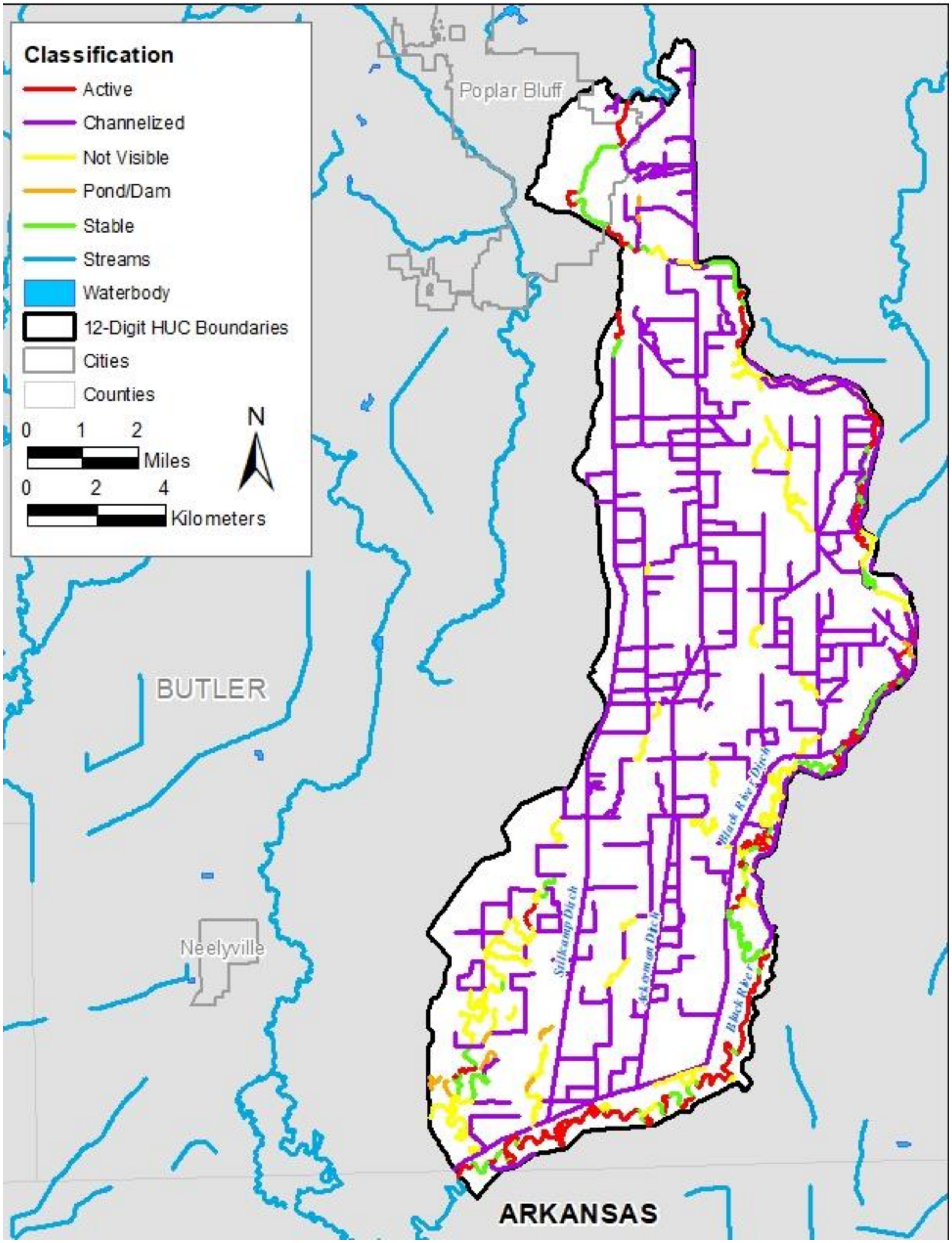

Figure 19. Channel stability classification.

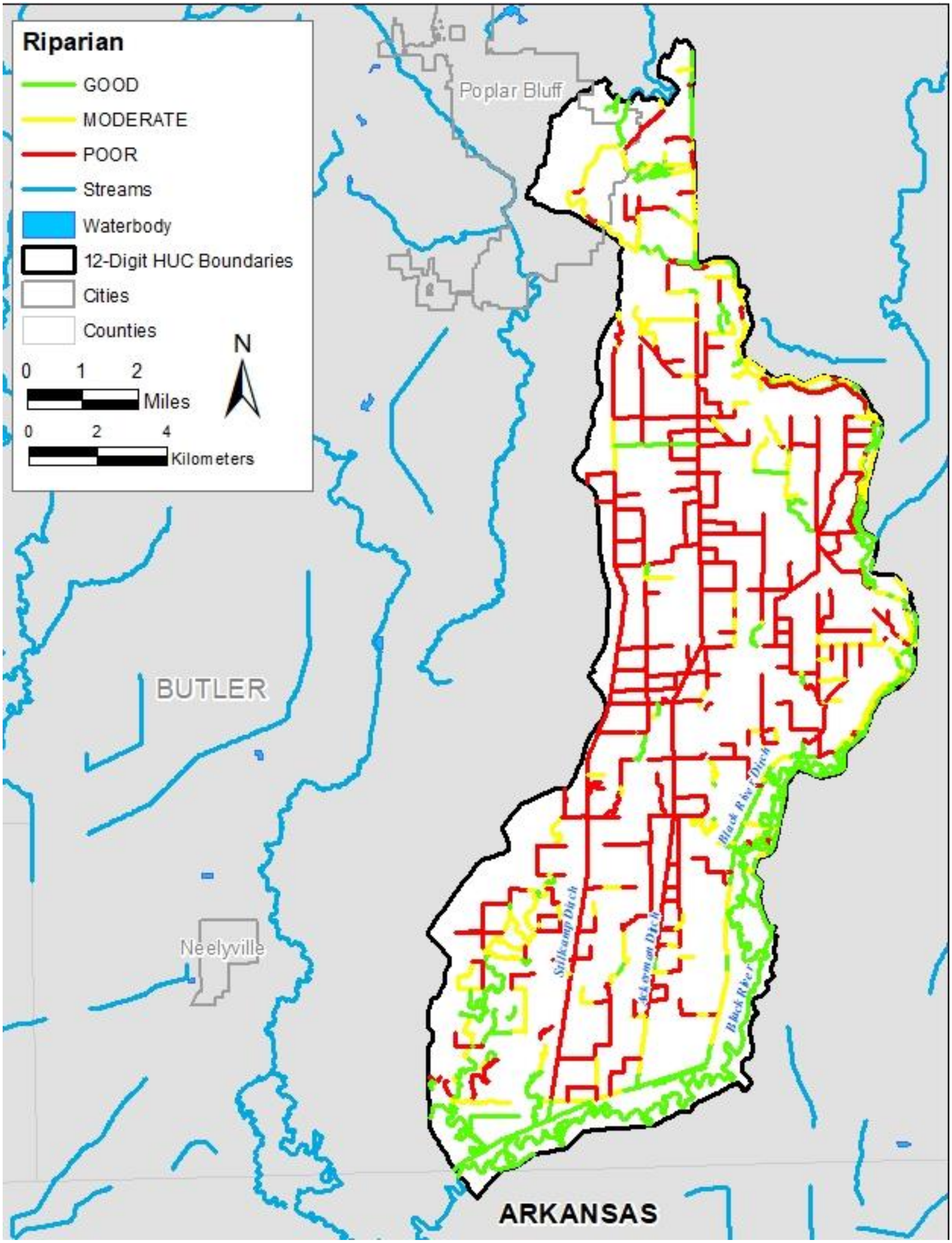

Figure 20. Riparian corridor classification

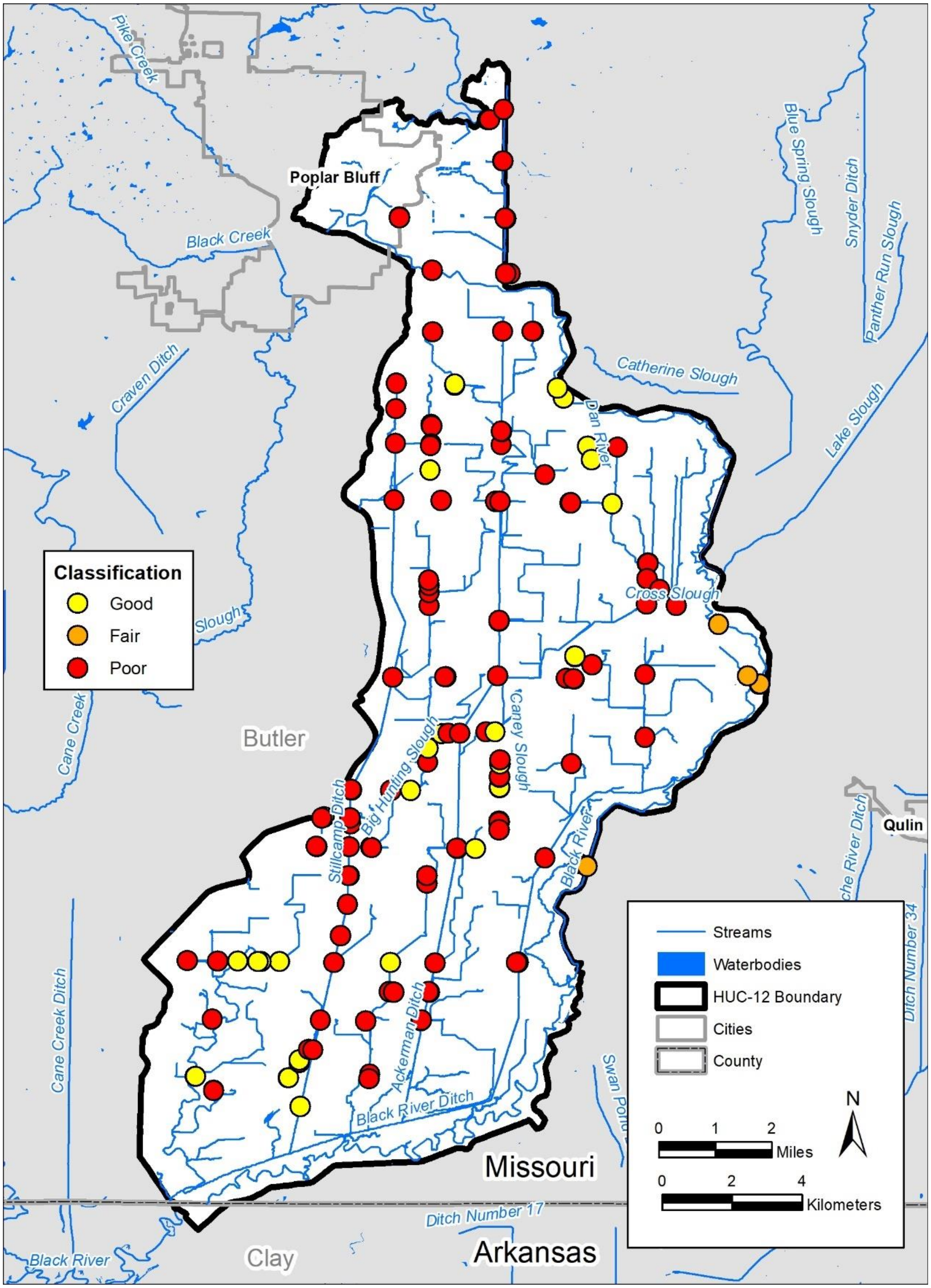

Figure 21. Visual stream assessment results

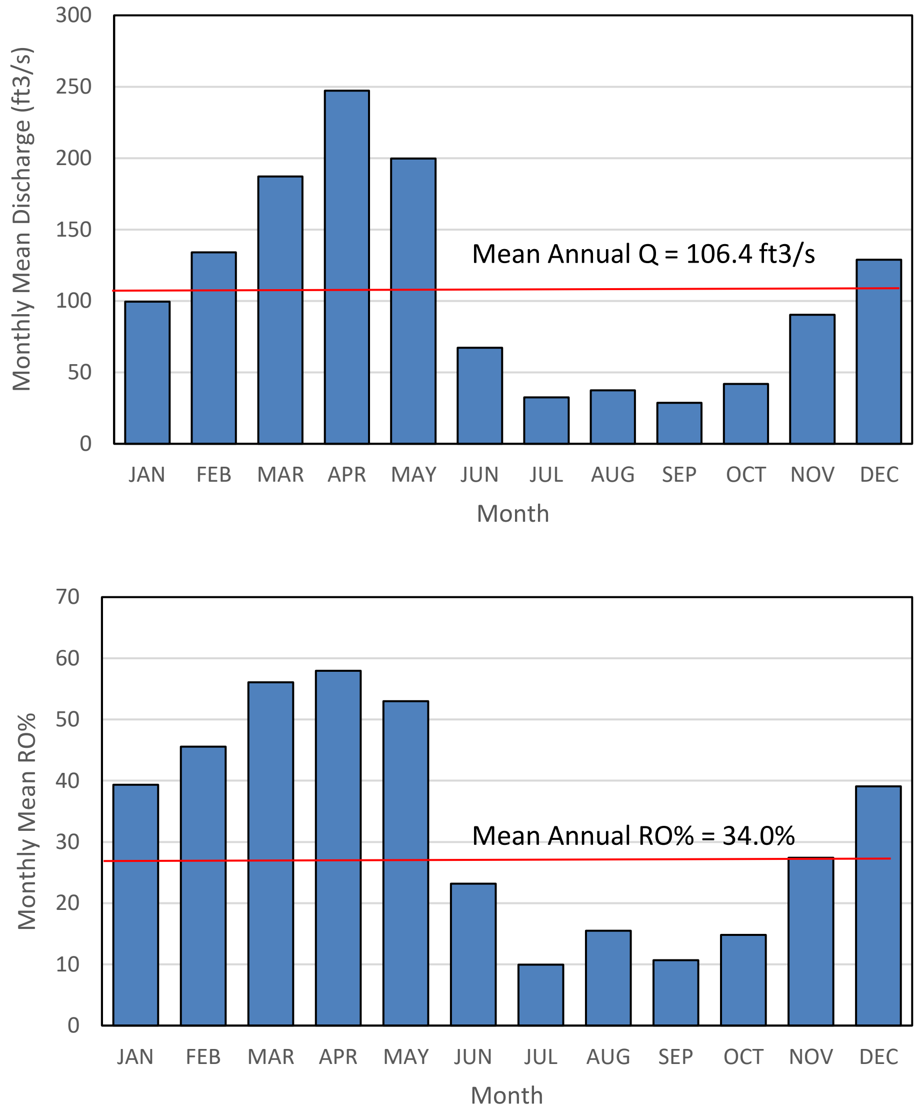

Figure 22. Mean monthly discharge and runoff percentage for the Little Hunting Slough watershed.

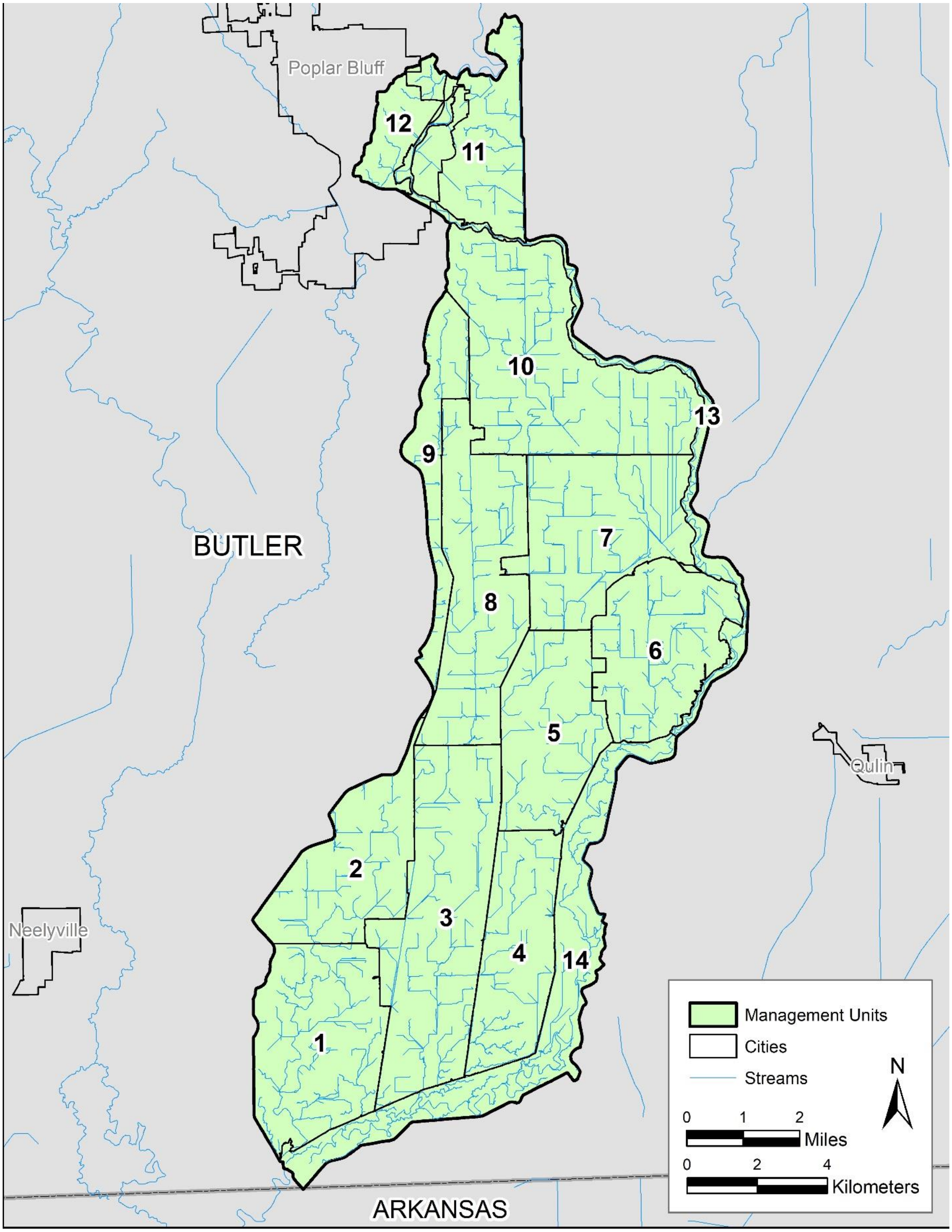

Figure 23. Management units within the watershed.

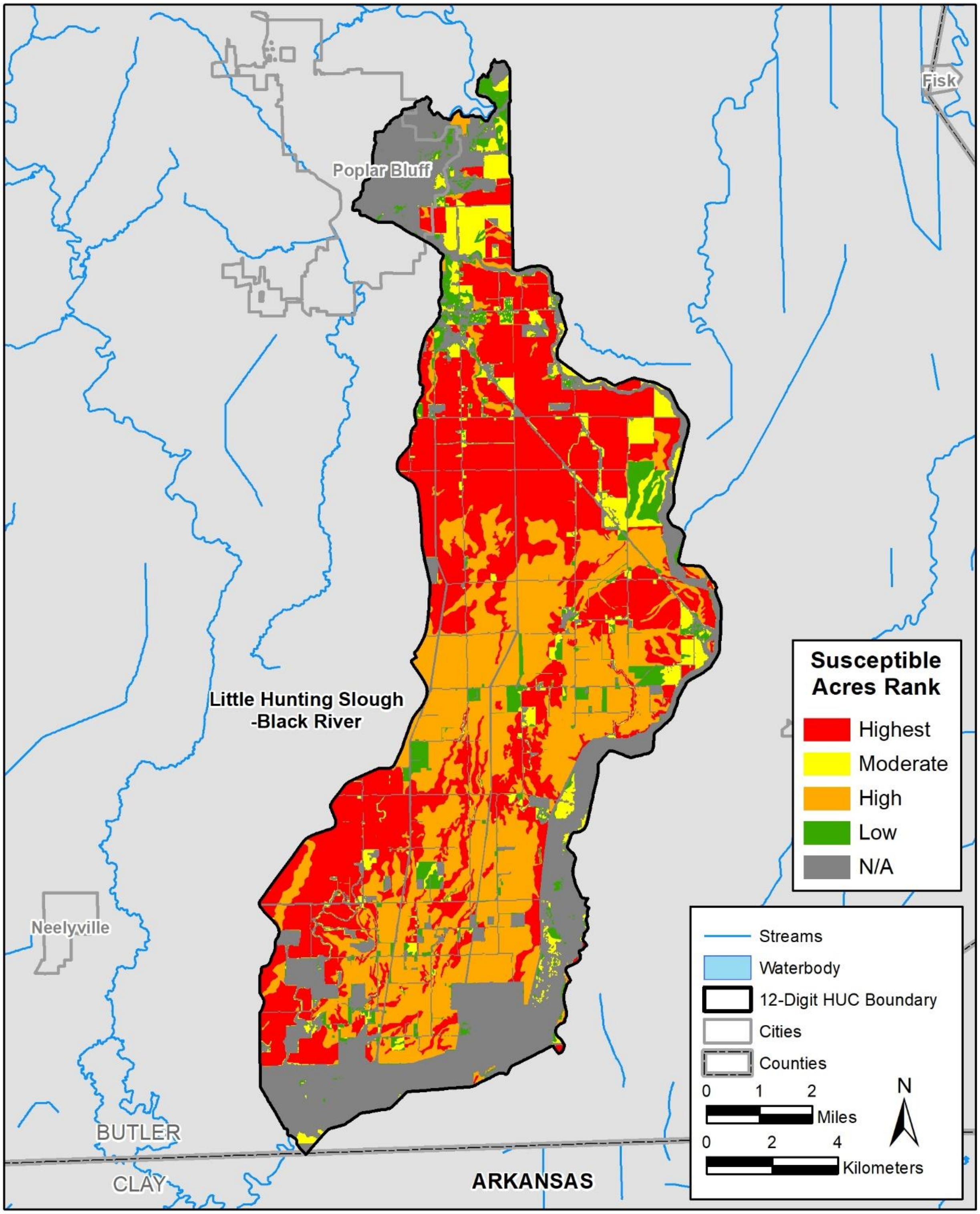

Figure 24. Distribution of susceptible acres classification within the Little Hunting Slough watershed.

APPENDICES

Appendix A. Soil series data and information for within the watershed.

MU#	Acres	% Area	Series Name	Hydrologic Soil Group	Landfrom	K Factor	Order	Land Capability Classification	Slope %	Slope-Length	LS Factor
73014	26	0.0	Clarksville very gravelly silt loam	A	Uplands	0.32	Ultisol	4s	12	98	1.807
73140	554	1.0	Clarksville-Scholten complex	B	Uplands	0.28	Ultisol	6s	25.5	49	4.506
73157	280	0.5	Captina silt loam	C/D	Uplands	0.43	Ultisol	3e	5	157	0.672
73395	17	0.0	Clarksville very gravelly silt loam	B	Uplands	0.28	Ultisol	4e	6	131	0.772
74699	43	0.1	Baylock silt loam	B/D	Stream Terraces	0.32	Alfisol	3w	2	298	0.279
75395	29	0.1	Jamesfin silt loam	B	Floodplains	0.49	Inceptisol	2w	1	200	0.159
75430	725	1.3	Wideman fine sandy loam	A	Floodplains	0.17	Entisol	3w	2	298	0.279
75452	109	0.2	Gladden fine sandy loam	A	Floodplains	0.17	Inceptisol	3w	2	98	0.200
76036	103	0.2	Midco very gravelly loam	A	Floodplains	0.24	Entisol	4w	2	298	0.279
82011	837	1.5	Overcup silt loam	D	Stream Terraces	0.43	Alfisol	3w	0.2	246	0.095
82033	405	0.7	Dubbs silt loam	B	Stream Terraces	0.49	Alfisol	2e	3	150	0.349
82044	37	0.1	Foley silt loam	D	Stream Terraces	0.64	Alfisol	4w	0.5	150	0.103
82049	25	0.0	Lafe silt loam	D	Stream Terraces	0.55	Alfisol	6s	0.5	298	0.119
82060	68	0.1	Calhoun silt loam	C/D	Stream Terraces	0.43	Alfisol	3w	0.5	242	0.114
82062	43	0.1	Wiville fine sand	A	Stream Terraces	0.05	Inceptisol	4s	0.2	200	0.091
82065	30	0.1	Bulltown fine sand	B	Stream Terraces	0.02	Alfisol	3e	2	147	0.225
82067	56	0.1	Wiville fine sandy loam	B	Stream Terraces	0.28	Alfisol	3e	2	196	0.246
82068	43	0.1	Wiville loamy fine sand	B	Stream Terraces	0.2	Alfisol	3e	5	147	0.650
82069	12	0.0	Patterson loamy fine sand	B/D	Stream Terraces	0.24	Alfisol	2w	2	147	0.225
82070	38	0.1	Bulltown fine sand	B	Stream Terraces	0.02	Alfisol	3e	2	147	0.225
82071	1,122	2.1	Dubbs silt loam	B	Stream Terraces	0.49	Alfisol	2e	3	150	0.349
82072	2	0.0	Patterson loamy fine sand	B/D	Stream Terraces	0.24	Alfisol	2w	2	147	0.225
82074	9	0.0	Foley silt loam	D	Stream Terraces	0.64	Alfisol	3w	0.5	150	0.103
82075	61	0.1	Overcup silt loam	D	Stream Terraces	0.49	Alfisol	3w	0.2	246	0.095
82096	181	0.3	Baldwin silty clay loam	C/D	Stream Terraces	0.37	Alfisol	3w	0.5	121	0.099
82097	190	0.4	Wiville fine sandy loam	B	Stream Terraces	0.28	Alfisol	3e	2	196	0.246

MU#	Acres	% Area	Series Name	Hydrologic Soil Group	Landfrom	K Factor	Order	Land Capability Classification	Slope %	Slope-Length	LS Factor
86000	20	0.0	Dubbs silt loam	B	Floodplains	0.49	Alfisol	2w	2	150	0.227
86001	8,210	15.2	Calhoun silt loam	C/D	Floodplains	0.37	Alfisol	4w	0.2	242	0.095
86003	9,877	18.3	Amagon silt loam	C/D	Floodplains	0.37	Alfisol	4w	0.5	200	0.110
86006	6,727	12.4	Adler silt loam	C	Floodplains	0.37	Inceptisol	2w	0.5	144	0.103
86036	9,717	18.0	Kobel clay	D	Floodplains	0.28	Alfisol	3w	0.5	413	0.127
86068	6,478	12.0	Tuckerman fine sandy loam	B/D	Floodplains	0.24	Alfisol	3w	0.5	246	0.114
86070	33	0.1	Tuckerman, occasionally flooded-Wiville fine sandy loams	B/D	Floodplains	0.24	Alfisol	3w,2e	1.25	221	0.185
86082	571	1.1	Adler silt loam	C	Floodplains	0.37	Inceptisol	4w	0.5	144	0.103
86086	93	0.2	Calhoun silt loam	C/D	Floodplains	0.43	Alfisol	4w	0.5	242	0.114
86095	339	0.6	Dubbs silt loam	B	Floodplains	0.49	Alfisol	4w	0.5	150	0.103
86110	288	0.5	Tuckerman-Wiville complex	B/D	Floodplains	0.24	Alfisol	3w,4w	0.35	200	0.100
86112	1,711	3.2	Amagon silt loam	C/D	Floodplains	0.37	Alfisol	4w	0.5	200	0.110
86113	1,020	1.9	Wiville fine sand	A	Floodplains	0.05	Inceptisol	4w	0.2	200	0.091
86114	1,265	2.3	Tuckerman fine sandy loam	B/D	Floodplains	0.24	Alfisol	4w	0.5	246	0.114
86116	90	0.2	Kobel clay	D	Floodplains	0.28	Alfisol	4w	0.5	413	0.127
90007	182	0.3	Loring silt loam	C	Uplands	0.49	Alfisol	3e	5	147	0.650
90010	8	0.0	Loring silt loam	C	Uplands	0.49	Alfisol	4e	11	108	1.658
99001	453	0.8	Water	NA	NA	NA	NA	NA	NA	NA	NA
99002	37	0.1	Borrow areas	NA	NA	NA	NA	NA	NA	NA	NA
99037	161	0.3	Urban land-Udorthents complex	NA	NA	NA	NA	NA	NA	NA	NA
99038	1,671	3.1	Levees-Borrow pits complex	NA	NA	NA	NA	NA	NA	NA	NA
11	116	0.2	Amagon soils	C/D	Floodplains	0.43	Alfisol	4w	0.5	246	0.114
39	2	0.0	Water	NA	NA	NA	NA	NA	NA	NA	NA

Appendix B. USGS gaging stations near the watershed.

USGS Gage ID	Station Name	Start Year	Years of Record	Drainage Area (mi2)	Elevation (ft)	90%	50%	10%	Max	Mean
7017200	BIG RIVER AT IRONDALE, MO	1965	54	175	753.28	10.0	55.1	370.4	49,100	191.3
7021000	CASTOR RIVER AT ZALMA, MO	1920	89	423	350.49	62.0	191	1,070	114,000	538.7
7064000	BLACK RIVER NEAR CORNING, AR	1938	78	1,750	272.90	412.9	1,100	4,270	40,700	1,934
7062500	BLACK RIVER AT LEEPER, MO	1921	89	987	430.56	252	557	2,912	40,900	1,019
7061500	BLACK RIVER NEAR ANNAPOLIS, MO	1939	79	484	569.72	123	280	1,150	109,000	606.6
7037500	ST. FRANCIS RIVER NEAR PATTERSON, MO	1921	97	956	370.45	57.0	350	2,370	155,000	1,162
7035800	ST. FRANCIS RIVER NEAR MILL CREEK, MO	1987	30	505	556.27	15.0	173	1,148	130,000	597.7
7036100	ST. FRANCIS RIVER NEAR SACO, MO	1983	28	664	472.00	31.2	256	1,830	161,000	923.7
7039500	ST. FRANCIS RIVER AT WAPPAPELLO, MO	1940	79	1,311	314.56	52.2	730	4,100	28,100	1,629
7043500	LITTLE RIVER DITCH 1 NEAR MOREHOUSE, MO	1945	70	450	280.76	73.2	208	1,350	12,200	558
7077380	CACHE RIVER AT EGYPT, AR	1964	55	701	222.99	28.0	292	2,930	8,940	892.4
7035000	LITTLE ST. FRANCIS RIVER AT FREDERICKTOWN, MO	1939	31	91	678.58	3.0	33.0	250.7	25,100	124.2
7061270	EAST FORK BLACK RIVER NEAR LESTERVILLE, MO	2001	17	52	825.26	3.9	20.1	134	16,400	76.0
7020550	SOUTH FORK SALINE CREEK NEAR PERRYVILLE, MO	1998	18	55	444.97	7.4	18.8	94.0	18,700	62.3
7063000	BLACK RIVER AT POPLAR BLUFF, MO	1936	81	1,245	317.48	401	864	3,460	65,600	1,417
7061600	BLACK RIVER BELOW ANNAPOLIS, MO	2006	12	493	555.31	170	333	1,310	71,200	755.6
7074420	BLACK RIVER AT ELGIN FERRY, AR	1978	40	8,420	200.00	3,030	6,905	21,700	212,000	10,530
7069000	BLACK RIVER AT POCAHONTAS, AR	1936	52	4,840	241.81	1,730	3,610	12,100	105,000	5,835
7072500	BLACK RIVER AT BLACK ROCK, AR	1929	81	7,370	229.56	2,740	5,840	19,000	190,000	8,978
7065495	JACKS FORK AT ALLEY SPRING, MO	1993	25	298	656.74	52.2	124	513.8	94,200	287.1
7065200	JACKS FORK NEAR MOUNTAIN VIEW, MO	2001	18	185	836.06	27.8	71.2	356	43,700	202.4
7068000	CURRENT RIVER AT DONIPHAN, MO	1918	100	2,038	321.42	1,200	1,950	4,960	183,000	2,839
7064533	CURRENT RIVER ABOVE AKERS, MO	2001	18	295	NA	167	273	758.2	38,800	431.1
7066000	JACKS FORK AT EMINENCE, MO	1921	97	398	615.87	128	251	900.0	106,000	474.1
7067000	CURRENT RIVER AT VAN BUREN, MO	1912	106	1,667	443.01	710	1,270	3,730	179,000	2,012
7068510	LITTLE BLACK RIVER BELOW FAIRDEALING, MO	1980	17	194	293.96	39.8	87.1	490	54,200	278.6
7072000	ELEVEN POINT RIVER NEAR RAVENDEN SPRINGS, AR	1929	81	1,130	291.98	414	828	2,100	162,000	1,170
7071500	ELEVEN POINT RIVER NEAR BARDLEY, MO	1921	97	793	411.25	272	566	1,410	122,000	790.7
7014000	HUZZAH CREEK NEAR STEELVILLE, MO	2007	11	259	665.04	54.4	111	500	33,300	282.2
7062575	BLACK RIVER ABOVE WILLIAMSVILLE, MO	2008	10	1,007	406.69	396	787	3,590	48,400	1,362
7037300	BIG CREEK AT SAM A. BAKER STATE PARK	2005	13	189	406.18	28.7	95.2	535	42,100	275.5

Appendix C. Score sheet for visual stream survey

Channel Condition:

Natural; no structures, dikes. No evidence of down-cutting or excessive lateral cutting	Evidence of past channel alteration, but with significant recovery of channel and banks. Any dikes or levies are set back to provide access to an adequate flood plain.	Altered channel; <50% of the reach with riprap and/or channelization. Excess aggradation; braided channel. Dikes or levees restrict flood plain width.	Channel is actively downcutting or widening. >50% of the reach with riprap or channelization. Dikes or levees prevent access to the flood plain.
10	7	3	1

Hydrologic Alteration:

Flooding every 1.5 to 2 years. No Dams, No dikes or other structures limiting streams access to the flood plain. Channel is not incised.	Flooding occurs only once every 3 to 5 years; limited channel incision.	Flooding occurs only once every 6 to 10 years: channel deeply incised.	No flooding; channel deeply incised or structures prevent access to flood plain or dam operations prevent flood flows. Flooding occurs on a 1-year rain event or less.
10	7	3	1

Riparian Zone:

Natural Vegetation extends at least two active channel widths on each side.	Natural vegetation extends one active width both sides. Or If less than one width covers entire flood plain.	Natural vegetation extends half of the active channel width on each side.	Natural vegetation extends a third of the active channel width on each side. OR, filtering function moderately compromised.	Natural Vegetation less than 1/3 of active channel width on each side. OR, Lack of regeneration OR, Filtering severely function compromised.
10	8	5	3	1

Bank Stability:

Banks are stable; banks are low (at elevation of flood plain); 33% or more of eroding surface area of banks in outside bends id protected by roots that extend to the base-flow elevation.	Moderately stable; banks are low, less than 33% of eroding surface	Moderately unstable; banks may be low but typically high; outside bends are actively eroding (overhanging vegetation at top of bank, some mature trees falling into stream annually, some slope failures apparent.	Unstable; banks may be low, but typically are high; some straight reaches and inside edges of bends are actively eroding as well as outside bends (overhanging vegetation at top of bare bank, numerous mature trees falling into stream annually, numerous slope failures apparent).
10	7	3	1

Canopy Cover:

> 75% of water surface shaded and upstream 2 to 3 miles generally well shaded.	>50% shaded in reach Or >75% in reach, but upstream 2 to 3 miles poorly shaded.	20 to 50% shaded.	< 20% of water surface in reach shaded.
10	7	3	1

Manure Presence:

	Evidence of livestock access to riparian zone	Occasional manure in stream or waste storage structure located on the flood plain	Extensive amount of manure on banks or in stream. or Untreated human waste discharge pipes present.
	5	3	1

Appendix D. Examples of VSA survey sites for the Little Hunting Slough watershed.

Black River

Channel condition	7
Hydrologic alteration	7
Riparian zone	10
Bank stability	5
Canopy cover	7
Manure presence	-

Overall Score
7.2

Main Ditch

Channel condition	1
Hydrologic alteration	1
Riparian zone	5
Bank stability	5
Canopy cover	5
Manure presence	-

Overall Score
3.4

Secondary Ditch

Channel condition	1
Hydrologic alteration	2
Riparian zone	3
Bank stability	7
Canopy cover	3
Manure presence	-

Overall Score
3.2

Road Ditch

Channel condition	1
Hydrologic alteration	3
Riparian zone	1
Bank stability	10
Canopy cover	1
Manure presence	-

Overall Score
3.2

Wetland Remnant #1

Channel condition	5
Hydrologic alteration	10
Riparian zone	10
Bank stability	10
Canopy cover	8
Manure presence	-

Overall Score
8.6

Wetland Remnant #2

Channel condition	5
Hydrologic alteration	10
Riparian zone	3
Bank stability	10
Canopy cover	3
Manure presence	5

Overall Score
6.0

Appendix E. Monthly mean discharge equations developed from regional USGS gaging stations.

Month	R^2	b_0	b_1	Little Hunting Slough Ad = 84.5 mi^2 Q (ft^3/s)
Jan.	0.98	0.924	1.0545	99.4
Feb.	0.98	1.7471	0.9783	134.1
March	0.99	2.8616	0.9422	187.1
April	0.97	4.7705	0.8898	247.2
May	0.98	2.9679	0.9487	199.8
June	0.97	0.4855	1.1113	67.2
July	0.94	0.1676	1.1868	32.4
Aug.	0.93	0.3176	1.0744	37.3
Sept.	0.94	0.1874	1.134	28.7
Oct.	0.96	0.449	1.0225	41.9
Nov.	0.96	1.3296	0.9507	90.3
Dec.	0.96	2.0154	0.9373	129.0

Equation: $y=b_0x^{b_1}$
Where: y = mean monthly discharge (ft^3/s)
x = drainage area (mi^2)

Appendix F. STEPL model inputs for the Little Hunting Slough Watershed.

Watershed	Total Ad (ac)	HSG	Land Use (ac) Urban	Cropland	Pastureland	Forest	Water	Beef Cattle	# Septic Systems
Little Hunting Slough	54,084	D	3,403	40,110	479	547	9,545	192	681

Appendix G. Eroding streambank inputs into STEPL for the Little Hunting Slough Watershed.

Length (ft)	Height (ft)	Area (ft2)	Mean Width (ft)	Avg. Erosion Rate (ft/yr)
498	1.3	6,314	12.7	0.7
147	2.0	1,585	10.8	0.6
373	2.3	12,373	33.2	1.7
196	2.3	5,843	29.8	1.6
602	3.0	21,015	34.9	1.8
752	3.3	29,883	39.7	2.1
122	3.3	1,336	11.0	0.6
409	3.6	12,567	30.7	1.6
178	3.6	1,762	9.9	0.5
117	3.9	1,050	9.0	0.5
829	3.9	47,216	56.9	3.0
738	3.9	20,382	27.6	1.5
1,397	3.9	42,039	30.1	1.6
693	3.9	19,411	28.0	1.5
1,094	3.9	36,497	33.4	1.8
63	3.9	301	4.8	0.3
557	3.9	6,213	11.2	0.6
393	3.9	8,569	21.8	1.1
769	3.9	10,988	14.3	0.8
785	3.9	27,878	35.5	1.9
171	3.9	1,391	8.1	0.4
422	3.9	6,953	16.5	0.9
53	3.9	291	5.5	0.3
599	3.9	12,318	20.6	1.1
420	4.3	6,248	14.9	0.8
453	4.3	13,860	30.6	1.6
1,283	4.3	51,100	39.8	2.1
621	4.3	20,124	32.4	1.7
70	4.6	452	6.4	0.3
511	4.6	14,463	28.3	1.5
1,076	4.6	33,444	31.1	1.6
878	4.6	42,087	47.9	2.5
256	4.6	2,367	9.2	0.5
593	4.6	9,334	15.7	0.8
241	4.6	2,368	9.8	0.5
106	4.6	321	3.0	0.2
372	4.6	2,220	6.0	0.3
311	4.6	4,742	15.2	0.8
664	4.6	9,958	15.0	0.8
476	4.9	6,304	13.3	0.7
132	4.9	585	4.4	0.2
451	4.9	5,656	12.5	0.7
330	4.9	4,476	13.6	0.7
925	4.9	7,990	8.6	0.5
442	4.9	7,328	16.6	0.9
118	4.9	1,222	10.3	0.5
157	4.9	2,298	14.6	0.8
571	5.2	11,936	20.9	1.1

541	5.2	14,266	26.4	1.4
176	5.2	1,725	9.8	0.5
741	5.2	30,084	40.6	2.1
903	5.2	12,132	13.4	0.7
724	5.6	13,183	18.2	1.0
812	5.6	21,974	27.1	1.4
734	5.9	15,789	21.5	1.1
52	5.9	361	6.9	0.4
219	5.9	3,459	15.8	0.8
148	5.9	1,298	8.8	0.5
153	5.9	2,253	14.7	0.8
167	5.9	2,144	12.8	0.7
132	6.2	596	4.5	0.2
331	6.2	7,942	24.0	1.3
204	6.2	1,609	7.9	0.4
198	6.6	1,839	9.3	0.5
281	6.6	2,653	9.4	0.5
430	6.6	6,501	15.1	0.8
101	6.6	626	6.2	0.3
165	6.6	2,285	13.8	0.7
176	6.6	2,065	11.7	0.6
147	6.9	924	6.3	0.3
127	6.9	881	6.9	0.4
452	7.2	7,616	16.8	0.9
113	7.2	293	2.6	0.1
423	7.2	2,338	5.5	0.3
261	7.9	4,903	18.8	1.0
233	7.9	1,697	7.3	0.4
547	8.2	12,825	23.4	1.2
519	8.2	10,166	19.6	1.0
469	9.8	9,974	21.3	1.1
413	9.8	4,693	11.4	0.6
399	9.8	12,246	30.7	1.6
385	9.8	8,197	21.3	1.1
1,104	9.8	33,722	30.6	1.6
163	11.5	608	3.7	0.2
681	13.1	13,619	20.0	1.1
278	13.1	2,541	9.1	0.5

Total Length = 37,515 ft
Weighted mean height = 6.0 ft
Weighted mean rate = 1.5 ft/yr

Appendix H. Combined conservation practice efficiencies for selected practices.

List of Practices	Combined BMP Efficiencies		
Soybeans and Corn	Nitrogen	Phosphorus	Sediment
Drop Pipe and 90-Day Wetland (winter)	0.762	0.794	0.799
Cover Crop, Drop Pipe, and Permanent Outside Berm	0.819	0.837	0.854
Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (winter)	0.786	0.856	0.869
No-till, Drop Pipe, and Permanent Outside Berm	0.831	0.945	0.963
Cover Crop, No-till, Drop Pipe, and Permanent Outside Berm	0.864	0.949	0.966
Cover Crop, No-till, Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (winter)	0.871	0.958	0.973
Land Retirement	0.898	0.808	0.950
Rice			
Drop Pipe and 90-Day Wetland (summer)	0.762	0.794	0.799
Drop Pipe, Permanent Outside Berm, and 90-Day Wetland (summer)	0.846	0.856	0.819
Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 90-day Wetland (summer)	0.869	0.899	0.869
Drop Pipe, Permanent Outside Berm, Drainage Water Management, and a 180-day Wetland (summer and winter)	0.876	0.911	0.899
Land Retirement	0.898	0.808	0.950