2016
Annual Report

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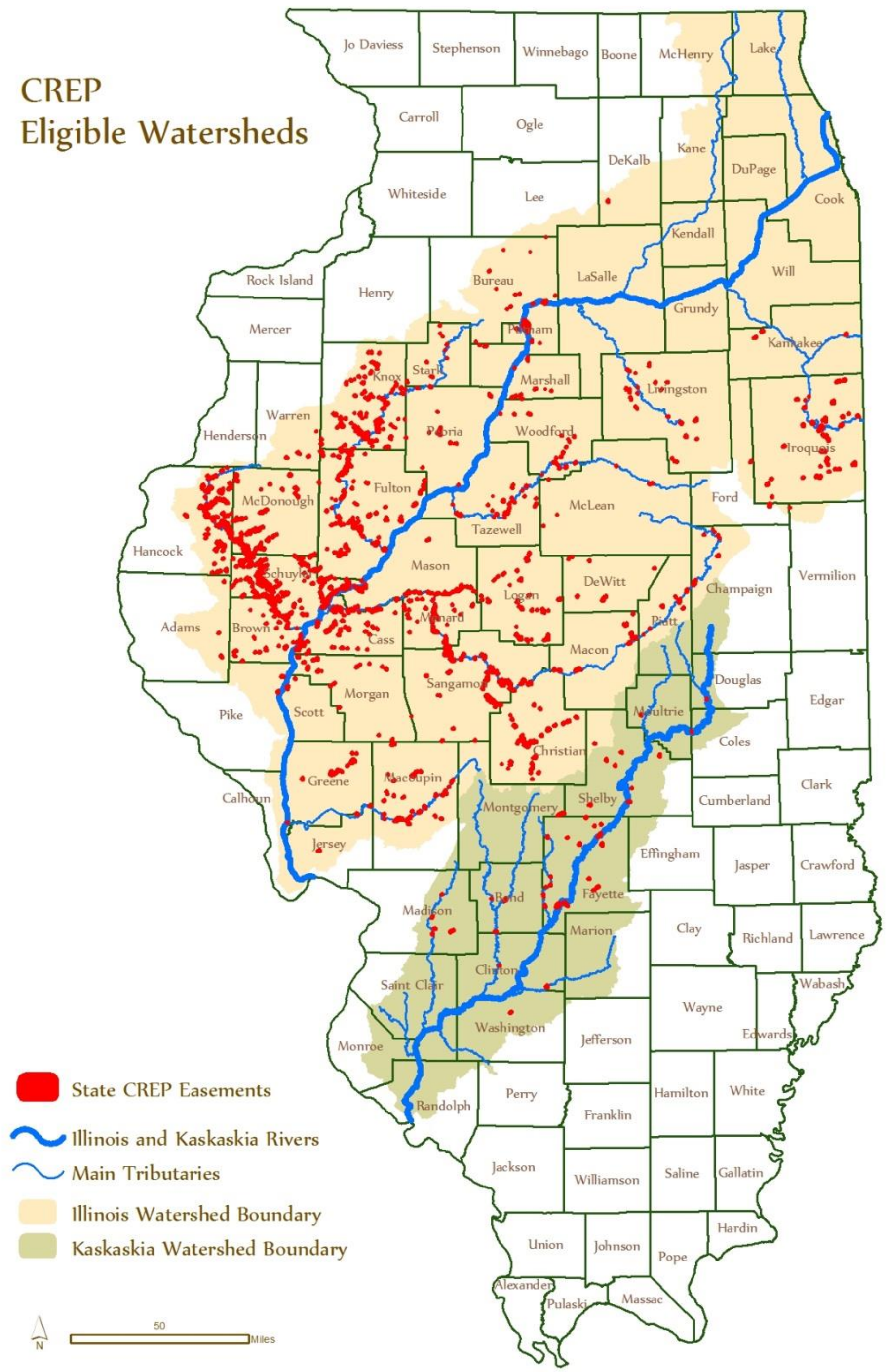
CREP ELIGIBLE AREA AND EXECUTED EASEMENTS



EXECUTIVE SUMMARY

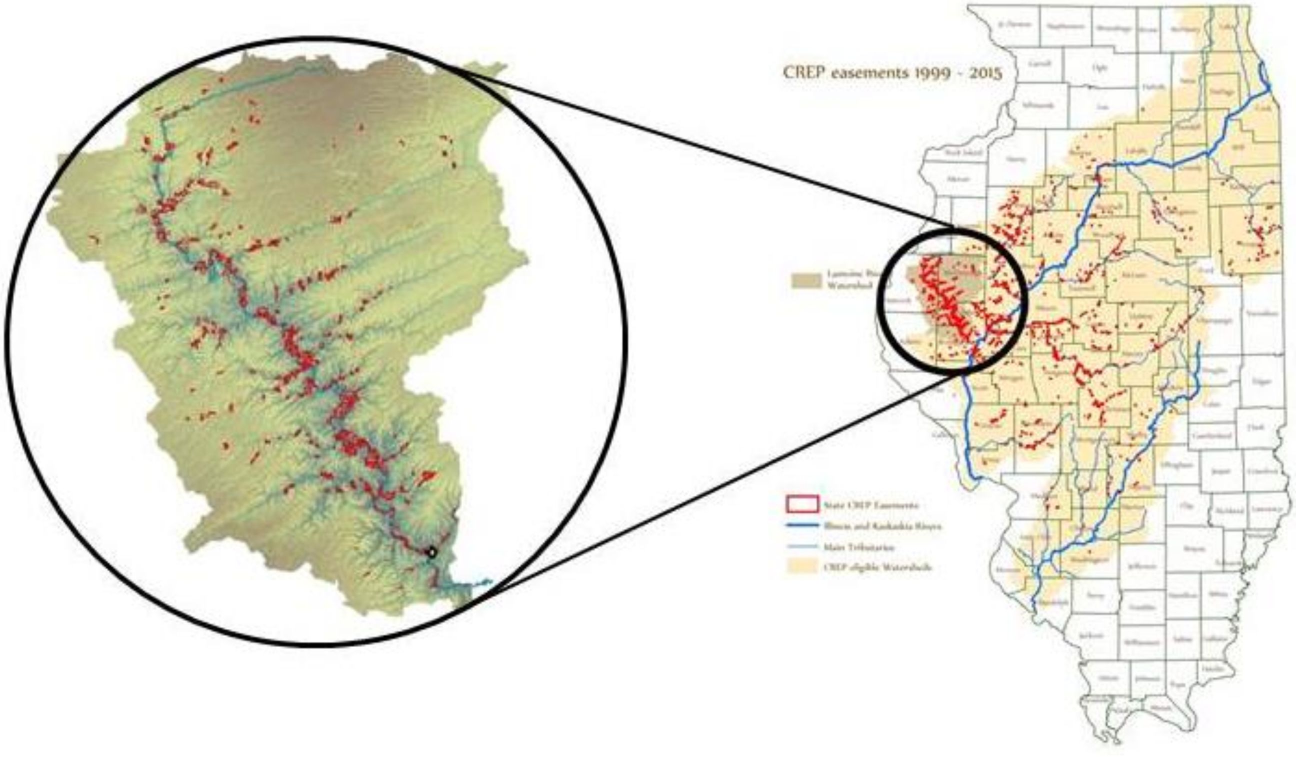
The Illinois Conservation Reserve Enhancement Program (CREP) is a state incentive program tied to the Federal Conservation Reserve Program (CRP). CREP provides long term environmental benefits by allowing 232,000 acres of eligible environmentally sensitive lands within the Illinois and Kaskaskia River Watersheds to be restored, enhanced, and protected over periods ranging from 15 years to perpetuity. CREP continues to be driven by locally led conservation efforts, which is evident by increased landowner support. This program is a prime example of how partnerships between landowners, governmental entities, and non-governmental organizations can network to address watershed quality concerns.

Having worked hand-in-hand with USDA over the years, Illinois CREP has been instrumental in facilitating the ongoing restoration and management efforts within the Illinois and Kaskaskia River Watersheds. To achieve the goal of improving water quality within the targeted watersheds CREP has utilized a variety of Best Management Practices (BMP's) designed to protect and restore miles of riparian corridors. CREP is one of the many tools used by IDNR conservation partners to implement the IDNR Illinois Comprehensive Wildlife Action Plan (IWAP), which provides a framework for the restoration of critical habitats, increasing plant diversity and expanding habitat for species in greatest need of conservation on an agricultural dominated landscape.

Due to the lack of a state budget for Fiscal Years 2016 and 2017, the Illinois Department of Natural Resources is unable to offer state options under the Conservation Reserve Enhancement Program. Therefore the FSA and IDNR has temporarily suspended CREP enrollment (as of preparation of this report CREP is still suspended)

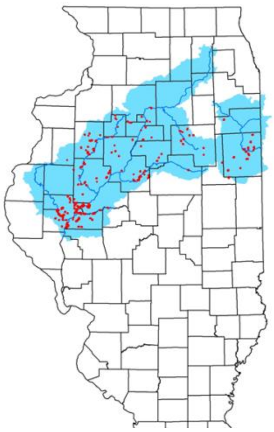
Currently there are 126,805 acres enrolled in Federal CREP contracts at an average rental rate of $212.30 per acre. The State has been successful in executing 1,408 CREP easements protecting 90,990 acres.

CREP's overall success is notably highlighted by the response within the watershed of the Lamoine River, a major tributary of the Illinois River (see map below). Overall, there are 3,271 miles of streams within the watershed, spread out over five counties. 326 long-term CREP Easements, adding up to over 25,500 acres of protected land, have been established in the area and more than 50% of those acres were converted from cropland. The Lamoine River itself is approximately 131 miles long, with 92 miles flowing directly through or alongside CREP properties. In other words, 70% of the main river is under long-term protection providing a valuable riparian corridor of wildlife habitat while also significantly contributing to the overall water quality improvement in the Illinois River.

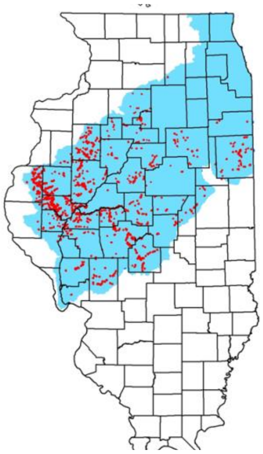


Illinois CREP Timeline

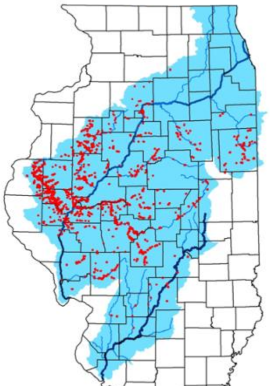
1998 - 2000



1998 - 2007



1998 - 2015



Map images depict the eligible watersheds in blue, and CREP easement locations in red

CREP is a federal-state program that was created by a Memorandum of Agreement (MOA) between the U.S. Department of Agriculture, the Commodity Credit Corporation, and the State of Illinois in March 1998. Enrollments into this program began on May 1, 1998. The MOU was amended several times during the early years to clarify terms, increase the number of practices offered, and to expand the eligible area.

In 2005 the IDNR, in cooperation with other conservation partners, initiated the implementation of The Illinois Comprehensive Wildlife Action Plan (ICWAP). The ICWAP's goals are to use consistent science-based natural resource management principles, to increase the amount and quality of habitat available to support Illinois' native plant and animal species and other game species; promote their population viability, and regulate the recreational, commercial, and scientific utilization of those species; to ensure their long-term persistence and abundance and provide for their appreciation and enjoyment by future generations of Illinoisans while also expanding the frontiers of natural resource management. CREP easements which lie within the ICWAP's priority areas will provide long term protection of quality habitats identified by the ICWAP's goals.

Due to insufficient State funds the Illinois CREP was temporarily closed to open enrollment in November 2007. However, monitoring and land stewardship continued.

In October 2010, after overwhelming public support The Illinois General Assembly appropriated $45 million to reopen and expand CREP to include the Kaskaskia River Watershed. The USDA, Commodity Credit Corporation, and the State of Illinois subsequently amended their Memorandum of Agreement (MOA) to include the Kaskaskia River Watershed with the Illinois River Watershed.

Since 2010 a total of 159 state easements have been approved in the Kaskaskia and Illinois River Watersheds totaling 13,018 acres; the acres in the Kaskaskia River Watershed totaling 4,708 acres and those in the Illinois Watershed totaling 8,310 acres. The average acreage per enrollment is 81.87 acres.

Since the program started in 1998, landowners have voluntarily enrolled 90,990 acres in CREP through 1,408 easements to help improve and restore natural habitats in the Illinois CREP eligible area.

July 1, 2015 - Due to the lack of a state budget, the Illinois Department of Natural Resources is unable to offer state options under the Conservation Reserve Enhancement Program. Therefore the FSA and IDNR temporarily suspended CREP enrollment (as of preparation of this report CREP is still suspended).

Recent Outreach, Stewardship, and Monitoring

The county Soil and Water Conservation Districts (SWCD) within the CREP area are the driving force spearheading CREP on the local level. As the Grantee of the CREP Conservation Easements (Easement) the SWCD's continue to enforce the terms of the recorded Easement by conducting compliance monitoring checks and annual land ownership reviews. Monitoring of the CREP Easements is an essential aspect of the overall future of the program. Monitoring not only protects the SWCD as the Grantee but, most importantly, it also protects the landowner from possible violations.

Prior to the suspension of CREP the Illinois Department of Natural Resources (IDNR) had partnered with the Illinois Environmental Protection Agency (IEPA) and the Association of Illinois Soil and Water Conservation Districts (AISWCD) to hire six (6) CREP Resource Specialists. These specialists were dedicated to counties primarily in the Illinois River Watershed to assist the SWCD's with landowner outreach and enrollment. IDNR also partnered with the National Great Rivers Research and Education Center (NGRREC) who were awarded a National Fish and Wildlife Fund Grant to hire four (4) Land Conservation Specialists to market CREP and assist the districts as needed in counties primarily in the Kaskaskia River Watershed. Once CREP is reopened the IDNR and the AISWCD and NGRREC will discuss details to reinstitute the CREP Resource and Land Conservation Specialists initiative.

The State continues to monitor and evaluate sediment and nutrient delivery to the Illinois River. Nutrient and sediment data have been collected since the program's inception in 1999. According to the Illinois State Water Survey's (ISWS) recent data indicates that both sediment and nutrient delivery to the Illinois River has gradually either stabilized or decreased as a result of the implementation of BMP's in the Illinois River watershed. The most significant outcome has been the slow decreasing trend of nitrate-N yield from major tributary watersheds.

The IDNR is working with the University of Illinois' Critical Trends Assessment Program (CTAP) staff to maintain a biological monitoring program for CREP to assess the conservation practices and wildlife habitat on property enrolled in CREP. CTAP samples the bird communities of forests, grasslands, and wetlands using point-count based methods. During data collection, the presence and abundance of each species seen or heard during the count period is recorded.

The IDNR is also working with Illinois Natural History Survey to maintain a basin-wide monitoring and assessment program for wadeable streams in the Kaskaskia River. Baseline information on aquatic macroinvertebrates (EPT), freshwater mussels, and fish have been collected at selected reaches using a stratified random sampling design to characterize conditions throughout the watershed and provide for long-term trends assessments. Populations of selected species are monitored in focal reaches associated with high biological diversity Biologically Significant Streams BSS reaches) or sensitive taxa enhanced Dissolved Oxygen (DO reaches), Species in Greatest Need of Conservation (SGNC).

The Illinois Nutrient Loss Reduction Strategy (Illinois NLRS) is a framework for using science, technology, and industry experience to assess and reduce nutrient loss to Illinois waters and the Gulf of Mexico. The Illinois NLRS builds upon existing programs to optimize nutrient loss reduction while promoting increased collaboration, research, and innovation among the private sector, academia, non-profits, wastewater agencies, and state and local government. CREP contributions to nutrient loss have been included in baseline reports and will be for all future reports. IDNR has been part of the Agricultural Water Quality Partnership forum, and helping to facilitate the best way to share and aggregate Best Management Practice (BMP) implementation data across agencies, decide which BMP implementation parameters will be tracked (e.g. cover crops, wetlands, buffer strips, etc.) and how the data will be aggregated The IDNR and CREP program will continue be involved in tracking statewide (and agency-wide) progress in accomplishing the INLRS.

Program Expenditures

The Memorandum of Agreement (MOA) for the Illinois CREP details the formula to determine the overall costs of the program: total land retirement costs (which will include the CRP payments made by the Commodity Credit Corporation (CCC) and the easement payments or the bonus payments made by Illinois), the total reimbursement for conservation practices paid by the CCC and Illinois, the total costs of the monitoring program, and the aggregate costs of technical assistance incurred by Illinois for implementing contracts and easements and a reasonable estimate of the cost incurred by the State to develop conservation plans.

Since the CRP contract payments are annual payments spread out over 15 years, a 2.9 percent net present value (NPV) discount rate (per MOA) was used to compare the CRP payments to the State Easement payments.

Per the current agreement, the State of Illinois must contribute 20% of the total program costs. Based on USDA reports at https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/oct2016summary.pdf IDNR contributed 27.22% of the total program costs based on the following calculations;

$269,212,062 (15 years x 71,618 acres x 250.61 avg. rental rate = $269,212,062) given to IDNR by USDA FSA* was amended by IDNR to reflect the 2013 re-enrollment of expired CRP acres with perpetual CREP easements ($1,528,283.64),

2016 USDA Report	$269,212.062.00
2013 USDA CREP re-enrollments	($1,528,283.64)
Amended total	$ $267,283,778.36

*- – https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/oct2016summary.pdf

CREP Enrollment and Financial Figures

Illinois CREP Summary 1998 - Sept 30, 2016	
Number of Current Federal Contracts - 4,443	Current Federal Acres - 71,618
Number of State Easements - 1,408	Total State Protected Acres - 90,990

CREP Contributions 1998 - Sept 30, 2016	IDNR	USDA *	USDA (NPV 2.9%) **
Acres Enrolled as of Sept, 30 2015	90,990	71,618.00	
Total Life of Contract Rent (15 Yrs)		$267,283,778.36	$ 170,299,955.79
Cost Share		$21,077,916.31	$21,077,916.31
Monitoring [a]	$7,369,334.87		
AISWCD CREP Assistants IEPA 319 [b]	$2,180,665.94		
Illinois State Enrollments [c]	$71,572,168.41		
IDNR In-Kind Services [d]	$6,135,894.82		

a – Illinois Natural History Survey, National Great Rivers Research and Education Center, Illinois State Water Survey and United States Fish and Wildlife Service.

b – Association of Illinois Soil and Water Conservation Districts CREP Specialists.

c – Landowner Easement Payment, Practice Cost Share, SWCD administrative costs, property survey costs, title and recording fees.

d – IDNR staff personal services associated with CREP enrollment and management.

Total CREP Contribution 1998 – Sept 30, 2015	IDNR	IDNR/USDA *	IDNR/USDA **
USDA Total		$288,361,694.67	$191,337,872.10
IDNR Total	$87,258,064.04		
Program Total		$375,619,758.71	$278,635,936.14
% of IDNR Program Contribution		23.23%	31.32%
IDNR Easement Payments Total	$71,572,168.41	$359,993,863.08	$262,950,040.51
% of IDNR Easement Contribution		19.88%	27.22%

***CRP Monthly Summary – October 2016 m https://www.fsa.usda.gov/Assets/USDA-FSA-Public/usdafiles/Conservation/PDF/oct2016summary.pdf**

****Net Present Value (NPV) https://www.whitehouse.gov/omb/circulars_a094/a94_appx-c**

Illinois CREP Goals

The goals for the Illinois CREP were revised in 2010 to reflect the expansion into the Kaskaskia River Basin and to highlight the importance of the connection to the Mississippi River and the Gulf of Mexico. The goals of the program are:

- **Goal 1:** Help meet the Federal goals to reduce nitrogen loading to the Mississippi River and the Gulf of Mexico, thereby helping to reduce hypoxia in the Gulf of Mexico.
    - **Goal 1a**: Reduce the amount of silt and sedimentation entering the main stem of the Illinois and the Kaskaskia Rivers by 20 percent;
    - **Goal 1b**: Reduce the amount of phosphorus and nitrogen in the Illinois River and Kaskaskia River by 10 percent;
- **Goal 2:** Increase by 15 percent, the populations of waterfowl, shorebirds, nongame grassland birds, and State and Federally listed threatened and endangered species such as bald eagles, egrets, and herons;
- **Goal 3:** Increase the native fish and mussel stocks by 10 percent in the lower reaches of the Illinois River (Peoria, LaGrange, and Alton reaches) and Kaskaskia River.

Illinois
CREP
Conservation Reserve Enhancement Program

Monitoring Progress toward Achieving CREP Goals

Pollutant Load Reduction Report

(Monitoring Goals 1a & 1B)

To better understand CREP's impact on water quality, a spatially based pollution load model was developed to estimate field level pollutant loading from Nitrogen, Phosphorus and Sediment. By analyzing soils, land-use and precipitation data the model provides both annual and storm event loading for individual land parcels within the Illinois River basin. Accepted equations for calculating runoff and soil erosion are integrated into the model to provide realistic estimations of the quantity and distribution of pollution loading throughout. Data collected between years 2002 and 2011 were used for model calibration of rainfall values and for evaluating in-stream water quality. Final model results for annual pollution loading are calibrated to existing in-stream water quality data.

Approximately 90,000 acres of State CREP were enrolled since the program opened. Within this total 51,300 acres of crop conversion will prevent following pollutants from entering the Illinois and Kaskaskia Rivers:

- 330,134 lbs of Nitrogen per year
- 165, 067 lbs of Phosphorus per year
- 165, 067 tons of Sediment per year

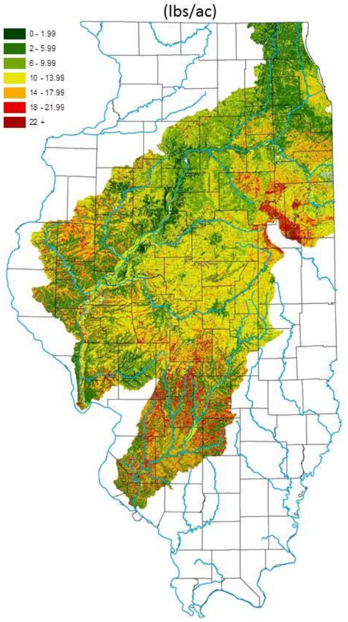
This one-time investment in a CREP easement will reduce non-point source inputs to the Mississippi River basin by the following amounts over a 15 year period:

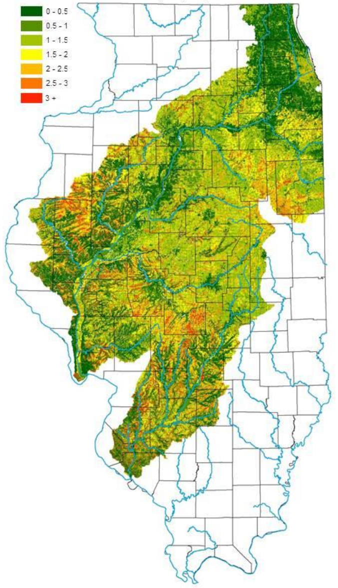
- 4,952,010 lbs of Nitrogen
- 2,476,005 lbs of Phosphorus
- 2,476,005 tons of Sediment

This one-time investment in a CREP easement will reduce non-point source inputs to the Mississippi River basin by the following amounts over a 100 year period:

- 33,013,400 lbs of Nitrogen
- 16,506,700 lbs of Phosphorus
- 16,506,700 tons of Sediment

Monitoring and Evaluation of Sediment and Nutrient Delivery to the Illinois and Kaskaskia


Total Annual Nitrogen Load
(lbs/ac)


Total Annual Phosphorus Load
(lbs/ac)


Total Annual TSS/Sediment Load
(tons/ac)

Rivers – Illinois State Water Survey

(Monitoring Goals 1a and 1b)

Please reference Appendix C for the Illinois River Report and Appendix D for the Kaskaskia River Report

The Conservation Reserve Enhancement Program (CREP) was initiated as a joint federal/state program with the goal of improving water quality and wildlife habitat in the Illinois River basin. Based on numerous research and long-term data in the Illinois River basin, the two main causes of water quality and habitat degradations in major river corridors were known to be related to sedimentation and nutrient loads. Based on this understanding, the two main objectives of the CREP were to reduce the amount of silt and sediment entering the main stem of the Illinois and Kaskaskia Rivers by 20 percent; and to reduce the amount of phosphorous and nitrogen loadings to by 10 percent. To assess the progress of the program towards meeting the two goals, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) are developing a scientific process for evaluating the effectiveness of the program. The process includes data collection, modeling, and evaluation.

The monitoring and data collection component consist of a watershed monitoring program to monitor sediment and nutrients for selected sub-watersheds within the Illinois and Kaskaskia River basins and also to collect and analyze land use data throughout the river basins. Historically, there are a limited number of sediment and nutrient monitoring stations within those river basins, and most of the available records are of short duration. To fill the data gap and to generate reliable data for small watersheds, the Illinois Department of Natural Resources funded the Illinois State Water Survey to initiate a monitoring program to collect precipitation, hydrologic, sediment, and nutrient data for selected small watersheds in the Illinois and Kaskaskia River basins that will assist in making a more accurate assessment of sediment and nutrient delivery. For the Illinois River basin, five small watersheds located within the Spoon and Sangamon River watersheds were selected for intensive monitoring of sediment and nutrients. Three monitoring stations are located in the Spoon River watershed which generates the highest sediment per unit area in the Illinois River basin, while the Sangamon River watershed, the largest tributary watershed to the Illinois River and delivers the largest total amount of sediment, has 2 monitoring stations. The four small watersheds selected for intensively monitoring sediment and nutrient in the Kaskaskia River basin are located within the Crooked Creek, North Fork Kaskaskia River, Hurricane Creek and Shoal Creek watersheds. Two of the monitored watersheds are direct tributaries to Carlyle Reservoir, a U.S. Army Corps of Engineers impoundment on the Kaskaskia River.

The five Illinois River Basin monitoring stations were established in 1999 and are the most detailed data available in the watershed. The full report presents the data that have been collected and analyzed at each of the monitoring stations. The Kaskaskia River basin monitoring stations were established in 2014 after assessing and evaluating many physical, geological, biological, land cover and CRP program data and information, as well as impacts of the 2012 drought. The data collection started in one of the coldest winters recorded in the region for some time. This was followed by a particularly wet spring and summer of 2014 and spring of 2015. The 2016 monitoring year was marked by unseasonal extreme events, particularly the Christmas flooding in December 2016. A full progress report for the Kaskaskia River also presents the data collected and preliminary analyses for each of the monitoring stations.

As outlined in the Illinois River Basin Restoration Plan, the alternative of no-action in the Illinois River watershed would have resulted in increased sediment delivery to the Illinois River and habitats and ecosystem would continue to degrade. However, analysis of the available long term data from different sources and the most recent data from the CREP monitoring program, indicate that sediment and nutrient loads from the tributary watersheds are gradually decreasing or stabilizing as a result of implementation of conservation practices in the watershed. We have also observed a recent rise in phosphorus delivery from the major tributaries since 2007 primarily driven by dissolved phosphorus. These increases are not observed from the CREP monitoring sites which represent headwater watersheds. With the knowledge that reduction in sediment delivery from large watersheds takes time to move through the system, the indication of stabilized sediment delivery shows progress is being made in restoring the Illinois River watershed. If the present trends continue for the next 10 to 15 years, sediment and nutrient delivery to the Illinois River will be significantly reduced, and lead to improved ecosystem in the river and tributary watersheds in the long-term. The Kaskaskia River basin hydrology, sediment, and nutrient monitoring is already establishing that the monitored sites exhibit different concentrations and yields between each watershed and in contrast to the Illinois River Basin monitoring results. Due to the three years of monitoring occurring during highly variable annual precipitation amounts and distributions, continued monitoring in future years will provide the climate variability needed to properly assess loadings and impact of CREP.

Establishing a Biological Monitoring Program for CREP to Assess the Conservation Practices and Wildlife Habitat on Property Enrolled – Illinois Natural History Survey

(Monitoring Goal 2)

Please reference Appendix B for the full species list

The Illinois Department of Natural Resources (IDNR) is working with the University of Illinois Critical Trends Assessment Program (CTAP) staff to establish a biological monitoring program for CREP to assess the benefit of conservation practices and wildlife habitat to avian species on property enrolled in CREP. The monitoring program samples the bird communities of shrublands, grasslands, and wetlands at randomly selected CREP easements using point-count based methods. During data collection, the presence and abundance of each species seen or heard during the count period is recorded. As of August 2015 all data collection has been completed. Avian point counts were conducted at 202 unique point locations located at 172 easements larger than 3.0 ha within 4 specific state CREP conservation practices, CP23, CP4D, CP22, and CP3A in the Illinois River watershed. Restored patches ranged in size from 2.9 to 174.7 ha (mean = 35.3, SE=2.6) from 2012-2015 resulting in 420,573, 602, and 401 point count surveys each year, respectively. While approximately 103 species were documented during their surveys as analyses moves forward, they have chosen to examine five focal species including Field Sparrow, Willow Flycatcher, Bell's Vireo, Northern Bobwhite, and Yellow-billed Cuckoo.

To date the first analyses has focused on understanding what local, patch, and landscape features were associated with focal species habitat selection. It was discovered that the most important local scale variables for Bell's Vireo, Field Sparrow, Northern Bobwhite, and the Yellow-billed Cuckoo density included distance to nearest tree and percent tree cover was the most important predictor of Willow Flycatcher density. There was a negative relationship between these variables and species density meaning that they were found primarily in areas with reduced tree density. At the patch scale, Bell's Vireo, Northern Bobwhite, and Yellow-billed cuckoo were all positively associated with increasing patch size however these relationships were relatively weak (Figure 1). Field Sparrow and Willow Flycatcher were more abundant in smaller patches but again these were weak relationships (Figure 1). Beyond the patch scale, it was found that Willow Flycatcher and Yellow-billed Cuckoos were somewhat positively associated with the amount of restored habitat in the landscape surrounding the focal patch however surprisingly Bell's Vireo, Field Sparrow, and Northern Bobwhite were all weakly negatively influenced by this variable (Figure 2). Overall, the results suggest that larger restored patches can positively influence some the focal species however given that there were no strong relationships even small patches (3.0 ha and above) play an important role in providing habitat for these species of concern. It was expected based on existing literature that having more restored habitat in the surrounding landscape would provide benefits to the focal species, the results suggest that while having a restored patch of 3.0 ha is important, these habitats may not need to be clustered to provide increased benefits for most of our focal species.

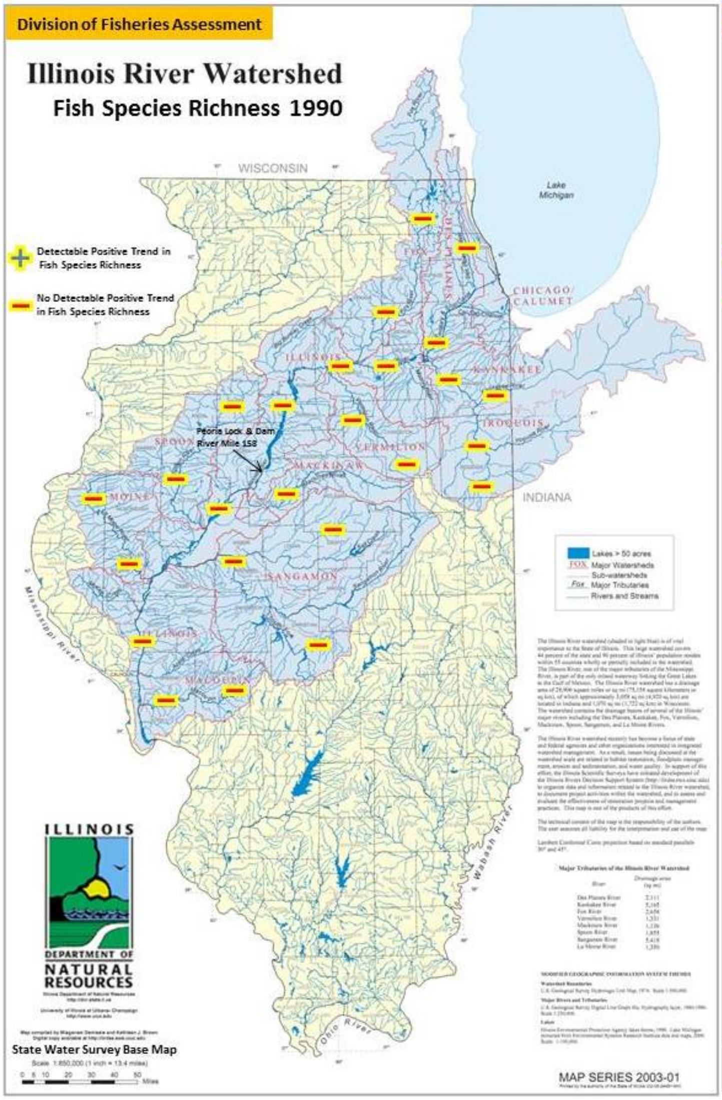
The second analyses utilized data from surveys and habitat selection information to calculate density estimates for four of the focal species of concern at study sites. This is particularly important given the Illinois Wildlife Action Plan (IWAP) population goals for these species. Based on density estimates the total number of these species can be extrapolated using CREP sites in Illinois and preliminary analysis suggests that CREP sites may be providing enough habitat for some species of concern to achieve those population goals. Based on abundance models, total population sizes in restored habitats for the Bell's Vireo was 3609 (bootstrap 95 % CI = 3,542–3,676), Field Sparrow was 76,888 (bootstrap 95 % CI = 78,850 –81,500), Northern Bobwhite was 17,249 (bootstrap 95 % CI = 16,747 –17,751), and Willow Flycatcher was 13,013 (bootstrap 95 % CI =12,443–13,583) which was 90.2, 30.0, 0.05, and 76.5 % of aspirational population goals, respectively. Notably, both Bell's Vireo and Willow Flycatcher are very close to their aspirational population goals and based on the confidence intervals may well be meeting those goals. While important, population contributions of CREP sites to the other species of concern listed above have been more modest such as for the Field Sparrow and Northern Bobwhite. Based on our abundance models, simulated landscape population sizes indicated that to meet Bell's Vireo, Willow Flycatcher, Field Sparrow, and Northern Bobwhite aspirational population goals restored habitat would need to be increased by approximately 4000, 14,000, 82,000, and 360,000 ha, respectively. Approximate cost estimates, based on average per ha rental rate of $212.30 (IDNR 2016),

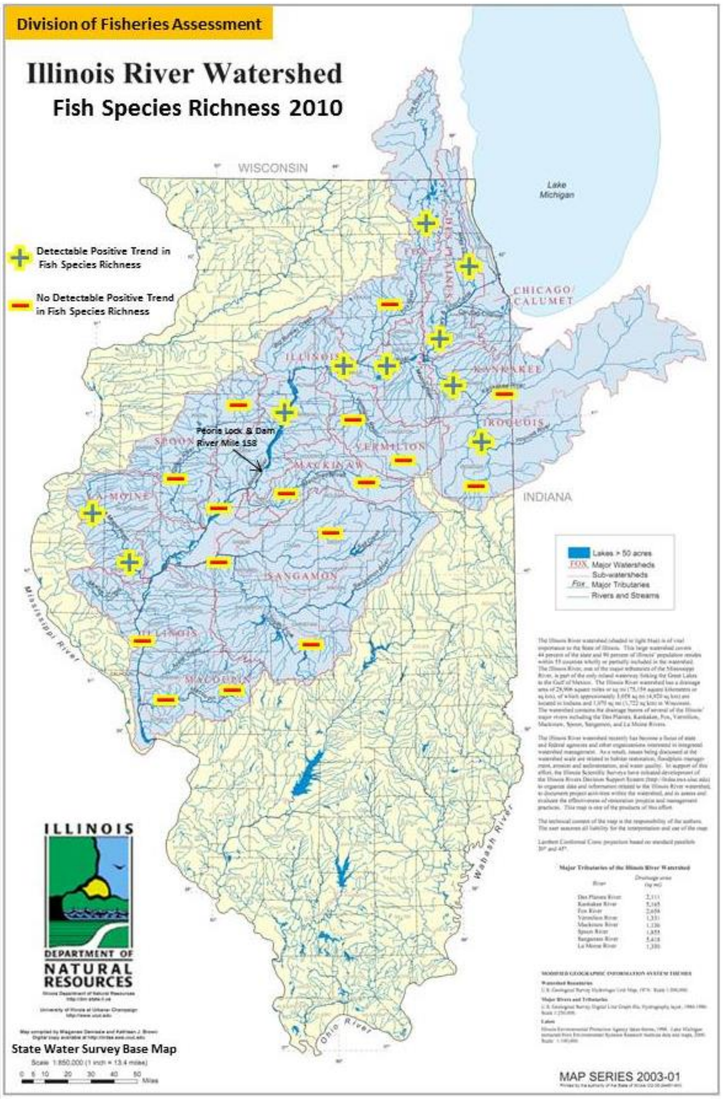
The Recovery of the Illinois River Basin*

(Monitoring Goal 3)

The Illinois River Basin contains 15 major watershed areas or basins comprised of 305 Hydrologic Units (HU). Within each HU, IDNR field biologists have evaluated the ecological well-being of the majority of the hydrounits under the IEPA cooperative basin survey project since the early 1980's. Fish species richness for 9 of the 15 major basins (river mainstem and tributary waters) are covered below in summary Table 1. Illinois River mainstem and tributary waters showing positive fish species trends are summarized in the table below and coresponding maps of 1990 and 2010 fish species richness for the Illinois River Basin.

Fish Species Richness determined by DNR fish sampling data from Illinois River Basin (see graphs below)	**Mainstem**	**Tributaries**	**1990**	**2000**	**2010**	**Fish Species Richness trend detected (+)**
Illinois River above RM 158	X		11	16	20	+
Illinois River all stations	X		13	16	19	+
Marseilles Pool (RM 246 to 271)	X		14	15	21	+
Starved Rock Pool (RM 231 to 245)	X		9	14	18	+
Peoria Pool (RM 158 to 230)	X		13	17	21	+
Major Watersheds						
Fox River	X		4	10	22	+
		X	15	16	18	+
Kankakee River	X		21	30	35	+
	X		22	26	28	+
	X		13	17	21	+
		X	2	13	23	+
LaMoine River	X		13	17	22	+
		X	17	18	19	+





**Information from "The Recovery of the Illinois River Basin – Status Report, IDNR Division of Fisheries, 2011*

Monitoring and Assessment of Aquatic Life in the Kaskaskia River for Evaluating IDNR Private Lands Programs – Illinois Natural History Survey

(Monitoring Goal 3)
Please reference Appendix A for the full report.

The initial focus of this Monitoring and Assessment Program was to characterize baseline conditions in stream reaches of the Kaskaskia River Basin to which future conditions could be compared. As these baseline conditions are described the Program continues to monitor status and trends and is beginning to initiate more intensive monitoring directed at evaluating the influences of CREP practices on aquatic life.

Survey events (i.e., at least one parameter was evaluated or one taxon collected) were completed at 139 locations through August 2015. There were four types of survey locations, each serving a specific purpose: 1) Randomly selected reaches (92) for basin-wide characterization of streams, 2) focal reaches (12) in areas with special biological significance for evaluation of temporal trends, 3) Illinois State Water Survey locations (4) to provide biological information in reaches with more intensive hydrologic and nutrient monitoring, and 4) locations to supplement research conducted by student work supporting these efforts (31). Biological (fish, benthic macroinvertebrates) and physiochemical (physical habitat, water quality, discharge) data were collected during the majority of collection events (not all parameters could be assessed at every location due to logistical constraints). In addition, existing information has been compiled on fish, mussels, macroinvertebrates, water chemistry, and in-channel habitat for the Kaskaskia River Basin from IDNR, INHS, and IEPA databases to supplement the surveys. This includes historical data as well as IDNR/IEPA Intensive Basin Survey fish and habitat collection data from 56 sites in 2012, and INHS mussel collections at 95 sites made from 2009-2012. Efforts are currently underway to use these data to describe baseline conditions in the biological condition of fish and mussel stocks within the Kaskaskia River Basin.

Twenty randomly selected reaches were surveyed in June and July of 2016 to continue basin-wide characterization and status assessment. Fish, benthic macroinvertebrate, water quality, in stream physical habitat, water temperature, and discharge were monitored within each reach using the previously established methods.

As baseline characterization efforts shift toward monitoring trends in status, more effort has been dedicated to research intended to directly assess the influence of CREP on aquatic life. Eight pairs of reaches were more intensively surveyed in July and August 2016. Each member of a pair is a tributary to the same higher order stream, and pairs contain one reach with relatively high conservation land density within the local catchment and one low density reach. These reaches were surveyed with the same collection methods undertaken for the basin-wide characterization and were supplemented with a mussel survey, adult aquatic insect collection using black lights, and additional length/weight measurements on fish. Twelve additional reaches were also selected to track population level responses of selected fish species as CREP matures in the basin. Surveys followed the methods used for the basin-wide characterization with additional length and weight measurements made on selected fish species.

Monitoring Freshwater Mussel Communities

(*Monitoring Goal 3*)

With help from State Wildlife Grant funding, IDNR and INHS collaborated to collect data on mussel communities in Illinois. Many of the sampling locations occur within the CREP Eligible Area; the Illinois River and Kaskaskia River Watersheds. Among those areas surveyed throughout the state, locations in the watersheds of the La Moine River, Sangamon River, Illinois River tributaries, and the Kaskaskia River were sampled.

Sampling of the mussel community of the La Moine River detected all known species historically reported and even detected four species not previously known to exist in the basin. Those four species share a common fish host, the freshwater drum, which may indicate success of the fish is closely tied to the appearance of those species. Recruitment within this basin was reported to be moderate to high, suggesting mussel communities to be viable and self-sustaining.

Historically, the Sangamon River supported more than 40 species of freshwater mussels, however only 29 were detected during the recent sampling effort. There were, however, multiple sites which continue to display high levels of species-richness and diversity. Consistent with previous studies, in the reach between Decatur and Springfield fewer species and smaller populations were detected compared with other areas in the basin. Areas in decline are likely seeing effects of habitat loss due to land cover change and channelization, sedimentation as well as agricultural and industrial nutrient and pollutant runoff (Price et al., 2012).

The sampled tributaries of the Illinois River were geographically categorized into Upper, Middle, and Lower Illinois tributaries. Tributaries feeding into the Lower Illinois were the most species-rich, while those in the Upper Illinois were the least. Overall, the tributaries of the Illinois sampled and reported on were neither particularly abundant nor diverse with regards to mussel communities. The most common species detected mirror the same diversity found throughout the state as well as tributary streams of the Mississippi River. Common factors limiting diversity in the sampled areas are similar to limitations in other areas including: small watershed size, spring flooding, flow regime changes, agricultural and industrial runoff, restricted connectivity and altered habitats. There were a few sampling sites which should be noted for their mussel communities, however. At one site, McKee Creek, high rates of recruitment were detected. While at another site, Tomahawk Creek, the State-Threatened slippershell mussel was collected in extraordinarily high numbers (Stodola et al. 2013).

Multiple mussel surveys have been conducted on the Kaskaskia River between 1954 and 2008. Comparing results of the recent survey, species richness is slightly lower with 32 total species detected compared to 43 historically. Also, dominant species comprising the mussel communities of the Kaskaskia appears to have shifted slightly over time. Overall, recruitment is relatively poor in the Kaskaskia River basin, however there are still many sites which display remarkably high recruitment rates. Shoal Creek has been shown both historically and currently to be a very high quality area for mussels and both species richness and abundance were high (Shasteen et al. 2013).

References:

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PARTNER UPDATES

Illinois Environmental Protection Agency

One of the key missions of Illinois EPA is to monitor and protect the water resources of Illinois; these resources are relied upon for drinking water, fishing, transportation and recreational use and other environmental and economic benefits. One of the most dramatic improvements in water quality that Illinois EPA has documented has taken place on the Illinois River.

Illinois EPA has eight Ambient Water Quality Monitoring Sites on the main channel of the Illinois River. Water chemistry is collected at these sites nine times per year. There are approximately 475 Intensive Basin Survey Sites in the Illinois and Kaskaskia River watersheds. These sites are monitored "intensively" once every five years. The monitoring includes water chemistry, macro-invertebrates, fish, habitat, sediment and at some sites fish tissue contaminants are collected. This information is cooperatively collected with the Illinois Dept. of Natural Resources, a partnership that began many years ago and continues annually.

The monitoring shows that the Illinois River mainstream water quality has improved significantly since the passage of the Federal Clean Water Act in 1972. Early improvements were due primarily to point source controls, such as additional treatment requirements and limits on discharges from wastewater treatment plants. The majority of water quality improvements over the last fifteen years have been from the implementation of nonpoint source management programs that reduce urban and agricultural runoff, and programs such as CREP.

As reported by the Illinois EPA in their 2016 Integrated Report, of the *stream miles assessed* in the Illinois River Basin for Aquatic Life Use Support attainment, 67.8% were reported as ―Good,‖ 27.6% as ―Fair,‖ and 4.6% as ―Poor.‖ This compares to statewide figures of 57.8% ―Good,‖ 37.3% ―Fair,‖ and 4.9% ―Poor.‖

Illinois EPA continues to participate on the State CREP Advisory Committee and continues to provide financial assistance to local soil and water conservation districts so they can assist landowner enrollment into CREP. Since 1999, more than $2,522,000 of Section 319 grant funds have been spent to hire and train personnel responsible for outreach and the enrollment process.

The benefits derived through this financial support is not only efficiency in the sign-up process to increase CREP enrollment, but it also allows the existing SWCD and NRCS staff to continue to implement the other conservation programs so desperately needed to improve water quality in the Illinois and Kaskaskia River watersheds.

Other Illinois EPA programs that complement CREP include:

Section 319: Since 1990, the Illinois EPA has implemented 303 Clean Water Act Section 319 projects within the Illinois and Kaskaskia River Watersheds. The Agency receives these federal funds from USEPA to identify and administer projects to prevent nonpoint source pollution. These projects include watershed management planning; best management practices implementation and outreach efforts. Illinois EPA has dedicated over $69 million with another $61 million of local and state funds for total project costs of over $130 million towards these projects to help improve the health of the Illinois and Kaskaskia Rivers, their tributaries and ultimately the Mississippi River and Gulf of Mexico. Hundreds of conservation practices have been installed in the Illinois and Kaskaskia River watersheds by dozens of our partners through the Section 319 program. Traditional practices such as terraces and waterways are dotting the landscape along with porous pavement parking lots, green roofs and miles of rural and urban stabilized streambank.

Since 1990, the 319 NPS program, through on the ground implementation can show load reductions in the Illinois and Kaskaskia River watersheds of: 599,853 lbs. of nitrogen, 267,403 pounds of phosphorus, and 227,116 tons of sediment per year, each and every year since the Best Management Practices were implemented as a result of 319 grant projects between Illinois EPA and our local partners, in both the private and government sectors. The Illinois EPA invites you to visit http://water.epa.gov/polwaste/nps/success319/ for a sample of Illinois‘ 319 success stories.

IGIG: Since 2011, the Illinois EPA has implemented 31 Illinois Green Infrastructure Grant Program for Stormwater Management (IGIG) projects within the Illinois and Kaskaskia River watersheds. IGIG is administered by the Illinois EPA. Grants are available to local units of government and other organizations to implement green infrastructure best management practices (BMPs) to control stormwater runoff for water quality protection in Illinois. Projects must be located within a Municipal Separate Storm Sewer System (MS4) or Combined Sewer Overflow (CSO) area. Funds are limited to the implementation of projects to install BMPs. Illinois EPA has dedicated over $15 million with another $6 million of local funds for total project costs of over $21 million towards these projects to help improve water quality in the Illinois and Kaskaskia River watersheds.

Construction Site Inspection Program: Illinois EPA continues to implement a program in partnership with nineteen soil and water conservation districts covering twenty-two counties. Those partners located with the Illinois and Kaskaskia River watersheds include the Champaign, DeKalb, Jersey, Kane/DuPage, Kankakee, Kendall, Knox, Macon, Madison, McHenry/Lake, Monroe, North Cook, Peoria, St. Clair, and Will/South Cook County Soil and Water Conservation Districts. District staff complete on-site NPDES Construction Stormwater Permit inspections and provide technical assistance in implementing best management practices to minimize runoff to nearby water bodies. This program is a natural fit for properly developing acreage that does not qualify for CREP.

Total Maximum Daily Load (TMDL): TMDLs are a tool that Illinois EPA uses to restore impaired watersheds so that their waters will meet Water Quality Standards and Full Use Support for those uses that the water bodies are designated. A TMDL looks at the identified pollutants and develops, through water quality sampling and modeling, the amount or load reductions needed for the water body to meet its designated uses. USEPA has approved 282 completed TMDL evaluations and Illinois EPA is currently developing another 222 TMDLs in the Illinois and Kaskaskia River watersheds.

Partners for Conservation: A total of 72 lake monitoring (study) or protection/restoration projects have been conducted in the Illinois and Kaskaskia River watersheds via the Illinois EPA‗s Illinois Clean Lakes Program and Priority Lake and Watershed Implementation Program. Over $11.8 million of local and state funds have been allocated for these efforts.

Excess Nutrients: A High Profile Water Quality Issue

The impact of excess nitrogen and phosphorus in rivers, lakes, streams and the Gulf of Mexico has become a very high profile water quality issue. Under the right conditions, nutrients can cause excessive algal blooms, low oxygen and nuisance conditions that adversely impact aquatic life, drinking water and recreational uses of the water. The Illinois EPA has identified many waterbodies in the state with these problems.

Nitrogen and phosphorus come from municipal wastewater treatment, urban stormwater, row crop agriculture, livestock production, industrial wastewater and combustion of fossil fuels. In other words, most aspects of modern society contribute to this pollution problem. The proportion of loading to a particular waterbody from these sources varies from watershed to watershed, with point sources and urban storm water being most important in urbanized watersheds and row crop and/or livestock production being predominant contributors in agricultural watersheds.

Illinois EPA has several on-going efforts concerning nutrients. In July of 2015 Illinois EPA jointly with the Illinois Department of Agriculture and a designated Nutrient Loss Reduction Policy Workgroup submitted to U.S. EPA Illinois' Nutrient Loss Reduction Strategy (NLRS) document that provides an implementation strategy to reduce nutrient losses from Illinois. The document identifies eleven priority watersheds for the reduction of nitrogen and/or phosphorus from point and/or nonpoint sources. Five of these watersheds are in the Illinois River Basin and one is in the Kaskaskia River Basin. The Strategy also moves forward the identification of eight watersheds that are considered ―KIC Nutrient Priority Watersheds. Six of the eight designated watersheds are in the Illinois River Basin. Each of these watersheds has a Total Maximum Daily Load developed or being developed for one or two nutrient pollutants (nitrogen and phosphorus) for the priority watersheds above. The agency is partnering with a program called ―KIC 2025‖ (www.kic2025.org). KIC 2025 is a commodity industry driven program being implemented in the watersheds listed above. This program seeks to educate the agricultural sector, dedicate significant resources toward research to reduce nutrient losses and enhance nutrient efficiency, educate suppliers and farmers, and measure the adoption of in-field practices to enhance nutrient stewardship beginning in priority watersheds and expanding over years to a state-wide nutrient stewardship program. The Agency is also involved in the Mississippi River Basin Initiative in the Indian Creek Watershed (Livingston County, Vermilion-Illinois Basin). The Agency is providing funds for significant outreach and water quality monitoring that includes weekly growing season sampling and monthly year-round sampling. The Illinois EPA invites you to visit http://www.epa.illinois.gov/topics/water-quality/watershed-management/excess-nutrients/nutrient-loss-reduction-strategy/index to examine the complete Illinois Nutrient Loss Reduction Strategy.

In conclusion, the Illinois and Kaskaskia River basins are a valuable resource that we are working hard to protect and restore. Illinois EPA will continue long-term monitoring of the rivers and their watersheds and will continue to pursue funds to help implement CREP and other water quality restoration and protection projects and to work with citizen groups and local government and industry to continue the progress we all have made.

Current Management Approaches and Issues

TMDL load limits are required to be implemented through National Pollutant Discharge Elimination System permits, which address point sources—municipal or industrial wastewater dischargers. Management of non-point source pollution is through voluntary implementation of best management practices (BMP) contrary to point sources which are regulated through permit limits.

Cost-share incentives to implement/install BMPs include federal Conservation Reserve Program and state Conservation Reserve Enhancement Program, state Partners for Conservation Program, various Farm Bill conservation programs and Section 319 non-point source management grants. The federal Farm Bill programs, though relatively well-funded, are not consistently targeted at water quality improvement, nutrient reduction or locations most in need of BMPs.

There are various other efforts through state agricultural groups, industry and non-profit organizations to promote the use of agricultural BMPs, but these efforts are not consistently coordinated nor targeted to particular watersheds. In addition, the degree of implementation of key nutrient-related BMPs is not comprehensively quantified or mapped, so the collective status of BMP implementation in the state is unknown.

Available data do indicate that Illinois producers are not over-applying fertilizers or manure and that the traditional suite of conservation practices will not be adequate to achieve such large reductions. Absent the development of an economically viable third crop such as a perennial for biofuels, the costs to significantly reduce nutrient losses from agriculture could be billions of dollars.

New and expanding major (one million gallons per day or greater design flow) municipal sewage treatment plants and some sewage treatment plants discharging to certain lake watersheds are required by Illinois Pollution Control Board regulations to limit total phosphorus to 1.0 mg/L on a monthly average basis. Plants currently achieving this level of phosphorus reduction represent 9% of the approximately 900 municipal discharges in the state. However, of the 214 major municipals discharges, whose effluent constitutes a large majority of the phosphorus loading from point sources, 25% are required to remove phosphorus. Requiring phosphorus removal from the minor facilities would be very costly for customers on a per capita basis and would represent a relatively small portion of the total point source phosphorus discharged. Therefore at this time minor facilities will not be targeted for reducing phosphorus discharge.

What U.S. EPA Expects

U.S. EPA expects states to establish numeric water quality standards for phosphorus and nitrogen and to carry out the other pieces of the Clean Water Act framework, as appropriate. U.S. EPA's Inspector General issued a finding in 2009 that U.S. EPA had not done enough to get state numeric nutrient water quality standards established. In response, U.S. EPA has developed a ―corrective action plan‖ which includes a commitment to identify states where federal promulgation of nutrient water quality standards is required. U.S. EPA has been petitioned and sued by various environmental groups for failure of states to establish numeric nutrient standards, so there is mounting pressure on U.S. EPA and states to address nutrients by developing numeric nutrient water quality standards.

States have concerns on the issue of numeric nutrient water quality standards. They raise two main points:

1. There is not a straightforward relationship between nutrient concentration in the water and adverse effects, so a statewide ―one size fits all‖ standard that meets the test of scientific defensibility is almost unachievable; and
2. The Clean Water Act programs are effective for point sources but do not assure reductions from non-point sources that are often the predominant contributors of nutrients in a particular watershed.

Through Illinois' Nutrient Loss Reduction Strategy the Illinois EPA has continued its commitment to using a science based approach to developing water quality standards. A Nutrient Science Advisory Committee has been convened to guide the development of nutrient criteria that helps protect aquatic life in Illinois' streams and rivers. It is comprised of scientific experts nominated by the stakeholder sectors represented in the Illinois Nutrient Loss Reduction Strategy Policy Working Group. Illinois EPA will propose numeric nutrient criteria to the Illinois Pollution Control Board in a rulemaking process based on the findings and determinations of the committee. The Illinois EPA will work with stakeholders to develop a plan for implementing the numeric nutrient criteria before filing the rulemaking with the Board.

Illinois Department of Agriculture

The Illinois Department of Agriculture (IDOA) administers numerous soil and water conservation programs that produce environmental benefits in the Illinois River Watershed. In FY15, the Partners for Conservation Program (PFC), administered by IDOA, allocated over $336,049 to 68 counties that have significant agricultural acreage in the Illinois River Watershed for cost-sharing the installation of upland soil and water conservation practices. With the assistance from County Soil and Water Conservation Districts (SWCDs), the PFC provides up to 70% of the cost of constructing conservation practices that reduce soil erosion and protect water quality.

Conservation practices eligible for partial funding under the PFC include terraces, grassed waterways, water and sediment control basins, grade stabilization structures and nutrient management plans. A total of 220 projects have been completed with significant environmental benefits to the Illinois River Basin during with fiscal year 2015 funding. These conservation projects were constructed and are responsible for bringing soil loss to tolerable levels on 10,978 of acres of land. This translates into over 11,969 fewer tons of soil loss over the next 10 years.

The IDOA provided grant funding to county SWCD offices in the Illinois River Watershed for operational expenses. Specifically, these funds were used to provide financial support for SWCD offices, programs, and employee' expenses. Employees, in turn, provided technical and educational assistance to both urban and rural residents in the Illinois River

Watershed. Their efforts are instrumental in delivering programs that reduce soil erosion and sedimentation that ultimately protects water quality.

In an effort to stabilize and restore severely eroding streambanks that would otherwise contribute a large amount of sediment to the Illinois River and its tributaries, the IDOA, with assistance from SWCDs, administers the Streambank Stabilization and Restoration Program (SSRP). The SSRP is a component of the Partners for Conservation Program that provides funds to construct low-cost techniques to stabilize eroding streambanks. In all, over 1,720 feet of streambanks have been stabilized to protect adjacent water bodies.

Illinois Department of Natural Resources

Illinois Recreational Access Program (IRAP)

One of the more challenging problems facing Illinois and the Department of Natural Resources (IDNR) is to provide more public outdoor recreational access and opportunities in Illinois. In order to carry on our outdoor traditions, it is important to connect youth and families to land and opportunities. 95 % of Illinois is privately owned and ranks 46th for public lands for recreation but hosts more than 323,000 hunters and 780,000 fishermen and millions of other recreational users.

Through the Illinois Recreational Access Program (IRAP), the IDNR is increasing public recreational opportunities for the following activities:

- Youth and Adult Spring Turkey Hunting
- Archery Deer Hunting
- Small Game and Upland bird hunting
- Waterfowl Hunting
- Fishing (Ponds and Streambanks)
- Non-Motorized Boat Access on Public Waterways
- Outdoor Naturalist (Birding, Nature Watching and Outdoor Photography)

Utilizing resources obtained from three separate grants from the US Department of Agriculture‘s Voluntary Public Access and Habitat Incentive Program, the IDNR pays an annual stipend to landowners enrolling their property into IRAP. IRAP also prepares a habitat management plan and assists with the implementation of those plans for landowners. - Emphasis is placed on developing a habitat management plan for the landowner and assisting with the implementation of the management plan. IRAP’s success has led to the creation of two Habitat Strike Teams to work on private lands enrolled in IRAP.

IRAP accomplishments in the first five years:

- Leased approximately 15,300 acres in 36 counties within the Illinois River watershed.
- Provided thousands of hunting and fishing opportunities for youth and adults.
- Obtained more than 65 habitat management plans for IRAP leased properties.
- Habitat Management on IRAP leased property include,
    - Non-Native Invasive Species (NNIS) removal on 4,725 acres
    - Aerial Spraying (NNIS) on 1,811 acres
    - Site Prep/Grassland management on 72 acres
    - Prescribed Burning on 1,146 acres
    - Timber stand Improvement on 253 acres
    - Prairie Plantings on 245 acres

Natural Resources Conservation Service (NRCS)

Conservation Accomplishments in the Illinois River Watershed

NRCS provides technical assistance to farmers, ranchers, and forest landowners as well as financial assistance through a number of Farm Bill conservation programs. Through the conservation title of the 2014 Farm Bill, NRCS provides cost-sharing for improved farming practices through the Environmental Quality Incentives Program (EQIP) and the Conservation Stewardship Program (CSP); and secures easements to protect agricultural lands and wetlands through the Agricultural Conservation Easement Program (ACEP). NRCS also has floodplain easements through the Emergency Watershed Protection Program (EWP).

In the Illinois River watershed as of the end of September 2015, there are a total of 1,582 active EQIP and CSP contracts. The dollar value of the 458 EQIP contracts in the Illinois River watershed is $7,466,146. In CSP, the Illinois River watershed has 1,114 active contracts covering 934,057 acres. A total of 42 ACEP conservation easements and 4 EWP-Floodplain Easements covering 12,771 acres are active in the Illinois River watershed.

For additional information on NRCS conservation programs, please visit www.nrcs.usda.gov.

US Fish and Wildlife Service

The US Fish and Wildlife Service Partners for Fish and Wildlife Program (PFW) has supported the Illinois River Conservation Reserve Enhancement Program (CREP) since its inception. The Midwest Region‘s PFW program assists with projects that conserve or restore native vegetation, hydrology and soils associated with imperiled ecosystems such as bottomland hardwoods, native prairies, marshes, rivers and streams. Collaborating with the Illinois and Kaskaskia River CREP has provided opportunities on a landscape scale for restoration, enhancement, and preservation of these natural habitats on private land. Benefits from this collaboration are the enhancements of privately–owned land for Federal Trust Species, such as migratory birds, inter-jurisdictional fish, federally threatened or endangered species of plants and animals, as well as numerous state threatened or endangered species. Specifically, the federally threatened decurrent false aster (*Boltonia decurrens*) has benefited from the Illinois CREP and with continued support, removing this species from the threatened species list is a possibility. Equally significant are both the direct and indirect positive benefits CREP has had on our National Wildlife Refuge lands located along the Illinois and Kaskaskia Rivers.

The primary contribution to the Illinois and Kaskaskia River CREP, by PFW, has been technical assistance through participation on the CREP Advisory Committee. In the field, PFW personnel coordinate with local NRCS, SWCD, and Illinois DNR staff as necessary on individual or groups of projects. Within the Illinois and Kaskaskia River Watersheds, individual Partners projects compliment CREP and other habitat programs. The PFW program provides a tool for restoration and enhancement of habitats on private lands that may not be eligible for other landowner assistance programs. PFW biologists review the full range of landowner assistance programs with each potential cooperator and refer landowners to CREP or other USDA and Illinois DNR programs that best meet their objectives. In 2016, the PFW program completed 2.7 acres of wetland restoration, 206.5 acres of upland habitat enhancement, and 8.3 acres of upland habitat restoration within the CREP area.

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Illinois Farm Bureau

CREP is a positive program in Illinois that provides cost share incentives and technical assistance to farmers looking to address resource concerns, including nutrient loss reduction efforts and other floodplain issues. Illinois Farm Bureau (IFB) continues to publicize and promote the Conservation Reserve Enhancement Program (CREP) through their statewide radio network and FarmWeek publication, as well as through the county Farm Bureau® system. During the time of no approved state funding for the program, IFB was in communication with IDNR and the United States Department of Agriculture (USDA) Farm Service Agency (FSA) to clarify IFB member questions and concerns about enrollment and participation in both the state and federal CREP programs. Illinois Farm Bureau continues to voice support for CREP.

Association of Illinois Soil and Water Districts (AISWCD)

The AISWCD, in partnership with the Illinois Environmental Protection Agency and the Illinois Department of Natural Resources, helped with administration of the CREP program, by providing funding to SWCDs through a two-year grant funded in part by IEPA 319 and IDNR CREP funds. The grant, which began in June 2012, is a cooperative effort between IEPA, IDNR and the AISWCD.

Through the grant, six positions have been established in strategic workload areas of the Illinois River basin. The six CREP Resource Specialists (CRSs) work with groups of SWCDs within Land Use Councils to monitor existing contracts and work with landowners to enroll additional acres into the Illinois River CREP Area. In addition, the CRSs work with interested landowners to help them enroll acres in the Federal CRP in an effort to increase the acres that will also be eligible for enrollment in CREP. CRSs are also working with landowners to help develop post enrollment management plans for their CREP acres.

The ability to utilize six full-time staff to work exclusively with the CREP program is helping to expedite the enrollment process, increasing the level of monitoring of existing contracts and providing landowners with additional services to benefit their CREP acres and ultimately increase water quality benefits attributable to the Conservation Reserve Enhancement Program. Unfortunately, due to state budget constraints the CREP grant ended almost mid-year, in May.

AISWCD, during the remaining five months of the grant, has kept track of CRSs timesheets, expense vouchers, trainings, and insurance. The office administers payment to the Housing Districts twice yearly, and issues paychecks and expense voucher checks to the CRSs monthly. AISWCD has held many conference calls with the CRSs and has had them attend large meetings in Springfield so that they can answer any questions the AISWCD Board may have.

Again, due to lack of funding, all CRS positions were laid off as of May 31, 2016. The positions have no hire back date at this time as funding does not seem to be available in the near future.

We thank IDNR and IEPA for their support over the years for this program. This program has provided monetary income for both AISWCD and Soil & Water Conservation Districts while also helping to preserve and enhance Illinois' natural resources. Overall, this program provided many benefits and we hope to see it reemerge in the near future.

The Nature Conservancy

For the past several years, The Nature Conservancy, McLean County Soil and Water Conservation District, Natural Resources Conservation Service, Farm Service Agency, and the City of Bloomington have worked with landowners and producers in McLean County to implement Farm Bill programs that reduce nutrient loss from farm fields. Since 2013, nine wetlands have been installed in watersheds of the Mackinaw River in McLean County through enrollment in the Farmable Wetlands Program, Conservation Practice-39, under the Conservation Reserve Program. These wetlands are built specifically to capture and treat tile drainage water before entering adjacent waterways through denitrification by bacteria and uptake through vegetation. Additionally, two tile-treatment wetlands were constructed on City of Bloomington property in 2013 and 2014 near Lake Bloomington and Evergreen Lake. All wetlands will be monitored by The Nature Conservancy, UIUC, and the City of Bloomington to determine their nutrient loss effectiveness.

National Great Rivers Research and Education Center

Providing boots-on-the-ground since 2012, the National Great Rivers Research and Education Center's (NGRREC) *Illinois CREP Initiative* has focused efforts within the newest CREP-eligible watershed—the Kaskaskia River basin. Working in partnership with soil and water conservation districts and the Illinois Department of Natural Resources, Land Conservation Specialists (LCS) with NGRREC are dedicated to outreach with private landowners about CREP, one-on-one attention with agricultural producers about CREP options and the CREP process, and technical assistance to complete CREP projects and manage CREP conservation easement parcels.

Although grant funding of NGRREC's original *Illinois CREP Initiative* has ended, it was supported by the National Fish and Wildlife Foundation and the Illinois Department of Natural Resources. It adds to other long-term agricultural conservation initiatives at NGRREC, including efforts providing technical assistance to agricultural producers who participate in the Conservation Reserve Program and other USDA conservation programs. Together, agricultural conservation efforts complement NGRREC's research and education missions as they provide high-quality, science-based technical assistance and develop innovative outreach strategies to agricultural producers and private landowners.

The Illinois Natural Resources Conservation Service (NRCS) has stepped in to provide matching funds for NGRREC's CREP support and has allowed for the continued employment of a Land Conservation Specialist in the upper Kaskaskia basin. Due to the state budget impasse in FY2016 no funding is available for CREP enrollment and we have not filled LCS positions in the lower and middle Kaskaskia basin, so our efforts involving programmatic and logistical support for CREP have been minimal. However, our Land Conservation Specialist continues to develop relationships with private landowners who have expressed interest in CREP and has done site-assessments on expiring Federal CREP CRP. NGRREC's new Conservation Program Manager started in April 2016, and continues to develop relationships with IDNR's CREP team in Springfield and local NRCS offices in Madison and Fayette County. The manager has done some administrative work in Fayette County to push a few CREP contracts further along in the enrollment process. Also, in working with IDNR's CREP team we have received a required monitoring list for Fayette County and plan to help with upcoming 2017 and 2018 CREP monitoring.

Appendix A

ILLINOIS NATURAL
HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

Monitoring and Assessment of Aquatic Life in the Kaskaskia River for Evaluating IDNR Private Lands Programs: Annual Report 2016

Brian A. Metzke

and

Leon C. Hinz, Jr.

Illinois Natural History Survey
Prairie Research Institute
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INHS Technical Report 2016 (50)

Prepared for: Illinois Department of Natural Resources,
Office of Resource Conservation

Unrestricted: for immediate online release.

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Annual Summary Report

Project Title:
Monitoring and Assessment of Aquatic Life in the Kaskaskia River
for Evaluating IDNR Private Lands Programs

Project Number:
RC13CREP01

Contractor information:
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Annual Reporting Period:
1 July 2015—30 June 2016

Annual Project Report Due Date:
13 December 2016

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Goals/ Objectives:
(1) Develop and initiate monitoring program that provides a basin-wide assessment of status and trends for aquatic life in wadeable streams of the Kaskaskia River; (2) track the status of selected populations of sensitive species in focal reaches of the Kaskaskia River associated with enhanced DO regulations, BSS designation, and presence of SGNC; (3) evaluate the influence of conservation easements and associated practices on biological communities within the Kaskaskia River Basin.

Project Title: Monitoring and Assessment of Aquatic Life in the Kaskaskia River for evaluating IDNR Private Lands Programs.

Summary of Work Completed During Reporting Period (7/1/2015 – 6/30/2016):

Work during this period continued monitoring efforts to characterize fish assemblages, benthic macroinvertebrate assemblages, physical habitat and water quality in streams within the Kaskaskia basin. During summer of 2015, 48 locations were surveyed (a survey event includes physiochemical and biological evaluations), bringing the total locations over three survey seasons to 139 (Table 1, Figure 1). Several of these locations have been surveyed in multiple years to evaluate interannual variation of stream characteristics or to compliment concurrent studies, and therefore the total number of monitoring events (i.e., efforts to characterize the physiochemical and biological attributes of a stream) is 179. Progress was made in assembling and evaluating relevant information from outside sources (e.g., Illinois Department of Natural Resources [IDNR], Illinois Environmental Protection Agency [IEPA]) during the reporting period.

Three types of survey locations, corresponding to monitoring objectives, were visited during the reporting period (Figure 2). Water quality, habitat, benthic macroinvertebrates and fish were evaluated at 27 randomly selected survey locations for characterization of streams in the basin. An additional twelve locations with biological significance were surveyed (no electrofishing occurred), as they were in 2013 and 2014. The four ISWS in the Kaskaskia basin were also surveyed, as they were in 2014. Seventeen additional locations were surveyed in support of graduate student research.

Continuous temperature recorders were placed at 44 survey locations. These records were combined with those from previous years (81 total records) to characterize thermal regime within the basin (Figure 3). Mean daily summer temperature in evaluated streams ranged from 18.9^{o}C to 27.2^{o}C with a mean of 23.5^{o}C. Temperature records were used to construct models for estimation of mean temperature, maximum temperature and temperature variability throughout the basin. These models may be valuable in identifying interactions between temperature and environmental characteristics and spatial patterns in assemblage composition.

Water quality parameters (dissolved oxygen, specific conductance, turbidity, pH, nitrate nitrogen, total reactive phosphorus, ammonia nitrogen and temperature) were measured during summer base flow conditions at 39 survey locations, bringing the total number of water quality measurement events to 210 for the three-year monitoring effort.

Physical habitat evaluations, using the Qualitative Habitat Evaluation Index (QHEI, OEPA 2006) and the Illinois Habitat Index (IHI, Sass et al. 2011), were completed at 47 locations during the reporting period. A total of 171 habitat evaluations have been completed during the monitoring effort.

Thirty-two summer benthic macroinvertebrate surveys were completed during the reporting period, bringing the three-year total to 151. All macroinvertebrate samples were prepped for processing and shipped to EcoAnalysts, Inc. (Moscow, ID) for identification and enumeration. Samples collected in 2013 and 2014 have been completed and those data have been received.

Electrofishing surveys occurred at 32 locations during the reporting period, and the total number of completed surveys is now 123.

More than 3250 water quality, habitat, fish and mussel survey records from external sources were compiled to improve spatiotemporal coverage of information regarding stream characteristics in the basin. These records will be evaluated separately from our monitoring data as several parameters differ from those we used. But, when appropriate, our monitoring data and those from external sources will be combined for additional evaluations. Evaluation of monitoring results and of external data is ongoing.

Potential survey locations for the 2016 field season were selected and scouted in spring 2016 (Figure 4). Temperature recorders were placed at selected locations.

Work conducted during this reporting period was performed primarily by one FTE research scientist aided by the Principle Investigators, two graduate students and three hourly workers. A total of 14 hourly workers (mainly undergraduate students) have assisted staff during the three years of study.

Objective 1: Basin-wide status and trends.

To evaluate contemporary physiochemical and biological status of streams in the Kaskaskia River basin and to provide a baseline for comparison to future conditions, stream segments were randomly selected using a stratified (size and CRP density categories) procedure. During the 2015 field season, 27 basin-wide status assessment locations were surveyed (Figures 1 and 2).

During the three-year monitoring effort, 92 locations were surveyed for characterization of the Kaskaskia River basin. Spatial distribution (HUC8 stratum) was roughly equal with 25 to 22 surveys in each subbasin. Survey efforts occurred more frequently at small (size class 1) streams with low CRP density (CRP classes 1-3) due to the limited availability and accessibility of large streams with high CRP density. Fish were collected at most (84) locations and those without fish had either spring or summer (or both) macroinvertebrate collections to fulfill the biological component for a survey event. Fall water quality measures were taken at 33 basin-wide survey locations and at 84 locations during base flow surveys. Habitat was evaluated during each survey where fish or summer macroinvertebrates were collected, but not in every occasion when spring macroinvertebrates were the only biota collected.

Objective 2: Status of streams with sensitive species (focal stream monitoring).

Focal stream survey locations (n=15, Figures 1 and 2) were established in stream segments where Biologically Significant Streams (BSS; Bol et al. 2007) and Enhanced Dissolved Oxygen streams (IDNR/IEPA 2006) overlapped. These locations were selected to evaluate impacts of private land programs in areas of conservation concern. During this reporting period efforts focused on surveying focal locations for a third summer year.

Twelve of the fifteen sensitive species locations were surveyed in each study year, and one trio was surveyed in both 2013 and 2014. Spring EPT were collected at each location in 2014 and 2015. Fall water quality measurements were taken at all locations in 2013 and at nine locations in 2014. Summer macroinvertebrates were collected at each location during each survey event.

Objective 3: Influence of private land conservation efforts (fixed site monitoring):

ISWS selected four locations for their monitoring that we use as fixed sites (Figures 1 and 2) to evaluate physiochemical and biological characteristics while ISWS concurrently evaluates discharge, sediment loading and nutrient loading.

Fixed locations were surveyed in 2014 and 2015 following their establishment by the ISWS. Water quality measurements were taken in three of the four locations in fall 2014. Spring EPT were collected at one location in 2014 and two locations in 2015. Macroinvertebrates were collected during each survey event, but fish could only be collected at three of the four locations.

Reporting:

Two presentations at scientific conferences (Drake et al. 2015, Metzke and Hinz, Jr. 2016) were given during the reporting period. Presentations described relationships between fish assemblages and watershed characteristics. The final project report is in preparation.

Literature Cited:

Bol, L., A.M. Holtrop, L.C. Hinz, Jr. and J. Epifanio. 2007. Evaluating Streams in Illinois based on Aquatic Biodiversity. INHS Technical Report 2007(57).

Drake, L., Y. Cao, L.C. Hinz, Jr., and B.A. Metzke. 2015a. The Conservation Reserve Program and Its Effect on Fish Diversity in the Kaskaskia Basin. American Fisheries Society Meeting, Portland, OR.

Illinois Department of Natural Resources and Illinois Environmental Protection Agency. 2006. Recommended Revisions to the Illinois General Use Water-Quality Standard for Dissolved Oxygen. Illinois Department of Natural Resources and Illinois Environmental Protection Agency, Springfield, IL.

Metzke, B.A. and L.C. Hinz, Jr. 2016. Evaluating the Relationship Between Incentive Based Conservation Land Programs and Fish Assemblages. Illinois Chapter of the American Fisheries Society Meeting, Springfield, IL.

Ohio Environmental Protection Agency. 2006. Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Technical Bulletin EAS/2006-06-1. State of Ohio Environmental Protection Agency, Division of Surface Water, June 2006.

Sass, L., L.C. Hinz, Jr., J. Epifanio and A.M. Holtrop. 2010. Developing a multi-metric index for wadeable streams in Illinois. Final Report to the Illinois Department of Natural Resources. Illinois Natural History Survey Technical Report 2010/21.

Table 1. Frequency of survey events (data collection) and number of locations (unique stream segments) for physiochemical and biotic characterization of streams in the Kaskaskia River basin between 2013 and 2015.

	Survey Purpose					
Evaluated Characteristic	**Basin-Wide Status**	**Focal**	**ISWS**	**Student Research/ Special Questions**	**Total Events**	**Total Locations**
Fish Assemblage	83	0	6	34	123	113
Benthic Macroinvertebrate Assemblage	78	42	8	23	151	126
Spring EPT Macroinvertebrate Assemblage	68	30	3	0	101	86
Water Quality	117	66	11	16	210	126
Temperature Regime	47	18	2	0	67	60
Habitat	87	42	8	34	171	159
Total Locations:	92	12	4	31		

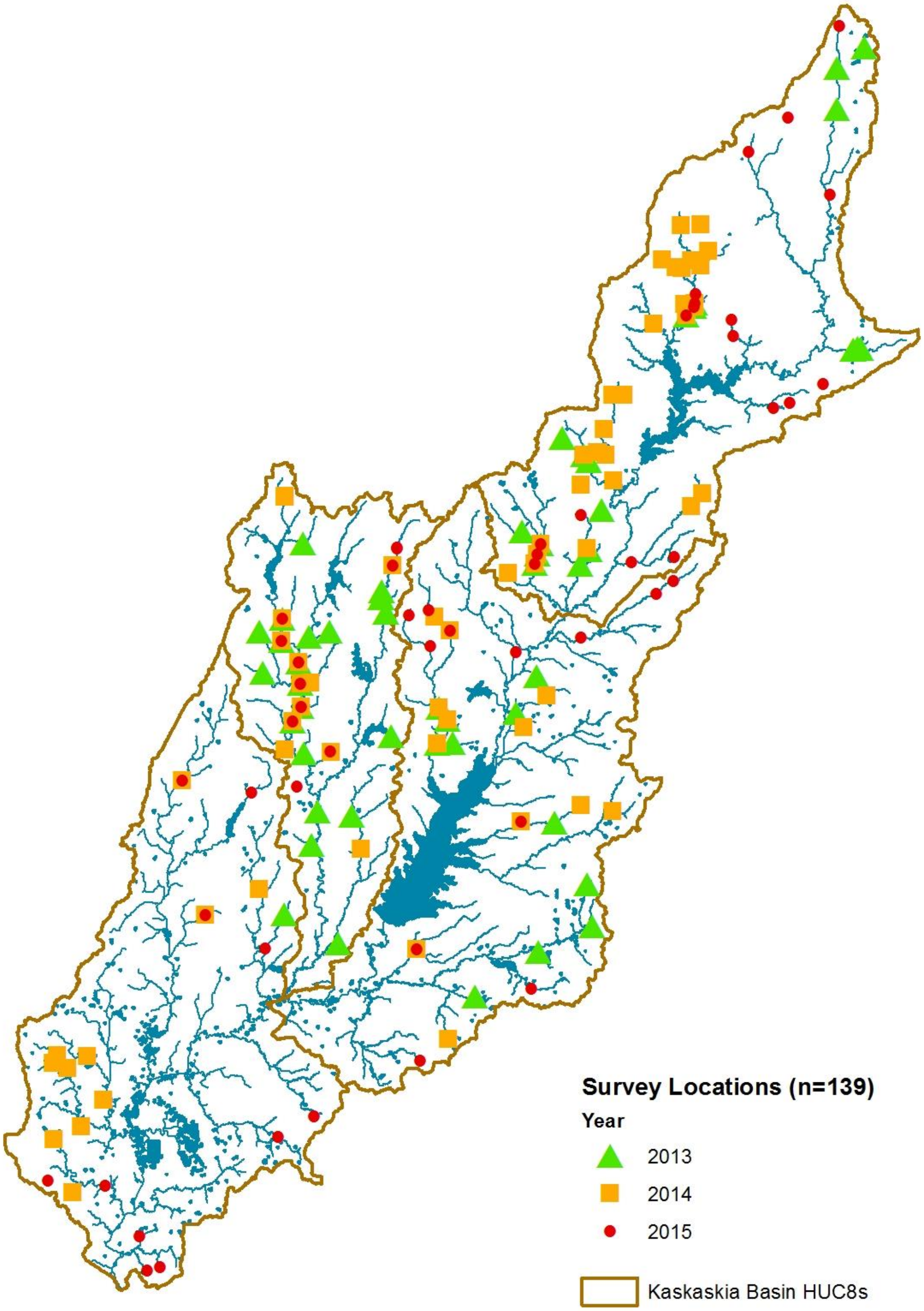

Figure 1. Location and survey year for all data collection events between 2013 and 2015.

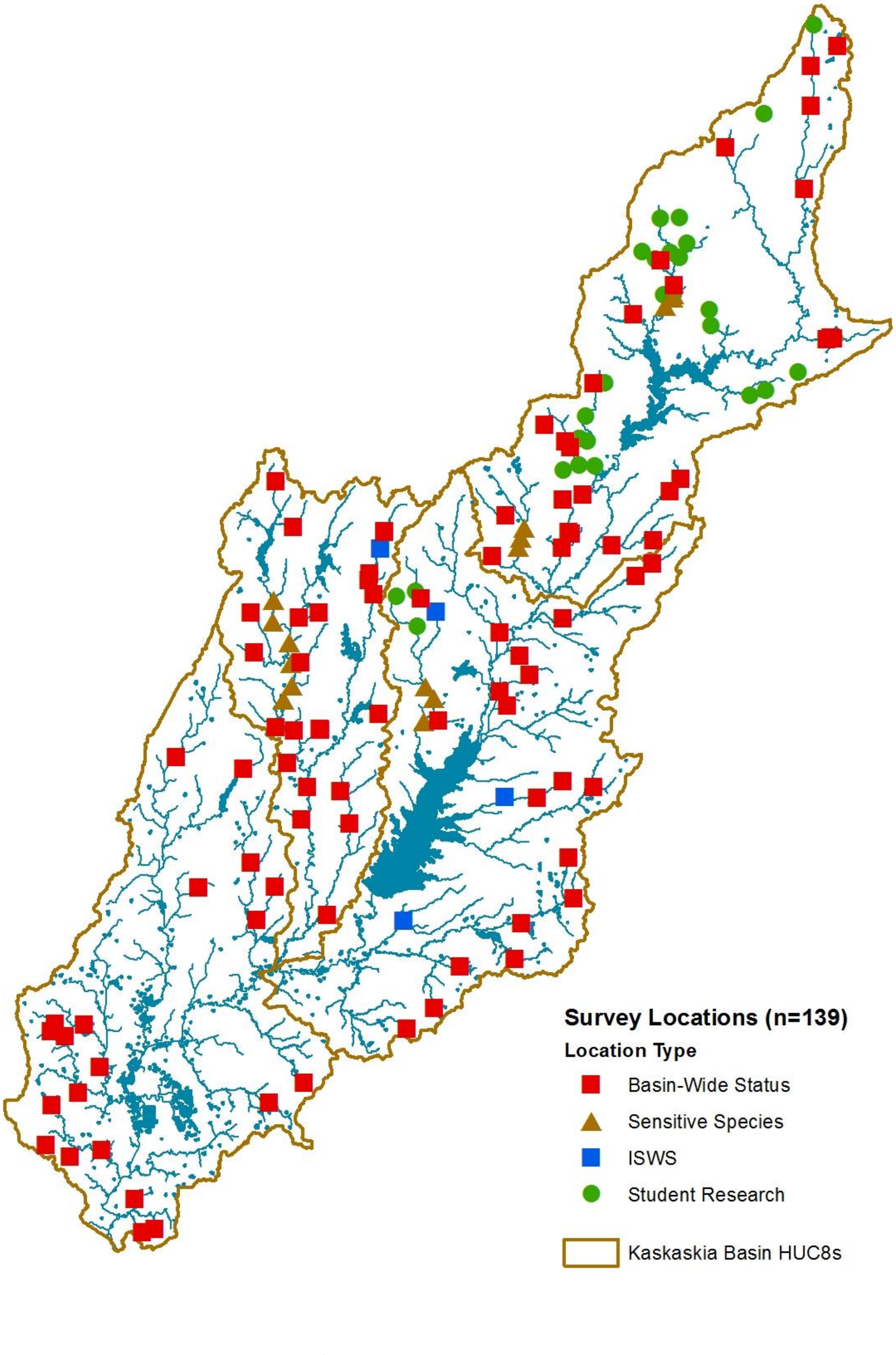

Figure 2. Location and purpose for all data collection events between 2013 and 2015.

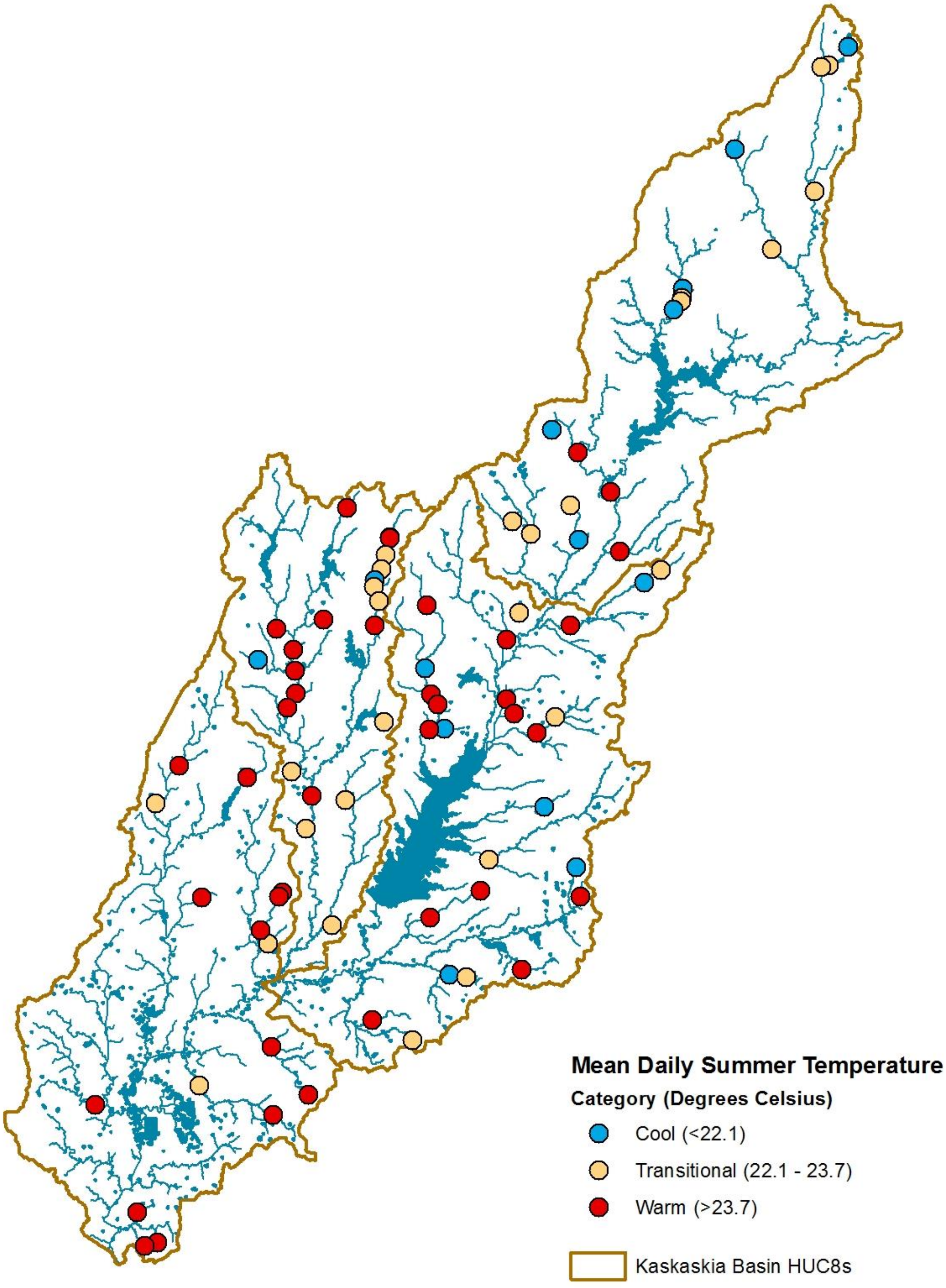

Figure 3. Location and mean daily summer temperature for all valid temperature data (n=81) recorded between 2013 and 2015.

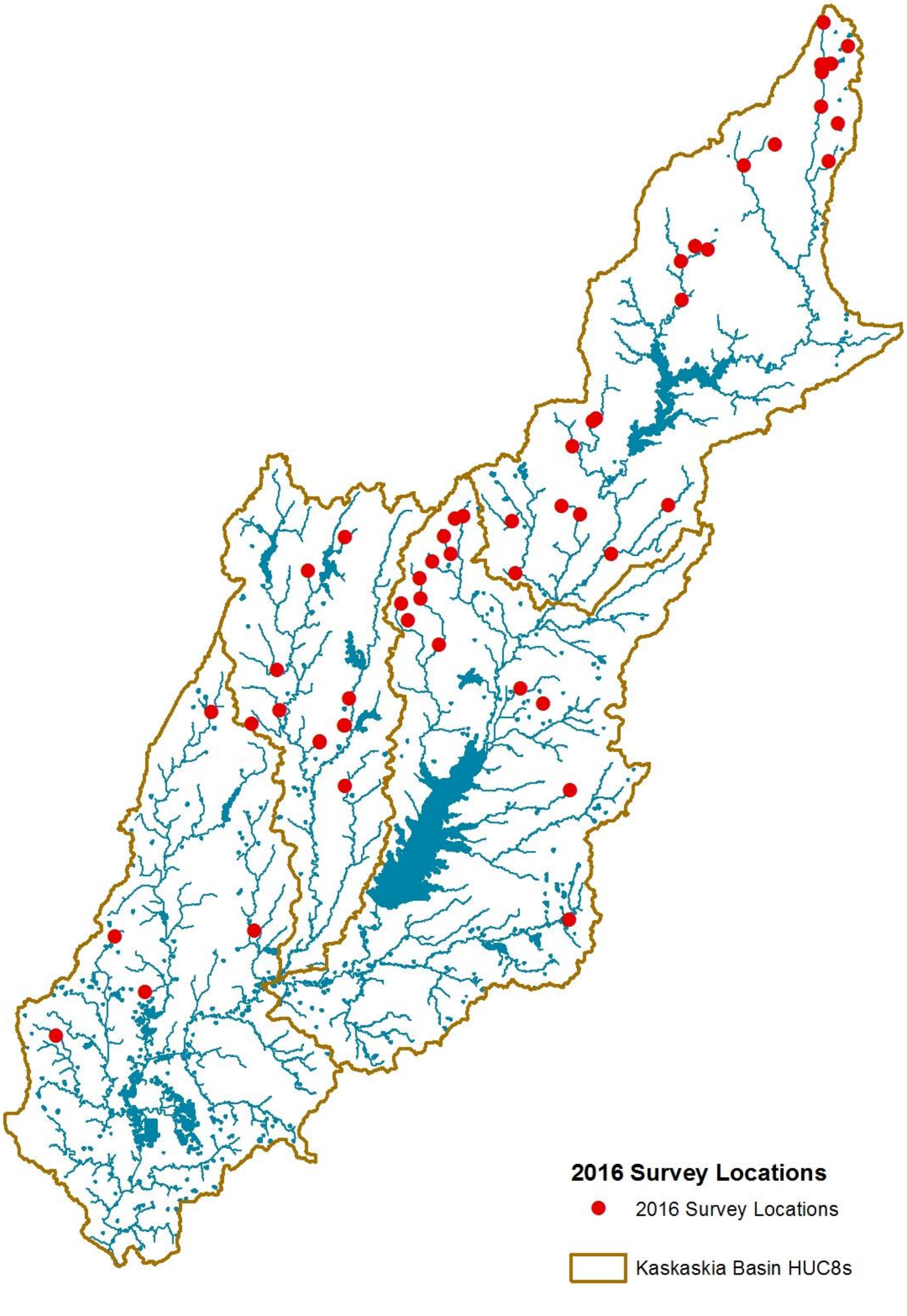

Figure 4. Survey locations for the 2016 field season monitoring effort.

Appendix B

Monitoring and Evaluation of Sediment and Nutrient Delivery to the Illinois River: Illinois River Conservation Reserve Enhancement Program (CREP)

by
Illinois State Water Survey
Illinois Department of Natural Resources

Prepared for the
Office of Resource Conservation,
Illinois Department of Natural Resources

Water Year 2015

This report was printed on recycled and recyclable papers.

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Monitoring and Evaluation of Sediment and Nutrient Delivery to the Illinois River: Illinois River Conservation Reserve Enhancement Program (CREP)

by
Illinois State Water Survey
Illinois Department of Natural Resources

1. Introduction

The Illinois River Conservation Reserve Enhancement Program (CREP) was initiated as a joint federal/state program with the goal of improving water quality and wildlife habitat in the Illinois River basin. Based on numerous research and long-term data, the two main causes of water quality and habitat degradations in the Illinois River were known to be related to sedimentation and nutrient loads. Based on this understanding, the two main objectives of the Illinois River CREP were stated as follows:

1) Reduce the amount of silt and sediment entering the main stem of the Illinois River by 20 percent.

2) Reduce the amount of phosphorous and nitrogen loadings to the Illinois River by 10 percent.

To assess the progress of the program towards meeting the two goals, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) are developing a scientific process for evaluating the effectiveness of the program. The process includes data collection, modeling, and evaluation. Progress made so far in each of these efforts is presented in this report.

Acknowledgments

The work upon which this progress report is based is supported by funds provided by the Office of Resource Conservation, Illinois Department of Natural Resources, under the guidance of Mike Chandler, IDNR CREP Program Director whose support and guidance is greatly appreciated. The project is also supported as part of the authors' regular duties at the Illinois State Water Survey under the guidance of Mike Demissie, Director, Illinois State Water Survey and ISWS Principal Investigator for the CREP studies.

Several Illinois State Water Survey staff participated and contributed towards the successful accomplishment of project objectives. Jim Slowikowski and Kip Stevenson are responsible for the data collection and analysis. Laura Keefer was responsible for analysis of the

land use data with assistance from Erin Bauer. Jas Singh and Yanqing Lian were responsible for the development of the watershed models. Elias Getahun and Vern Knapp provided the analyses on variability and trends in precipitation and streamflow in the Illinois River basin. Momcilo Markus analyzed the Illinois Environmental Protection Agency nutrient data for analyses of long-term trends. Sangeetha Chandrasekaran and Elias Getahun analyzed the Benchmark Sediment Monitoring data for long-term trend analysis. Patti Hill prepared the draft and final reports.

2. Monitoring and Data Collection

The monitoring and data collection component consist of a watershed monitoring program to monitor sediment and nutrient for selected watersheds within the Illinois River basin and also to collect and analyze land use data throughout the river basin. Historically, there are a limited number of sediment and nutrient monitoring stations within the Illinois River basin, and most of the available records are of short duration. For example, figure 2-1 shows all the active and inactive sediment monitoring stations within the Illinois River basin prior to the start of monitoring for CREP. Out of the 44 stations shown in the map, only 18 stations had records longer than 5 years and only 8 stations had more than 10 years of record. Therefore the available data and monitoring network was insufficient to monitor long-term trends especially in small watersheds where changes can be observed and quantified more easily than in larger watersheds.

To fill the data gap and to generate reliable data for small watersheds, the Illinois Department of Natural Resources funded the Illinois State Water Survey to initiate a monitoring program that will collect precipitation, hydrologic, sediment, and nutrient data for selected small watersheds in the Illinois River basin that will assist in making a more accurate assessment of sediment and nutrient delivery to the Illinois River.

Sediment and Nutrient Data

Five small watersheds located within the Spoon and Sangamon River watersheds were selected for intensively monitoring sediment and nutrient within the Illinois River basin. The locations of the watersheds and the monitoring stations are shown in figures 2-2 and 2-3 and information about the monitoring stations is provided in table 2-1. Court and North Creeks are located within the Spoon River watershed, while Panther and Cox Creeks are located within the Sangamon River watershed. The Spoon River watershed generates the highest sediment per unit area in the Illinois River basin, while the Sangamon River watershed is the largest tributary watershed to the Illinois River and delivers the largest total amount of sediment to the Illinois River. The type of data collected and the data collection methods have been presented in detail in the first progress report for the monitoring program (Demissie et al., 2001) and in the Quality Assurance Project Plan (QAPP) given in Appendix A. This report presents the data that have been collected and analyzed at each of the monitoring stations.

Table 2-1. Sediment and Nutrient Monitoring Stations Established for the Illinois River CREP

Station ID	*Name*	*Drainage area*	*Watershed*
301	Court Creek	66.4 sq mi (172 sq km)	Spoon River
302	North Creek	26.0 sq mi (67.4 sq km)	Spoon River
303	Haw Creek	55.2 sq mi (143 sq km)	Spoon River
201	Panther Creek	16.5 sq mi (42.7 sq km)	Sangamon River
202	Cox Creek	12.0 sq mi (31.1 sq km)	Sangamon River

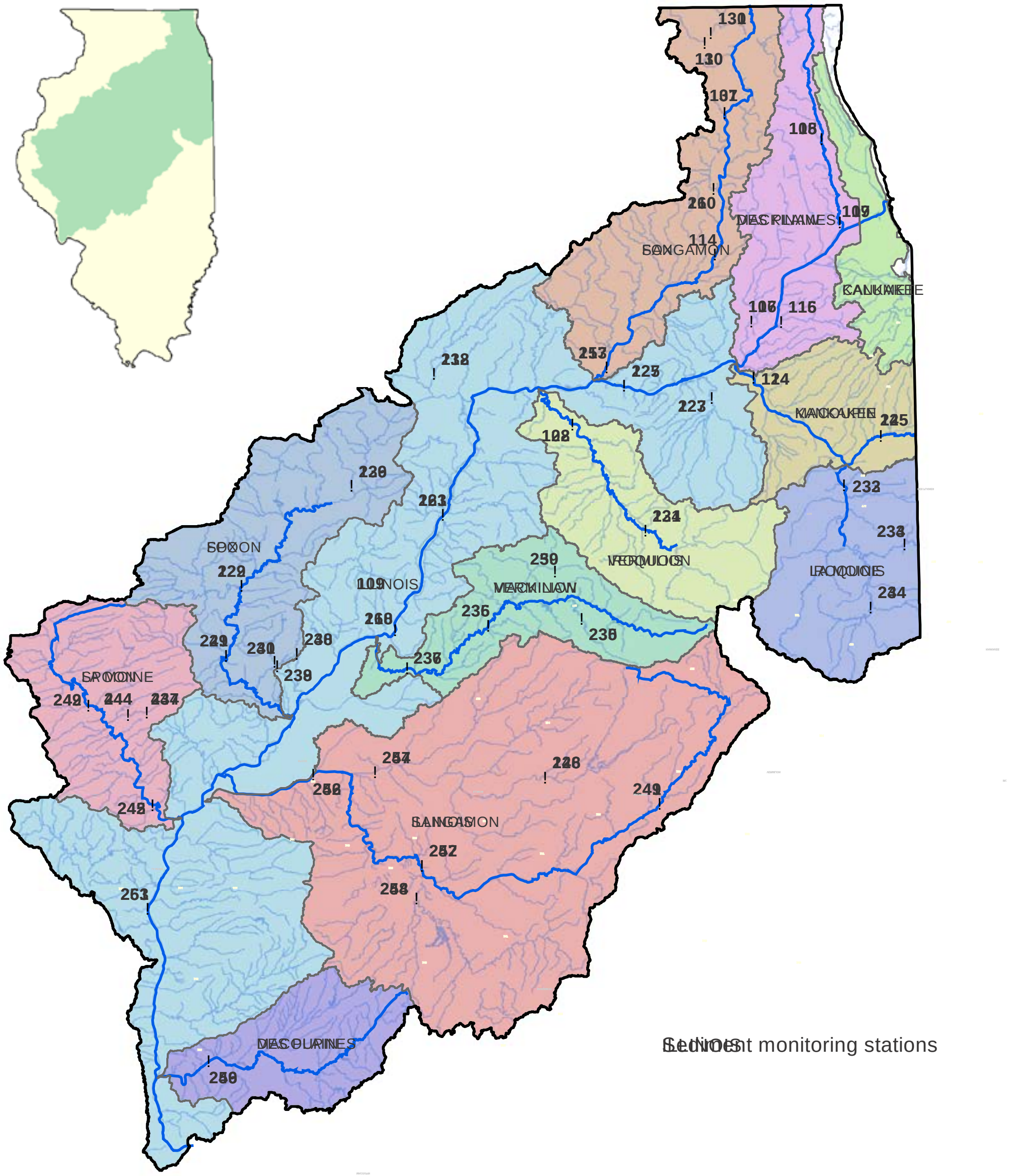


Figure 2-1. Locations of available in-stream sediment data within the Illinois River watershed, 1981-2000

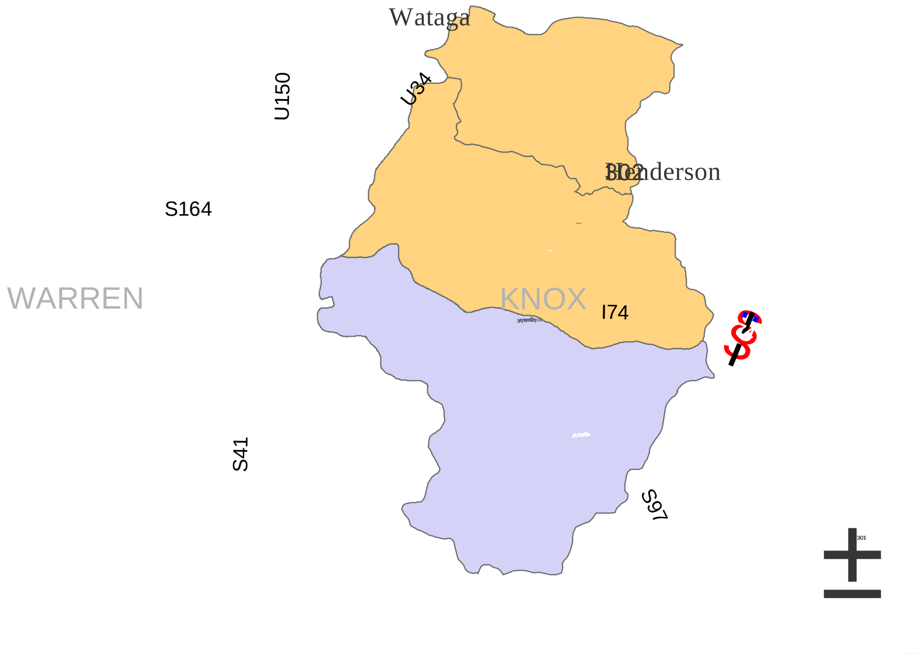


Figure 2-2. Location of monitoring stations in Court and Haw Creek watersheds

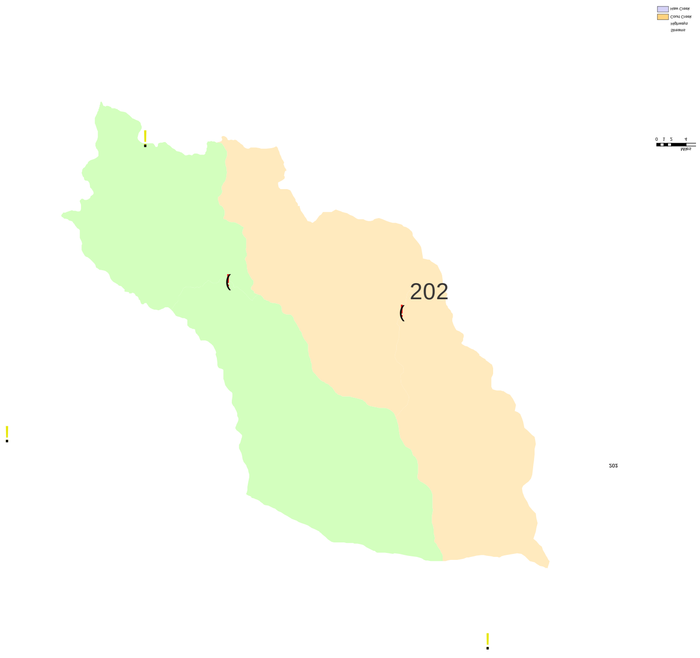


Figure 2-3. Location of monitoring stations in Panther and Cox Creek watersheds

Sediment Data

The daily streamflow and suspended sediment concentrations observed at all the five monitoring stations from Water Year 2000 to Water Year 2015 are given in Appendix B and C. Examples of the frequency of data collection are shown in figures 2-4 for the Court Creek Station. A summary of statistics for all stations showing the mean, medium, minimum maximum, 25th percentile, and 75th percentile are given in table 2-2. Over 32,509 samples have been collected and analyzed at the five monitoring stations since the monitoring program was initiated. As can be seen in the figures, suspended sediment concentrations are highly variable throughout a year and also from year to year depending on the climatic conditions. It is also evident that sediment concentrations are the highest during storm events resulting in the transport of most of the sediment during storm events. Therefore, it is extremely important that samples are collected frequently during storm events to accurately measure sediment loads at monitoring stations.

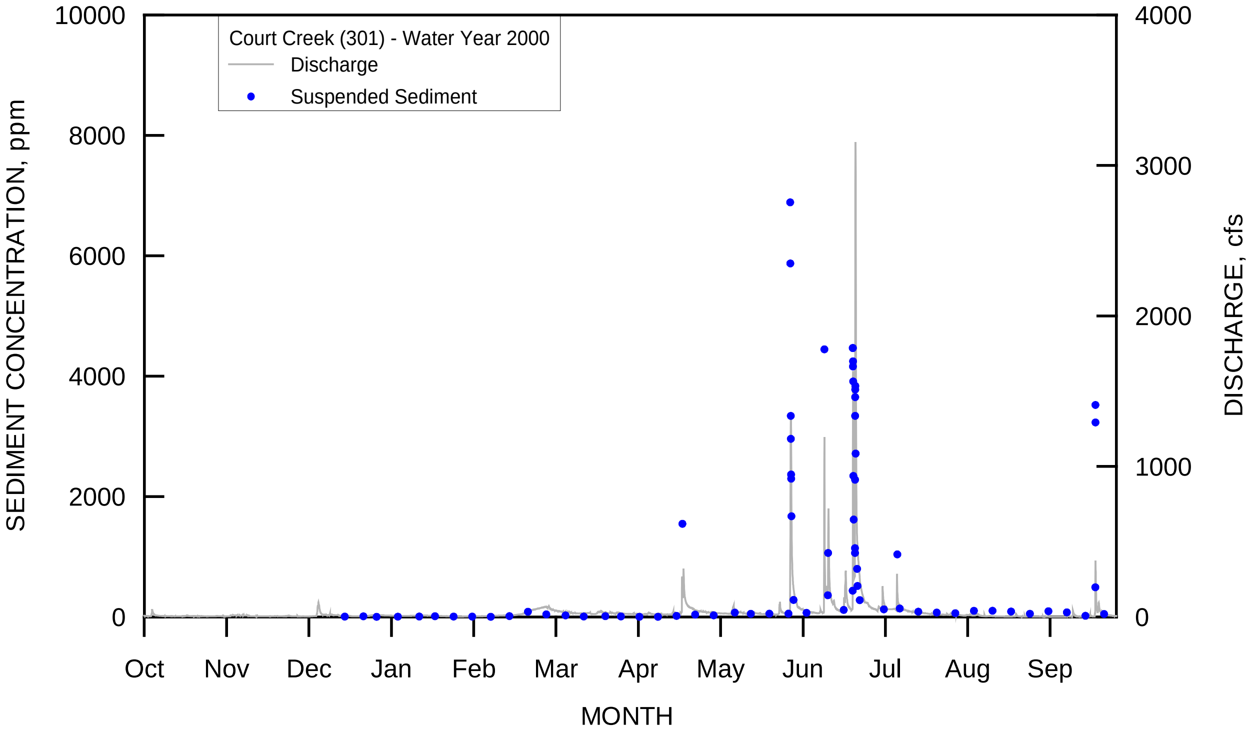
Nutrient Data

All the nutrient data collected and analyzed from Water Year 2000 through Water Year 2015 at the five monitoring stations are given in Appendices D and E. The nutrient data are organized into two groups: nitrogen species and phosphorous species. The nitrogen species include nitrate-nitrogen (NO_3-N), nitrite-nitrogen (NO_2-N), ammonium-nitrogen (NH_4-N), and total Kjedahl nitrogen (TKN). The phosphorous species include total phosphorous (TP), total dissolved phosphorous (TDP), and orthophosphate (P-ortho). Over 5,883 samples have been collected and analyzed for nitrate (NO_3-N), ammonium (NH_4-N) and orthophosphate (P-ortho). In addition, more than 3,310 samples have been analyzed for nitrate (NO_2-N), total Kjeldahl nitrogen (TKN), total phosphorous (TP), and total dissolved phosphorous (TDP). Examples of the type of data collected for the nitrogen species are shown in figure 2-5, while those for the phosphorous species are shown in figure 2-6. A summary statistics for all stations showing the mean, median, minimum, maximum, 25th percentile, and 75th percentile are given in table 2-2.

Data for the nitrogen species at all five monitoring stations show that the dominant form of nitrogen transported by the streams is nitrate-N. However, during storm events, the concentration of TKN rises significantly, sometimes exceeding the nitrate-N concentration. TKN is highly correlated to suspended sediment concentrations.

One significant observation that can be made from the data is the consistently higher concentrations of nitrate-N at Panther Creek and Cox Creek (tributaries to the Sangamon River) than at Court Creek, North Creek, and Haw Creek (tributaries of the Spoon River).

Data for the phosphorous species at all five monitoring stations show that most of the phosphorous load is transported during storm events. Concentrations of total phosphorous are the highest during storm events and relatively low most of the time. This is very similar to that shown by sediment and thus implies high correlations between sediment and phosphorous concentrations and loads. In terms of phosphorous concentrations, it does not appear there is any significant difference between the different monitoring stations from the Spoon and Sangamon River watersheds.



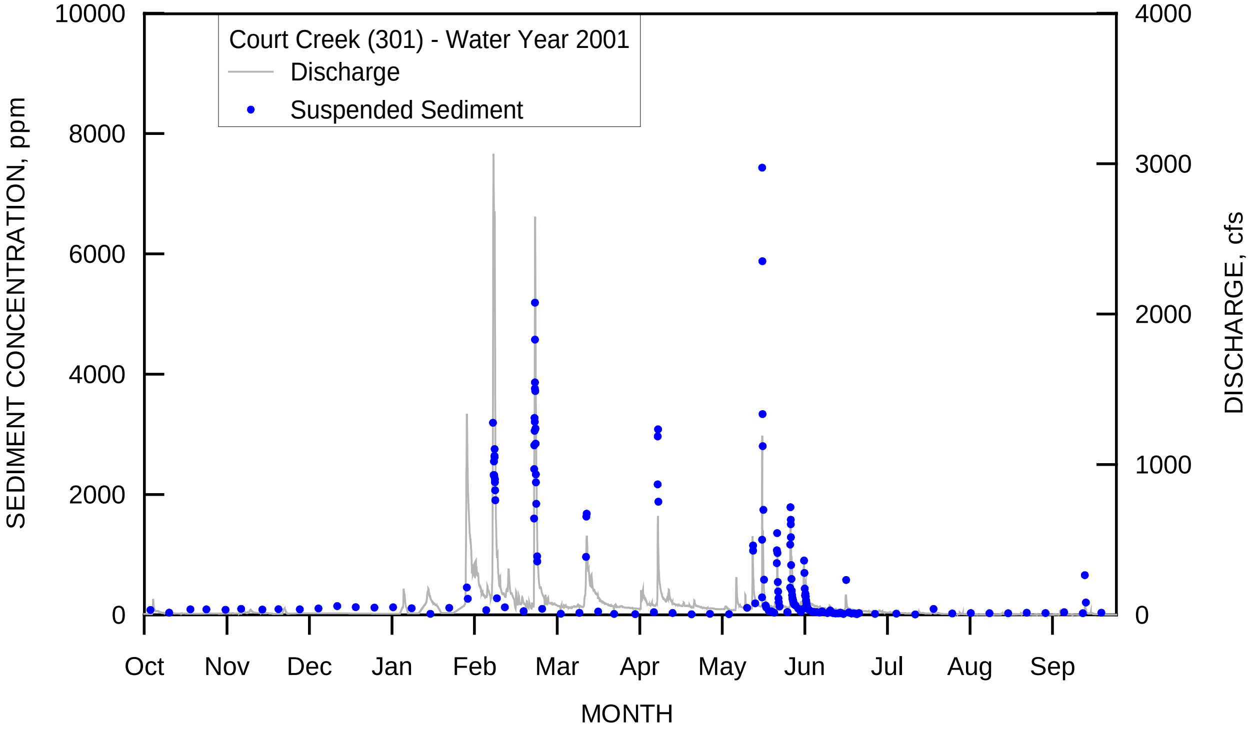


Figure 2-4. Suspended sediment concentrations and water discharge at Court Creek (301) for Water Years 2000 and 2001

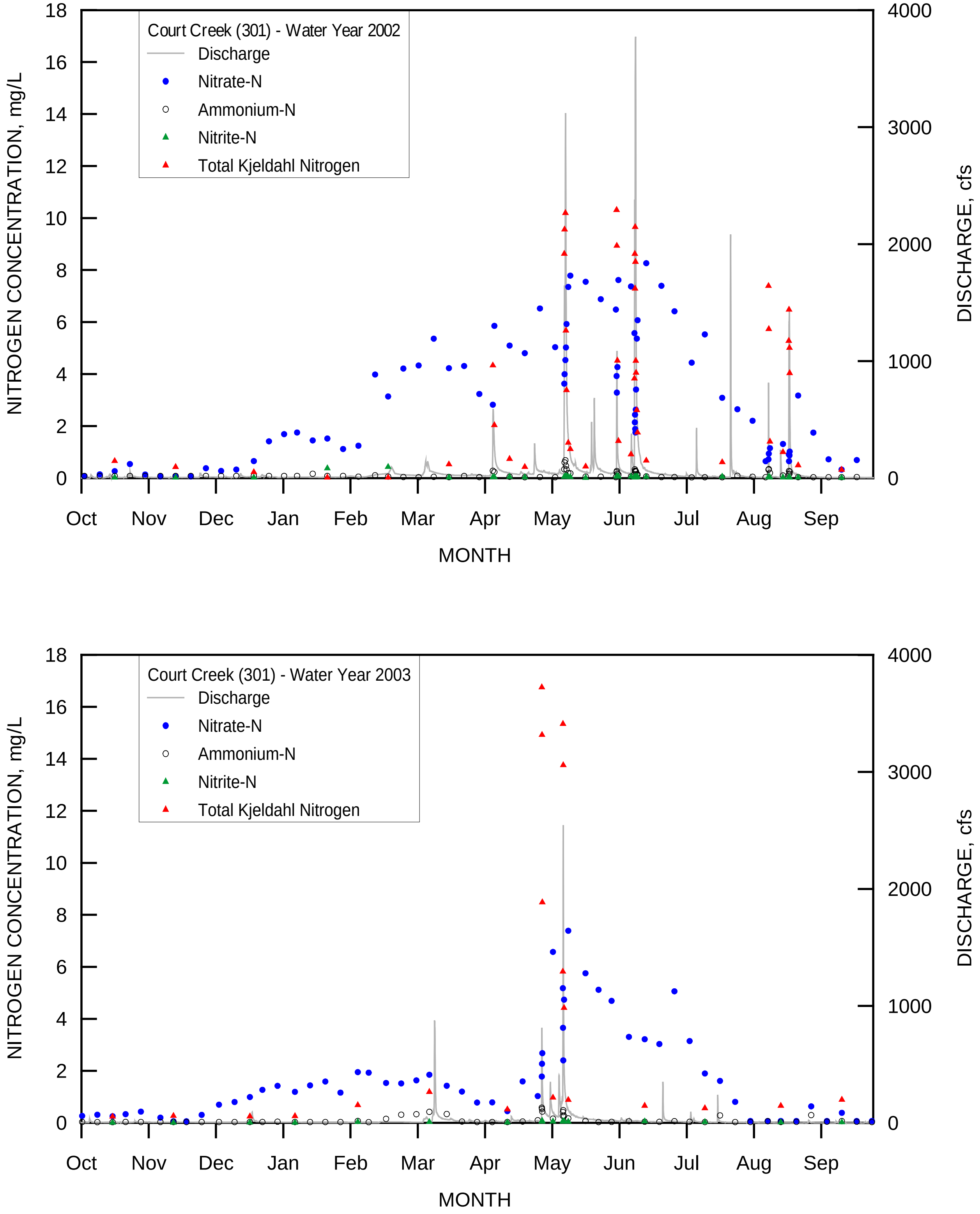


Figure 2-5. Concentrations of nitrogen species and water discharge at Court Creek (301) for Water Years 2002 and 2003

Table 2-2. Summary Statistics for Water Years 2000–2015. All concentrations in mg/L

	NO3-N	*oPO4-P*	*NH4-N*	*NO2-N*	*TKN*	*t-P*	*t-P-Dissolved*	*SSC*
Panther Creek (Station 201)								
Count	1059	1059	1059	530	529	529	529	6431
Mean	3.85	0.12	0.10	0.03	2.35	1.01	0.18	907.7
Median	3.14	0.08	0.06	0.02	1.02	0.35	0.13	134.5
Min	< 0.04	< 0.01	< 0.03	< 0.01	< 0.12	< 0.03	< 0.03	1.47
Max	14.76	1.31	5.99	0.21	23.99	11.21	1.38	48289.0
25th Percentile	0.27	0.05	< 0.03	0.01	0.46	0.13	0.08	60.9
75th Percentile	6.32	0.14	< 0.08	0.04	2.93	1.24	0.20	483.3
Cox Creek (Station 202)								
Count	1071	1071	1071	538	538	538	538	5744
Mean	5.62	0.21	0.64	0.05	3.39	1.10	0.30	700.2
Median	5.23	0.11	0.07	0.04	1.44	0.45	0.17	156.2
Min	< 0.04	< 0.01	< 0.03	< 0.01	< 0.14	< 0.04	< 0.03	0.95
Max	19.83	7.81	300.33	1.26	390.37	29.10	8.21	23010.8
25th Percentile	0.93	0.06	0.05	0.02	0.60	0.17	0.09	81.6
75th Percentile	9.06	0.22	0.20	0.06	3.39	1.30	0.34	403.7
Court Creek (Station 301)								
Count	1250	1250	1250	748	747	747	747	6201
Mean	2.92	0.08	0.14	0.04	2.47	0.84	0.12	616.7
Median	2.70	0.05	0.07	0.03	1.39	0.37	0.09	110.7
Min	< 0.04	< 0.003	< 0.03	< 0.01	0.23	0.03	< 0.03	1.93
Max	11.37	0.93	1.73	0.13	18.69	6.58	0.97	13632.0
25th Percentile	0.90	0.03	0.05	0.02	0.67	0.13	0.06	47.9
75th Percentile	4.57	0.09	0.17	0.05	3.23	1.11	0.13	484.7
North Creek (Station 302)								
Count	1236	1236	1236	733	733	733	733	7107
Mean	2.93	0.08	0.15	0.04	2.27	0.77	0.13	485.5
Median	2.63	0.05	0.07	0.03	1.19	0.32	0.09	98.4
Min	< 0.04	< 0.003	< 0.03	< 0.01	0.23	< 0.04	< 0.03	0.36
Max	12.66	1.05	2.43	0.19	17.95	6.69	1.07	15137.1
25th Percentile	0.66	0.02	0.05	< 0.02	0.64	0.11	0.06	43.7
75th Percentile	4.65	0.09	0.15	0.05	2.62	0.90	0.14	280.0
Haw Creek (Station 303)								
Count	1267	1267	1267	761	761	761	761	7026
Mean	4.32	0.09	0.13	0.05	2.38	0.81	0.13	583.3
Median	4.14	0.06	0.07	0.04	1.51	0.45	0.09	169.3
Min	< 0.04	< 0.003	< 0.03	< 0.01	0.23	< 0.04	< 0.03	2.17
Max	12.59	1.38	1.49	0.21	17.15	7.27	1.41	12586.1
25th Percentile	1.76	0.04	0.05	0.03	0.69	0.16	0.06	57.1
75th Percentile	6.52	0.10	0.14	0.06	3.06	1.11	0.13	631.8

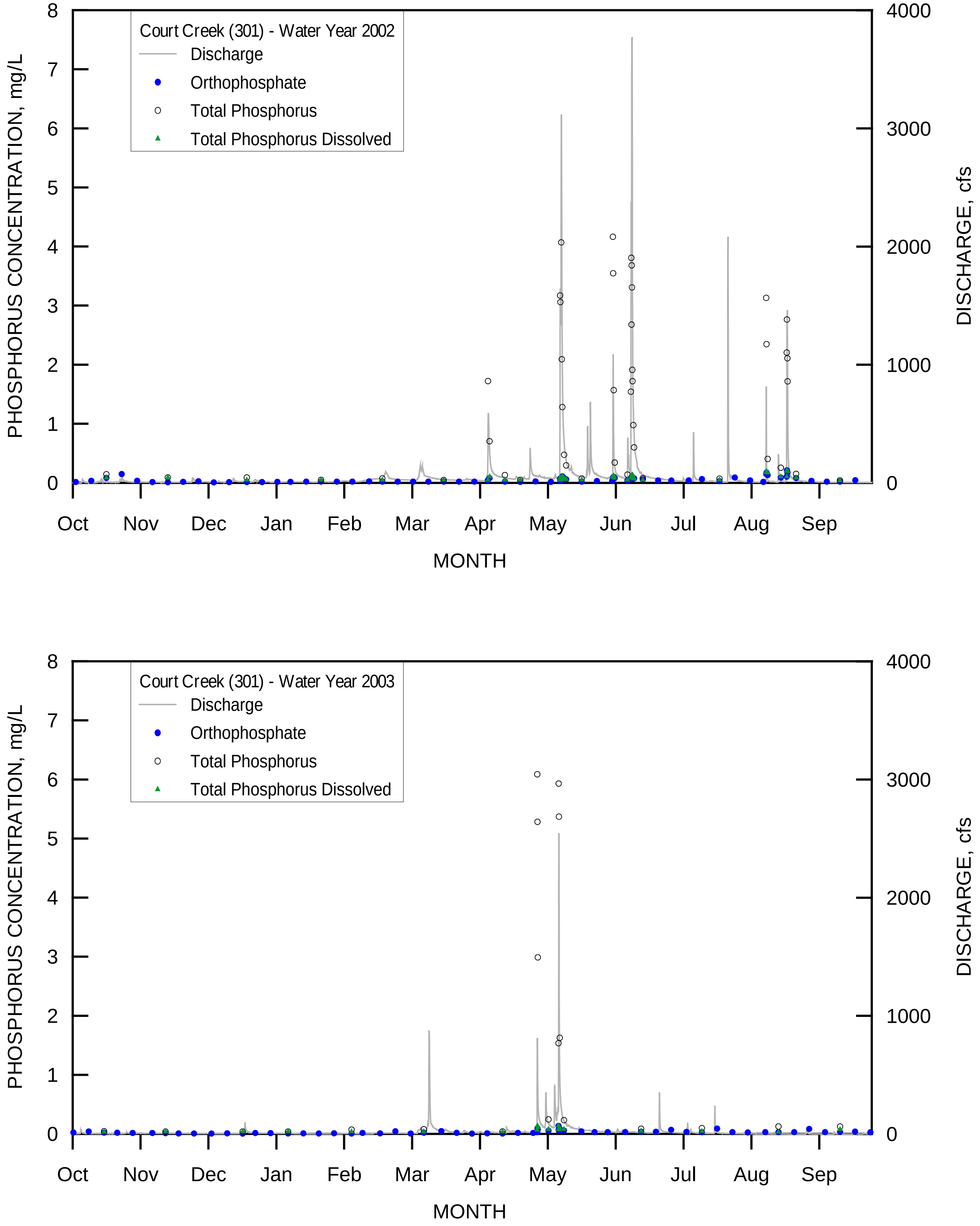


Figure 2-6. Concentrations of phosphorous species and water discharge at Court Creek (301) for Water Years 2002 and 2003

Sediment and Nutrient Loads

The sediment and nutrient concentrations and water discharges are used to compute the amount of sediment and nutrient transported past monitoring stations. Based on the available flow and concentration data, daily loads are computed for sediment and the different species of nitrogen and phosphorous. The daily loads are then compiled to compute monthly and annual loads. Results of those calculations are summarized in tables 2-3 to 2-7 for each of the five monitoring stations. Each table presents the annual water discharge, sediment load, nitrate-N load, TKN, and the total phosphorous load for one of the stations. Similar calculations have been made for the other species of nitrogen and phosphorous, but are not included in the summary tables. The annual sediment loads are highly correlated to the water discharge, and thus the wetter years, 2001, 2002, 2005, 2007, 2008, 2009, 2010, 2011, 2013, 2014 and 2015 generated more sediment at all stations as compared to drier years, 2000, 2003, 2004, 2006, and 2012. The annual sediment loads ranged from a low of 105 tons in WY2012 at Panther Creek to a high of 174,742 tons in 2009 at Court Creek. The nitrate-N loads ranged from a low of 1.8 tons in 2012 at Cox Creek to a high of 585 tons in WY2010 at Haw Creek. The TKN loads ranged from a low of 0.5 tons in WY2012 at Panther Creek to a high of 322.5 tons in WY2010 at Court Creek. The total phosphorous loads ranged from a low of 0.2 tons in 2012 at Cox Creek and Panther Creek to a high of 117.6 tons in 2010 at Court Creek. For comparison purposes, the runoff, sediment, nitrate-N, nitrite-N, ammonium-N, Kjeldahl-N, total phosphorous, total dissolved phosphorous, and total ortho-phosphate phosphorous loads (for the five monitoring stations) are shown in figures 2-7 to 2-14. In terms of the total annual loads, the larger watersheds, Court and Haw, consistently carry higher sediment and nutrient loads than Panther and Cox Creeks. However, per unit area Panther and Cox generate more sediment than Court, North, and Haw Creeks.

Table 2-3. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Court Creek Monitoring Station (301)

		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	11880	26527	131.2	89.1	35.0
2001	22100	43633	274.8	121.4	39.2
2002	17320	62898	203.7	131.9	47.9
2003	6805	21749	59.9	56.9	18.3
2004	7459	7359	76.0	26.1	7.5
2005	14400	18831	207.5	58.1	20.4
2006	5650	7897	84.3	23.2	6.5
2007	19376	48974	240.8	140.1	46.8
2008	22442	41077	265.4	131.4	45.6
2009	41207	174742	429.6	318.9	116.9
2010	44836	146202	425.9	322.5	117.6
2011	23311	55337	270.9	125.2	43.3
2012	6129	4145	36.7	18.0	4.8
2013	26158	116616	270.8	250.4	94.9
2014	14338	25407	59.9	88.9	30.4
2015	14834	24740	112.3	76.9	26.3

Table 2-4. Summary of Annual Water Discharges, Sediment and Nutrient Loads at North Creek Monitoring Station (302)

		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	4009	6969	42.8	28.2	10.4
2001	8091	16747	102.9	39.4	12.7
2002	7372	29269	97.8	66.4	24.2
2003	3039	11422	32.9	26.0	9.1
2004	3224	2038	37.7	10.0	2.4
2005	5266	6061	76.3	22.8	7.7
2006	2151	4179	36.2	11.3	3.4
2007	7524	16702	99.3	43.6	14.3
2008	9416	19762	119.0	58.7	21.0
2009	16544	62806	167.9	126.4	45.2
2010	18577	66501	167.4	143.6	52.7
2011	9491	25979	105.4	69.7	25.2
2012	2506	2207	14.9	7.6	2.0
2013	12624	60934	121.1	117.2	44.9
2014	5374	9176	19.4	36.1	12.1
2015	5525	8399	41.9	25.2	8.2

Table 2-5. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Haw Creek Monitoring Station (303)

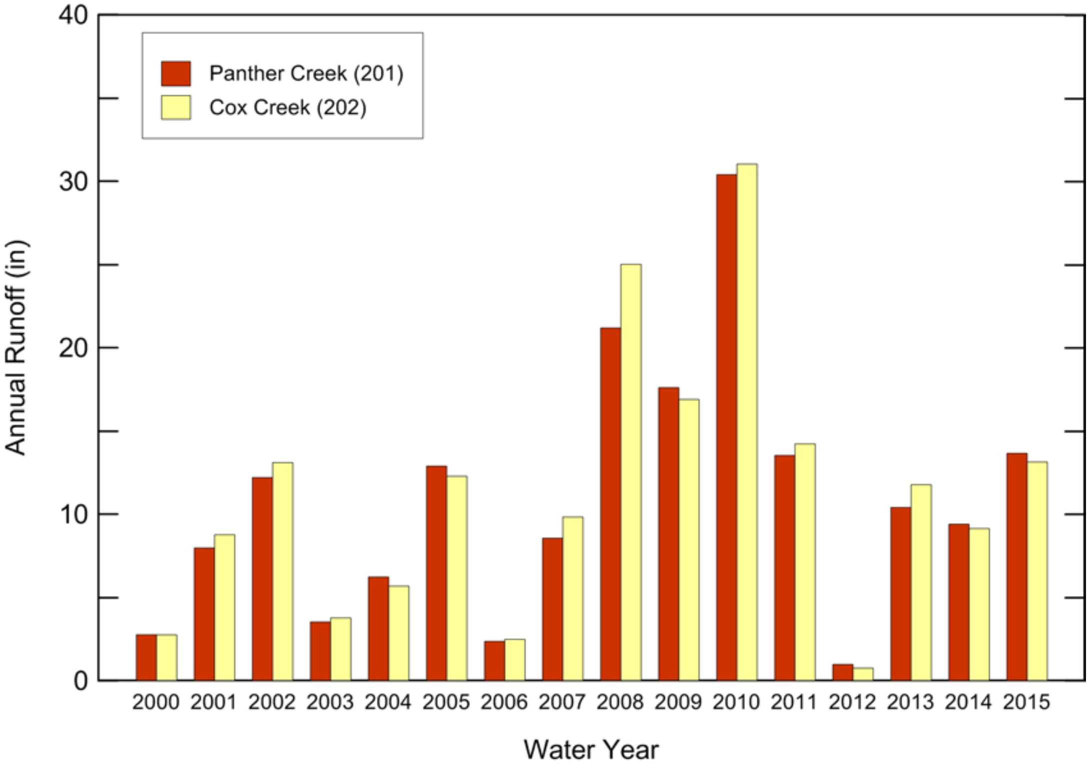
		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	11433	21283	162.2	85.2	32.0
2001	19878	49580	322.0	146.9	58.0
2002	15603	44221	256.5	119.5	42.8
2003	4337	5908	41.7	27.0	8.3
2004	8676	10914	143.4	38.8	12.6
2005	14661	18047	281.4	51.1	18.5
2006	5341	5770	113.7	20.1	6.0
2007	15032	20127	262.5	76.1	23.9
2008	14054	16396	227.0	69.5	25.5
2009	34003	104081	506.4	260.4	85.9
2010	40230	92974	585.2	236.2	85.4
2011	20788	37379	372.5	103.9	34.3
2012	5326	2185	55.1	13.5	3.3
2013	23581	75175	357.8	205.0	74.1
2014	14640	24149	115.3	86.9	29.8
2015	21718	49921	229.0	135.2	50.0

Table 2-6. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Panther Creek Monitoring Station (201)

		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	1236	4342	13.8	10.0	4.4
2001	3550	9839	84.9	11.0	5.1
2002	5440	34596	101.8	43.8	16.4
2003	1578	2955	26.4	5.0	1.8
2004	2787	7820	52.5	13.0	5.8
2005	5743	13793	112.2	21.6	10.2
2006	1053	2694	22.5	6.2	2.5
2007	3809	13410	75.4	22.1	10.6
2008	9437	83924	123.1	100.6	46.7
2009	7833	30921	117.7	31.5	13.9
2010	13539	56979	124.8	57.0	25.7
2011	6033	16786	72.8	26.7	9.9
2012	437	105	2.5	0.5	0.2
2013	4637	12309	123.9	16.8	6.0
2014	4184	21806	26.2	25.5	11.0
2015	6086	29908	78.1	27.8	12.3

Table 2-7. Summary of Annual Water Discharges, Sediment and Nutrient Loads at Cox Creek Monitoring Station (202)

		Load			
Water Year	*Water discharge (cfs)*	*Sediment (tons)*	*Nitrate-N (tons)*	*TKN (tons)*	*Total phosphorus (tons)*
2000	894	4153	10.3	12.4	5.7
2001	2833	9626	77.9	13.0	5.5
2002	4242	23207	100.6	44.6	16.1
2003	1226	1827	29.6	4.9	1.7
2004	1844	4597	45.3	8.7	3.7
2005	3976	8132	109.0	19.0	8.8
2006	806	3662	19.3	3.9	1.6
2007	3181	10105	81.5	17.5	7.2
2008	8097	73678	154.7	79.3	31.4
2009	5459	16331	135.9	21.9	8.6
2010	10040	27283	155.9	41.0	17.5
2011	4607	14021	91.5	29.7	9.6
2012	246	149	1.8	0.7	0.2
2013	3810	9906	149.7	13.9	5.2
2014	2955	13759	25.3	19.1	8.7
2015	4253	15156	97.7	16.8	6.9



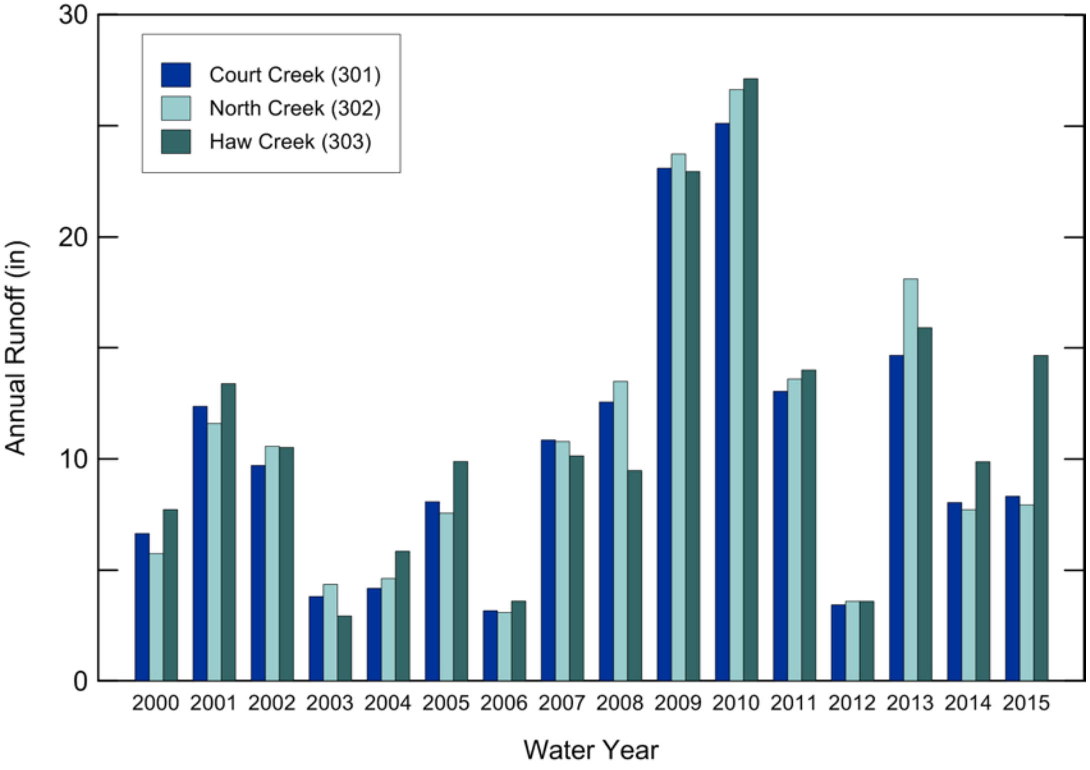


Figure 2-7. Annual runoff at the five CREP monitoring stations

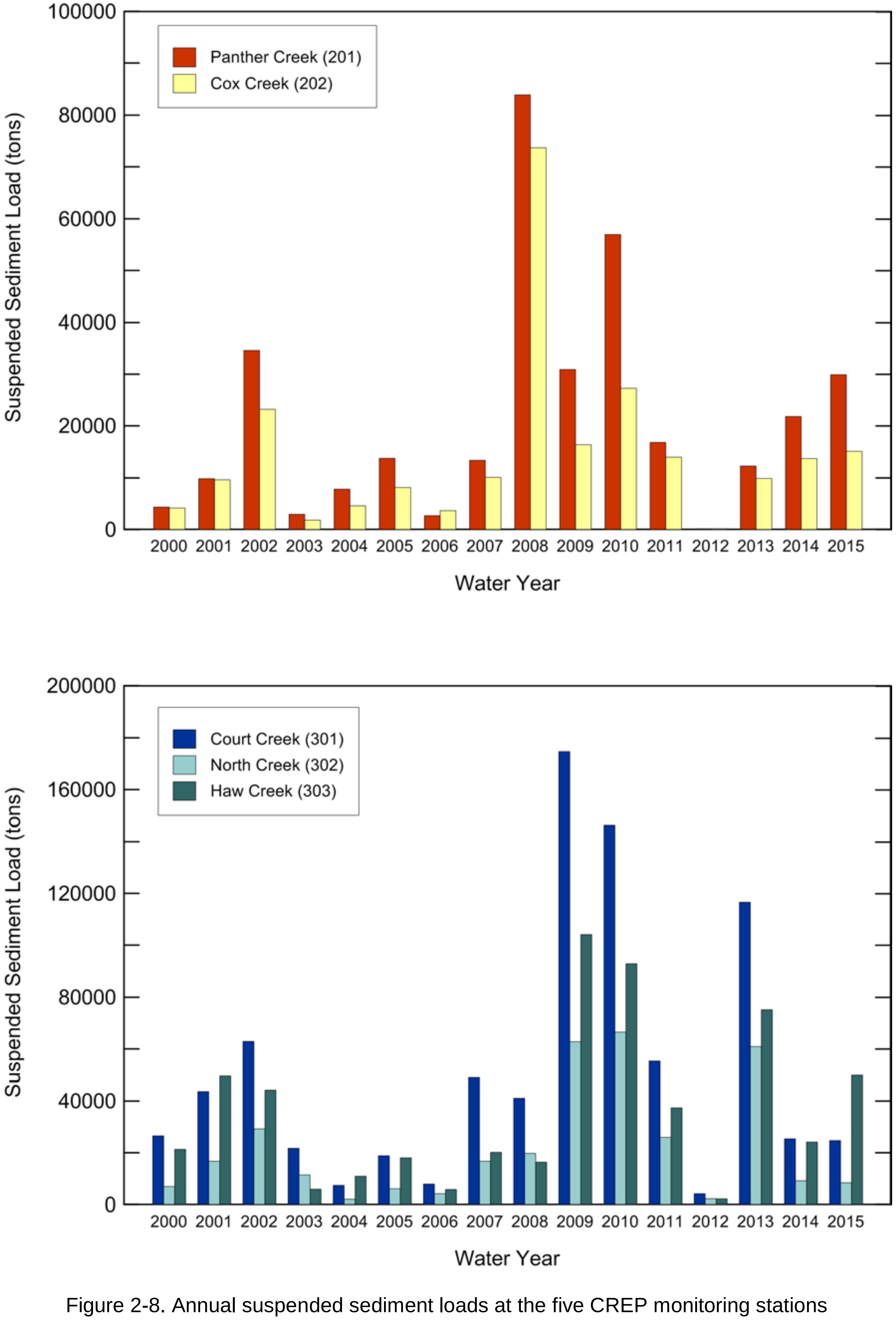
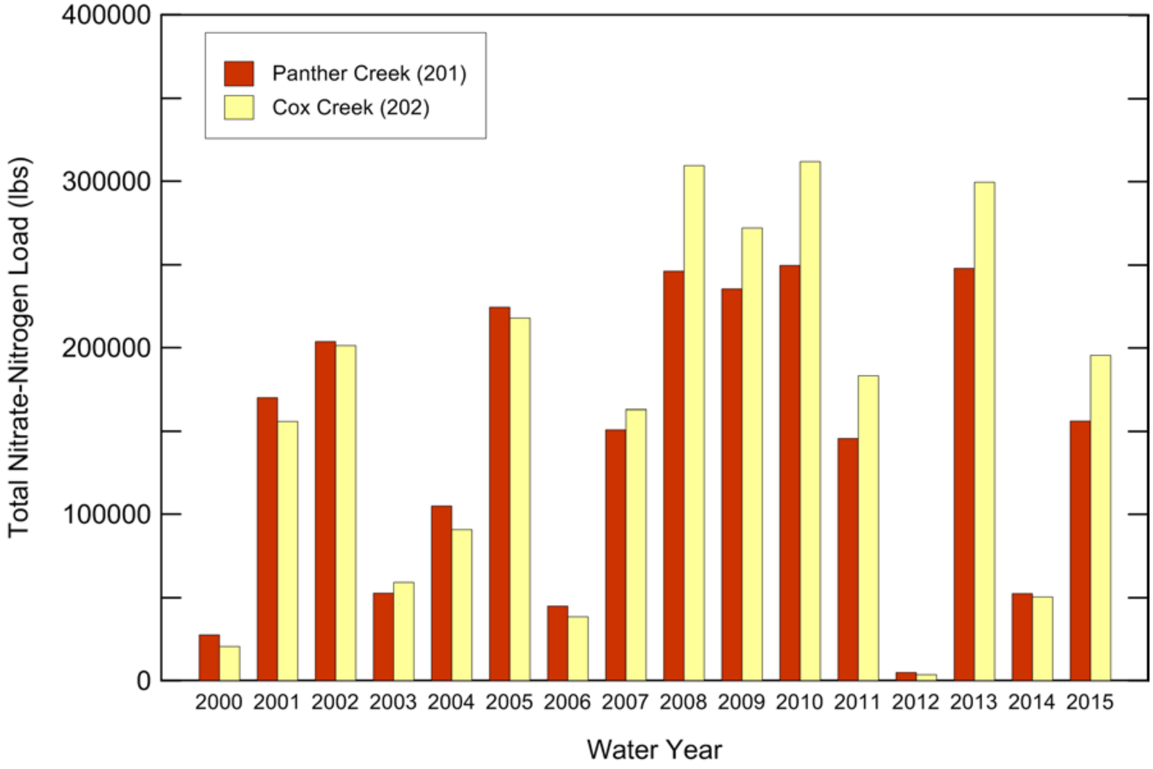


Figure 2-8. Annual suspended sediment loads at the five CREP monitoring stations



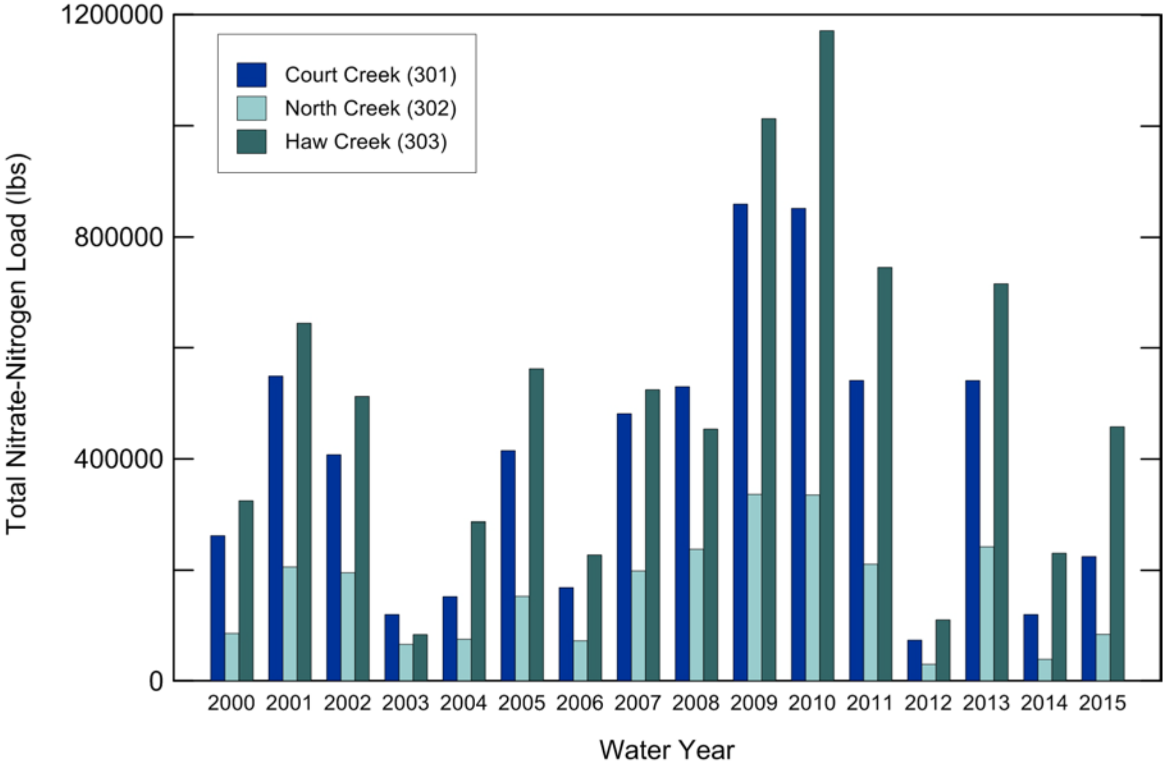


Figure 2-9. Annual nitrate-N loads at the five CREP monitoring stations

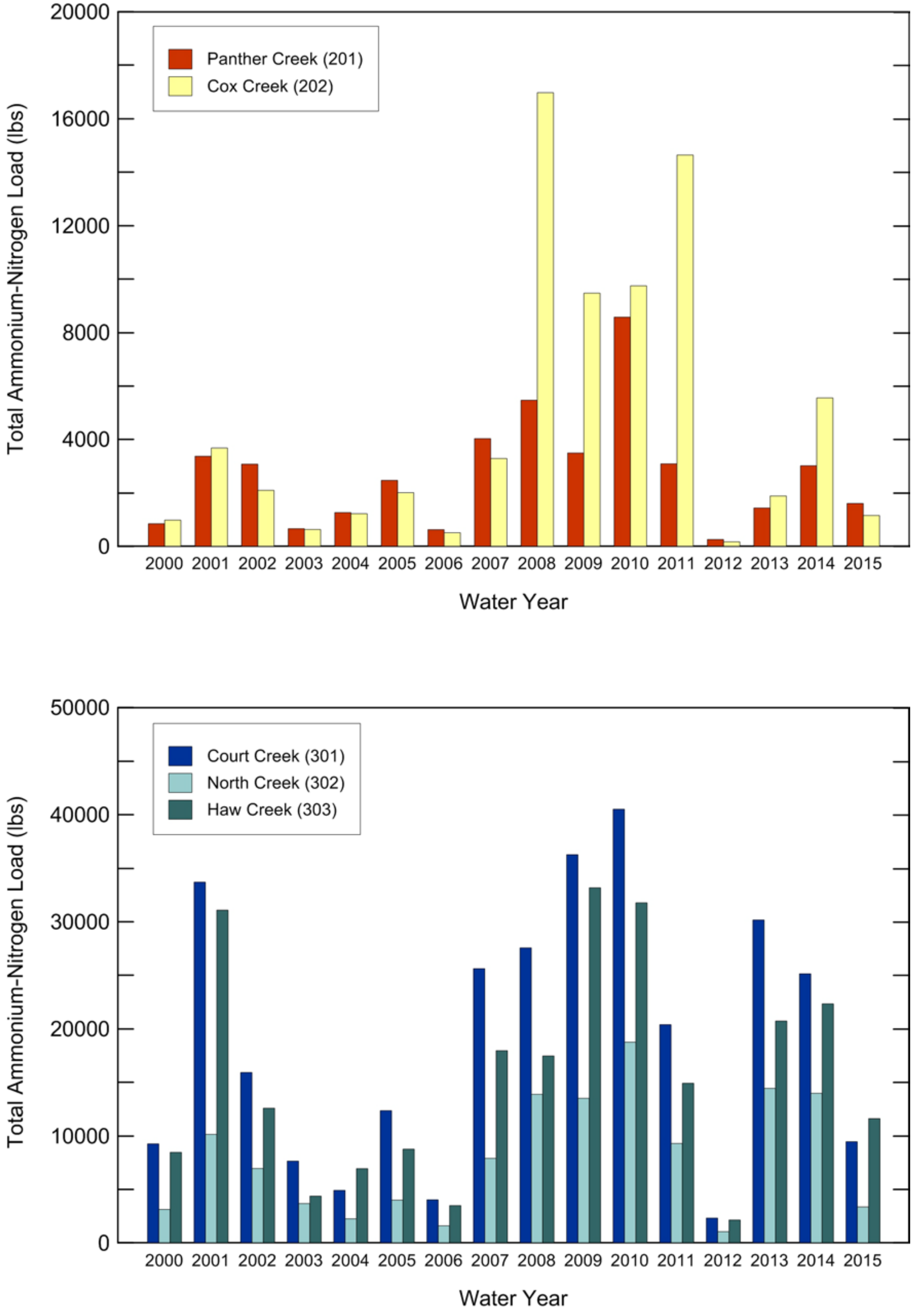
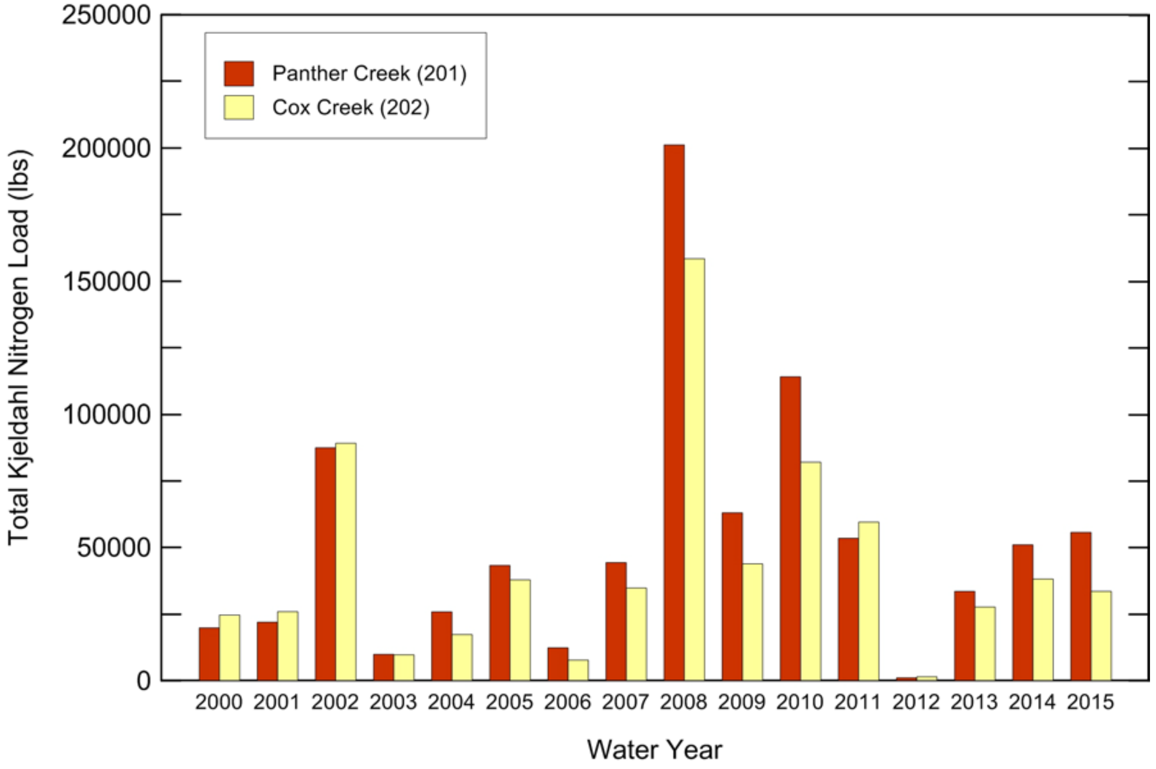


Figure 2-10. Annual ammonium-N loads at the five CREP monitoring stations



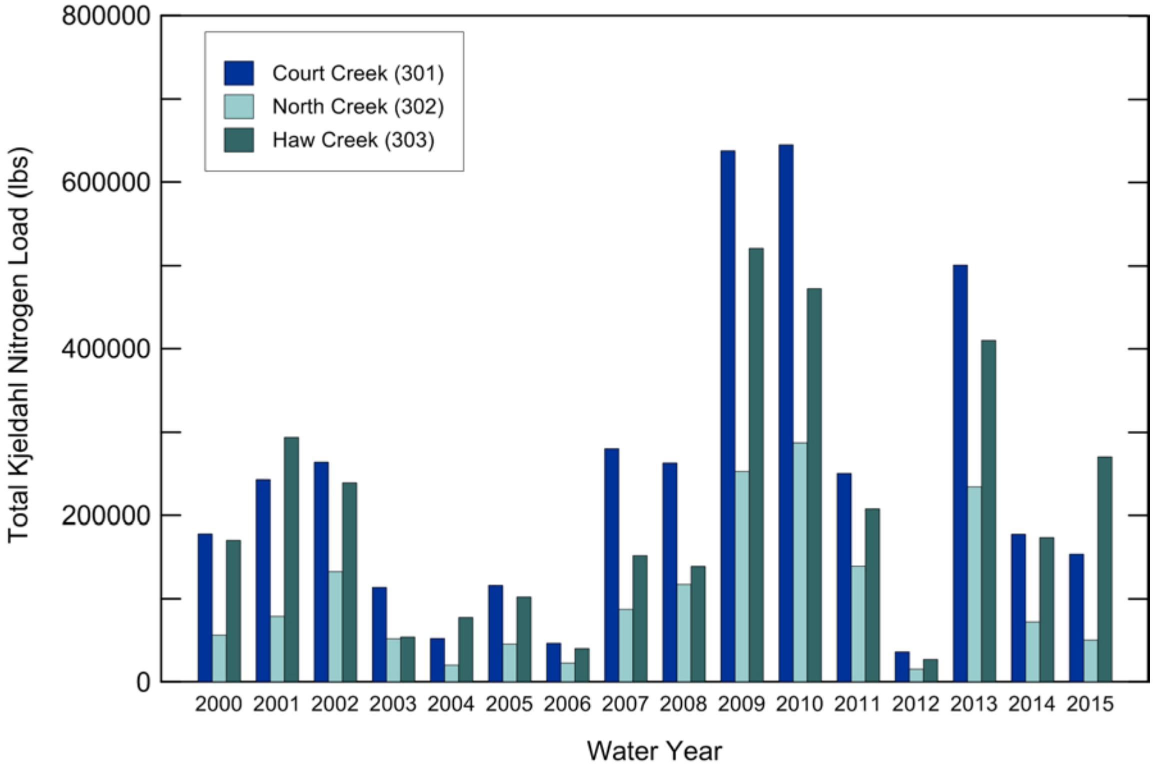


Figure 2-11. Annual Kjeldahl nitrogen loads at the five CREP monitoring stations

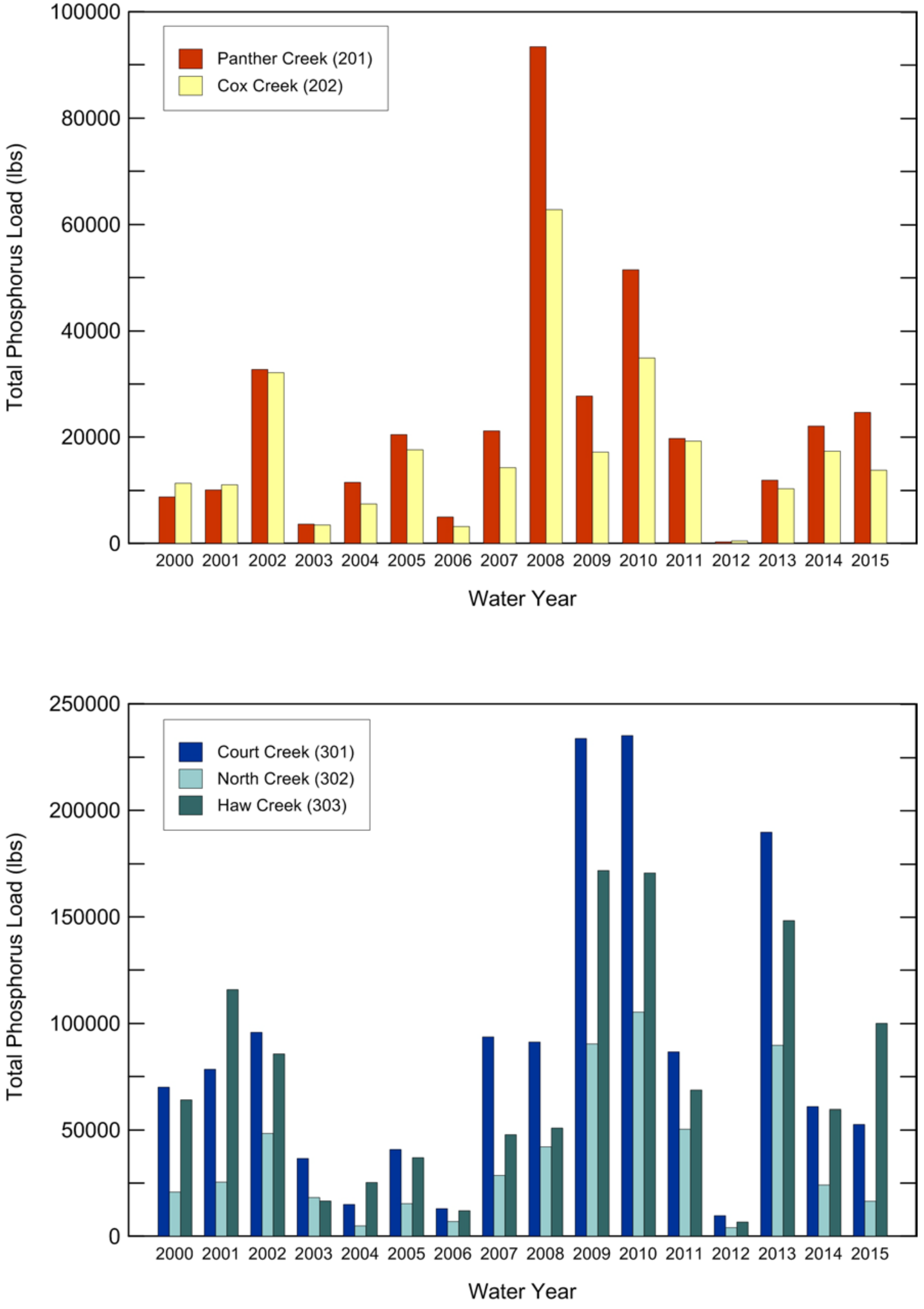


Figure 2-12. Annual phosphorus loads at the five CREP monitoring stations

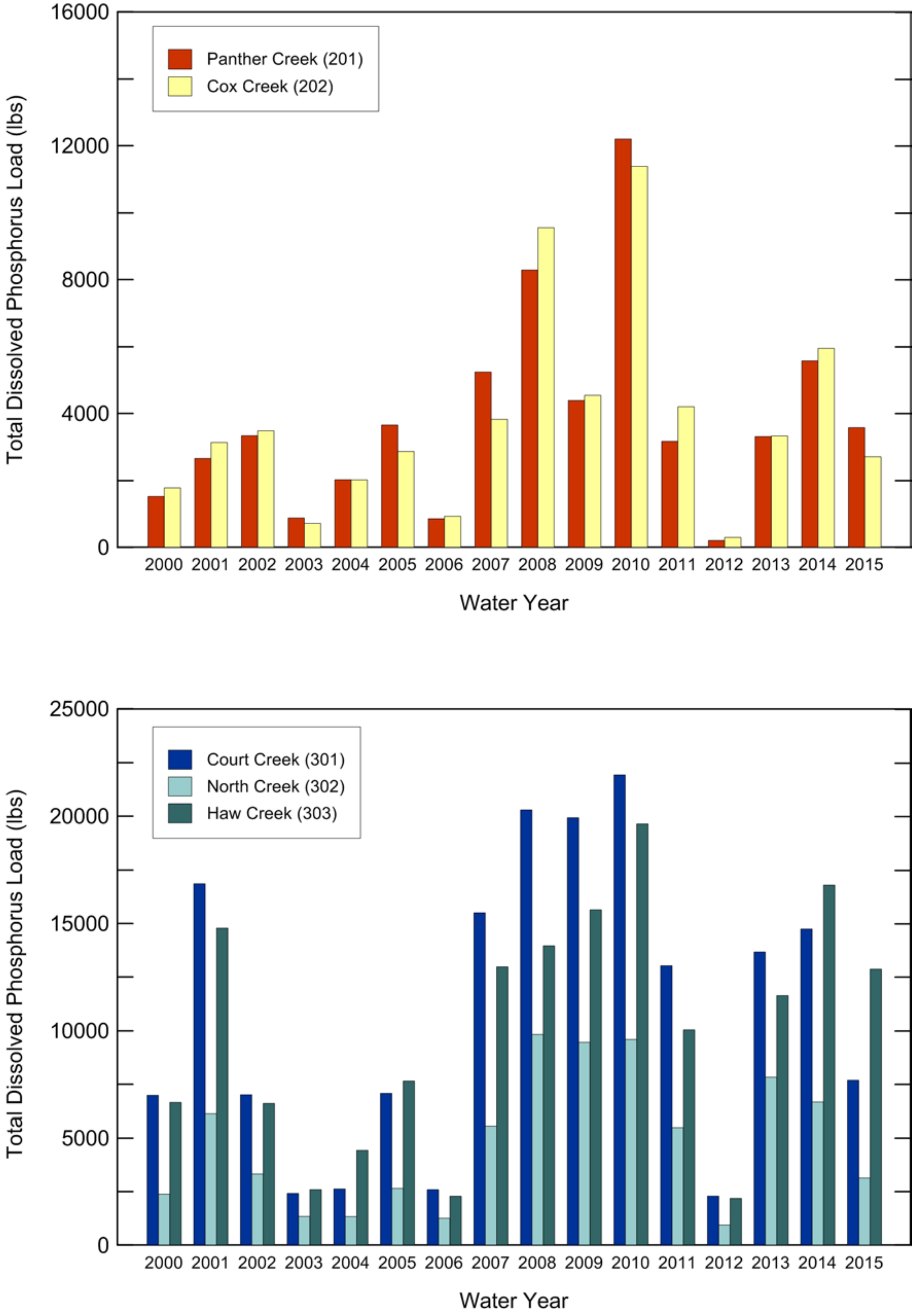


Figure 2-13. Annual dissolved phosphorus loads at the five CREP monitoring stations

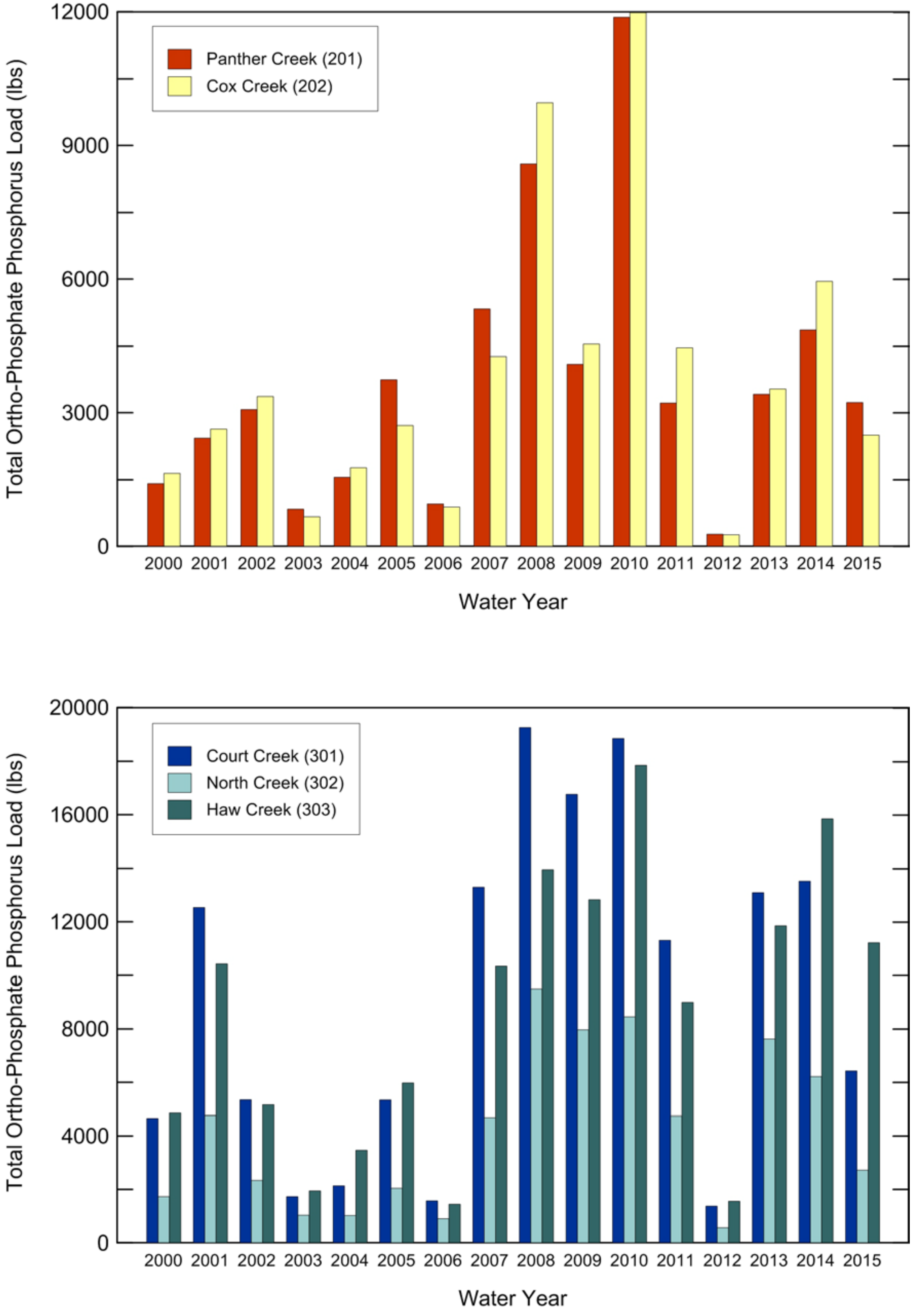


Figure 2-14. Annual ortho-phosphate phosphorous loads at the five CREP monitoring stations

Sediment and Nutrient Yields

To compare the different watersheds in terms of the amount of sediment and nutrient generated per unit area from each of the watersheds, the annual sediment and nutrient yields were computed by dividing the total annual load with the drainage area in acres for each of the monitoring stations. The results are provided in table 2-8 for sediment yield, table 2-9 for nitrate-N yield, table 2-10 for total phosphorous and table 2-11 for TKN. Sediment yields range from a low of 0.01 tons/acre for station 201 in WY2012 to a high of 9.57 tons/acre for station 202 in WY2008. Because of the high level of variability from year to year the average sediment yield for the 1 years of data collection are compared in figure 2-15. The stations are arranged in order of their drainage area, with the station with the smallest drainage area (202) on the left and the station with the largest area (301) on the right. As can be seen in the figure, on the average the stations with the smaller drainage areas (202 and 201) yield higher sediment (about 2.0 ton/acre) than the stations with the larger areas (302, 303, 301) that yield less than 1.5 tons/acre.

Nitrate-N yields vary from a low of 0.5 lbs/acre for stations 201 and 202 in WY2012 to a high of 40.5 lbs/acre for station 202 in WY2010. For comparison purposes the average annual nitrate-N yield for the five stations is shown in figure 2-16. In general the stations with smaller drainage areas generate more nitrate per unit area than those with larger drainage areas, except for station 303 that is generating similar amounts as station 201 that has a smaller area.

Total phosphorous yields vary from a low of 0.03 lbs/acre for station 201 in WY2012 to a high of 8.81 lbs/acre for station 201 in WY2008. For comparison purposes, the average annual total phosphorous yield for the five stations is shown in figure 2-17. Similar to the nitrate-N yield, the stations with the smaller drainage areas generally generate more total phosphorous per unit area than those with larger drainage areas but the difference is very small.

Total Kjedahl Nitrogen (TKN) yields vary from a low of 0.1 lbs/acre for station 201 in WY2012 to a high of 20.6 lbs/acre for station 202 in WY2008. For comparison purposes, the average annual TKN yield for the five stations is shown in figure 2-18. Yields for the stations with small drainage areas are only slightly less than those for the larger.

Table 2-8. Sediment Yield in tons/acre for the CREP Monitoring Stations

	Sediment yield (tons/ac)				
Water Year	*201*	*202*	*301*	*302*	*303*
2000	0.41	0.54	0.62	0.42	0.60
2001	0.93	1.25	1.03	1.01	1.40
2002	3.26	3.01	1.48	1.76	1.25
2003	0.28	0.24	0.51	0.69	0.17
2004	0.74	0.60	0.17	0.12	0.31
2005	1.30	1.06	0.44	0.37	0.51
2006	0.25	0.48	0.19	0.25	0.16
2007	1.27	1.31	1.15	1.01	0.57
2008	7.92	9.57	0.97	1.19	0.46
2009	2.92	2.12	4.11	3.78	2.95
2010	5.38	3.54	3.44	4.01	2.63
2011	1.58	1.82	1.3	1.57	1.06
2012	0.01	0.02	0.10	0.13	0.06
2013	1.16	1.29	2.74	3.67	2.13
2014	2.06	1.79	0.60	0.55	0.68
2015	2.82	1.97	0.58	0.51	1.41

Table 2-9. Nitrate-N Yield in lbs/acre for the CREP Monitoring Stations

	Nitrate-nitrogen yield (lbs/ac)				
Water Year	*201*	*202*	*301*	*302*	*303*
2000	2.6	2.7	6.2	5.2	9.2
2001	16.0	20.2	12.9	12.4	18.2
2002	19.2	26.1	9.6	11.8	14.5
2003	5.0	7.7	2.8	4.0	2.4
2004	9.9	11.8	3.6	4.5	8.1
2005	21.2	28.3	9.8	9.2	15.9
2006	4.2	5.0	4.0	4.4	6.4
2007	14.2	21.2	11.3	12.0	14.9
2008	23.2	40.2	12.5	14.3	12.9
2009	22.2	35.3	20.2	20.2	28.7
2010	23.6	40.5	20.0	20.2	33.2
2011	13.7	23.8	12.8	12.7	21.1
2012	0.5	0.5	1.7	1.8	3.1
2013	23.4	38.9	12.7	14.6	20.3
2014	5.0	6.6	2.8	2.3	6.5
2015	14.7	25.4	5.3	5.1	13.0

Table 2-10. Total Phosphorus Yield in lbs/acre for the CREP Monitoring Stations

	Total phosphorus yield (lbs/ac)				
Water Year	*201*	*202*	*301*	*302*	*303*
2000	0.83	1.48	1.65	1.25	1.81
2001	0.95	1.44	1.84	1.53	3.28
2002	3.09	4.17	2.25	2.92	2.43
2003	0.34	0.45	0.86	1.10	0.47
2004	1.09	0.97	0.35	0.29	0.72
2005	1.93	2.28	0.96	0.92	1.05
2006	0.47	0.42	0.31	0.41	0.34
2007	2.00	1.86	2.20	1.72	1.35
2008	8.81	8.16	2.15	2.53	1.44
2009	2.62	2.23	5.50	5.45	4.87
2010	4.86	4.53	5.54	6.35	4.84
2011	1.86	2.50	2.04	3.03	1.94
2012	0.03	0.06	0.23	0.24	0.19
2013	1.13	1.34	4.46	5.40	4.20
2014	2.08	2.25	1.43	1.45	1.69
2015	2.32	1.80	1.24	0.99	2.83

Table 2-11. Total Kjeldahl Nitrogen Yield in lbs/acre for the CREP Monitoring Stations

	Total Kjeldahl Nitrogen yield (lbs/ac)				
Water Year	*201*	*202*	*301*	*302*	*303*
2000	1.9	3.2	4.2	3.4	4.8
2001	2.1	3.4	5.7	4.7	8.3
2002	8.3	11.6	6.2	8.0	6.8
2003	0.9	1.3	2.7	3.1	1.5
2004	2.4	2.3	1.2	1.2	2.2
2005	4.1	4.9	2.7	2.7	2.9
2006	1.2	1.0	1.1	1.4	1.1
2007	4.2	4.5	6.6	5.3	4.3
2008	19.0	20.6	6.2	7.1	3.9
2009	5.9	5.7	15.0	15.2	14.8
2010	10.8	10.7	15.2	17.3	13.4
2011	5.0	7.7	5.9	8.4	5.9
2012	0.1	0.2	0.8	0.9	0.8
2013	3.2	3.6	11.8	14.1	11.6
2014	4.8	5.0	4.2	4.3	4.9
2015	5.2	4.4	3.6	3.0	7.7

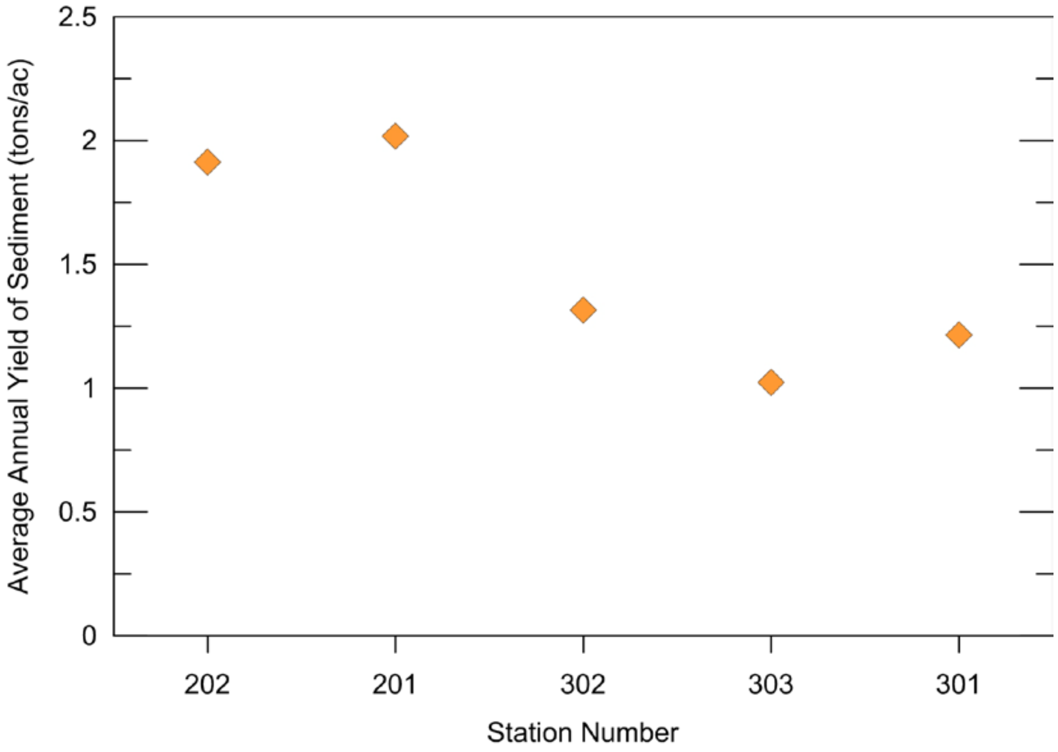


Figure 2-15. Average annual sediment yield in tons/acre for the CREP monitoring stations

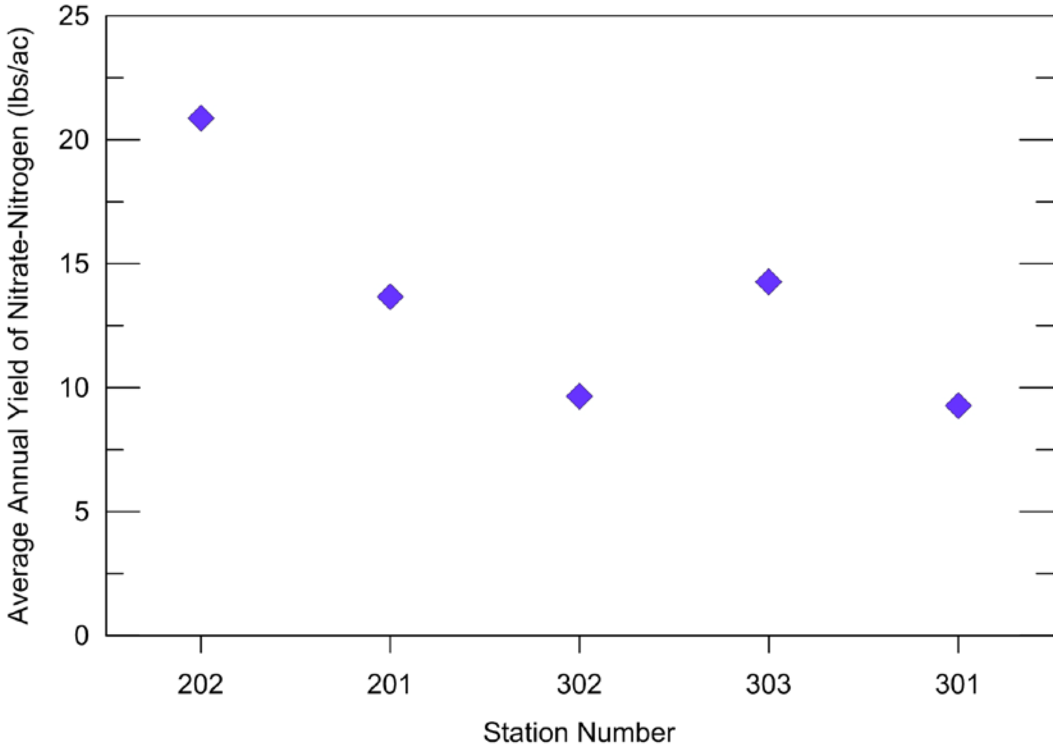


Figure 2-16. Average annual nitrate-N yield in lbs/acre for the CREP monitoring stations

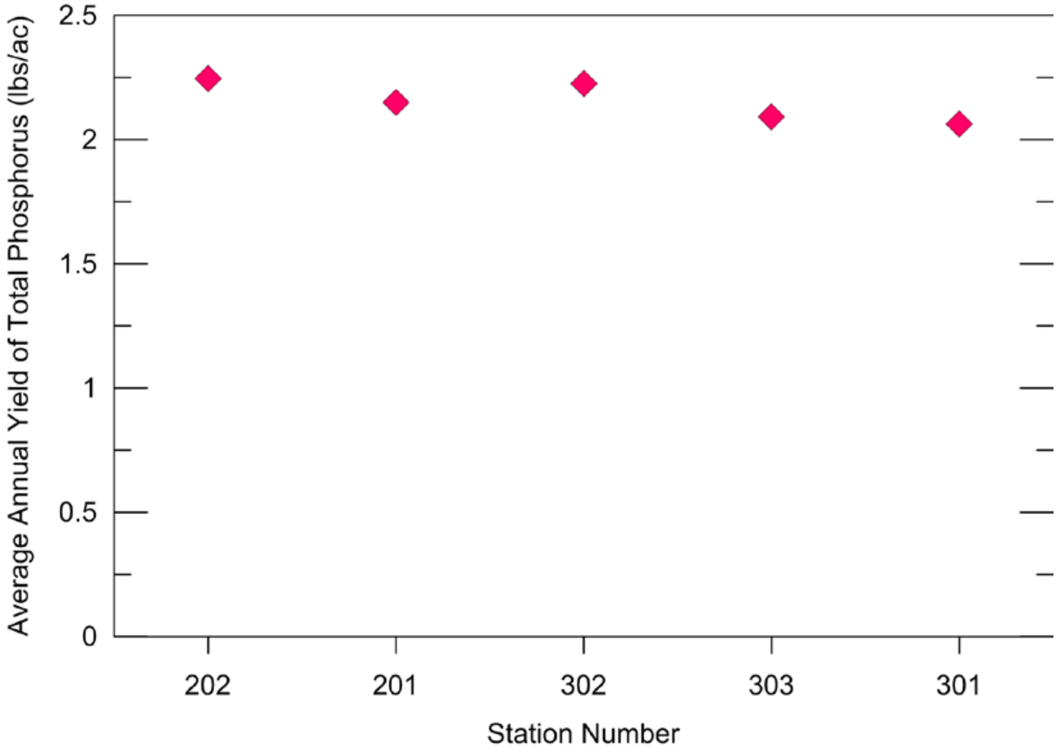


Figure 2-17. Average annual total phosphorous yield in lbs/acre for the CREP monitoring stations

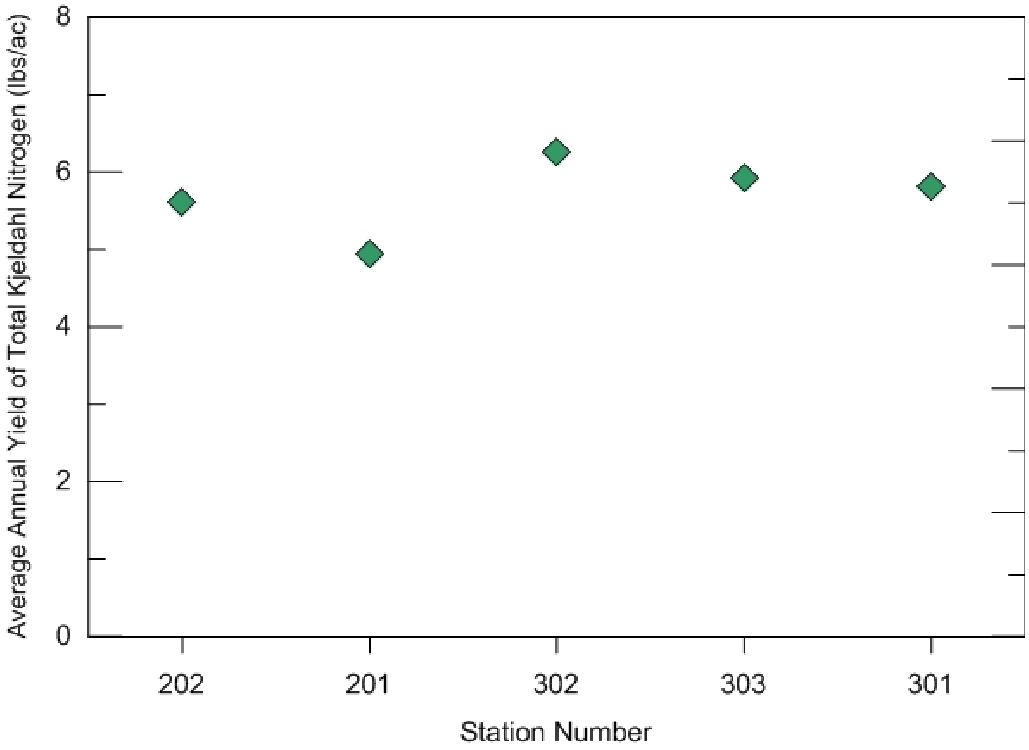


Figure 2-18. Average annual TKN yield in lbs/acre for the CREP monitoring stations

Additional CREP Data Collection Efforts

In addition to the CREP monitoring in the Court/Haw and Panther/Cox watersheds, that was initiated in 1999, several additional monitoring efforts have been initiated by the ISWS through the CREP project in order to provide additional information on the role BMPs in reducing sediment and nutrient yields and to better define the context of existing CREP data on a larger watershed scale.

During September of 2006 in response to significant CREP enrollments and an intensive restoration effort by the Natural Resources Conservation Service (NRCS), two additional monitoring stations (table 2-12) were installed in the Cedar Creek watershed, located in the Spoon River basin (figure 2-19). Station 306 is located on the right descending bank of the mainstem of Cedar Creek where it intersects CR 000 E in Fulton County (border with Warren Co). The second gage, station 305, is located near the left descending bank of Swan Creek, a major tributary of Cedar, where it flows beneath CR 000 E Fulton County, approximately 2.1 miles south of the Cedar Creek (306) gage.

Table 2-12. Additional CREP Monitoring Stations in the Spoon River Watershed

Station ID	*Name*	*Drainage area*	*Location*	*Watershed*
305	Swan Creek	98.1 sq mi (254 sq km)	N 40.67700 W 090.44391	Spoon River
306	Cedar Creek	146.2 sq mi (379 sq km)	N 40.70847 W 090.44540	Spoon River
RG39	Rain Gage 39	NA	N40.79145 W090.49999	Spoon River

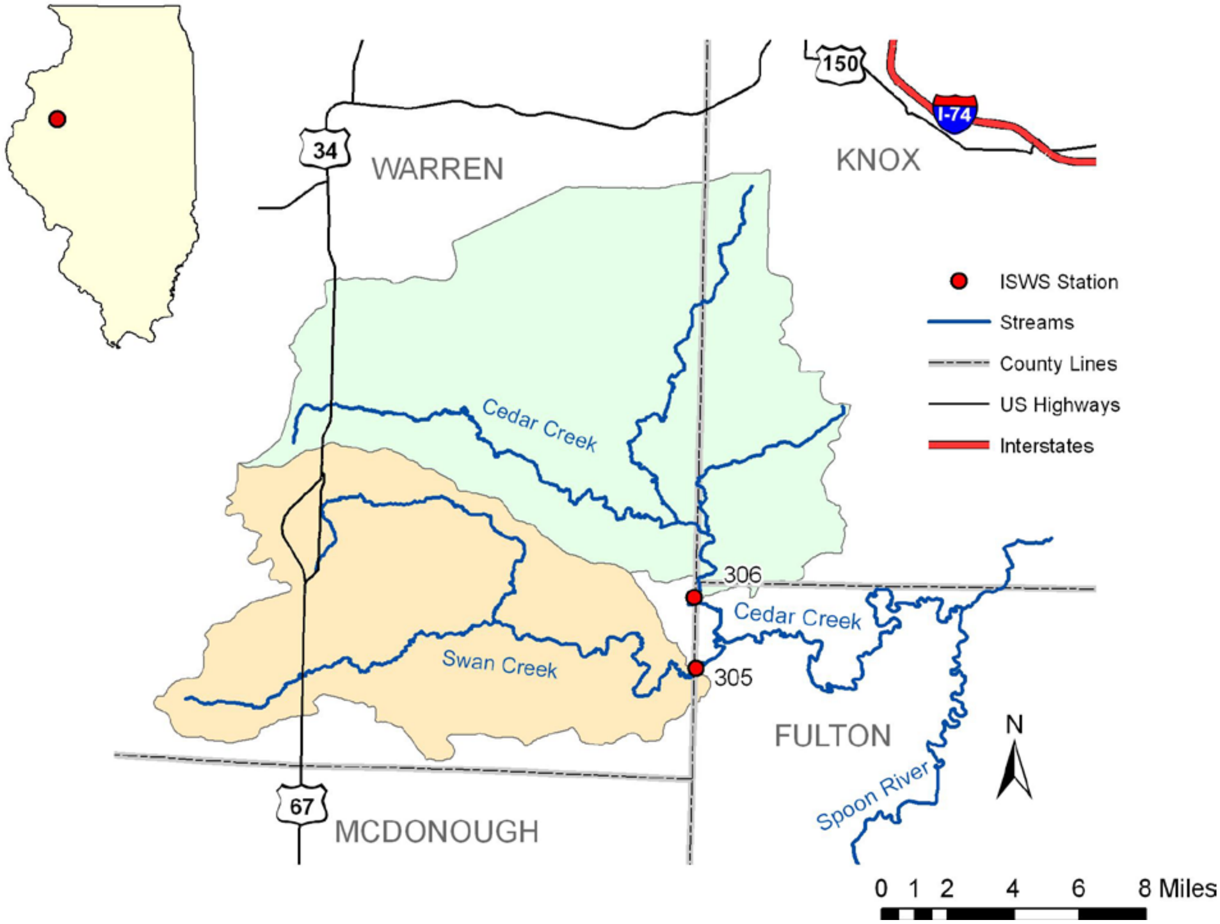


Figure 2-19. Locations of monitoring stations in the Cedar and Swan watersheds

Both watersheds are located in the Galesburg Plain physiographic region. The topography is flat to gently rolling and the soils are primarily loess. Stream channels and associated floodplains are heavily dissected with stream channels commonly being incised into the floodplain. Both watersheds are mostly rural with agriculture the predominant land use. Pasture and woodlands are also common due to the topography introduced by the dissected stream channels.

Both gages became operational near the end of WY2006 (9/15/2006) and are instrumented and operated as are all CREP gages, in accordance to the CREP QAPP (Appendix A). Both stations utilize a pressure transducer to determine stage, log data on a 15 minute time step and are equipped with an ISCO automated pump sampler slaved to the stage sensor in order to augment manual discrete sampling efforts. Thirty-eight and thirty-three discharge measurements have been collected at stations 305 and 306 respectively in an effort to establish a reliable rating in as short a time as possible. Based on provisional data, summary statistics for suspended sediment concentration data is provided in table 2-13.

In addition to the two streamgages the ISWS has installed a recording raingage immediately east of CR1500E and approximately 0.5 mi north of CR1100N in Warren Co. The raingage is a modified Belfort equipped with a linear potentiometer, in order to provide a digital output, and can be operated throughout the year. Raingage deployment and maintenance as well as the download and reduction of precipitation data can be found in the CREP QAPP (Appendix A).

ISWS field staff began suspended sediment sampling at two U.S. Geological Survey (USGS) gages located on the mainstem of the Spoon River on 3/29/2004. Samples are collected weekly at both sites with additional samples collected during runoff events. Sampling at London Mills (05569500) is done from the Route 116 bridge where the USGS gaging station is located. Sediment sampling at Seville (05570000) is done approximately 1 mile downstream of the current USGS gage location on State Route 95. Current USGS sediment data are also collected at this location. As of 9/30/12, 568 samples have been collected at London Mills while 521 samples have been collected at Seville. Summary statistics for suspended sediment concentration data collected through WY2012 are presented for each station in Table 2-14.

Table 2-13. Suspended Sediment Concentration Data (mg/L) for Swan and Cedar Creeks

	Swan (305)	*Cedar (306)*
Count (samples)	3515	3623
Mean	380.1	471.3
Max	7872.6	8101.8
Min	1.99	1.59
Median	137.1	132.6
25th Percentile	49.3	51.0
75th Percentile	416.3	462.7

Table 2-14. Suspended Sediment Concentration Data (mg/L) for Spoon River at London Mills and Seville

	London Mills (05569500)	*Seville (05570000)*
Count (samples)	568	521
Mean	296.1	293.1
Max	4952.7	4730.7
Min	1.91	3.93
Median	116.0	122.2
25th Percentile	49.9	58.8
75th Percentile	285.7	266.7

3. Land Use Cover and Conservation Practices

Land Cover

The Illinois River Basin (IRB) is nearly 16 million acres with a diverse range of land covers. The extent of these land covers is illustrated in figure 3-1 using the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) 2014 land cover data. The database contains almost 150 land cover category types. For the purpose of this study those types have been grouped into 11 categories: corn, soybeans, small grains, other row crops, other crops, grass/pasture, developed, woodland, wetlands, water, and other. Figure 3-2 show in 2014 the Illinois River Basin was dominated by agricultural land, comprising of 63% of the basin. Corn and soybean acreage accounts for most of the agricultural land cover. Developed urban-type lands, woodlands, and grass/pasture lands are the next highest with 14%, 12%, and 8%, respectively. The Illinois River Basin is unique in that a large portion of the watershed contains the six-county developed areas surrounding the City of Chicago.

As seen in Figure 3-3, these are the same dominant land covers in the five monitored watersheds with some variations. The Panther (201) and Cox Creek (202) watersheds are located next to one another (Figure 2-3) but show marked differences in land cover between agriculture production and woodland. Cox Creek watershed has 78% land cover in corn/soybean acreage whereas Panther Creek watershed has 55%. Woodland acreage in Panther Creek watershed is 3 times more than Cox Creek due to the IDNR Jim Edgar Panther Creek State Fish and Wildlife Area. Both watersheds have similar acreages in grassland/pasture/open lands and developed urban areas. Court Creek (301) and Haw Creek (303) watersheds are also located next to each other. North Creek (302) is a subwatershed within the Court Creek (301) watershed. Percent area of agriculture is 47% and 59% in Court and Haw Creek watersheds, respectively, where difference is offset b y the woodland and developed areas of 39% and 29%. The higher woodland land cover area in Court Creek watershed is due to the North Creek (302) subwatershed.

Outside of natural factors such as the physical settings and climate variability, land use is the main driving factors that affect a watershed's hydrology, erosion, sedimentation, and water quality. It is therefore important to document and analyze changes in land use for a given watershed to properly understand and explain changes in its hydrology, water quality, and the erosion and sedimentation process. The Illinois River basin has undergone significant changes in land use practices during the last century. These changes have been used to explain degradation in water quality and aquatic habitat along the Illinois River. In recent years, there have been significant efforts at the local, state, and federal level to improve land use practices by implementing conservation practices throughout the watershed. The Illinois River CREP is a course of major state and federal initiatives to significantly increase conservation and restoration practices in the Illinois River basin.

The USDA National Agriculture Statistics Service (NASS) land cover data has been available since 1999. In 2006 an evaluation of the usefulness of the crop data layers for annual land cover information in Illinois was undertaken by the Illinois State Geological Survey (ISGS) and NASS. Based on inherent errors associated with satellite data, irreparable mechanical problems with older multispectral imagery satellites and land cover classification methods used

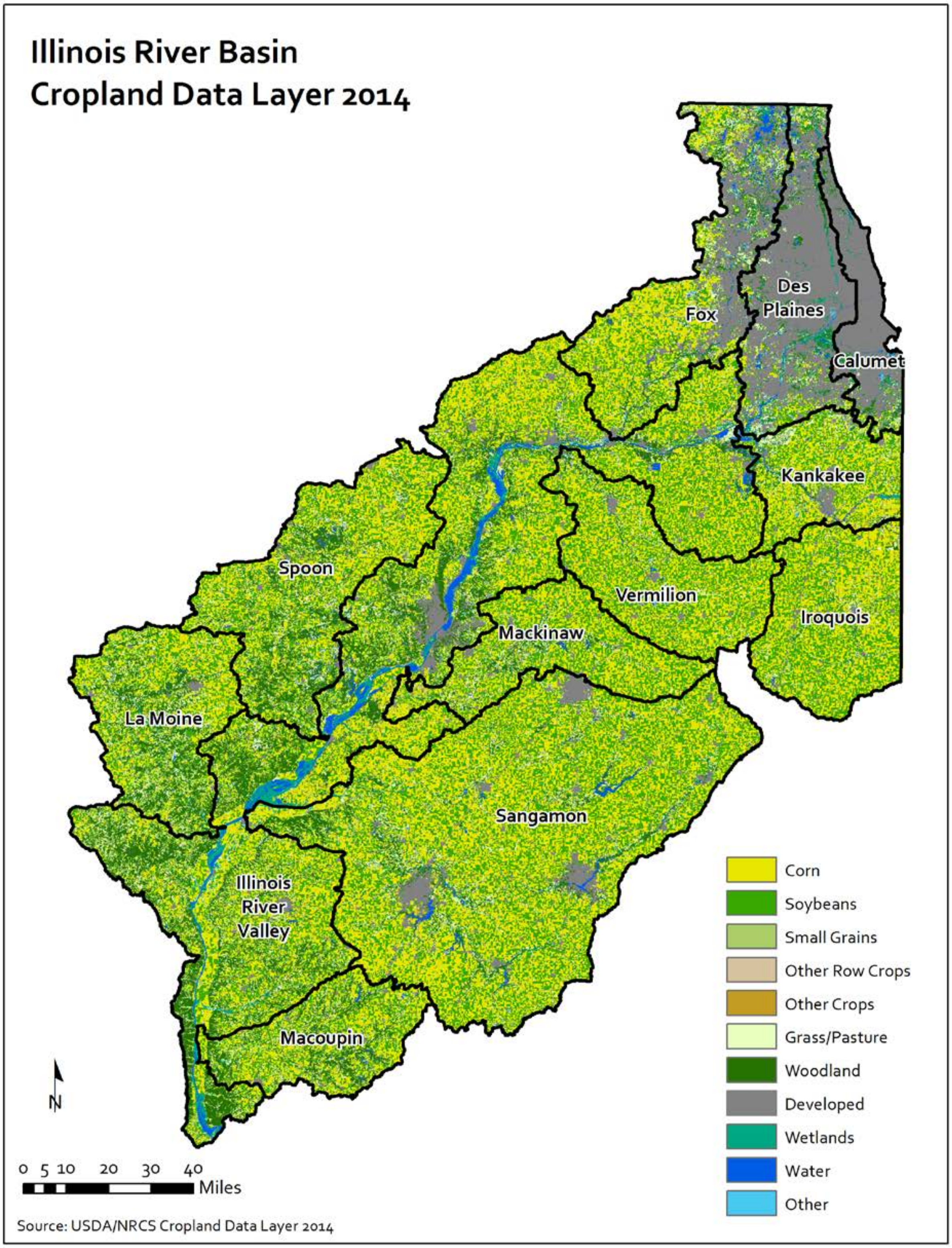


Figure 3-1. Land cover of the Illinois River Basin (NASS, 2010)

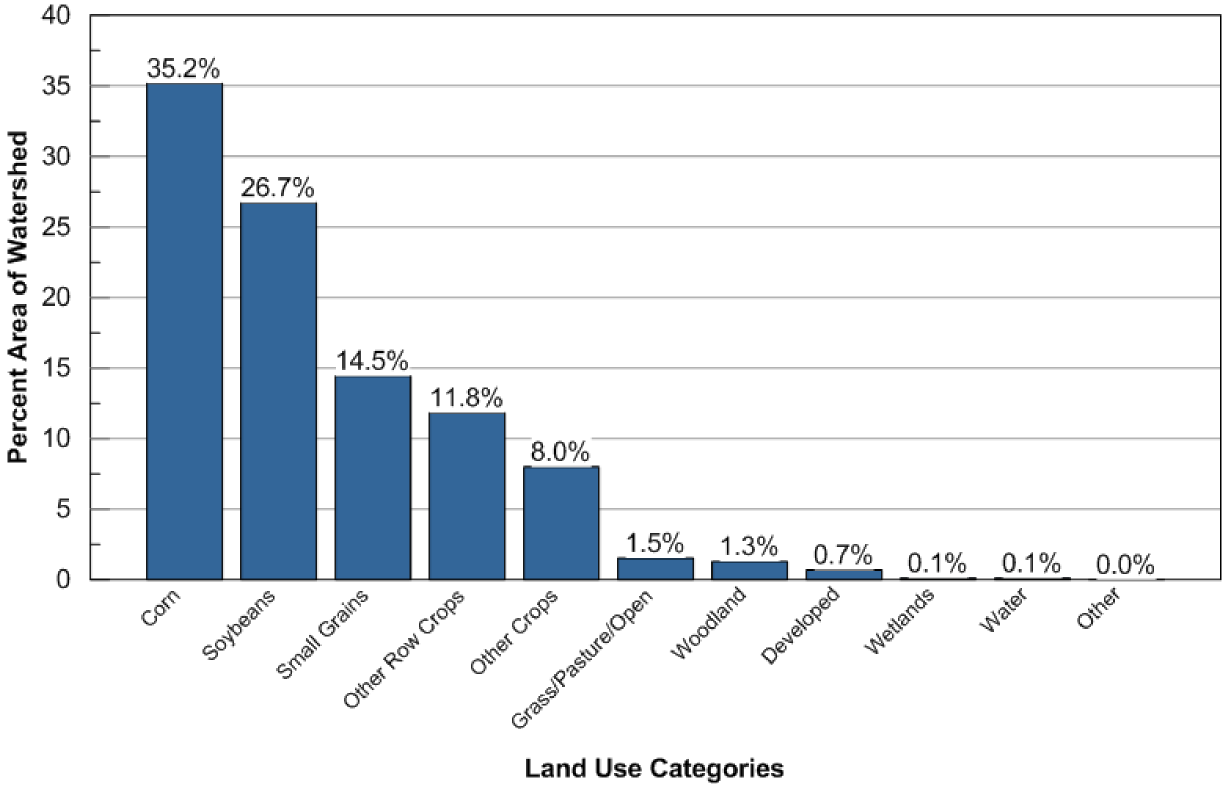


Figure 3-2. Percent watershed area of types of land cover in Illinois River Basin (NASS, 2014)

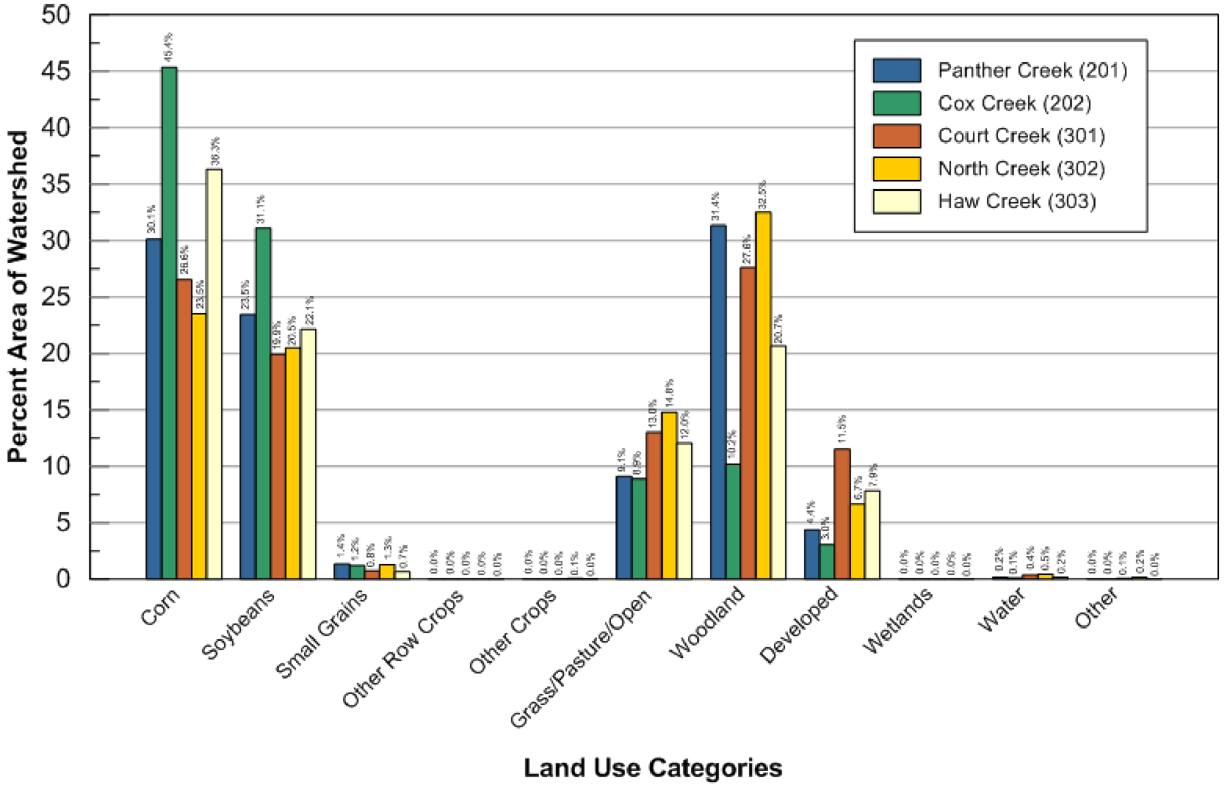


Figure 3-3. Percent watershed area of types of land cover in five monitored watersheds in the Illinois River Basin (NASS, 2014)

to interpret that imagery, new enhanced CDL protocols were established in 2007 for Illinois. Consequently, land cover misclassifications were identified prior to the new protocol, which became more apparent when evaluating the land cover in the monitored watersheds (figure 3-4): Panther Creek (201), Cox Creek (202), Court Creek (301), North Creek (302), and Haw Creek (303). Therefore, any changes in land cover will be evaluated for this study beginning in 2007 through 2013 which is the most currently available NASS CDL data.

The five monitored watersheds have somewhat different ratios of land cover types. The Panther and Cox Creek watersheds in the Spoon River watershed have 53 and 73 percent area in agriculture and 47 and 27 percent in non-agriculture land covers, respectively (table 3-1). The main difference is Panther Creek has over 20 percent more land in forest/shrubland than Cox Creek, due to a large portion of the watershed lies in the Panther Creek State Conservation Area. Agriculture land cover is 44 and 56 percent in Court and Haw Creeks, respectively, while the non-agriculture area is the inverse. North Creek watershed, a tributary of Court Creek, has a larger portion of land area in forest/shrubland than Haw Creek. Figure 3-5 illustrates the percent change in total watershed acres between 2007 and 2013 for six generalized land cover categories in each of the five monitored tributary watersheds in the Illinois River Basin. Agriculture land covers were categorized into Corn, Soybeans, Double Crop with Soybeans and Other Cropland, as well as summed in one category identified as Agriculture. Non-agriculture land covers were categorized into Grassland and Forest/Shrubland, and summed as Non-Agriculture. All five watersheds had a 5 percent reduction in non-agricultural land cover area (Grasslands and Forest/Shrubland) between 2007 and 2013. An increase in agricultural land cover area (Corn, Soybeans, Double Crop with Soybeans and Other Cropland) ranged from 2 to nearly 11 percent occurred on all five watersheds. The three Spoon River tributary watersheds (Court, North, and Haw Creeks) had marked percent increases in soybean acres and decreased percent of corn acres. The two Sangamon River watersheds (Panther and Cox Creeks) had an increase percent of corn acres, with Panther having an increase percentage of soybean acres and Cox with an increase in other cropland acres.

Figures 3-6 to 3-10 show the changes in each land cover for each year between 2007 and 2013. For this report, NASS Cropland Data Layer (CDL) categories for the monitored watersheds were combined into 6 general land cover categories: 1) corn, 2) soybean, 3) other cultivated crops, 4) grassland, 5) forest/shrubland and 6) developed, barren, open space, water and wetlands. Land cover area changes between years is represented in acres. Therefore, some watersheds may appear to have greater changes in acreage from year to year but may only represent a small percentage of the watershed depending on the total watershed acres. Panther Creek watershed (figure 3-6) acres remained constant for move land covers when comparing 2007 and 2013. Corn and soybean acres shifted between years and inversely as reflected by normal corn and soybean rotation practices. Forest/shrubland saw a minor shift in 2010. Cox Creek watershed (figure 3-7) saw similar variability as Panther Creek watershed in most land cover acreage. Only minor increases in acres for cultivated crops and developed, barren, open space, water and wetlands. Court Creek (figure 3-8) appeared to have corn and Grasslands trade acres each year, with Corn increasing to a high in 2011 and then returning to near 2007 acreage. Soybean acres increased every other year for a seven year increase. Forest/Scrubland acres decreased slightly with little variability. North Creek watershed (figure 3-9) is a subwatershed within Court Creek watershed explaining the significant reduction in total watershed acres. The same patterns and variability as Court Creek watershed appear here. Finally, Haw Creek watershed (Figure 3-10) land cover patterns and variability in acreages were similar to Court/North Creek watersheds.

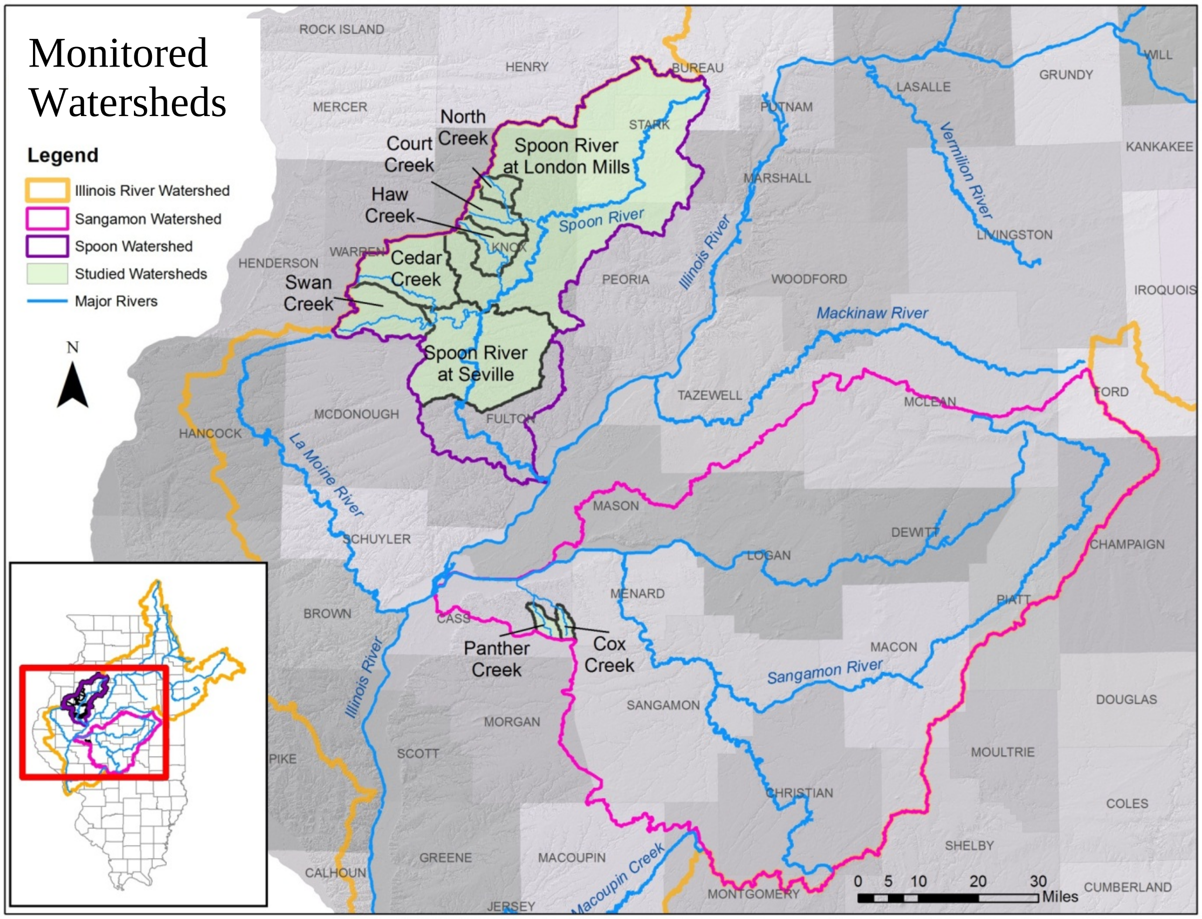


Figure 3-4. Watersheds being monitored for hydrology, sediment and nutrients.

Table 3-1. 7-year average (2007-2013) percent acres of land cover area by watershed

	ISWS Station Number				
	201	*202*	*301*	*302*	*303*
Corn	31	46	28	26	36
Soybeans	21	26	16	16	20
Other Crops	1	2	0	0	0
Grasslands	11	13	20	20	17
Forest/Shrubland	32	11	29	34	21
Developed, Barren, Open Space, Water, Wetlands	4	3	7	4	6
AGRICULTURE	53	73	44	42	56
NON-AGRICULTURE	47	27	56	58	44

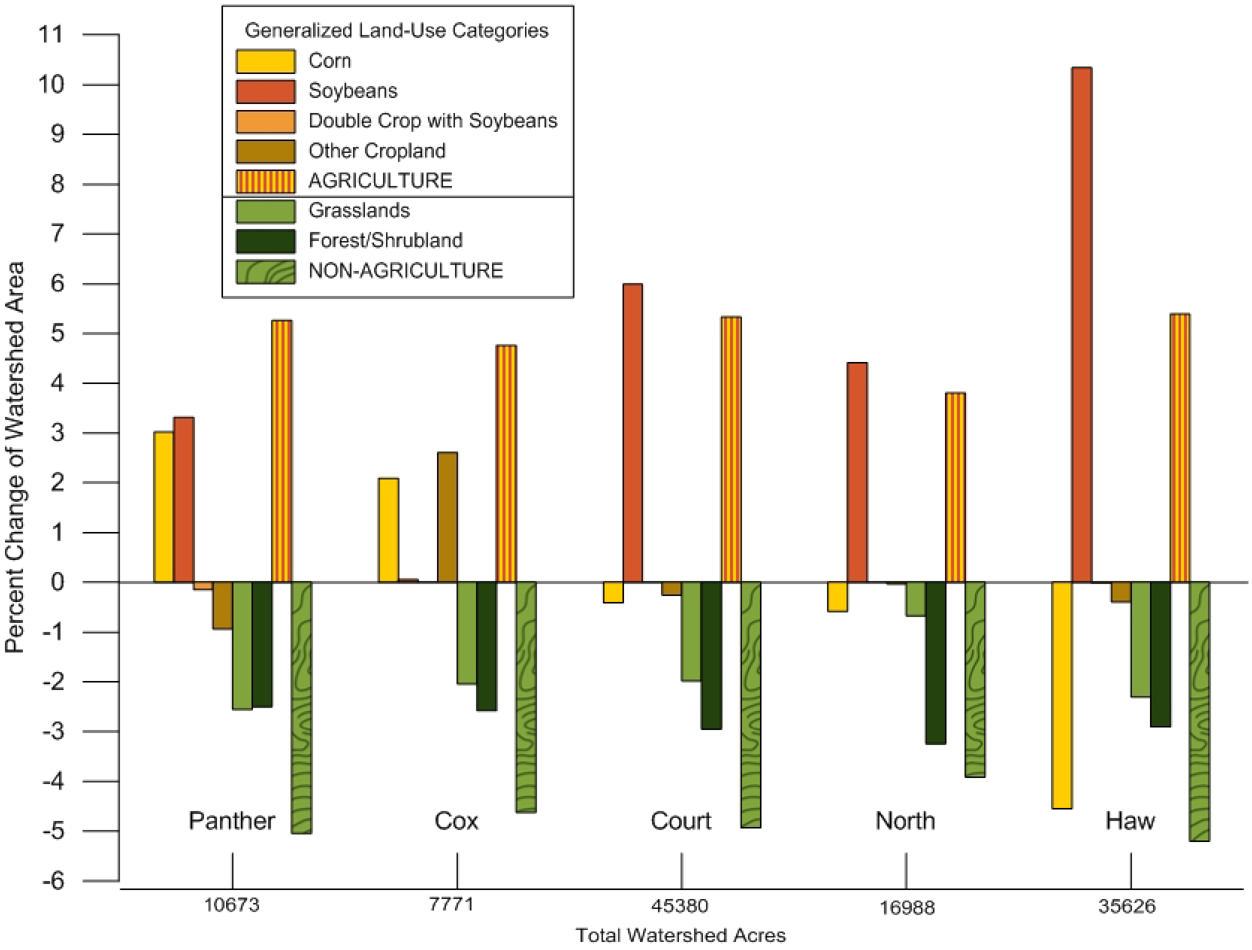


Figure 3-5. Illinois River Basin Watersheds: Percent Change in Generalized NASS Land-Use from 2007-2013.

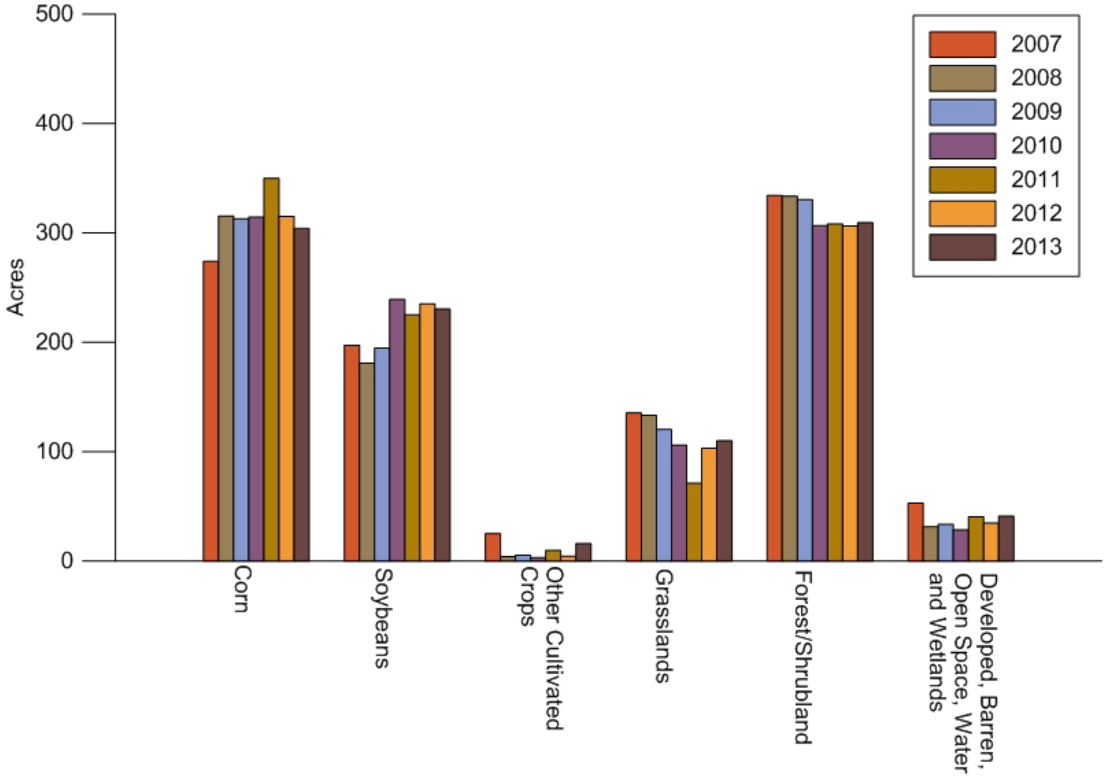


Figure 3-6. Panther Creek Watershed from ISWS Station 201: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

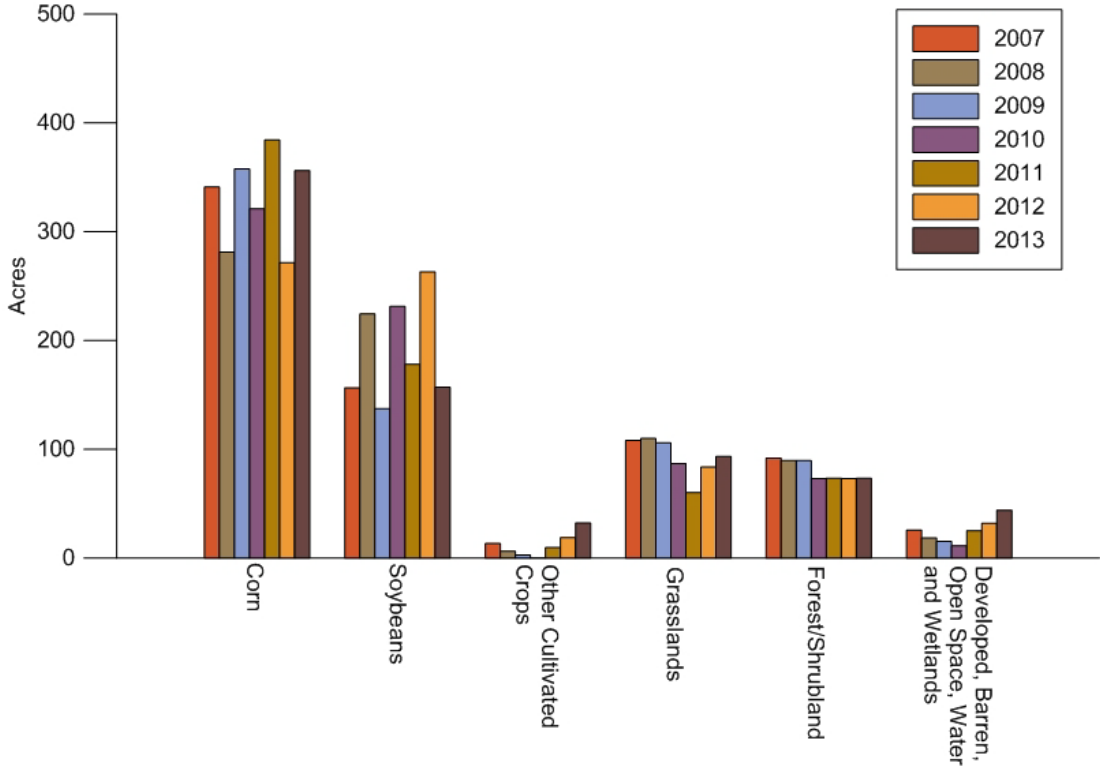


Figure 3-7. Cox Creek Watershed from ISWS Station 202: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

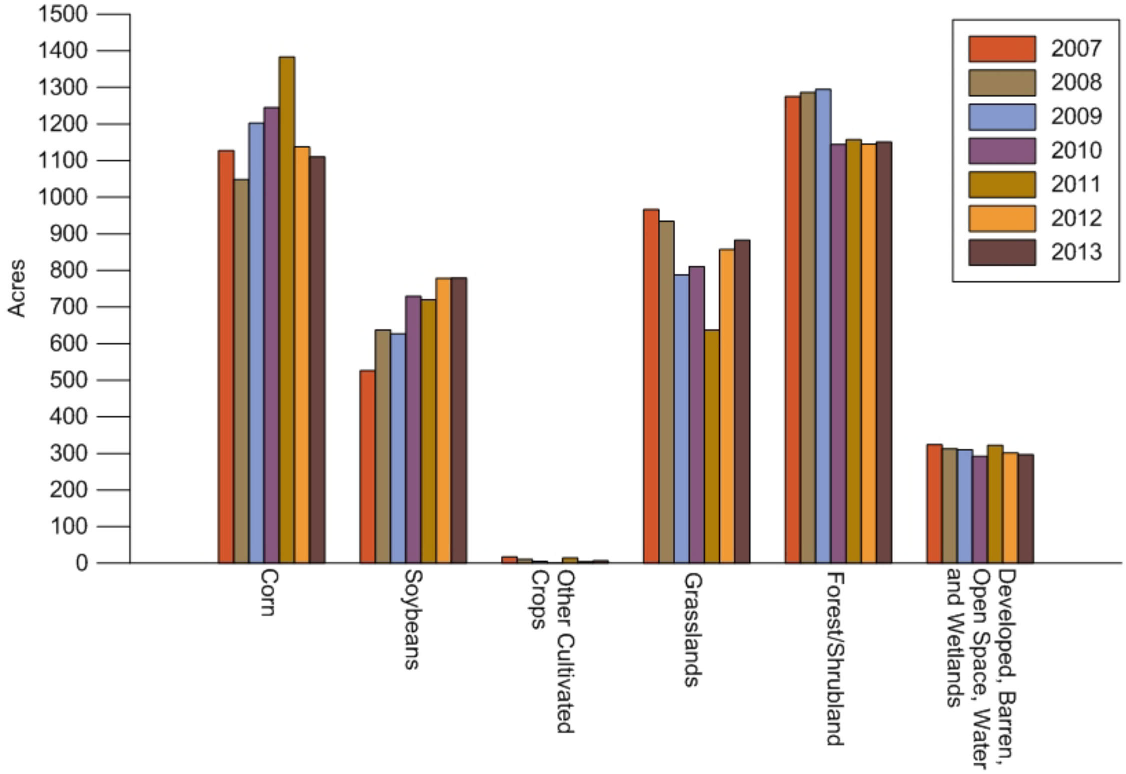


Figure 3-8. Court Creek Watershed from ISWS Station 301: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

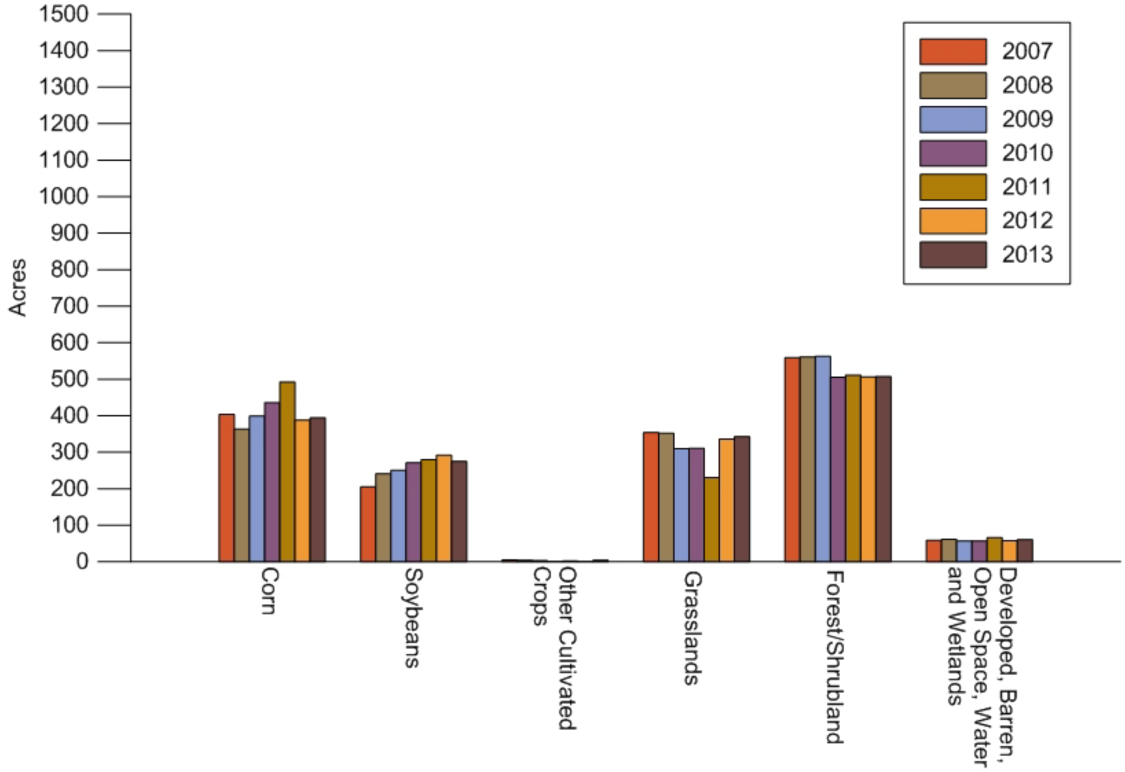


Figure 3-9. North Creek Watershed from ISWS Station 302: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

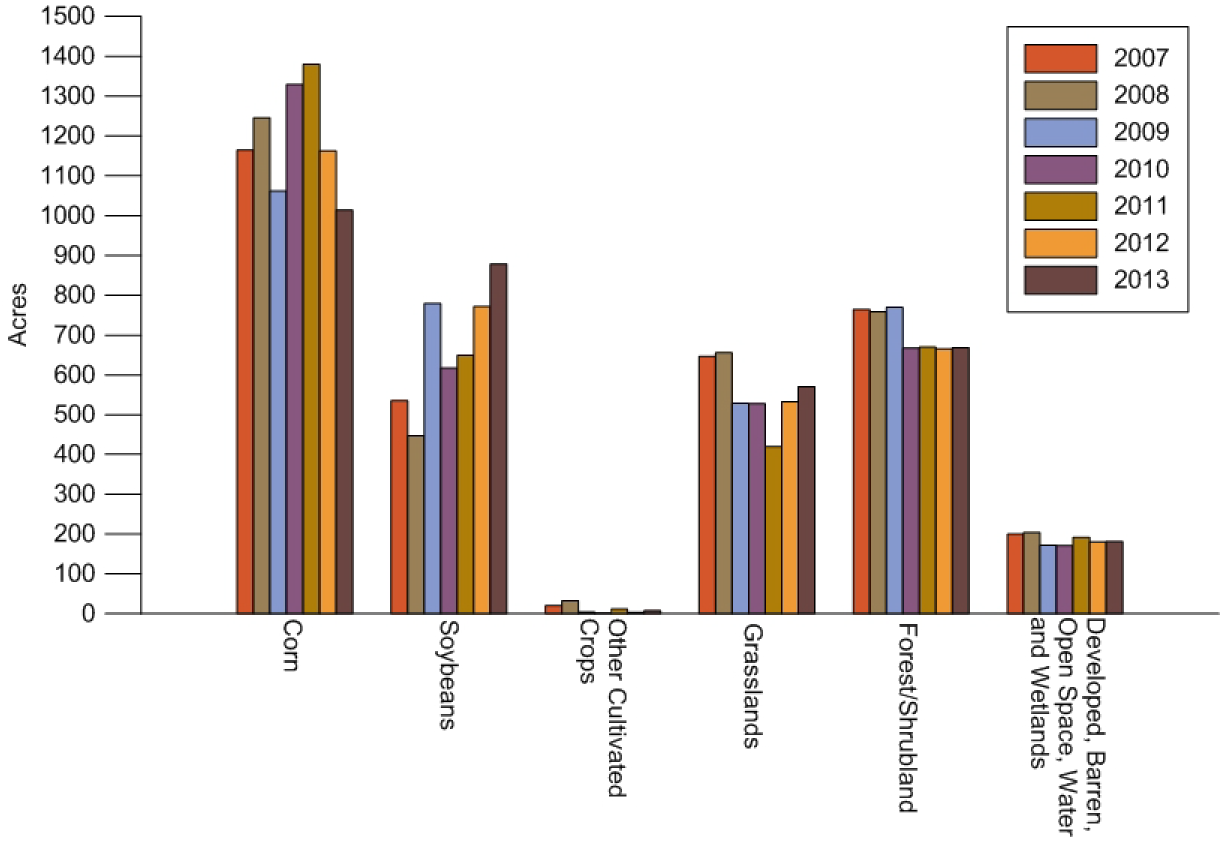


Figure 3-10. Haw Creek Watershed from ISWS Station 303: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

Conservation Practices

There has been a significant increase in the implementation of conservation practices in Illinois in recent years with CREP making a major contribution. Figure 3-11 shows the location of approved Illinois CREP contracts from the State of Illinois as of 2014. With this type of information it will be possible to identify areas where there has been significant participation in the CREP program and where changes in sediment and nutrient delivery should be expected. The information will provide important input data to the watershed models that are being developed to evaluate the impact of CREP practices.

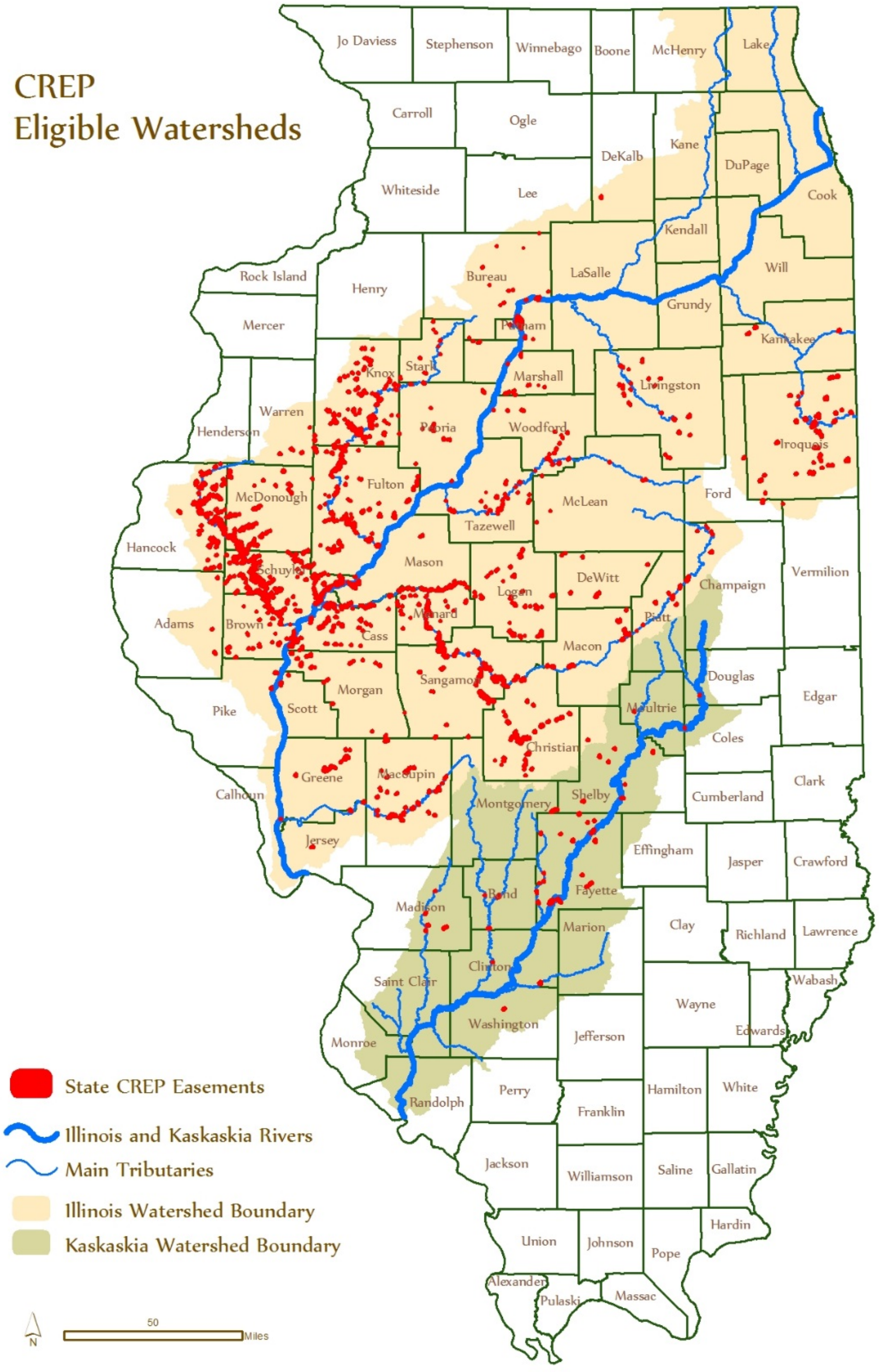


Figure 3-11. State of Illinois CREP contract locations (IDNR, 2015).

There are many conservation practices implemented through the watersheds as a result of federal and state conservation reserve programs. In order to evaluate watershed monitoring efforts, knowing when and what conservation practices are implemented in the watershed is important. Figures 3-12 to 3-13 are examples of cumulative acres of conservation practices installed in a couple of the monitored watersheds from 1999 through 2015. The order by which the practices are listed in the legend represent, from the largest to smallest, the sum of the acres by practice from 1999-2015. Riparian buffers, wetland restoration, filter strips and SAFE habitat are the most installed conservation practice in Court Creek (301) watershed with most of the acres occurring prior to 2009. Whereas, permanent wildlife habitat (Additional Acres) was the most installed practice installed prior to 2005 in the Haw Creek (303) watershed. Existing grasses and trees, filter strips and grass waterways are the next most installed.

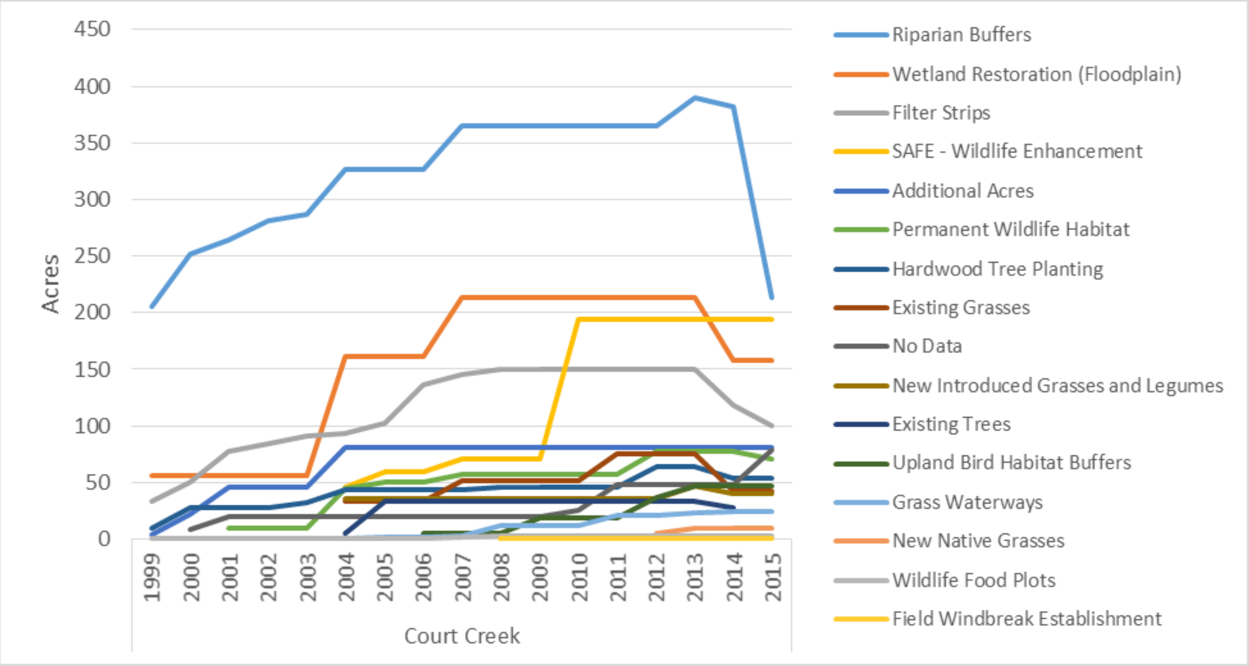


Figure 3-12. Cumulative acres of conservation practices installed in Court Creek watershed at monitoring station ISWS #301 from 1999-2015.

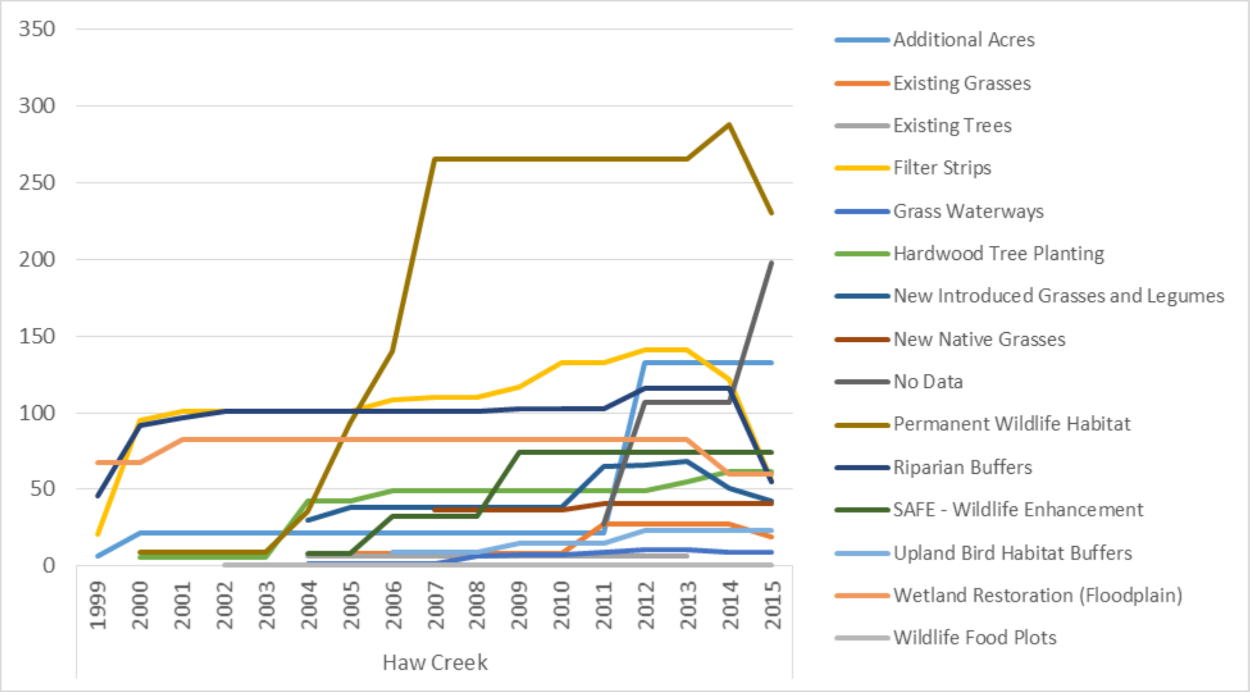


Figure 3-13. Cumulative acres of conservation practices installed in Haw Creek watershed at monitoring station ISWS #303 from 1999-2015.

4. Variability and Trends in Precipitation and Streamflow

Results of a short-term monitoring program have to be viewed with respect to the climatic and hydrologic conditions under which the data was collected. Under ideal conditions, which rarely happen, the monitoring period would include a combination of wet, dry, and normal climatic conditions that represent the range of variability in climatic and hydrologic conditions in the watershed. The influence of climatic and hydrologic conditions on the data collected has been taken into consideration, especially when different datasets collected at different times and conditions are combined or compared. The Illinois River basin, as any major watershed, has experienced significant variability in precipitation and streamflow over the last century and recent periods. Data collection for the CREP program started in 1999 to provide a perspective as to how the current monitoring period compares to the long-term variability of precipitation and stramflows within the Illinois River basin. Historical precipitation and streamflow data are analyzed and presented in this segment of the report.

Climate and hydrologic records from the past 100 years in Illinois show considerable long-term variability. These variabilities and trends were analyzed for two stations on the Illinois River and six tributary stations in the Illinois River basin (figure 4-1). Figure 4-2 compares average precipitation and streamflow for the Upper Illinois River watershed since the 1880s, as expressed in moving 10-year average values. Similar comparisons are shown in figures 4-3 to 4-8 for the Fox, Kankakee, Spoon, Sangamon, LaMoine, and Macoupin subwatersheds, respectively, but for shorter time periods as limited by the available gaging records. Figure 4-9 for the entire Illinois River Basin (at the Valley City streamgage) is nearly identical to figure 1 except for the period of record. The 10-year average precipitation and streamflow values plotted in figures 4-2 to 4-9 represent the approximate midpoint of the 10 years; for example, the value for 1995 represents the average for 10 years from 1990-1999, the value for 1996 represents the average for the 10 years 1991-2000, and so forth. Streamflow values are expressed in inches of water spread uniformly over the entire watershed such that average streamflow can be compared directly with precipitation for the concurrent period. Streamflow values in figure 4-2 are computed from flow and stage records at Peoria prior to 1940 and at Kingston Mines since 1940.

Figure 4-2 shows that precipitation and streamflow in the Upper Illinois River watershed from 1970 to 1995 were considerably higher than at any other time in the 20th Century. Prior to 1895, precipitation for the Illinois River watershed is estimated from a small set of gaging records dating back to 1870. These precipitation records show that there was a decade of high precipitation in the late 1870s and early 1880s similar in magnitude to high precipitation amounts during 1970-1995. A comparison of 10-year average precipitation and streamflow amounts clearly shows that streamflow has been very closely related to concurrent precipitation throughout the past 125 years, with a correlation coefficient (*r*) of 0.958.

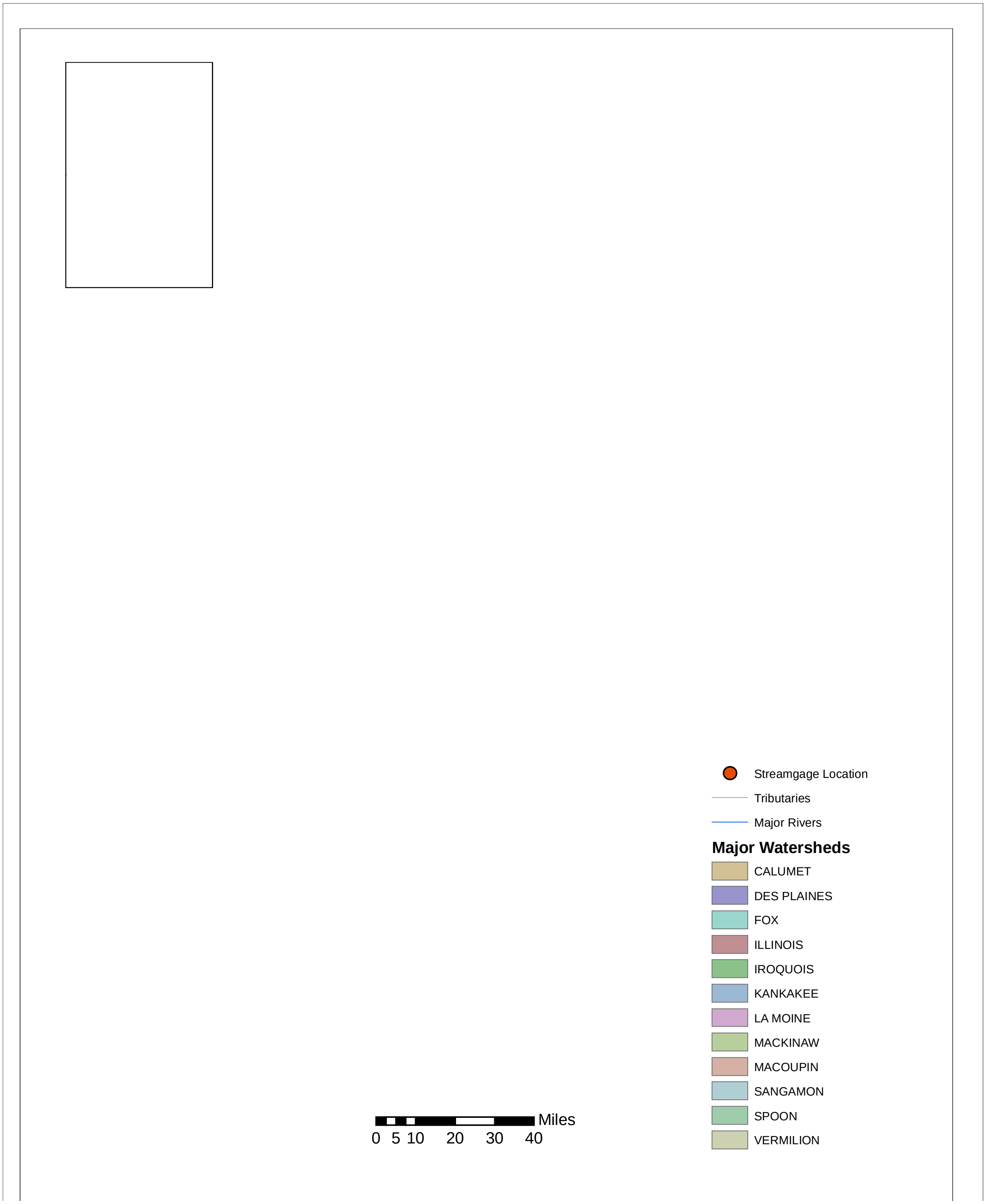


Figure 4-1. Location of streamgaging stations with long-term data used in the analysis of variability and trends

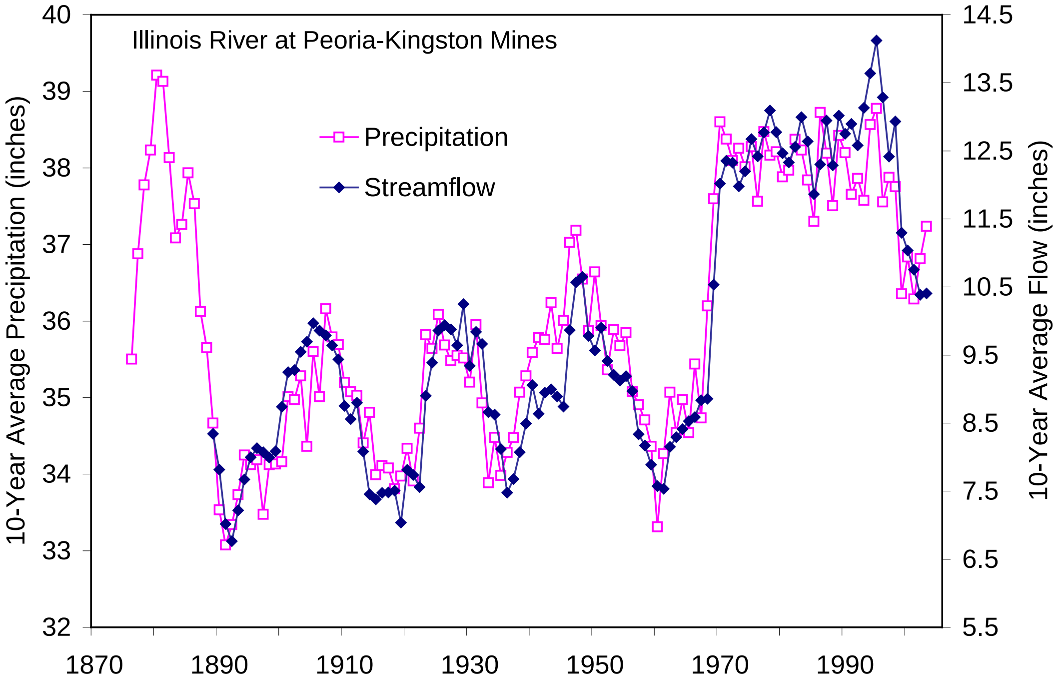


Figure 4-2. Ten-year average precipitation and streamflow,
Illinois River at Peoria-Kingston Mines

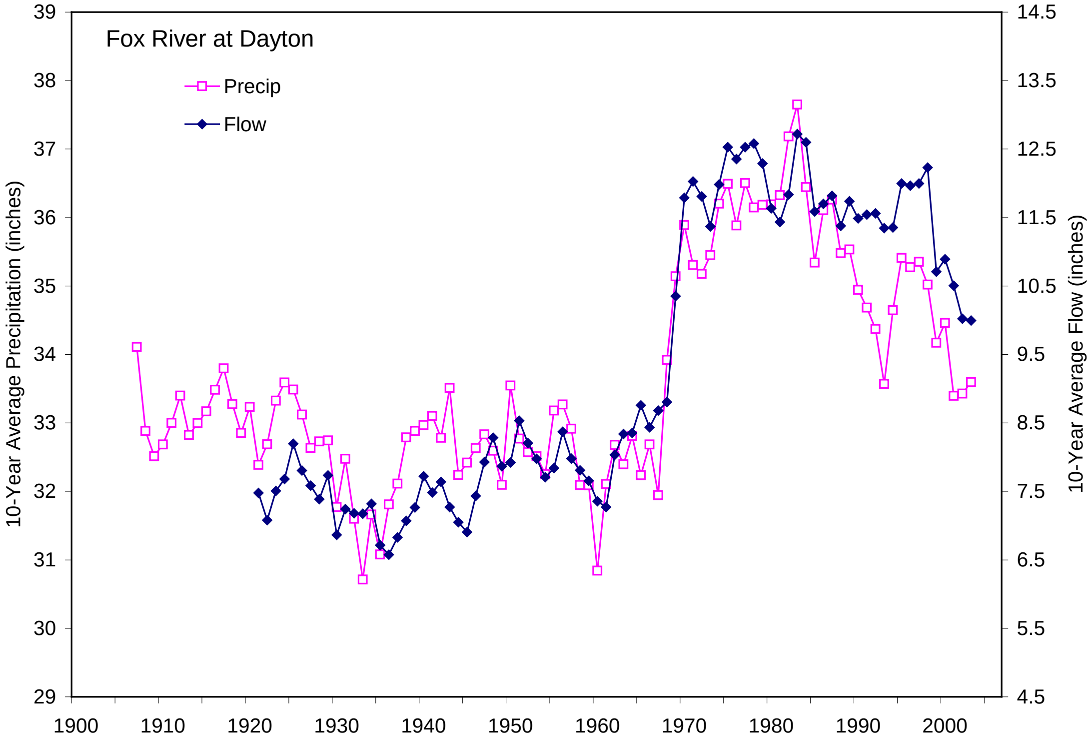


Figure 4-3. Ten-year average precipitation and streamflow, Fox River at Dayton

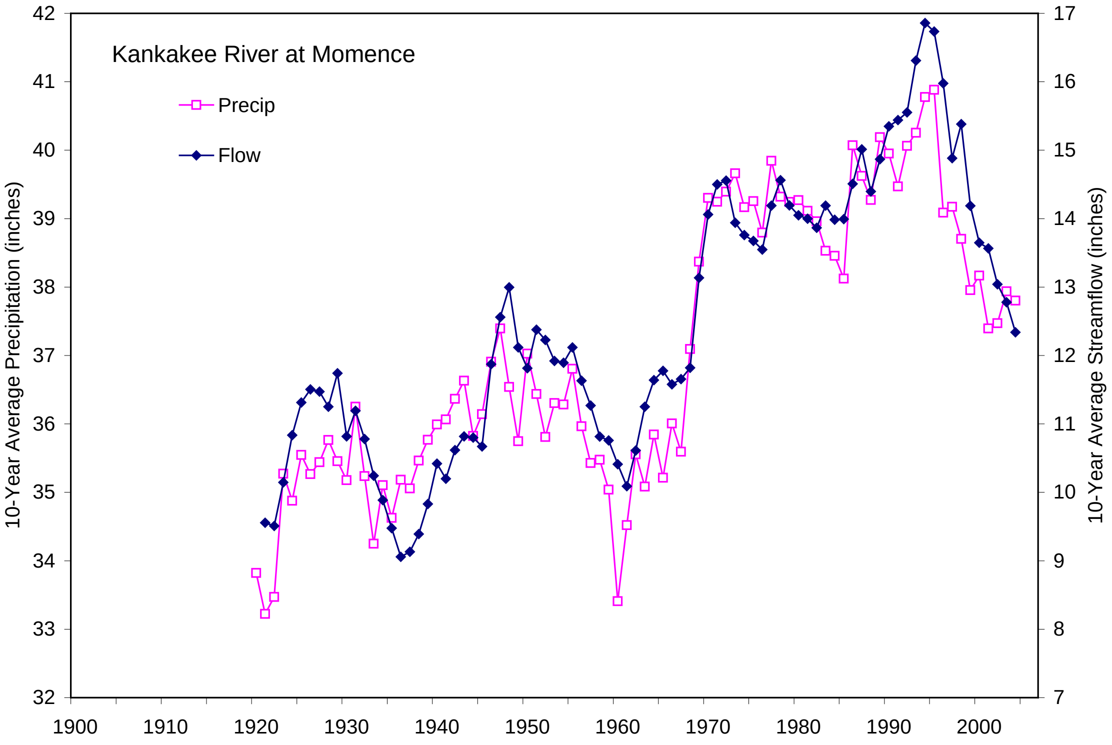


Figure 4-4. Ten-year average precipitation and streamflow, Kankakee River at Momence

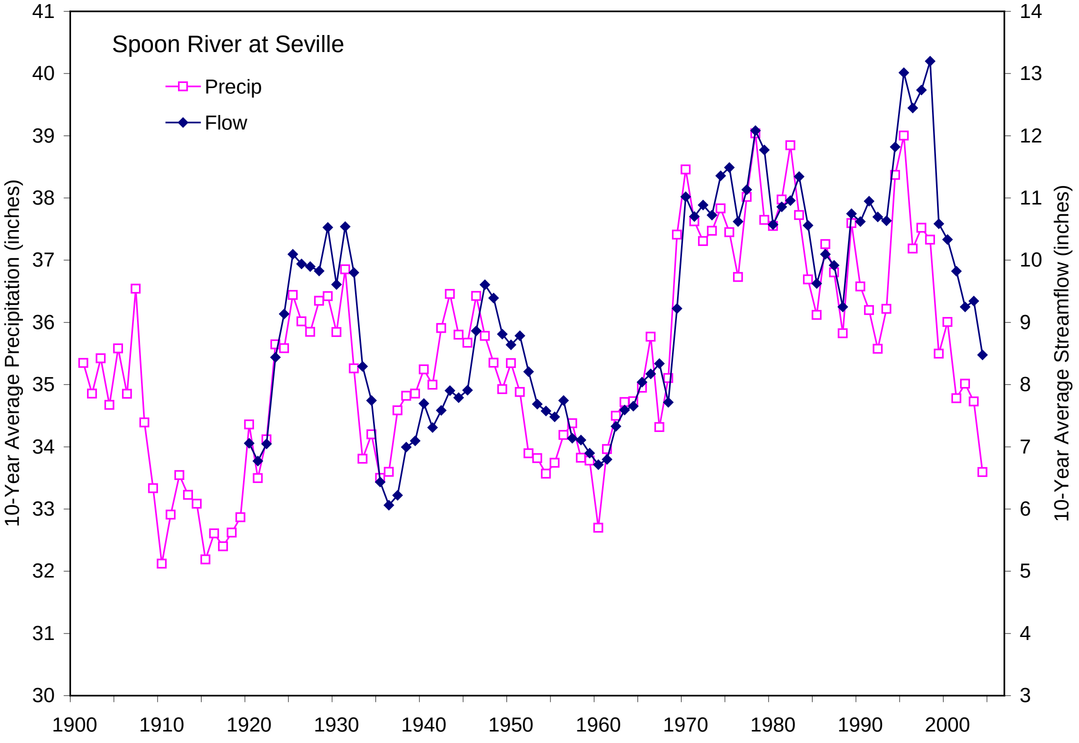


Figure 4-5. Ten-year average precipitation and streamflow, Spoon River at Seville

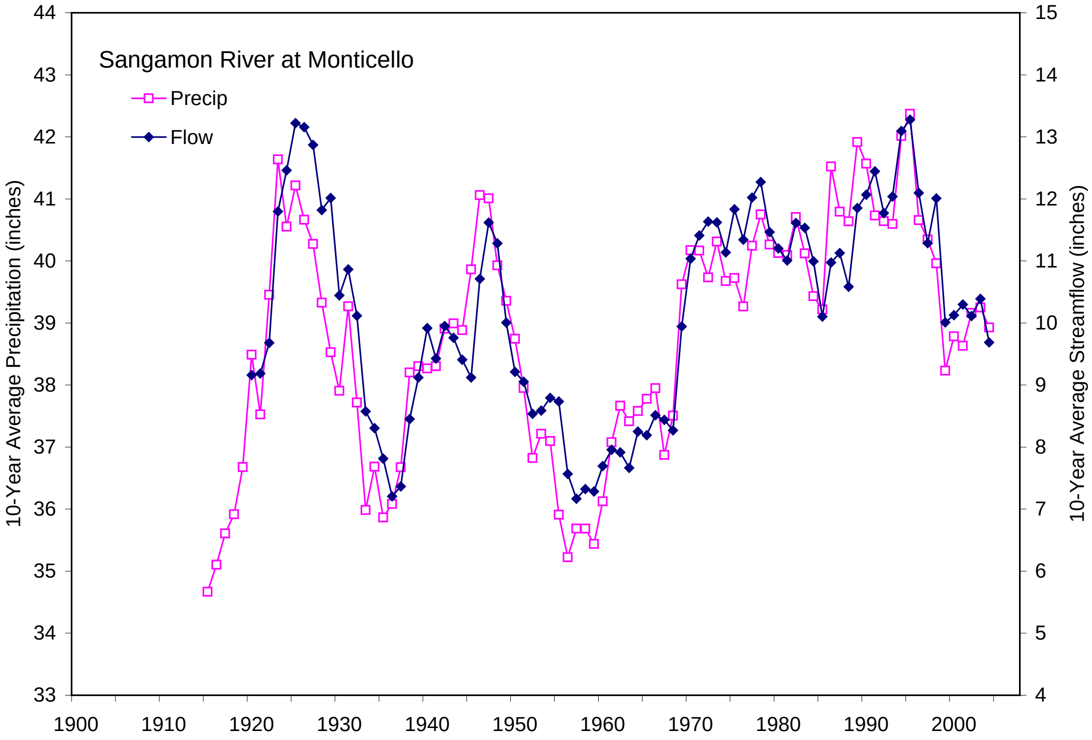


Figure 4-6. Ten-year average precipitation and streamflow, Sangamon River at Monticello

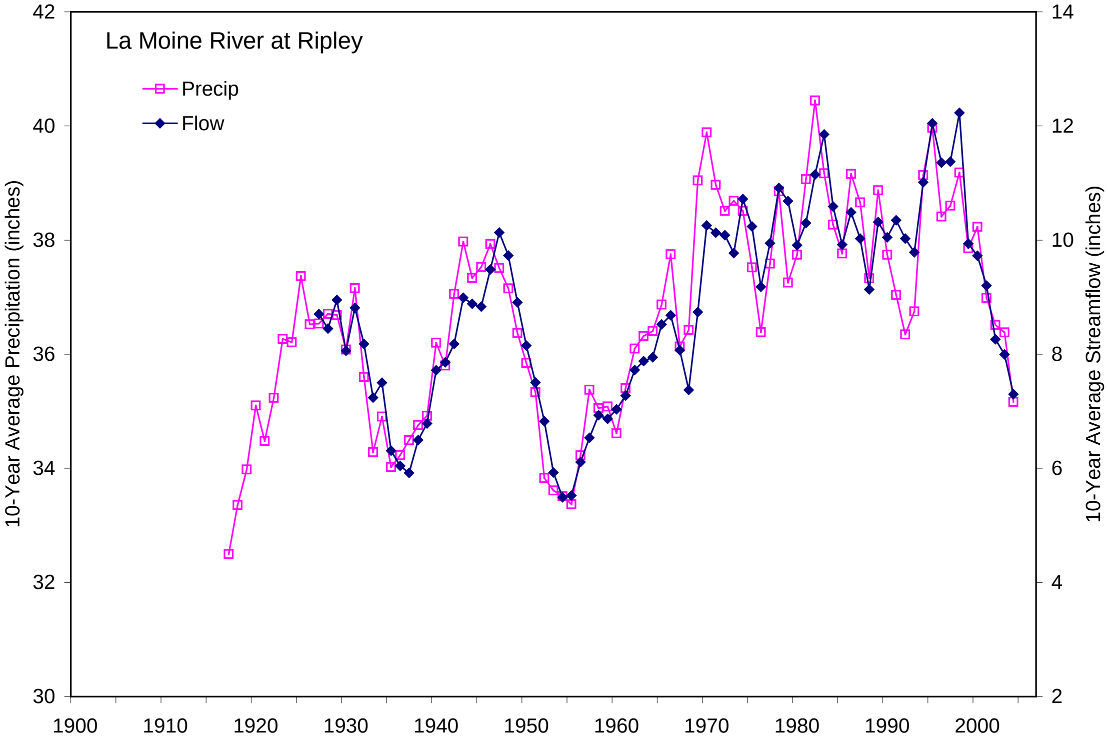


Figure 4-7. Ten-year average precipitation and streamflow, LaMoine River at Ripley

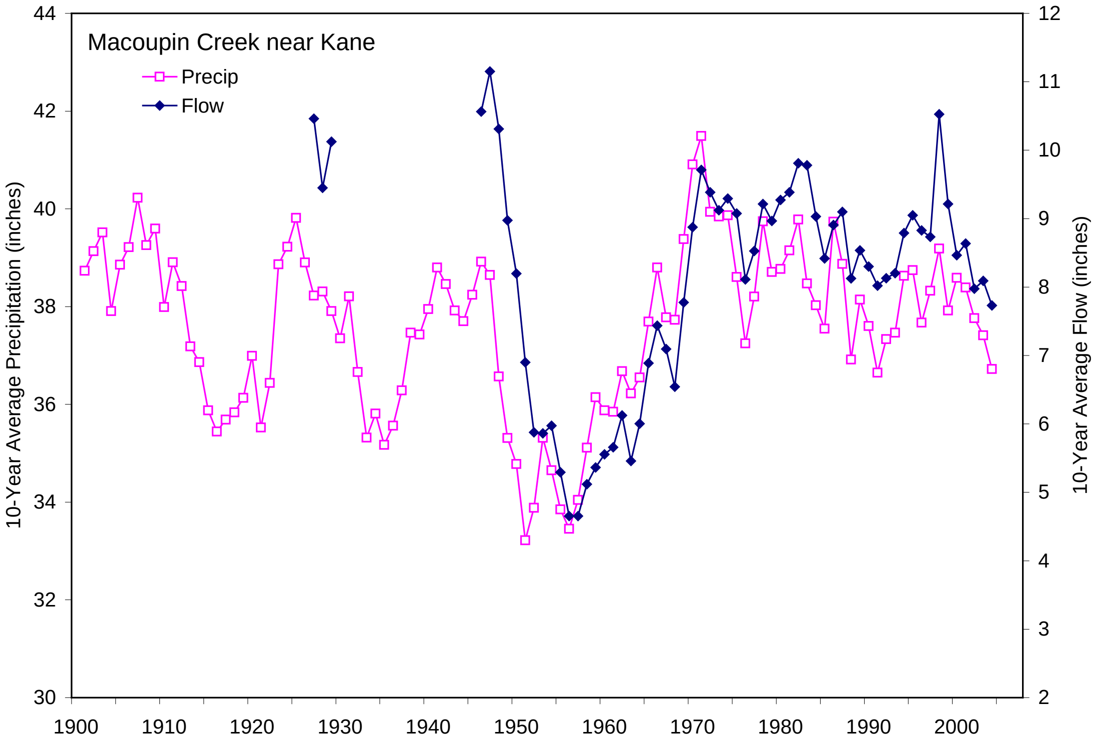


Figure 4-8. Ten-year average precipitation and streamflow, Macoupin Creek near Kane

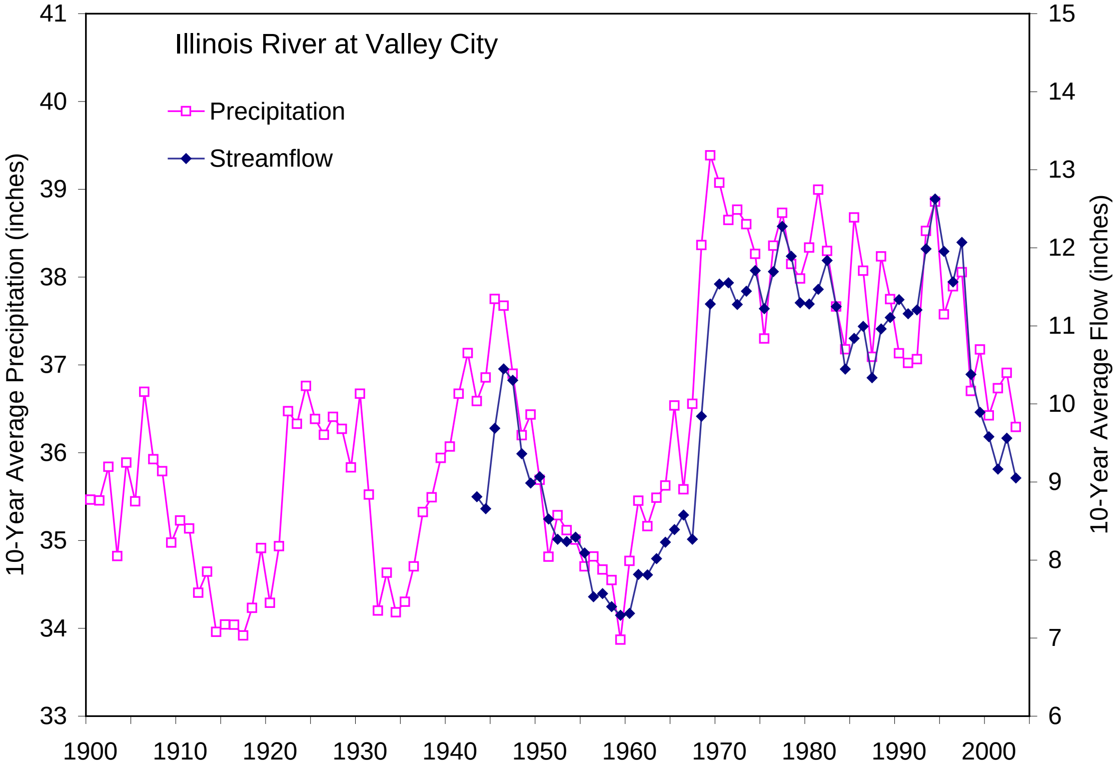


Figure 4-9. Ten-year average precipitation and streamflow, Illinois River at Valley City

Precipitation and streamflow trends shown in figure 4-2 are consistent with regional trends that have affected northern Illinois and much of the upper Midwest (Knapp, 2005). Statistical analyses of long-term streamflow records by Knapp (2005) using the Kendall tau-b trend statistic indicate that streamgage records in northern Illinois, eastern Iowa, and Minnesota all exhibit increasing trends in average streamflow (figure 4-10). Conversely, long-term flow records in the southern two-thirds of Illinois generally do not show significant increases in streamflow.

Figures 4-2 to 4-9 illustrate that trends in precipitation and streamflow vary across the Illinois River watershed. Increasing trends are particularly evident in the Upper Illinois River watershed and its two primary tributaries, the Fox and Kankakee River (figures 4-3 and 4-4). In contrast, the Macoupin, LaMoine, and Sangamon River subwatersheds, in the southern portion of the Illinois River basin, show much less or no overall trend in precipitation or streamflow — even though these records show considerable variation in precipitation and streamflow from decade to decade. The Spoon River watershed, having an intermediate location, shows an increasing trend in flow amount, but to a lesser degree than the Fox and Kankakee River watersheds located farther to the north. In all cases, there is a strong correlation between average precipitation and streamflow.

The significance of the trends is identified using the Kendall tau-b statistic. The Kendall tau-b statistical test provides a quantitative measure of trend, with a coefficient value of 0 indicating no trend and a value of 1 indicating an absolute increasing trend. For the 93-year flow records dating back to 1915, a coefficient value greater than or equal to 0.115 indicates an increasing trend at a 90 percent confidence level, and a value greater than or equal to 0.162 indicates an increasing trend at a 98 percent confidence level. Table 3-2 shows the Kendall Tau-b trend coefficients computed for two time periods, 1915-2007 and 1970-2007. The 1915-2007 trend analyses for the Fox, Kankakee, and Upper Illinois (Peoria-Kingston Mines) flow records show increasing trends with very high levels of confidence. The 1915-2007 trend analysis for the Spoon River record shows an increasing trend, with roughly a 94 percent level of confidence. The flow records for the tributaries located farther south in the watershed do not show a significant trend (having less than an 80 percent level of confidence). The 1915-2007 trend coefficient for the Illinois River at Valley City is not shown because the flow record does not date back to 1915.

Although flow records from the northern half of the Illinois River watershed display an general increasing trend over their full period of record, a closer look indicates: 1) there was a geographically widespread and sizable jump in average flow amount between the 1960s and 1970s (this jump also occurred in the southern part of the basin to a lesser extent); and 2) for most locations there has been little or no additional increase since the 1970s. In fact, for most locations, the average flows since 1995 have declined from the high flow levels that occurred from 1970 to 1995. Table 3-3 presents the average annual precipitation and streamflow amounts for the Illinois River and its major tributaries over the past 12 years (1996-2007) and compares these amounts to those for earlier periods (1915-1969 and 1970-1995) and to the overall long-term record. Except for the Kankakee River, the average flow from 1996-2007 for these rivers is much closer to the long-term average than it is to the higher flow amounts that were experienced

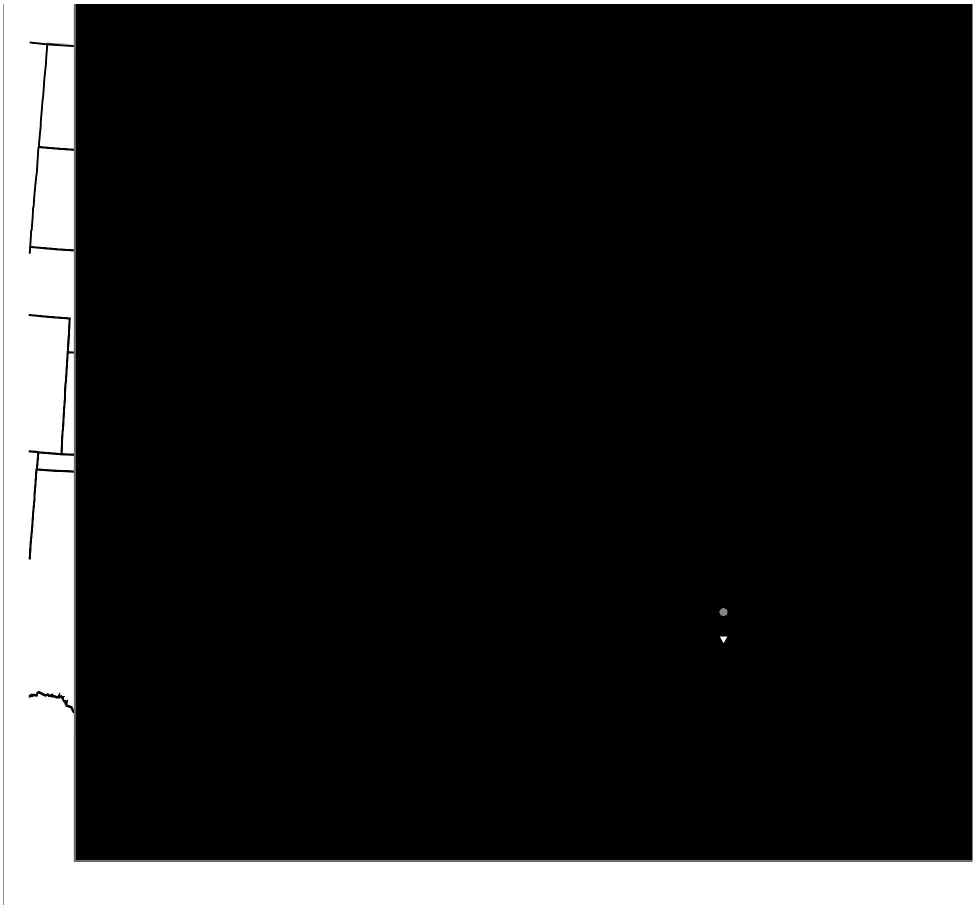


Figure 4-10. Locations of long-term streamflow gages (at least 89 years of record) showing statistically significant trends in mean annual flow in the eastern United States (from Knapp, 2005)

from 1970 to 1995. Thus, with the exception of the Kankakee River watershed, it is reasonable to conclude that other flow records collected throughout the Illinois River watershed over the 1996-2007 timeframe may represent conditions similar to their expected long-term average condition.

Although it is not possible to predict how these trends will progress in the future, concerns expressed in previous decades regarding the potential for continued increases in flows throughout the Illinois River watershed (for example by Ramamurthy et al., 1989) for the time being may no longer be an issue. If anything, there may be growing concerns that the occurrence of drought periods such as existed prior to 1970 may become more frequent. This analysis does not specifically look at trends of flooding or low flows. However, for long-term gaging records in the Illinois River watershed, Knapp (2005) found that trends in high flows and low flows tended to be coincident and proportional to trends in average flow.

Table 4-1. Kendall Tau-b Trend Statistics for Flow Records on the Illinois River and Major Tributaries

	Kendall Tau-b coefficient value period-of-record used in the analysis	
Streamgage record	*1915-2007*	*1970-2007*
Fox River at Dayton	0.294	-0.135
Kankakee River at Momence	0.316	-0.007
Illinois River at Peoria-Kingston Mines	0.315	-0.144
Spoon River at Seville	0.127	-0.127
Sangamon River at Monticello	0.087	-0.081
LaMoine River at Ripley	0.075	-0.166
Macoupin Creek near Kane*	-0.009	-0.081
Illinois River at Valley City**	------	-0.112

Notes:

* The periods of record for the Macoupin Creek gage near Kane are 1921-1933 and 1941-2007.

** The flow record at Valley City only extends back to 1939. The trend coefficient for the 1939-2007 period at Valley City, 0.162, is somewhat less than the trend coefficient for Peoria-Kingston Mines for the same time period (0.192).

Table 4-2. Average Annual Precipitation and Streamflow (inches) for Different Periods of Record

Precipitation

Watershed	*1915-2007*	*1915-1969*	*1970-1995*	*1996-2007*
Fox	33.7	32.6	35.9	34.4
Kankakee	37.0	35.5	39.5	38.4
Upper Illinois (Peoria)	36.3	35.2	38.3	37.1
Spoon	35.7	34.9	37.7	34.8
Sangamon	38.9	38.1	40.7	38.9
LaMoine	36.6	35.8	38.6	35.9
Macoupin	37.4	37.0	38.6	36.9
Entire Illinois (Valley City)	36.5	35.6	38.3	36.6

Streamflow

Watershed	*1915-2007*	*1915-1969*	*1970-1995*	*1996-2007*
Fox	9.3	7.7	12.1	10.0
Kankakee	12.3	10.9	14.7	13.5
Upper Illinois (Peoria)	10.2	8.8	12.9	10.8
Spoon	9.1	8.0	11.3	9.2
Sangamon	10.4	9.5	12.4	10.1
LaMoine	8.7	7.7	10.7	8.2
Macoupin	8.4	8.1	9.1	7.8
Entire Illinois (Valley City)	9.8	8.4	11.7	9.5

5. Model Development and Application

The Illinois State Water Survey has been developing a watershed model for the Illinois River basin in support of the Illinois River Ecosystem project. In the initial phase, a hydrologic model of the entire Illinois basin has been developed and used to evaluate potential impacts of land use changes and climate variability on streamflow in the Illinois River basin. The model is based on the U.S. Environmental Protection Agency's BASINS 3.0 modeling system. The Hydrologic Simulation Program – FORTRAN or HSPF (Bicknell et al., 2001) which is part of BASINS was used to simulate the hydrology of the Illinois River basin. The HSPF is a comprehensive and dynamic watershed model that also has the capability to simulate water quality and sediment transport.

To make the model applicable for assessing and evaluating the impact of CREP and other land use changes on water quality and sediment transport, the Water Survey has been developing the sediment transport and water quality capabilities of the HSPF model for the Illinois River basin. The initial effort has focused on the Spoon River watershed (figure 5-1) where two of the four intensively monitored watersheds, Court and Haw Creek, are located. Streamflow, sediment, and water quality data being collected at three monitoring stations are being used to calibrate and test the model for the Spoon River watershed. Once the calibration and validation process are completed for the Spoon River watershed, the model parameters can be used to develop models for other similar watersheds to simulate the hydrology, sediment transport and water quality under different climatic and land use scenarios. Over time, as land use practices change significantly as a result of CREP and other conservation practices, the models being developed will provide the tools to evaluate and quantify changes in water quality and sediment delivery to the Illinois River.

The progress in model development for the Spoon River watershed is discussed in the following sections.

HSPF Model

The HSPF model is a conceptual, comprehensive, long term continuous simulation watershed scale model which simulates non-point source hydrology and water quality, combines it with point source contributions, and performs flow and water quality routing in the watershed and its streams. The HSPF model simulates land-surface portion of the hydrologic cycle by a series of interconnected storages – an upper zone, a lower zone, and a ground-water zone. The fluxes of water between these storages and to the stream or atmosphere are controlled by model parameters. The model uses a storage routing technique to route water from one reach to the next during stream processes.

For sediment simulation, the surface erosion component of the HSPF model performs processes such as sediment detachment from the soil matrix in the pervious land segments during rainfall event, washoff of this detached sediment, scour of the soil matrix, and reattachment or compaction of the sediment. Storage and washoff of sediments from the impervious surfaces is

Figure 5-1. Location of the Spoon River watershed

also considered. The sediment load and transport in the stream channel is dependent on the particle diameter, density, fall velocity, shear stress for deposition and scour, and erodibility. The noncohesive (sand) and cohesive (silt and clay) sediment transport is simulated in the model using different subroutines.

Nutrients in the watershed soil in the HSPF model are simulated either as attached to organic or inorganic solids, dissolved in the overland flow, or as concentrations in the subsurface flow reaching the streams laterally. For both nitrogen and phosphorous compounds, the processes simulated include immobilization, mineralization, nitrification/denitrification (nitrogen only), plant uptake, and adsorption/desorption. The nutrient loads from the watershed undergo further transformation in the stream reaches.

Model Input Data

The HSPF model requires spatial information about watershed topography, river/stream reaches, land use, soils, and climate. The hourly time-series of climate data required for hydrologic simulations using HSPF include precipitation, potential evapotranspiration (ET), potential surface evaporation, air temperature, dew-point temperature, wind speed, and solar radiation. The hourly precipitation data from the two ISWS gages, one each in Court Creek (ISWS31) and Haw Creek (ISWS32) watersheds, were used (figures 5-2 and 5-3). Daily precipitation data from the MRCC (Midwestern Regional Climate Center) gaging station at Galesburg (ID 113320) was also used after it was disaggregated into hourly data based on the hourly precipitation data from an ICN (Illinois Climate Network) station located in Monmouth (MON). The other time series of the climate inputs for the above three precipitation stations were obtained from the ICN station at Monmouth. Daily data from nine additional MRCC stations (figure 5-4) in or near the Spoon River watershed were also disaggregated into hourly data based on the hourly data from three stations at Peoria, Moline, and Augusta, as found in the BASINS database. These additional stations were used for the Spoon River watershed model.

For topographic inputs, the 30-meter Digital Elevation Model (DEM) raster dataset produced by the Illinois State Geological Survey (ISGS) and the United States Geological Survey (USGS) was used. The high resolution National Hydrography Dataset (NHD) developed by the USGS was used to provide stream/river reach information to the model. The land use data were obtained from the Illinois Department of Agriculture which is based on the satellite imagery of the State of Illinois acquired from three dates during the spring, summer, and fall seasons of 1999 and 2000. Land use in the study watersheds was classified as corn, soybean, rural grassland, forest, urban, wetland and other (figures 5-5, 5-6, and 5-7). The soils data were based on digitized County Soil Association Maps of the Knox County and the STATSGO dataset (figure 5-8). The soil type for various parts of the study watersheds were determined spatially from the digitized soils maps, but the parameters corresponding to the soil type were manually entered during development of the HSPF model.

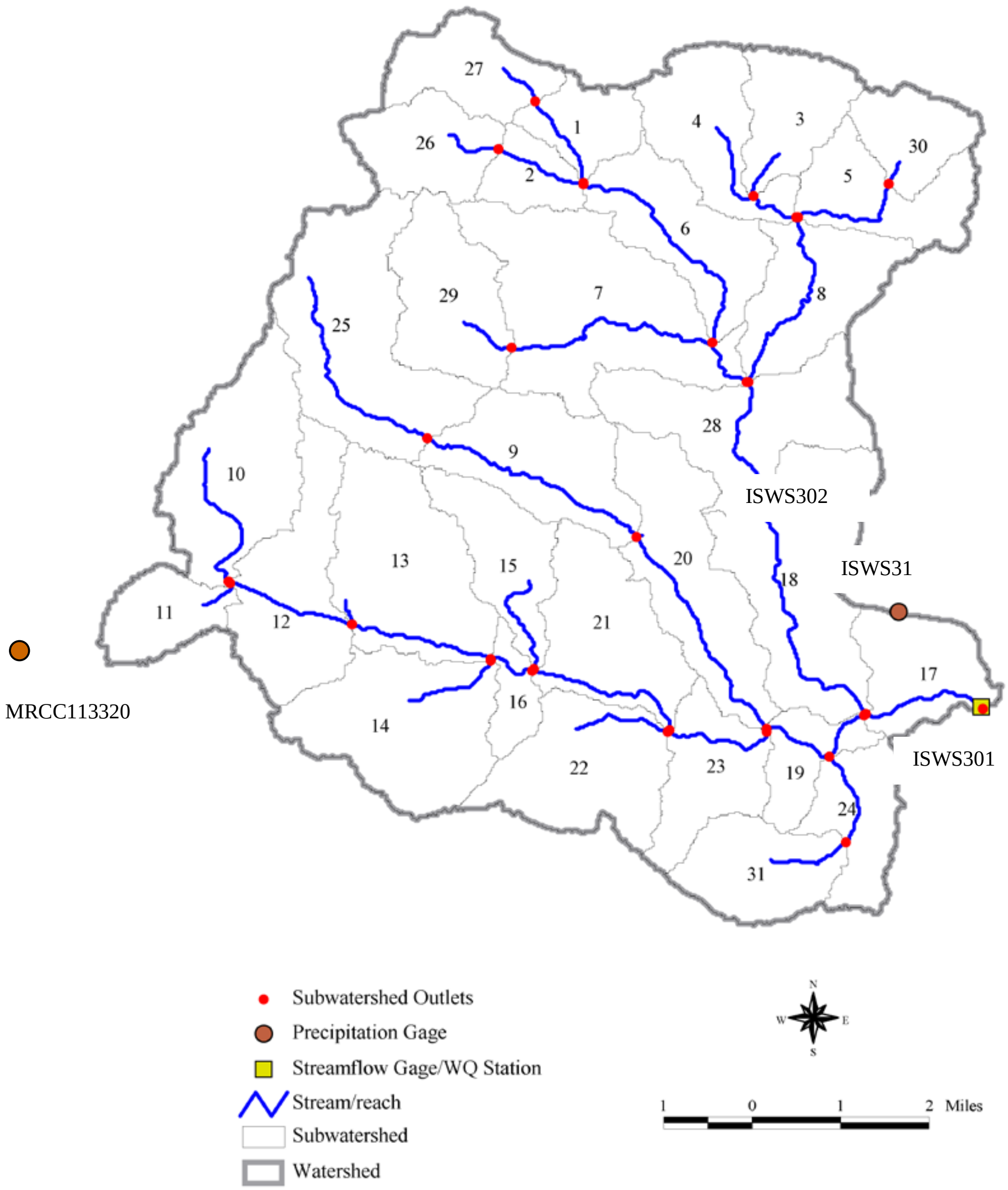


Figure 5-2. Schematic of the subwatershed and stream delineation, and precipitation gages used for the Haw Creek model

Figure 5-3. Schematic of the subwatershed and stream delineation, and precipitation gages used for the Haw Creek model

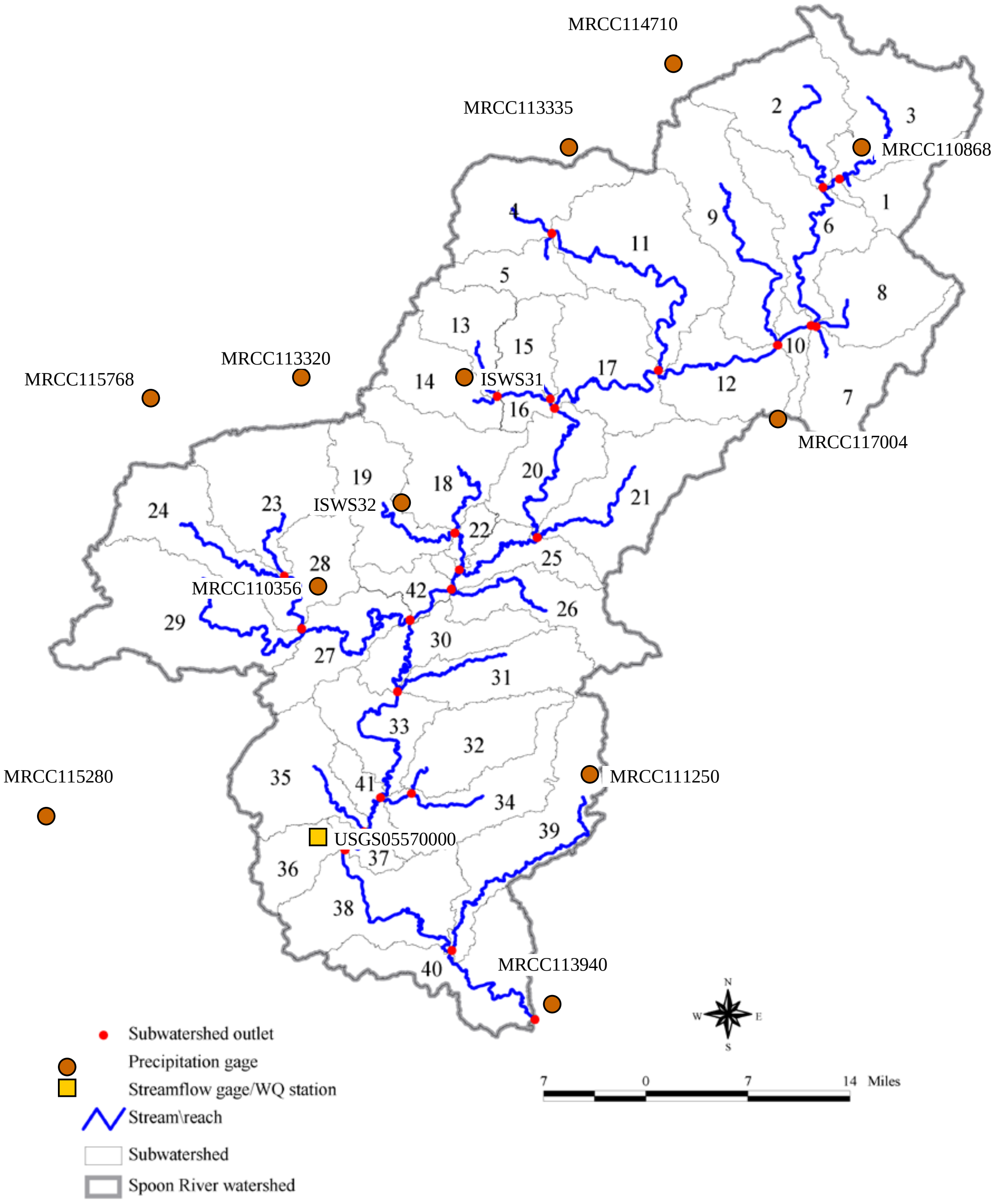


Figure 5-4. Schematic of the subwatershed and stream delineation, and precipitation gages used for the Spoon River watershed model

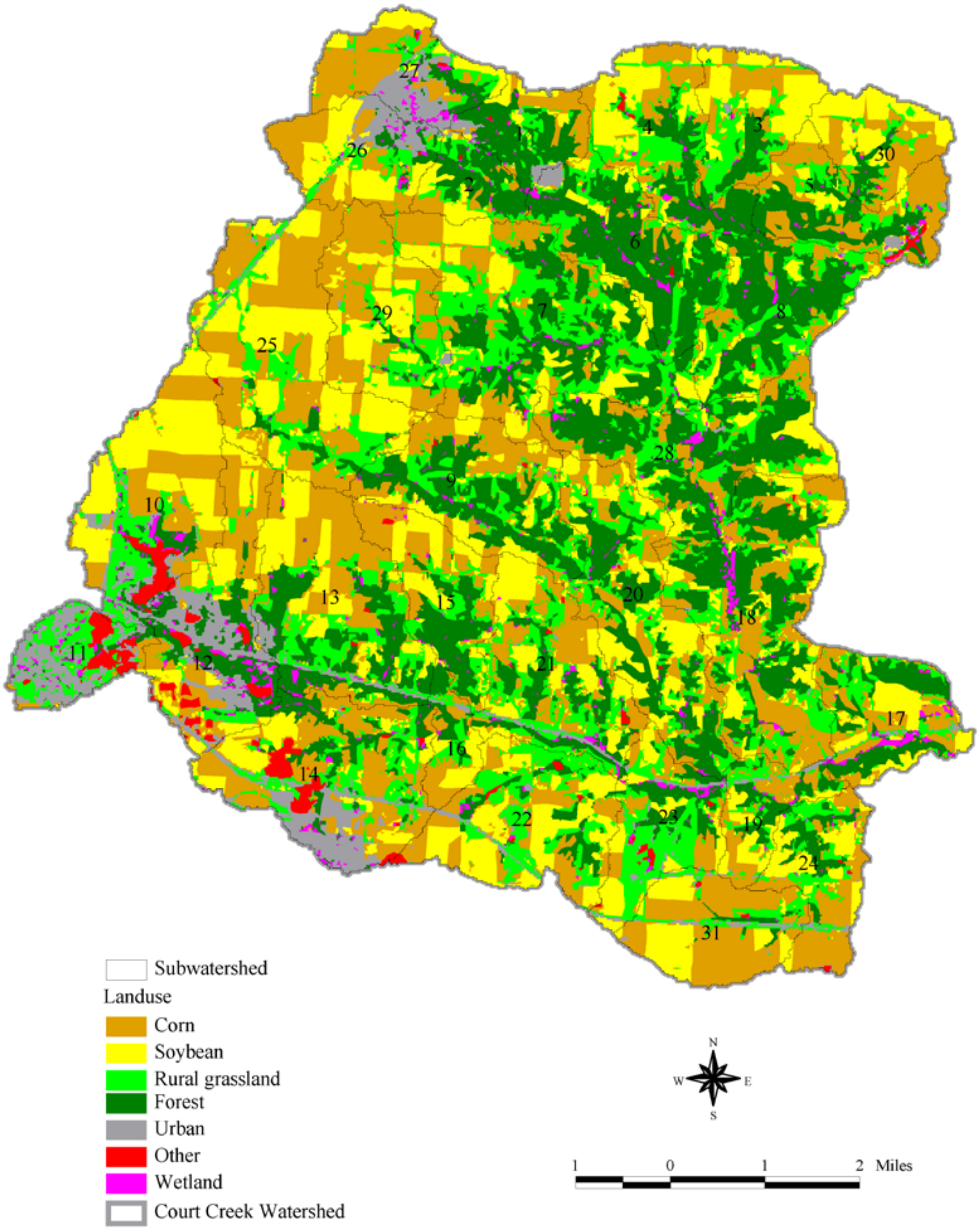


Figure 5-5. Land use in the Court Creek watershed

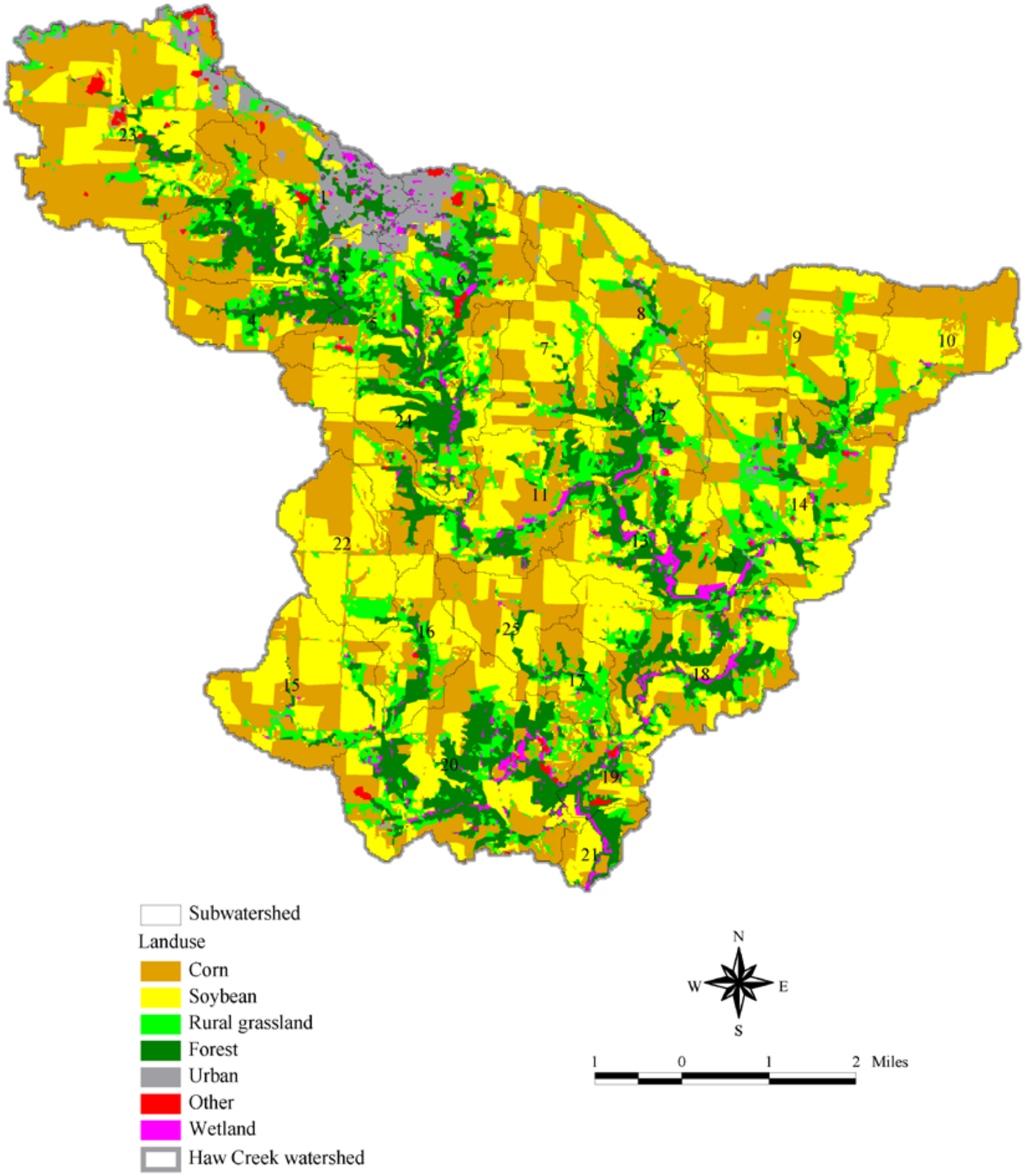


Figure 5-6. Land use in the Haw Creek watershed

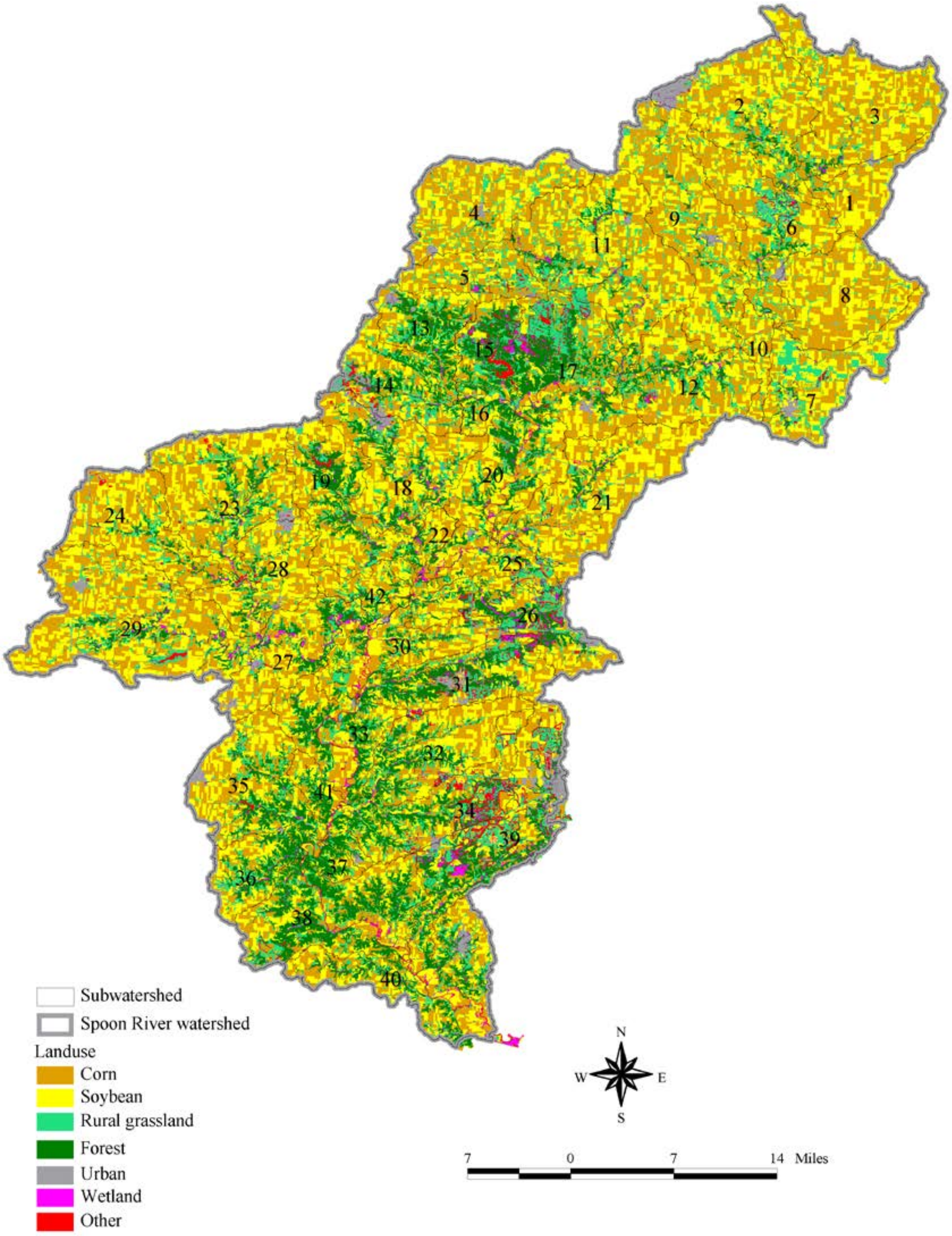


Figure 5-7. Land use in the Spoon River watershed

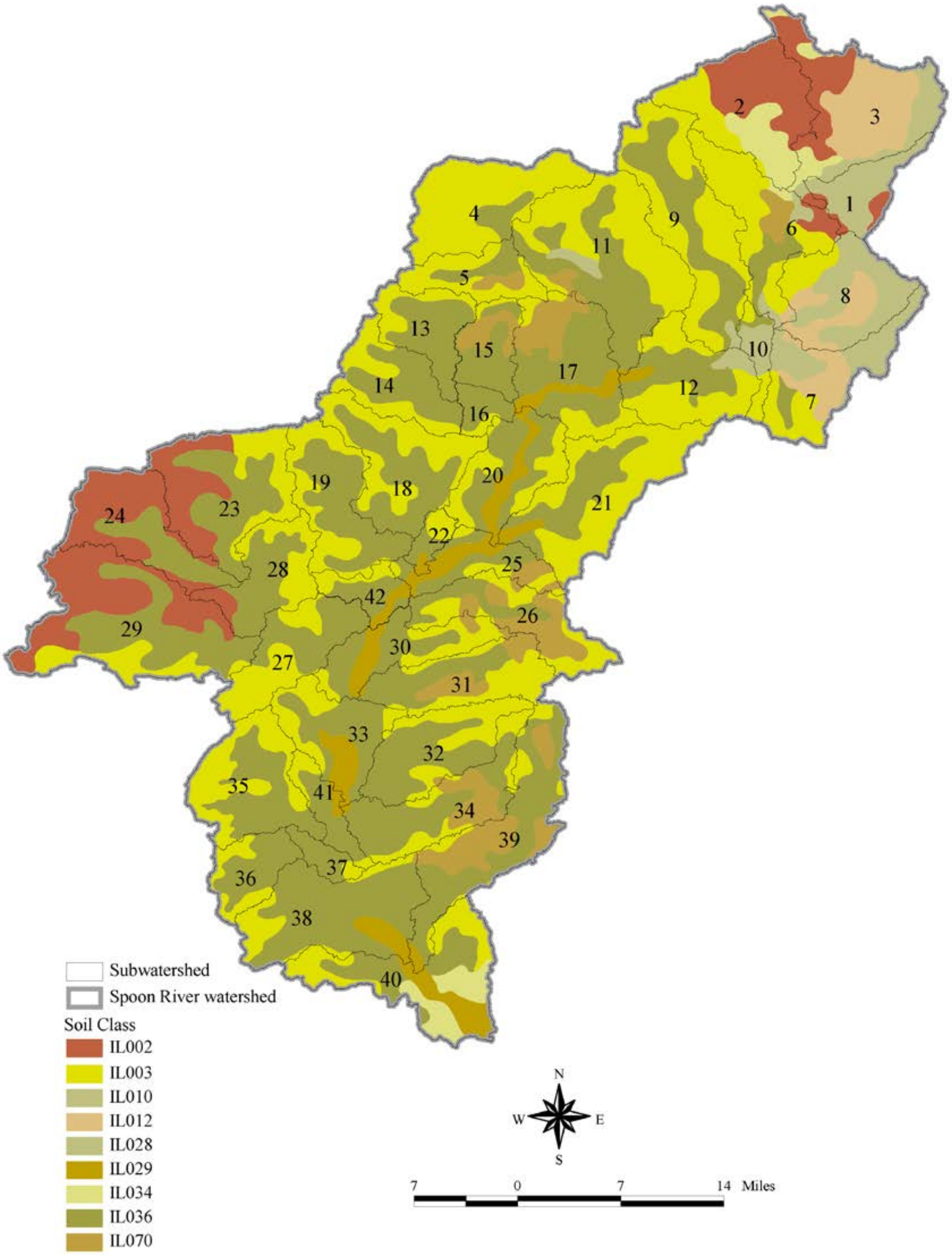


Figure 5-8. Soil types in the Spoon River watershed

Model Development

Based on the topographic and hydrographic data, the watersheds were subdelineated into smaller hydrologically-connected subwatersheds and stream reaches, and respective outlets. The Automatic Delineation procedure in BASINS with an option of ‘burning in’ existing streams was used. Subdelineation was done for representing spatially variable physical and other characteristics of a watershed in the HSPF model. The Court, Haw, and Spoon River watersheds were subdivided into 31, 25, and 42 subwatersheds, respectively (figures 5-2, 5-3, and 5-4). During subdelineation, outlets were specified in the models corresponding to the streamflow gaging/water quality monitoring stations on the North Creek (ISWS302), Court Creek (ISWS301), Haw Creek (ISWS303), and the USGS streamflow gaging station at Seville (USGS05570000) in the Spoon River watershed (figures 5-2, 5-3, and 5-4). The subwatersheds were further subdivided into Hydrologic Response Units (HRUs) based on land use, soil, and climate to account for the spatial variability of a basin’s physical and hydrologic characteristics at a finer scale. An HRU is an area within a watershed that is expected to have a similar hydrologic response to input of precipitation and evapotranspiration. Each HRU has a set of parameter values that must be determined through the calibration process to define runoff characteristics as well as loading of various constituents from that HRU. In the Court Creek watershed HSPF model, climate data from the Court Creek and Galesburg precipitation gages were input to different subwatersheds based on the proximity. Similarly, in the Haw Creek HSPF model data from the Haw Creek and Galesburg gages were input to various subwatersheds. In case of Spoon River watershed HSPF model, data from all ten MRCC stations were specified for different subwatersheds based on their proximity to the gages.

Model of the Court Creek watershed was developed first using two years (WY2001-WY2002) streamflow and sediment concentration data from the ISWS301 streamflow gage/WQ station on the Court Creek. Calibrated model parameters from this model were then used to populate the models of the Haw Creek and Spoon River watersheds. No further calibration of these two models was performed. Haw Creek watershed model was run for the same two year period as Court Creek watershed model and the model results were compared with the observed data from the ISWS303 gage on the Haw Creek. Since long-term climate and streamflow data were available for the Spoon River watershed, this model was run for 1972-1995 period using data from the USGS05570000 at Seville.

Modeling Results

Values of a large number of HSPF model parameters can not be obtained from field data and need to be determined through model calibration exercise. The Court Creek watershed model was calibrated to assign best possible parameter values to each HRU and stream reach so that the model simulated daily streamflows and pollutant concentrations similar to the values observed at the gaging/monitoring stations. Calibration of the hydrologic component of the model was followed by the calibration of the water quality component for the sediment concentration. Model was run for hourly time step. For the two year calibration period of WY2001-WY2002, percent volume error between the model simulated and observed streamflows at gages ISWS301 on the Court Creek and ISWS302 on the North Creek were 1.2% overestimation, and 3.5%

underestimation, respectively. Comparisons of the daily streamflows simulated by the model for WY2001-WY2002 period with those observed at gages ISWS301 and ISWS302 are shown in figures 5-9a and 5-9b. The performance of this preliminary model is promising and overall the simulated streamflows follow the similar trend as the observed values. The timings and shape of the simulated streamflow hydrographs resemble the observed ones but some peak flows were underestimated by the model. In this study the model was not calibrated to match the individual stormflow events, rather it was calibrated to fit the long-term and daily data over the two year calibration period. Also, data from only two precipitation gaging stations, both near the boundary of the watershed (figure 5-2), were used to spatially represent the precipitation over the entire watershed. It is possible that rainfall measured for a particular event at one of the gages did not represent the rainfall that actually occurred in different parts of the watershed, thereby resulting in discrepancies between the observed and simulated streamflow hydrographs. Thus, more precipitation gaging stations will help improve the performance of the hydrologic model by more accurately simulating the stormflow hydrographs.

For sediment simulation by the model in the Court Creek watershed, parameters controlling soil erosion on the surface and sediment transport in the stream channel were calibrated. Comparison of sediment concentration simulated by the model and those observed at gages ISWS301 and ISWS302 are shown in figure 5-10 for the WY2001-WY2002 period. The simulated values generally followed the same trend as the observed sediment concentration values at both gages. Since most soil erosion occurs during extreme runoff events, some high sediment concentrations were underestimated by the model as a result of poor estimation of the stormflow peaks by the model during hydrologic simulations.

Streamflow and sediment concentration simulation results from the Haw Creek watershed model are compared with the observed data as shown in figures 5-11 and 5-12, respectively. Similar results from the Spoon River watershed model are shown in figures 5-13 and 5-14. In this preliminary phase, the performances of these two models were similar to the calibrated model of the Court Creek watershed. Performance of these models can be improved in the future if climate, streamflow, and water quality data are available for more stations and longer time period to improve the model calibration.

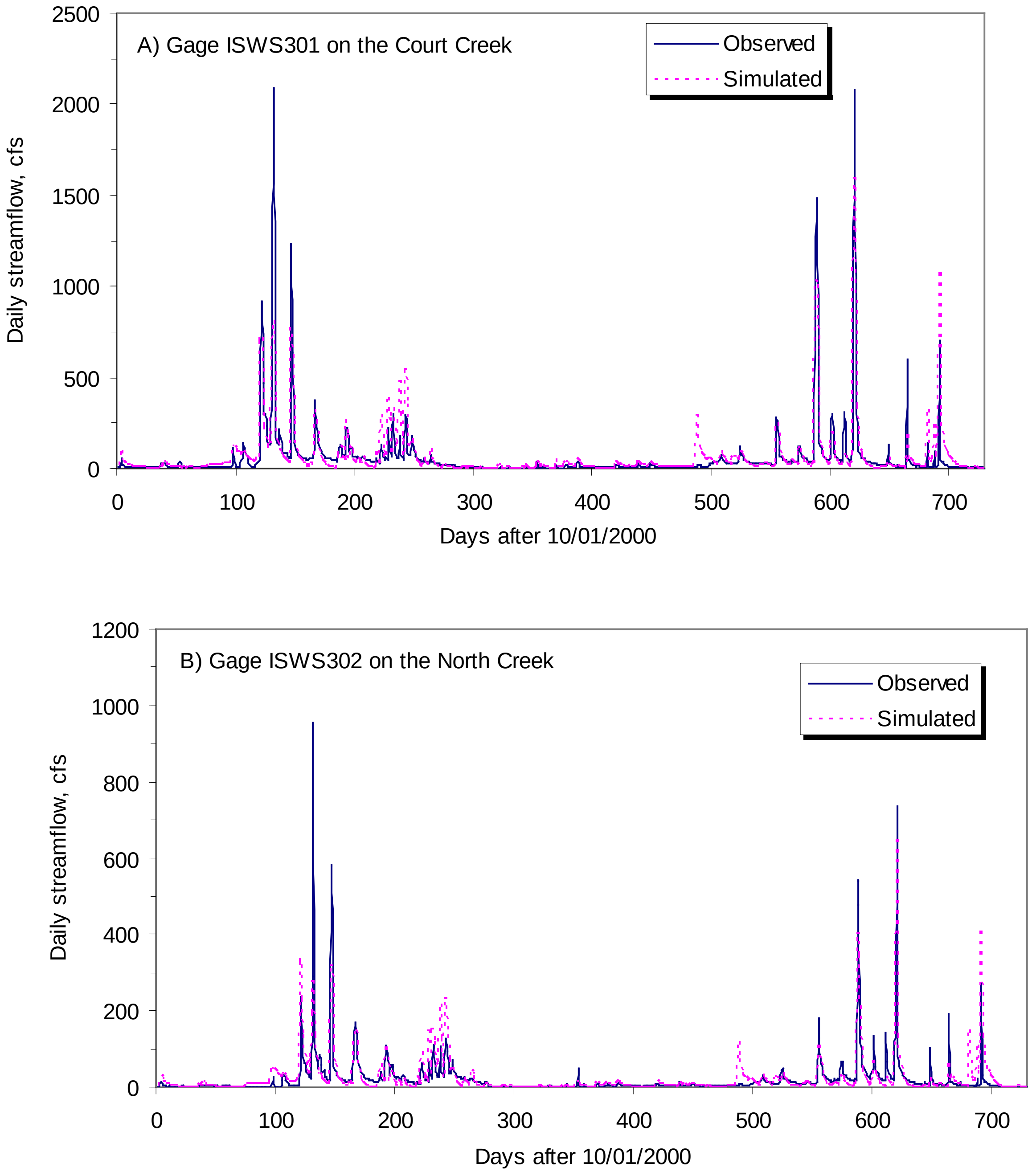
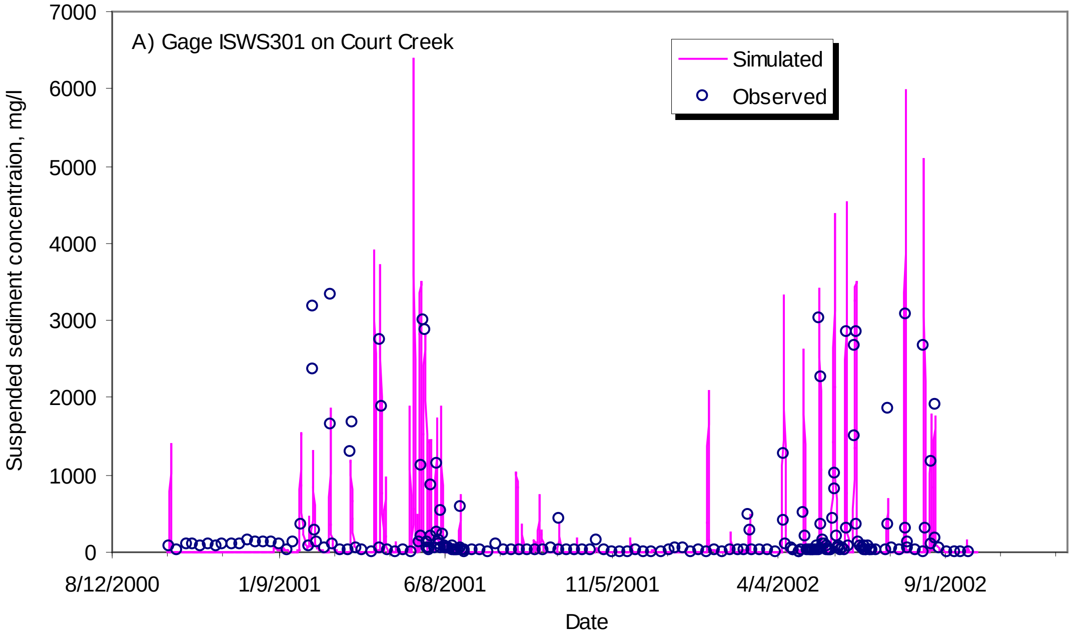


Figure 5-9. Results of model calibration for streamflow simulation for the Court Creek watershed



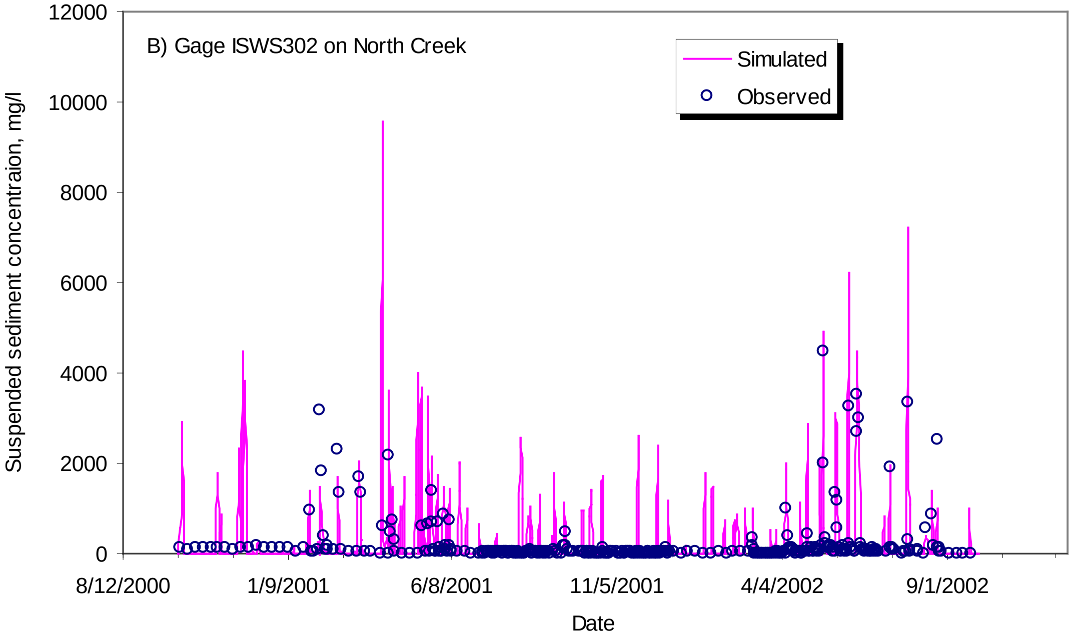


Figure 5-10. Preliminary results of model calibration for suspended sediment concentration simulation for the Court Creek watershed

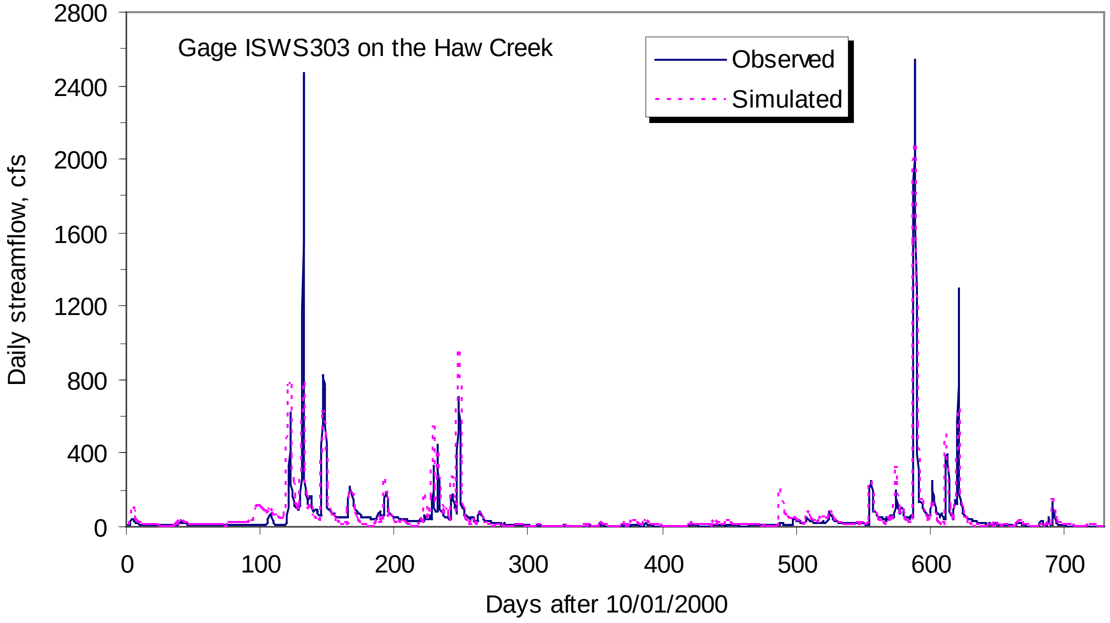


Figure 5-11. Comparison of observed and simulated streamflow by the Haw Creek watershed model developed using the calibrated parameters from the Court Creek watershed model

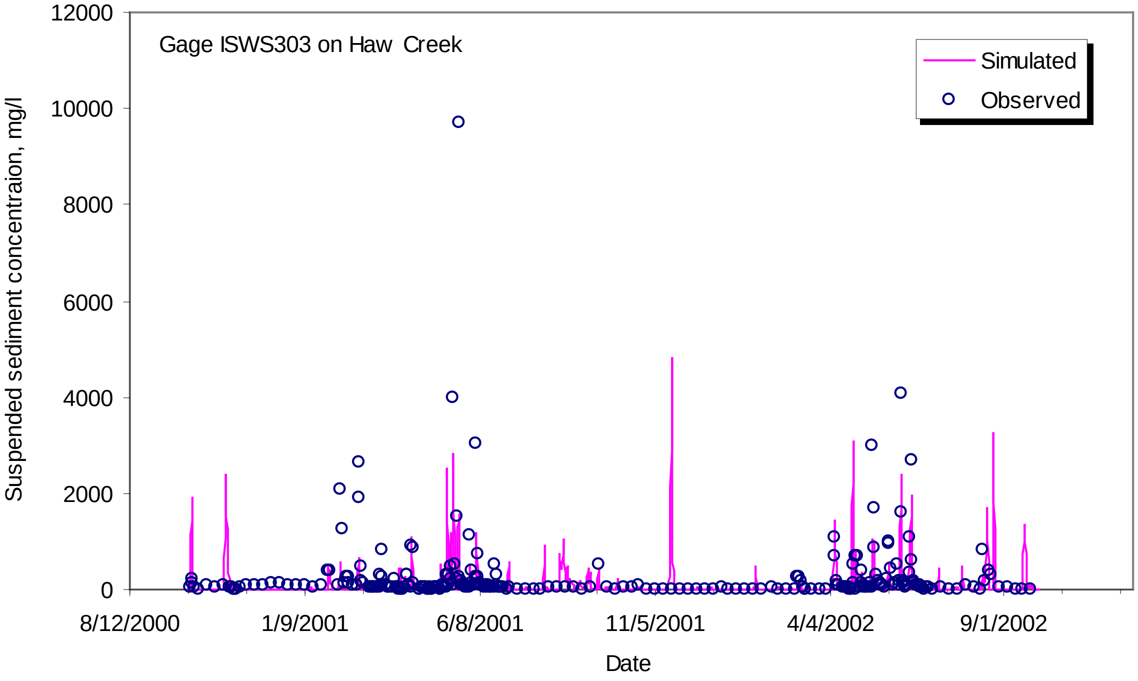


Figure 5-12. Preliminary results for suspended sediment concentration from the Haw Creek watershed model developed using the calibrated parameters from the Court Creek watershed model

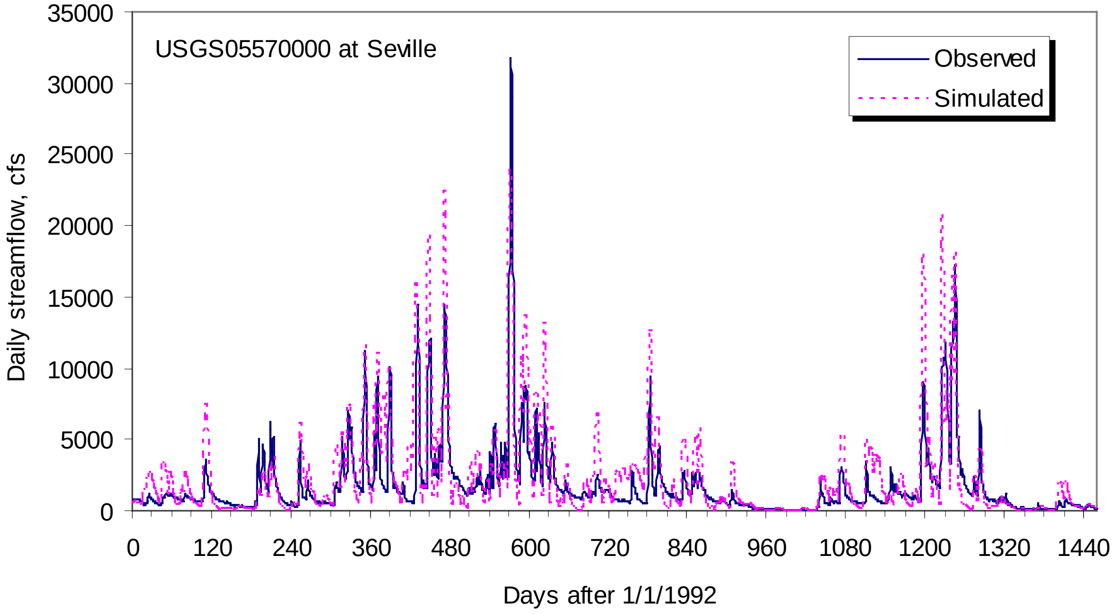


Figure 5-13. Comparison of observed and simulated streamflow simulation by the Spoon River watershed model developed using the calibrated parameters from the Court Creek watershed model

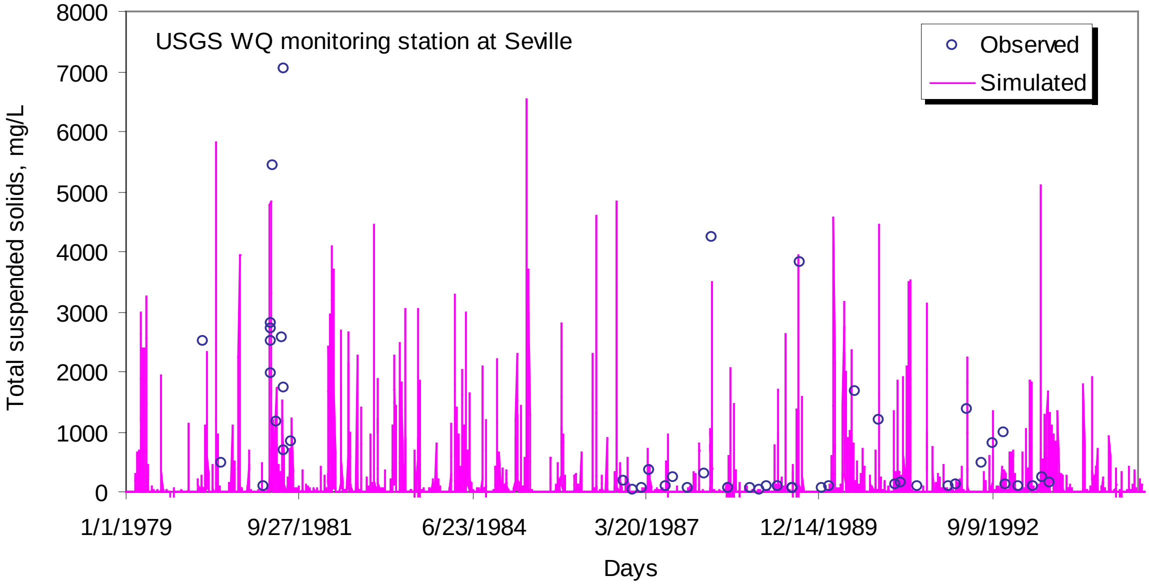


Figure 5-14. Preliminary results for suspended sediment concentration from the Spoon River watershed model developed using the calibrated parameters from the Court Creek watershed model

6. Analyses and Discussion

Sediment Loadings

Based on sediment records since 1980, the Illinois River on the average receives approximately 13 million tons of sediment annually from tributary streams (Demissie et al., 2016). About 60 percent of the sediment delivered to the river (7.8 million tons) is deposited in the river, backwater lakes, and side channels along the river. Most of this sediment is generated in the tributary watersheds to the Lower Illinois River, with the Spoon and LaMoine River watersheds as the highest per unit area generators of sediment among the major tributaries. The smaller tributaries draining directly to the river also contribute significant sediment. Controlling the erosion processes that are producing excessive sediment and reducing sediment delivery to the Illinois River will be a long-term effort, since sediment storage and mobilization along major rivers is a slow process. It will take some time to flush the sediment already in the system. In the initial phase of a restoration project, the major goal is to stabilize the system so that the erosion process is not accelerating and generating more sediment. The readjustment processes will take a number of years to reach a dynamic equilibrium condition where the natural processes of erosion and sedimentation are in balance. The long-term goal of the Illinois River restoration projects is to reach such a state where continued excessive sedimentation is eliminated.

To assess these processes, long-term monitoring is needed. The CREP program has been collecting sediment data at selected watersheds to supplement other monitoring programs. The data collection for the CREP program started in 1999 and has generated fourteen years of data. The annual sediment load data for each of the five CREP monitoring stations have been presented in chapter 2. Because of the short duration of data collection program, this data cannot yet be used to assess long-term trends. However, the short-term trends are shown in figure 6-1, where the sediment load per unit area was normalized by the runoff in inches to account for the variability of runoff from year to year. Even though the extreme wet year 2008 stands out as the year with the highest yield (for Panther and Cox Creeks), the general trend for the other stations is a gradual decrease or no trend. Again, these are short term trends and any major climatic or hydrologic variability in the coming years could change the trends, as illustrated with the influence of 2008 on Panther and Cox Creeks. As we continue the monitoring program, the trends will be more clear and reliable as the duration of the monitoring period increases.

The data were also compared with historical data collected by the USGS for small watersheds in the Illinois River basin as shown in figure 6-2. As shown in the figure, the CREP dataset is consistent with the older dataset and will be used to develop improved sediment delivery estimates for small watersheds in the Illinois River basin and improve our assessment and evaluation capability.

To assess long-term trends, data collected by the USGS and ISWS since 1980 were used to compute sediment delivery for the major tributaries to the Lower Illinois River. For the USGS data, sediment delivery from the three major tributary watersheds to the Lower Illinois River was computed for the downstream gaging stations near the outlet of the watersheds using the same methods developed by Demissie et al. (2004). The outflow of sediment from the Illinois River basin is measured at Valley City. The sediment loads and the corresponding water discharges for

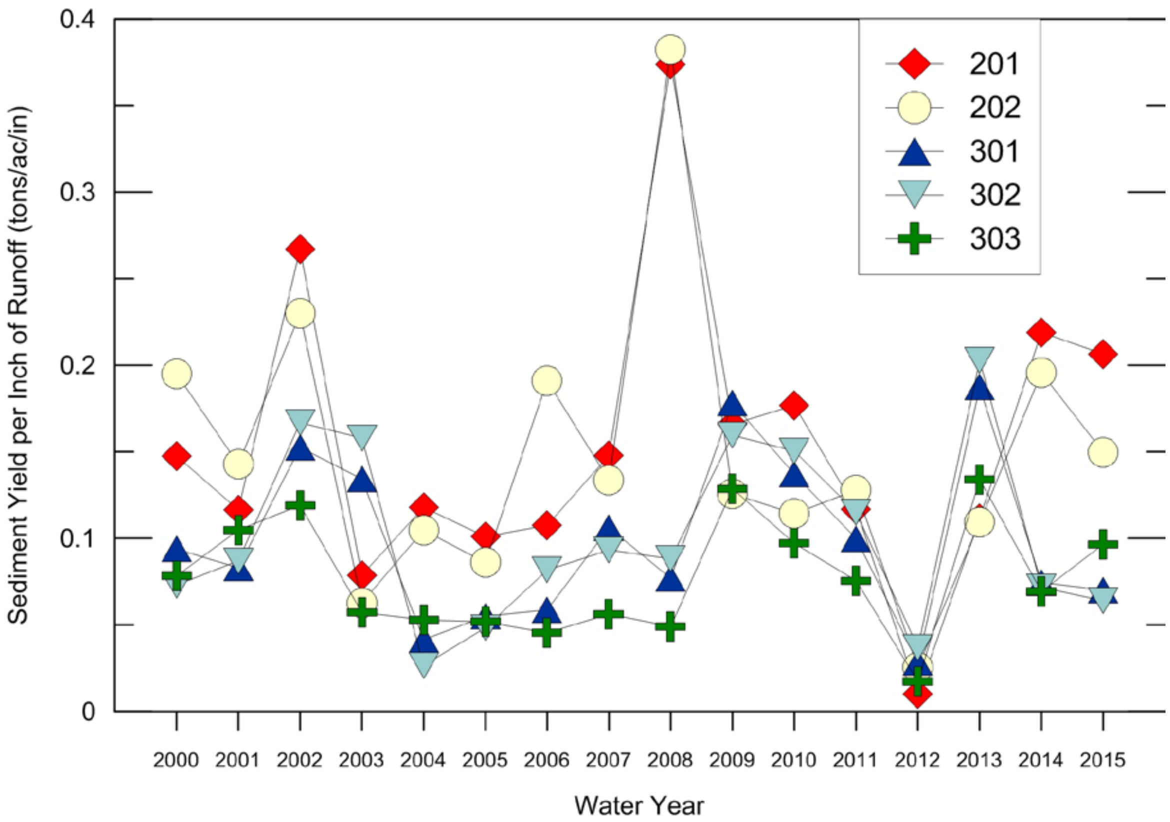


Figure 6-1. Variability of sediment yield per inch of runoff for CREP monitoring stations

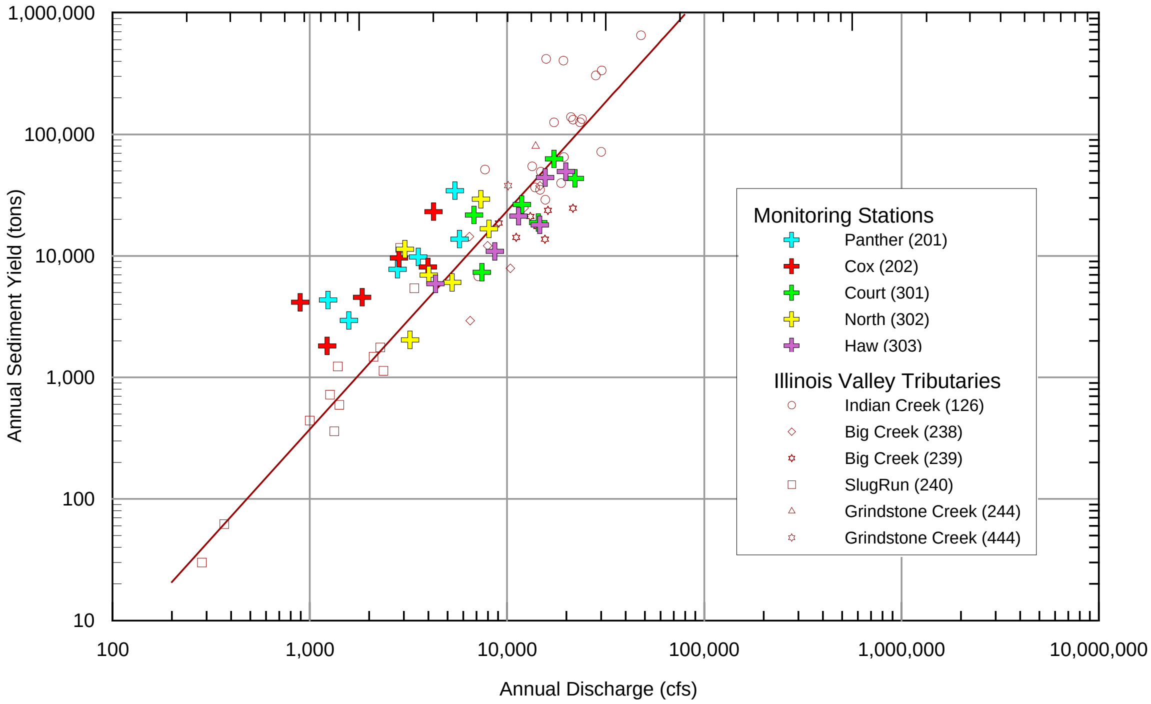


Figure 6-2. Comparison of sediment load from CREP monitoring stations with historical sediment data for small watersheds by the USGS

five-year increments since 1980 are shown in figure 6-3. The period 1991-1995 generally shows the highest sediment delivery to the Illinois River and the highest outflow from the Illinois River for the period under consideration, primarily because of the 1993 major floods. Since that period, sediment delivery from the tributaries and outflow from the Illinois River have generally been decreasing. If these trends continue into the future, there would be significant reduction in sediment delivery to the Illinois River.

Similar trends are also observed from the analyses of sediment data collected by the ISWS for the Benchmark Sediment Monitoring Program for Illinois Streams. The Benchmark Sediment Monitoring Program has been collecting weekly sediment data at selected monitoring stations throughout the state since 1980 (Allgire and Demissie, 1995). The data collected over that last 30 years have been processed and analyzed to observe trends in sediment concentrations and loads. Figures 6-4 to 6-6 show the trend in sediment load since 1980 for the Spoon River at Long Mills, LaMoine River at Ripley, and Sangamon River at Monticello, respectively. All three stations show a decreasing trend since 1980 even though the 2009 and 2010 annual loads are higher than the mean annual loads.

Nutrient Loadings

To assess long-term trends in nutrient loadings as conservation practices are implemented, the state has been collecting nutrient data at the five CREP monitoring stations where sediment data have been collected since 1999. Even though there are some low and high nutrient load years, the dataset is not long enough to assess long-term trends in nutrient loading. However, the short-term trends based on the data collected so far are shown in figures 6-7 and 6-8 for nitrate-N and total phosphorous yields per inch of runoff respectively. The nutrient yield values were divided by the inches of runoff to partly remove the effect of the variability of runoff from year to year. As shown in figure 6-7, the nitrate-N yields show a gradual decline since 2006 for all stations except for a spike in 2013 for stations 201 and 202 following a major drought in 2012. Figure 6-8 shows no significant trend for total phosphorous over the whole monitoring period except for the jump in yield in 2000 and 2008 for stations 201 and 202 and a significant drop for all the stations in 2012 due to the drought.

Long-term data collected by the Illinois EPA as part of their Ambient Water Quality Monitoring Network can, however, provide a fair indication of the general long-term trend in nutrient delivery to the Illinois River. Figure 6-9 shows annual nitrate-N yields in tons per square mile from the three major tributaries of the Lower Illinois River (Spoon, Sangamon, and LaMoine Rivers). Nitrate-N represents about 70 percent of the total nitrogen load in most of Illinois' agricultural watershed, and thus is a good surrogate for total nitrogen load. As can be seen in the figure, the nitrate yields can range from almost zero during a drought year like 1989 to a high of about 11 tons per square mile during a major wet period like the 1993 flood year. Therefore, climatic factors do play a major role in nutrient transport and delivery. The most important observation that can be made for the figure is the slow decreasing trend of nitrate-N yield from the major tributary watersheds. Even though it is very difficult to measure how much of the change is due to the CREP program, it is obvious that conservation practices in these watersheds, where most of the CREP lands are located, are making a difference in nitrogen delivery to the Illinois River.

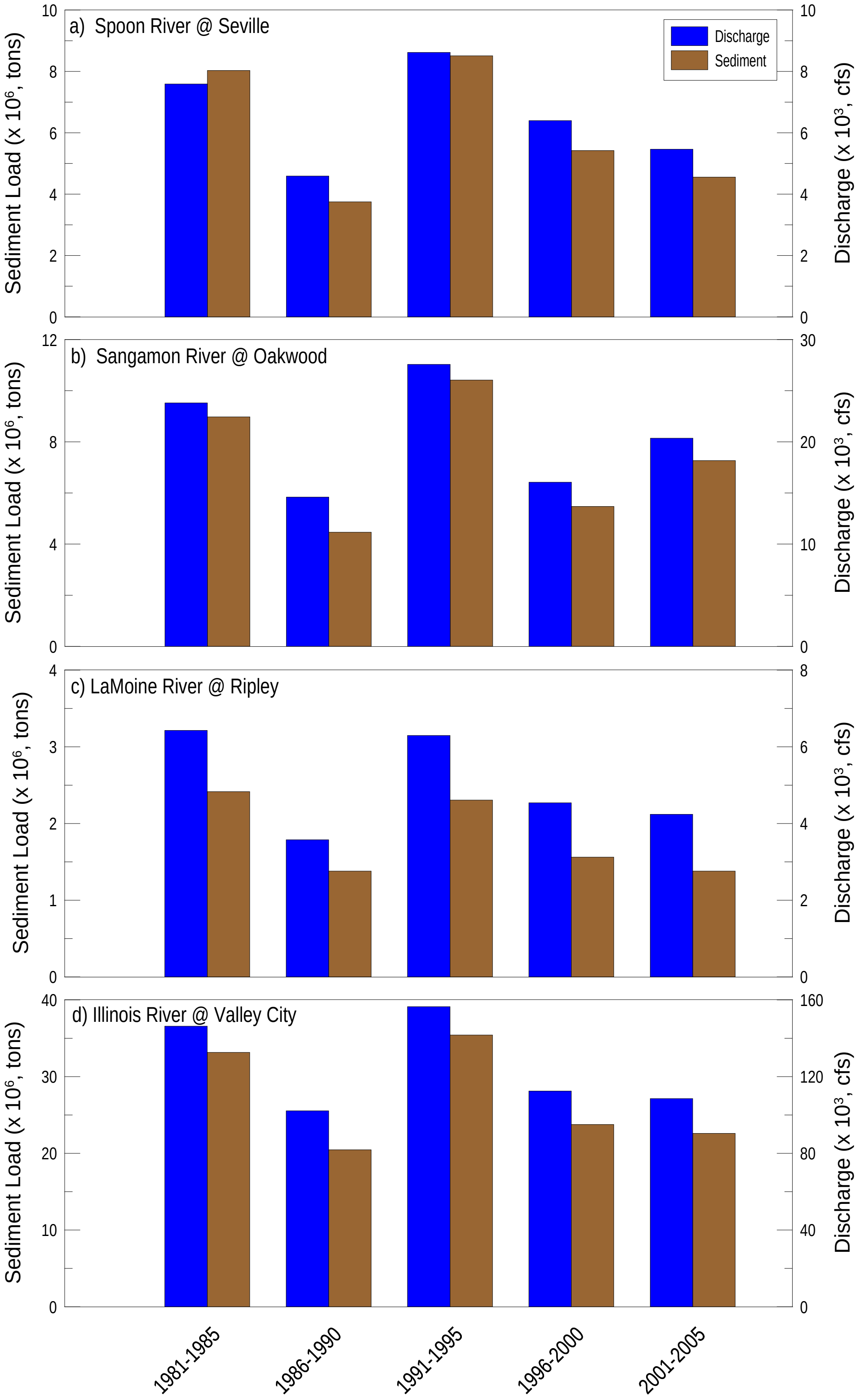


Figure 6-3. Sediment delivery from the three major tributary watersheds to the Illinois River and sediment outflow from the Illinois River at Valley City

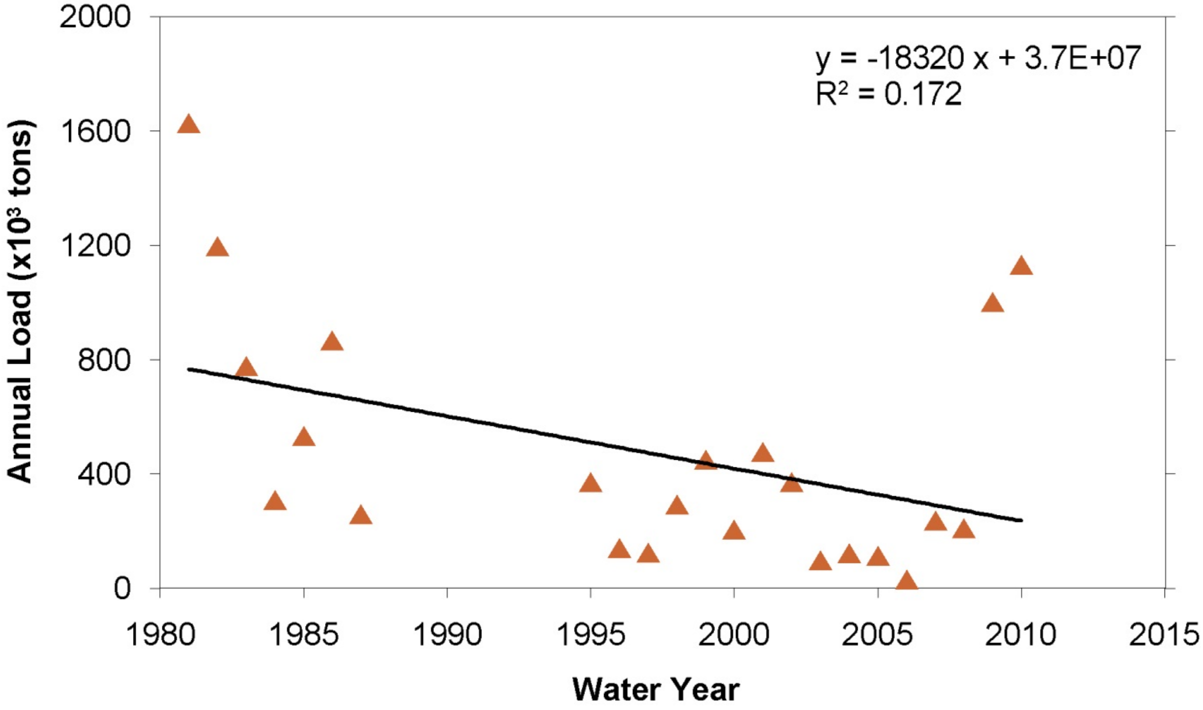


Figure 6-4. Trends in sediment load at Spoon River at London Mills (after Crowder et al., 2008)

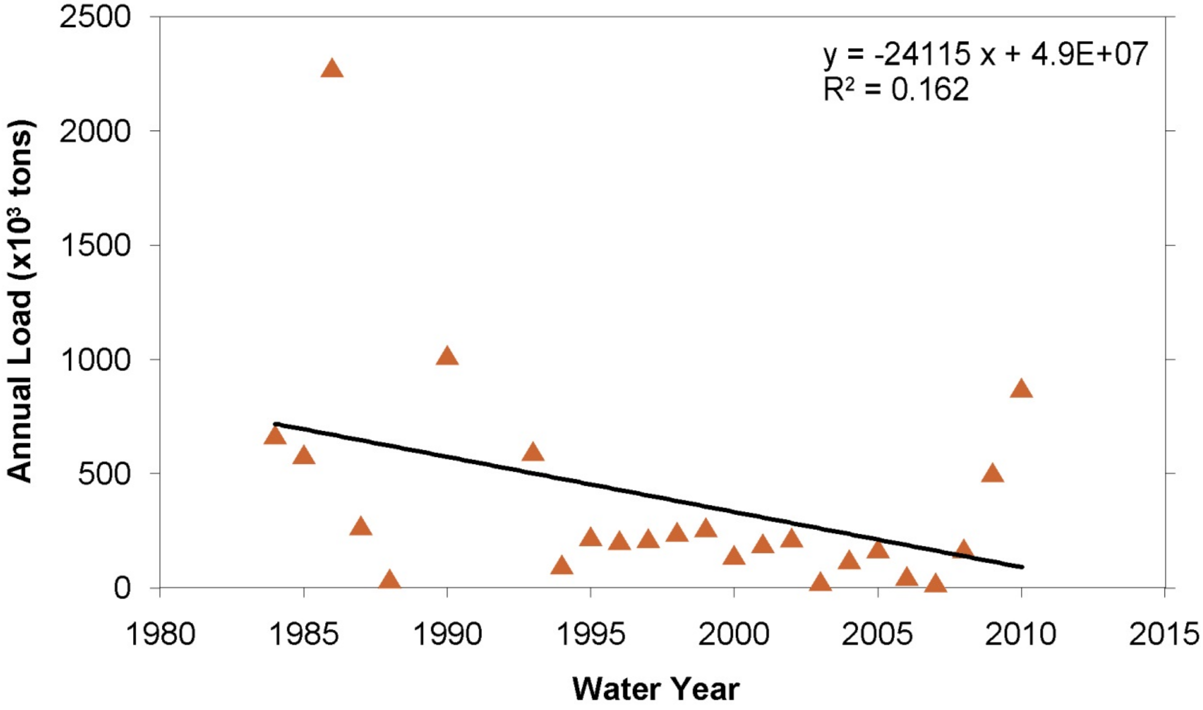


Figure 6-5. Trends in sediment load at LaMoine River at Ripley, IL (after Crowder et al., 2008)

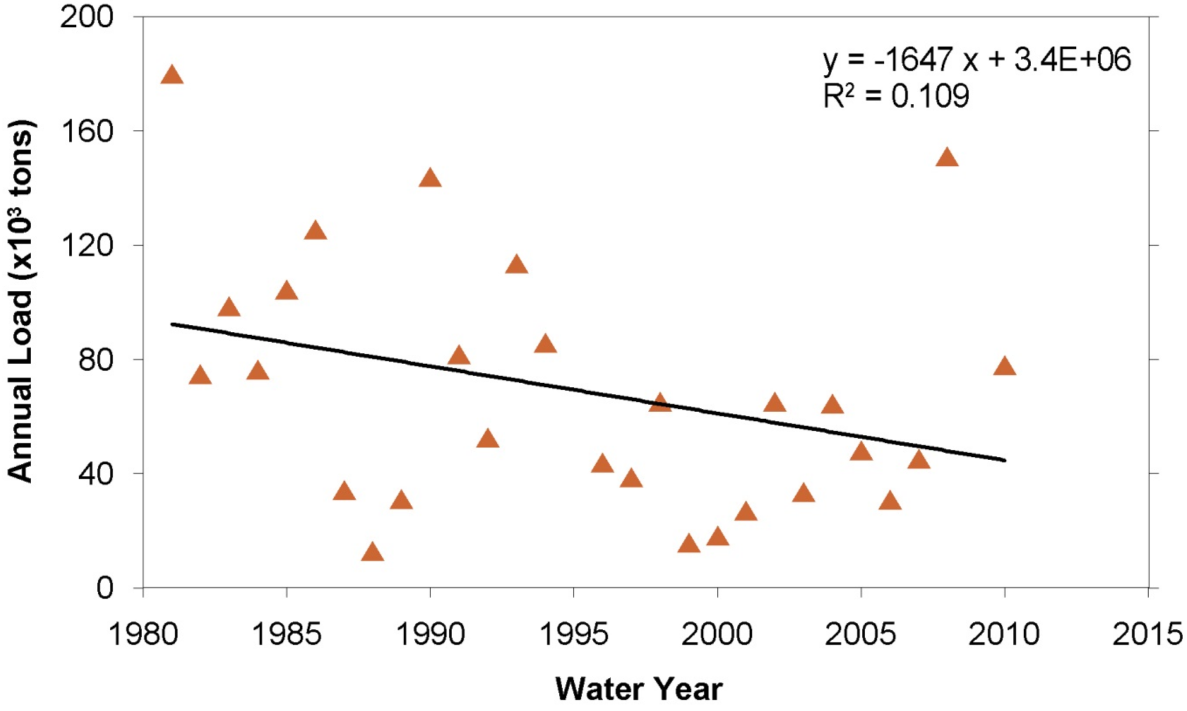


Figure 6-6. Trends in sediment load at Sangamon River at Monticello, IL
(after Crowder et al., 2008)

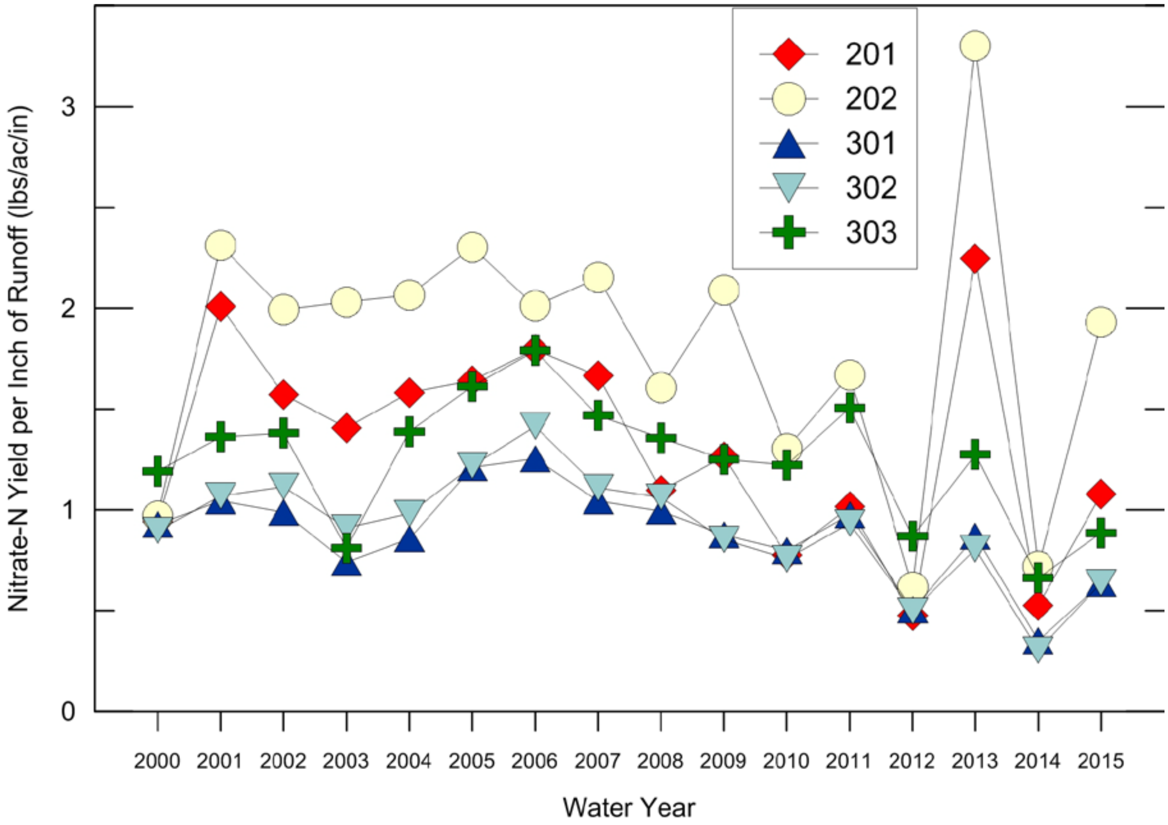


Figure 6-7. Variability of nitrate-N yield per inch of runoff for CREP monitoring stations

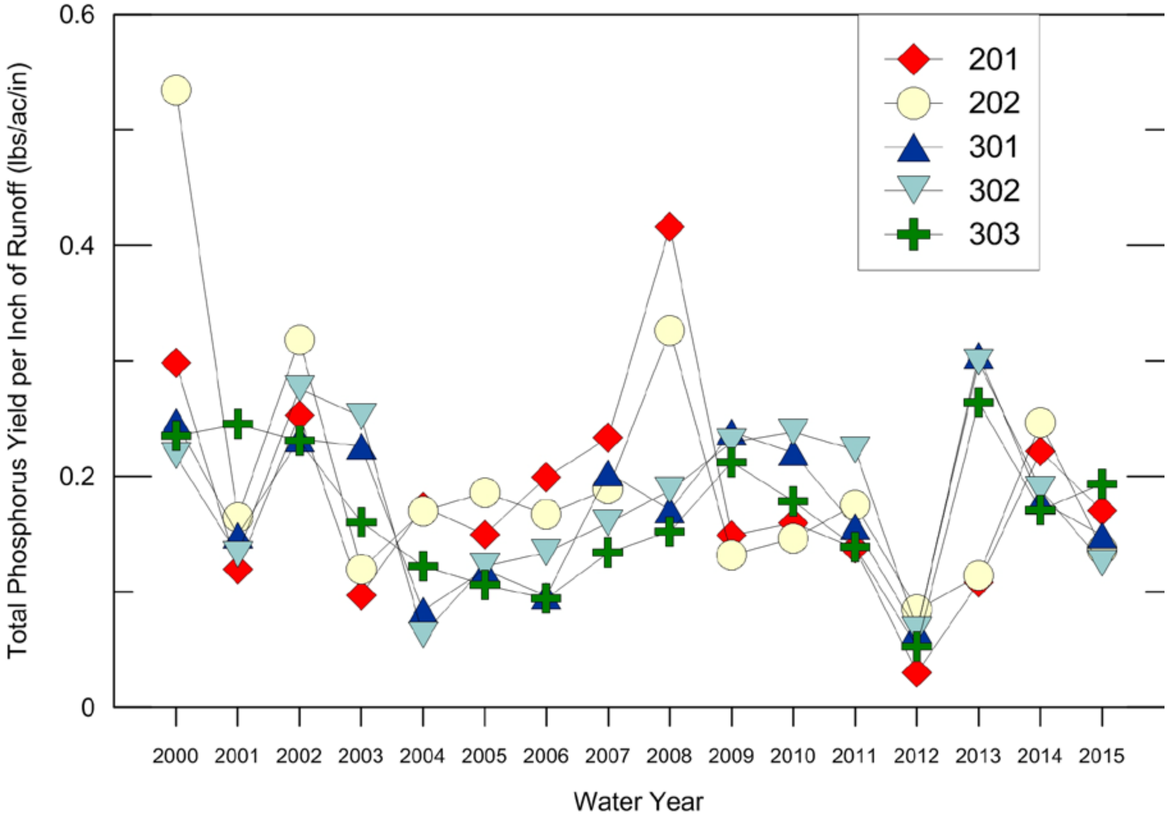


Figure 6-8. Variability of total phosphorous yield per inch of runoff for CREP monitoring stations

Figure 6-10 shows the total phosphorous yield from the same three major tributary watersheds discussed in the previous figure. Annual phosphorous delivery ranges from a low of almost zero during the drought years 1989, 2006, and 2012 to a high of almost 1.7 tons per square mile for the extreme wet year of 1993. The data also show how extremely dependent phosphorous delivery is on climatic variability. Similar to the trends to the nitrate delivery, there was a slow but gradual decreasing trend in phosphorous yield from the Spoon and LaMoine Rivers until 2007 and an increase since then except for the drought year 2012. Overall, there is a gradual increase in phosphorous primarily driven by increases in dissolved phosphorous starting in 2007.

The trends in nutrient loads from the major tributaries are reflected in nutrients transported by the Illinois River. Analyses of the data from the two downstream monitoring stations, Havana and Valley City, are shown in figure 6-11 for nitrate-N and total phosphorous. In general, the trend is a gradual decrease for Nitrate-N for the whole period and a decreasing trend from 1975 to 2006 for phosphorous, but has increased starting in 2007 primarily due to an increase in dissolved phosphorous loading. The cause for a sudden increase in dissolved phosphorous starting in 2007 disrupting a long-term decreasing trend from 1975 to 2006 is being studied closely to find the primarily cause. These observations are extremely important as to nutrient delivery from Illinois streams to the Mississippi River and eventually to the Gulf of Mexico. Illinois had been identified as one of the major sources of nutrients to the Gulf of

Mexico, and the fact that nitrate delivery from Illinois has not increased and is gradually decreasing is good news not only to Illinois but to the Gulf of Mexico, too.

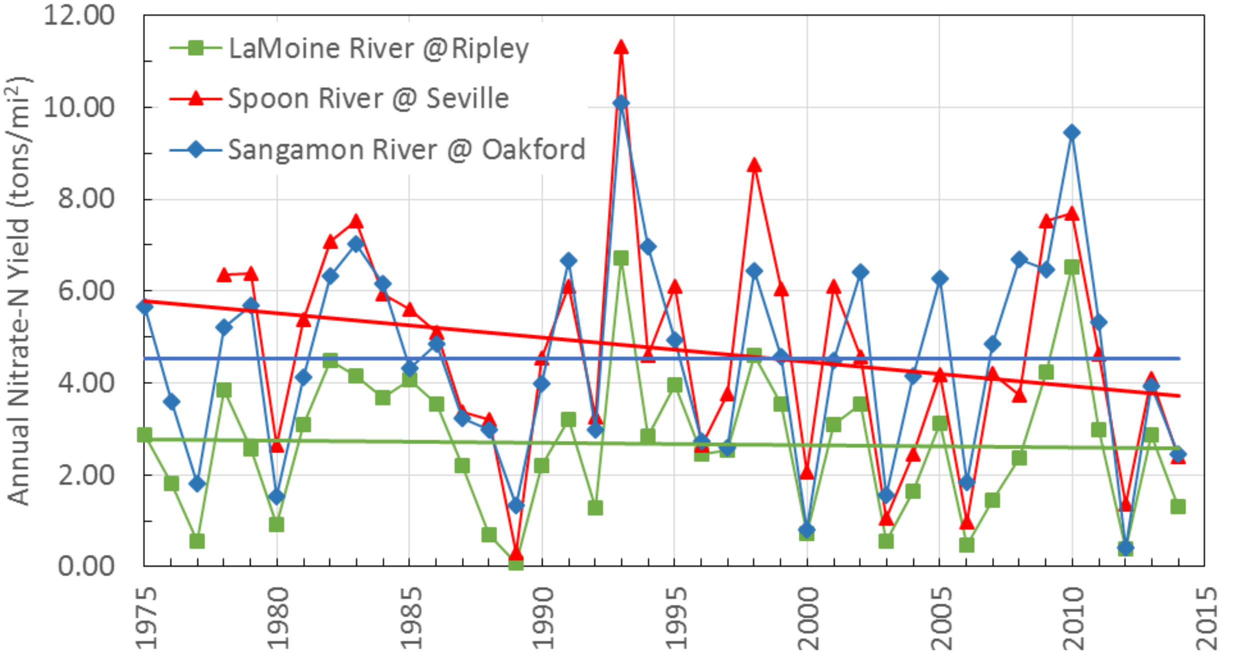


Figure 6-9. Annual nitrate-N loads for the three major tributary watersheds to the Lower Illinois River

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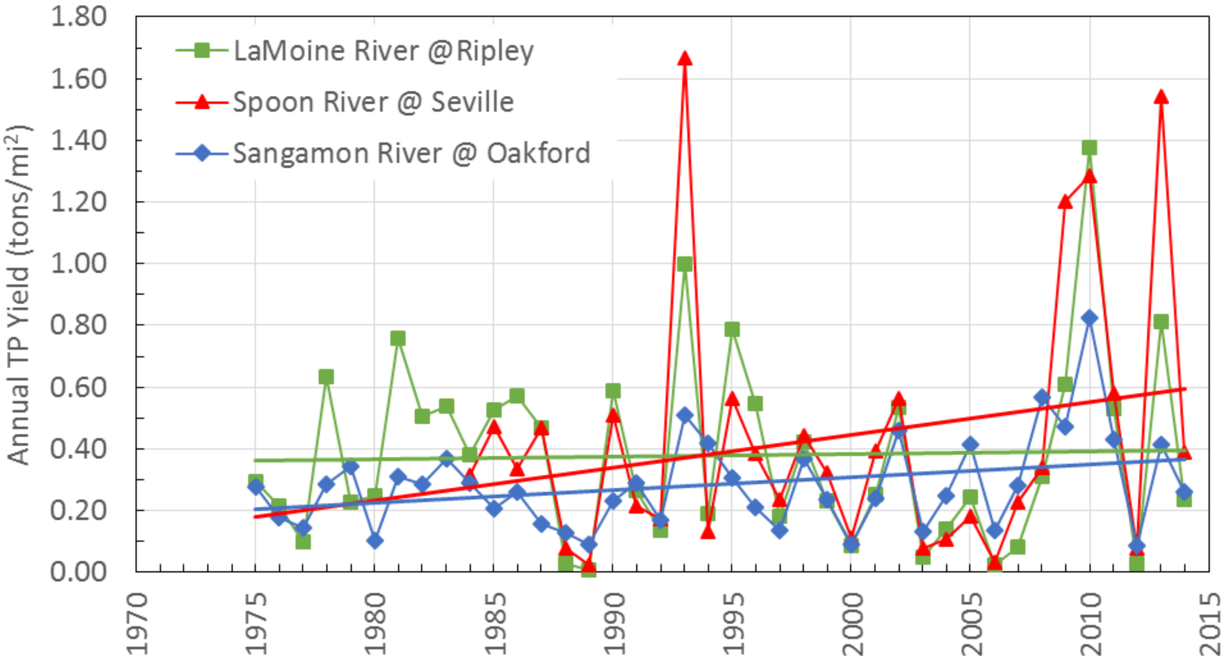

Figure 6-10. Annual total phosphorous loads for the three major tributary watersheds to the Lower Illinois River

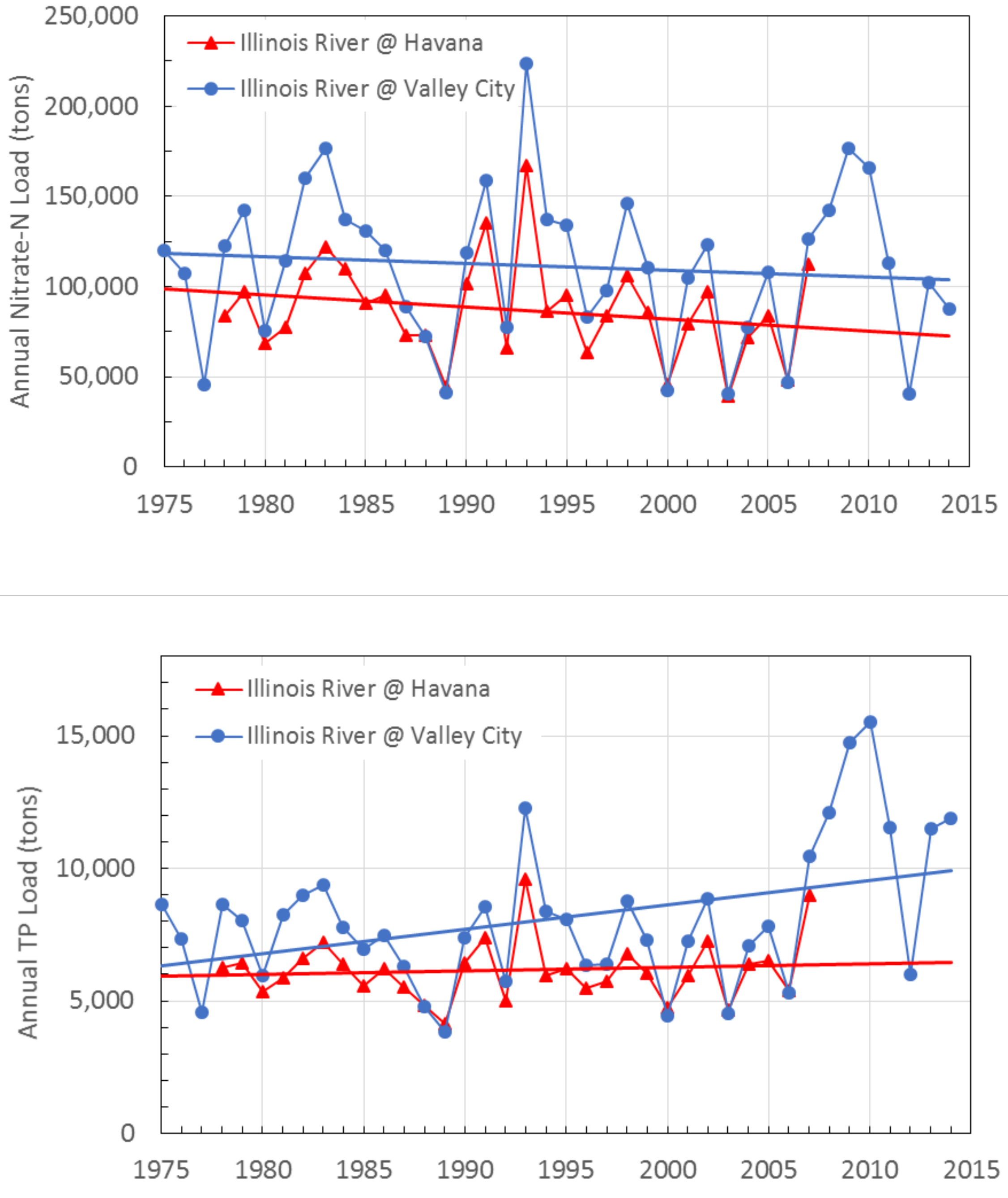

Figure 6-11. Nitrate-N and total phosphorous loads along the Lower Illinois River

7. Summary and Conclusions

The Illinois River Conservation Reserve Enhancement Program (CREP) was initiated as a joint federal/state program with the goal of improving water quality and wildlife habitat in the Illinois River basin. Based on numerous research and long-term data, the two main causes of water quality and habitat degradations in the Illinois River were known to be related to sedimentation and nutrient loads. Based on this understanding, the two main objectives of the Illinois River CREP were to reduce the amount of silt and sediment entering the main stem of the Illinois River by 20 percent; and to reduce the amount of phosphorous and nitrogen loadings to the Illinois River by 10 percent. To assess the progress of the program towards meeting the two goals, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) are developing a scientific process for evaluating the effectiveness of the program. The process includes data collection, modeling, and evaluation.

The monitoring and data collection component consist of a watershed monitoring program to monitor sediment and nutrient for selected watersheds within the Illinois River basin and also to collect and analyze land use data throughout the river basin. Historically, there are a limited number of sediment and nutrient monitoring stations within the Illinois River basin, and most of the available records are of short duration. To fill the data gap and to generate reliable data for small watersheds, the Illinois Department of Natural Resources funded the Illinois State Water Survey to initiate a monitoring program that will collect precipitation, hydrologic, sediment, and nutrient data for selected small watersheds in the Illinois River basin that will assist in making a more accurate assessment of sediment and nutrient delivery to the Illinois River. Five small watersheds located within the Spoon and Sangamon River watersheds were selected for intensively monitoring sediment and nutrient within the Illinois River basin. The Spoon River watershed generates the highest sediment per unit area in the Illinois River basin, while the Sangamon River watershed is the largest tributary watershed to the Illinois River and delivers the largest total amount of sediment to the Illinois River.

As outlined in the Illinois River Basin Restoration Plan, the alternative of no-action in the Illinois River watershed would have resulted in increased sediment delivery to the Illinois River and habitats and the ecosystem would continue to degrade. However, analysis of the available long term data from different sources and the most recent data from the CREP monitoring program, indicate that sediment and nutrient loads from the tributary watersheds are gradually decreasing or stabilizing as a result of implementation of conservation practices in the watershed. We have also observed a recent rise in phosphorous delivery from the major tributaries since 2007 primarily driven by dissolved phosphorous. These increases are not observed from the CREP monitoring sites. With the knowledge that reduction in sediment delivery from large watersheds takes time to move through the system, the indication of stabilized sediment delivery shows progress is being made in restoring the Illinois River watershed. If the present trends continue for the next 10 to 15 years, sediment and nutrient delivery to the Illinois River will be significantly reduced, and lead to improved ecosystem in the river and tributary watersheds in the long-term.

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Appendix C

Sediment and Nutrient Monitoring at Selected Watersheds within the Kaskaskia River Watershed for Evaluating the Effectiveness of the Illinois River Conservation Reserve Enhancement Program (CREP)

Progress Report

by
Illinois State Water Survey
Prairie Research Institute, University of Illinois
Champaign, Illinois

Prepared for the
Office of Resource Conservation, Illinois
Department of Natural Resources
Springfield, Illinois

November 2016

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Progress Report

by
Illinois State Water Survey
Prairie Research Institute, University of Illinois

1. Introduction

The Conservation Reserve Enhancement Program (CREP) was initiated as a joint federal/state program with the goal of improving water quality and wildlife habitat in the Illinois and Kaskaskia River basins. Based on numerous research and long-term data, the two main causes of water quality and habitat degradations in the rivers of Illinois were known to be related to sedimentation and nutrient loads. Based on this understanding, the two main objectives of the Illinois CREP were stated as follows:

1) Reduce the amount of silt and sediment entering the main stem of the Illinois and Kaskaskia River by 20 percent.
2) Reduce the amount of phosphorous and nitrogen loadings to the Illinois and Kaskaskia River by 10 percent.

To assess the progress of the program towards meeting the two goals, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) are developing a scientific process for evaluating the effectiveness of the program. The process includes data collection, modeling, and evaluation. Progress made so far in each of these efforts is presented in this report.

Acknowledgments

The work upon which this progress report is based is supported by funds provided by the Office of Resource Conservation, Illinois Department of Natural Resources, under the guidance of Mike Chandler, IDNR CREP Program Coordinator, whose support is greatly appreciated. The project is also supported as part of Laura Keefer's, Co-Principal Investigator, regular duties at the Illinois State Water Survey under the guidance of Mike Demissie, Director, Illinois State Water Survey and ISWS Principal Investigator for the CREP studies.

Several Illinois State Water Survey staff worked diligently to meet project objectives and their tireless dedication is much appreciated. Erin Bauer supervised the field data collection personnel and activities, as well as developed and implemented the data collection computer programming and protocols for the field instrumentation. John Beardsley and Jim Osborne designed, fabricated, and installed the instrument shelters. Erin Bauer designed, developed and managed the project databases, software programming for data processing and computations, and performs quality control. Yao Hu, University of Illinois Ph.D. candidate, wrote the MatLab code

for the project data processing. Lara Seek, John Beardsley and Erin Bauer perform the field data collection efforts that amount to many long, wet, and tiring days. Joyce Wyse performs data entry as well as track and organize project records. Erin Bauer compiled, investigated and analyzed the land cover data (Illinois and Kaskaskia Basins). Phil Graff, ISWS, and Lisa Beja, IDNR, compiled the CREP contract conservation practices database (Illinois and Kaskaskia Basins). Erin Bauer and Lara Seek produced the tables and figures. Laura Keefer is responsible for the overall investigation, implementation, management and analyses of the ISWS Kaskaskia study, as well as writing the progress report. Leon Hinz, Illinois Natural History Survey (INHS), collaborated in the ISWS/INHS co-location site selection of intensive monitoring stations and his assistance was most appreciated.

2. Watershed Characteristics

The Kaskaskia River watershed has a drainage area of 5,810 mi^2, is generally located in the southwest region of the State of Illinois, and occupies all or portions of 15 counties (Figure 2-1). The headwaters begin in Champaign and Piatt Counties in east-central Illinois and flows in a southwesterly direction to join the Mississippi River in Randolph County. Table 2-1 lists the tributary watersheds and associated drainage areas. Figure 2-1 illustrates approximately 22 tributary watersheds in the basin that range in drainage area from 53 to 917 mi^2. The two largest tributary watersheds are Shoal Creek (917 mi^2) and Silver Creek (480 mi^2) and together occupy nearly 25 percent of the Kaskaskia River watershed drainage area. In general, the Kaskaskia River watershed is divided into four sub-watersheds (Upper, Middle, Lower, and Shoal Creek) that are associated with the outlets at the two main reservoirs, Lake Shelbyville and Carlyle Reservoir, and confluence with the Mississippi River. The Shoal Creek tributary watershed is distinguished due to its large drainage area. See (Illinois Department of Natural Resources 2000) for further information.

Hydrology

Knapp and others (2012) describe the Kaskaskia River as one of the more highly managed river systems in Illinois. The streamflow on the main stem of the Kaskaskia River is controlled by two federal reservoirs (Shelbyville and Carlyle Reservoirs) and the navigation pools in the lower reaches of the river are maintained by a lock and dam. Water is withdrawn for industry and public water supplies from several reservoirs constructed on tributaries throughout the watershed. Other inflows come from effluent discharges throughout the drainage system by municipal systems and industries, as well as power plant cooling water returns. A detailed water supply assessment of the Kaskaskia River watershed can be found in (Knapp, Roadcap et al. 2012).

Geology

The surficial geology plays a role in the types of land cover in the Kaskaskia River watershed. Figure 2-2 illustrates the boundaries of the physiographic regions, loess (windblown silt) thicknesses, and shaded relief for the Kaskaskia River watershed. The watershed is predominantly in the Bloomington Ridged Plain and Springfield Plain of the Till Plains Section.

The Upper sub-watershed is entirely in the Bloomington Ridged Plain and characterized by low, broad ridges with intervening wide stretches of relatively flat or gently undulatory ground (Leighton, Ekblaw et al. (1948). These alternating ridges with flat ground are indicative of the most recent glacial period, referred to as the Wisconsinan. Therefore, the drainage system is more recent than the Springfield Plain which is older and more developed.

The Middle, Shoal Creek, and most of the Lower sub-watersheds are in the Springfield Plain which is part of the Illinoisan glacial drift period that occurred before the Wisconsinan. The Illinoisan is characteristically flat with low and broad ridges (moraines) but some areas in the Kaskaskia watershed have ridges and hills with irregular assemblages of gravel with small intervening plains. The drainage system is characterized by major rivers in low gradient and broad terraced valleys and tributaries in wide v-shaped valleys with headwaters originating from the low gradient, broad shallow valleys of the till plains. Basically, the Springfield Plain occupies the older Illinoisan glacial drift with older drainage development, whereas the

Bloomington Ridge Plain occupies the Wisconsinan, which overlies the Illinoisan, and is flat with sequences of ridges and initial stages of drainage.

Another geologic characteristic that controls drainage development and is a factor in erosion is the thickness of the windblown silt (loess) that overlies the glacial drift, similar to frosting on a layer cake (Illinoisan and Wisconsinan glacial drift), somewhat smoothing out imperfections on the surface. As seen in Figure 2-2, the loess in the Upper sub-watershed is between 0-5 feet thick and lies in the ridged and wide flat valleys of the Bloomington Ridged Plain. Most of the Middle sub-watershed and upper reaches of the Shoal Creek sub-watershed the loess is 0-5 feet thick and lies in the more developed drainage landscape of the Springfield Plain. The lower reaches of Shoal Creek and most of the Lower sub-watersheds have thicknesses that can range from 5 to greater than 20 feet proceeding from east to west toward the Mississippi River. However, many of the stream valleys in these areas do not have loess present and is considered to have been eroded. Areas with thick loess are considered prone to erosion under steep conditions which can result in unstable stream channels. A more extensive discussion on the geology and surficial materials in the Kaskaskia River watershed can be found in (Illinois Department of Natural Resources 2000).

In summary, the four sub-watersheds of the Kaskaskia River watershed are fairly distinct from each other based on geology and land cover features. These features have an influence on water quality, erosion, and aquatic habitat. Agriculture production is dominant in the Upper sub-watershed due to the consistent, relatively flat and wide valleys between gentle ridges, as well as the highly productive soil developed in the loess cap. Large areas dominated by highly productive soil and agriculture tend to have elevated nutrient levels in the stream system. The Middle and Upper-Shoal sub-watersheds have a mix of agriculture and woodlands/grasses, where the agriculture is in the flatter uplands and woodlands in the deeper valleys. Nutrients may be slightly more elevated in the drainage system but some erosion issues may play a factor in the valleys. The lower-Shoal and lower sub-watersheds are similar in land use to the Middle sub-watershed, slightly more agriculture but the loess thicknesses in combination with higher relief result in erosion being more of an issue in these areas.

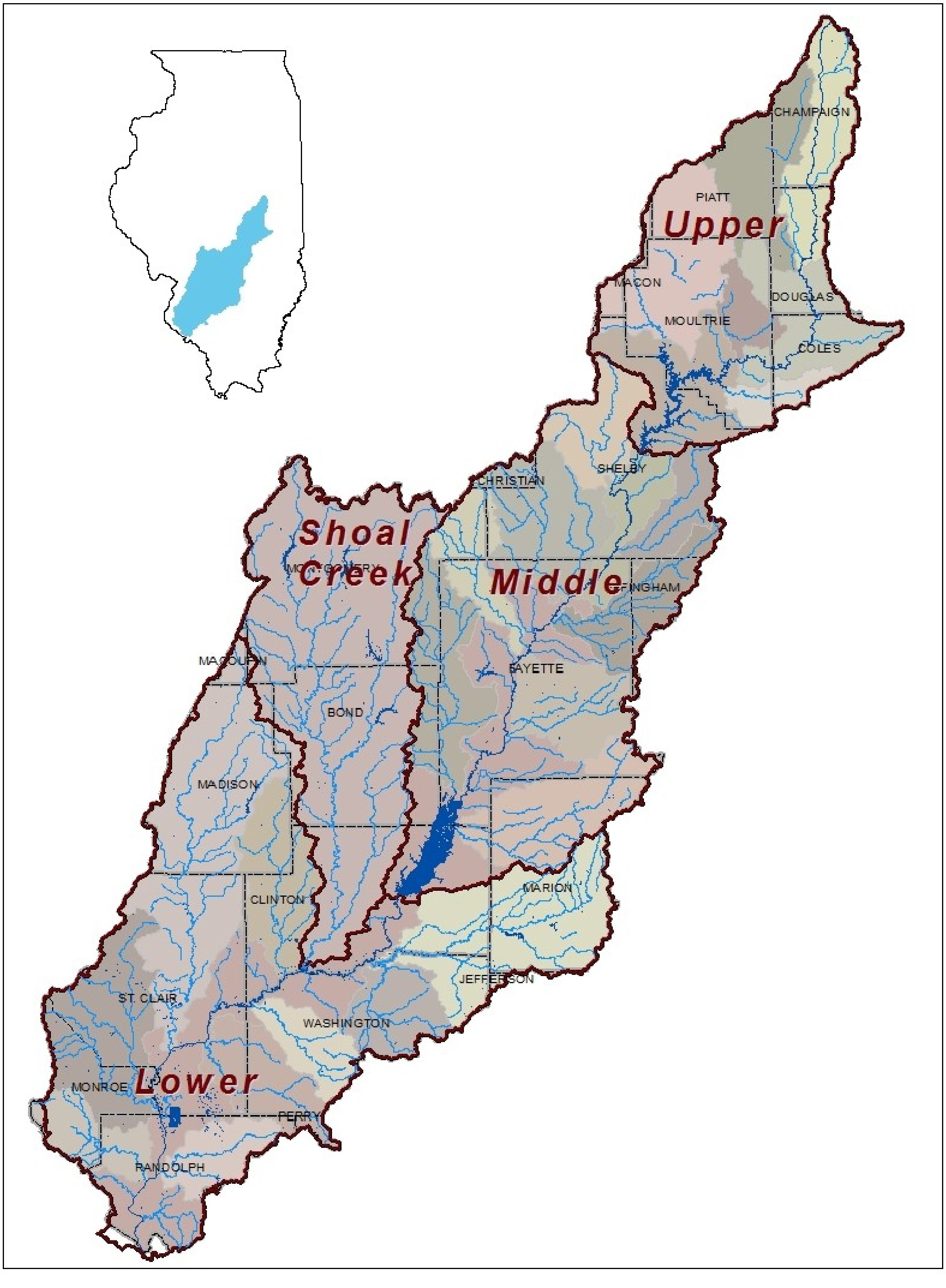


Figure 2-1. Kaskaskia River Basin, sub-basins, and major tributary watersheds

Table 2-1. Kaskaskia tributary watersheds and drainage areas

	Drainage Area	
Tributary Name	*(acres)*	*(mi^2)*
Ash Creek	89,610	140
Beck Creek	130,771	204
Crooked Creek	224,663	351
East Fork Kaskaskia River	132,477	207
Elkhorn Creek	56,760	89
Hickory Creek	92,224	144
Hoffman Creek	67,428	105
Horse Creek	60,175	94
Hurricane Creek	128,822	201
Johnathan Creek	36,896	58
Kaskaskia-L. Shelbyville	**122,705**	**192**
Kaskaskia Ditch	103,474	162
Kaskaskia River	**658,183**	**1,028**
Lake Fork	109,537	171
Little Crooked Creek	73,254	114
Mud Creek	87,207	136
Plum Creek	57,399	90
Richland Creek	213,431	333
Robinson Creek	79,112	124
Shoal Creek	586,584	917
Silver Creek	307,171	480
Sugar Creek	112,775	176
West Okaw River	154,219	241
Whitley Creek	33,687	53
Total	*3,718,563*	*5,810*

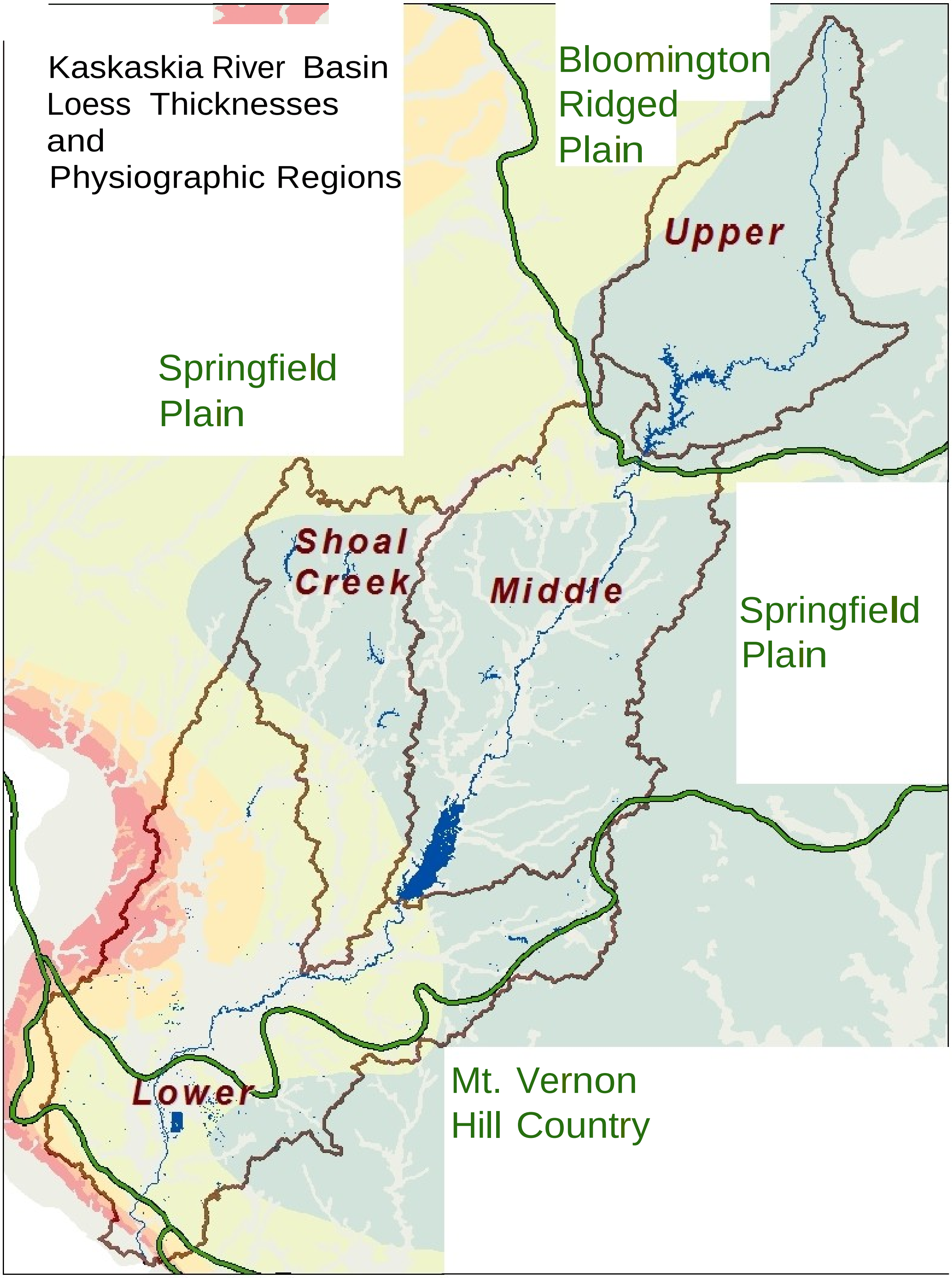


Figure 2-2.Physiographic regions and loess thicknesses in Kaskaskia Basin

3. Monitoring and Data Collection

The monitoring and data collection component consists of a watershed monitoring program to monitor sediment and nutrient for selected sub-watersheds within the Kaskaskia River basin and also to collect and analyze land use data throughout the river basin. Currently available data is insufficient to monitor long-term trends especially in small watersheds where changes can be observed and quantified more easily than in larger watersheds. To fill the data gap and to generate reliable data for small watersheds, the Illinois Department of Natural Resources funded the Illinois State Water Survey to initiate a monitoring program that will collect precipitation, hydrologic, sediment, and nutrient data for selected small watersheds in the Kaskaskia River basin that will assist in making a more accurate assessment of sediment and nutrient delivery.

The monitoring strategy for the project was to select small Kaskaskia River tributary watersheds to establish an intensive monitoring program to detect any changes in sediment and nutrient transport characteristics that could be attributed to changes in land use or other factors. The project is designed to measure the cumulative impact within the watershed on sediment and nutrient yield and is not designed to measure the impact of specific BMPs on water quality or sediment yield. Several factors were evaluated to determine the final locations of the intensive monitoring sites, such as artificial inflow and outflow of water due to water supply, industrial, and recreation needs, geology, land use, currently available water quality data for more prescriptive monitoring plans, areas likely to have appreciable CREP sign-ups, and co-location with other physical, biological, and water quality program stations. Co-locating and/or supplementing monitoring stations with other water quality and aquatic sampling stations in the watershed is an integrated approach that contributes to understanding the mechanisms that link hydrologic, sediment, nutrient, biological, and physical information for application in other watersheds in Illinois.

Due to the highly managed nature of the Kaskaskia River watershed hydrology, this project assessed locations of water inflows and outflows that could mask monitoring results by affecting the normal balance of the sediment and nutrient loading character. For example, the streamflow in the main stem of the Kaskaskia River and several tributaries are significantly controlled by the periodic releases from reservoirs. Also, the water from those releases are more of a reflection of the water quality from lake processes rather than the transport of water and nutrients from the upper portions of the drainage system. Also assessed were locations of waste water treatment plant (WWTP) effluent, NPDES discharges, and other smaller reservoirs in the tributary watersheds. This project capitalized on a recently completed water supply assessment for the Kaskaskia River watershed, which assembled existing water availability and supply information mentioned above by Knapp, Roadcap et al. (2012).

To effectively monitor any changes in sediment and nutrient loading due to CREP, small-scale intensive monitoring in several places improves the ability to monitor changes over time. Ideally, these small-scale study watersheds should be in areas that will have the highest likelihood of CREP sign-ups. The ISWS contacted several local stakeholder groups, county Soil and Water Conservation Districts and CREP program staff to estimate areas likely to have appreciable CREP sign-ups within the Kaskaskia River watershed. This assessment period overlapped with the 2012 drought which appeared to have appreciably reduced CREP sign-ups for the first year of the project. Consequently, in collaboration with Illinois Natural History Survey (INHS) investigators, an analysis was made based on land cover, geology, hydrology, biology and conservation reserve programs (CRP) already in the watershed. This allowed for comparing and contrasting watershed land uses with physical character for selection of watersheds estimated to be likely and unlikely for CREP signups. Four watersheds were then selected to represent combinations of physical watershed character and land cover.

Monitoring Stations

The four small watersheds selected for intensively monitoring sediment and nutrient within the Kaskaskia River basin are located within the Crooked Creek, North Fork Kaskaskia River, Hurricane Creek and Shoal Creek watersheds. In addition, two continuous recording raingages were established near the monitored watersheds. The general locations of the watersheds, monitoring stations and raingages are shown in figure 3-1 and more detailed station maps are shown in figures 3-2 through 3-4. Information about the stations is provided in table 3-1. Lost Creek (402) is a tributary of Crooked Creek which, in turn is a direct tributary to the Kaskaskia River with its confluence downstream of Carlyle Reservoir. The Carlyle Reservoir is a U.S. Army Corps of Engineers impoundment on the Kaskaskia River. The North Fork Kaskaskia River (403) and Hurricane Creek (404) are a direct tributaries to the Kaskaskia River at the upstream end of Carlyle Reservoir. East Fork Shoal Creek (405) is a tributary of Shoal Creek, the largest tributary of the Kaskaskia River, with its confluence downstream of Carlyle Reservoir. The type of data collected and the data collection methods have been presented in detail in the first progress report for the CREP monitoring program (Demissie et al., 2001) and in the Quality Assurance Project Plan (QAPP) which is available upon request. The data collected at each of the monitoring stations follows these protocols.

Table 3-1. Sediment and Nutrient Monitoring Stations and Raingages Established for the Kaskaskia River CREP

Station ID	*Name*	*Drainage area*	*Watershed*
402	Lost Creek	38.0 sq mi (24,320 acres)	Crooked Creek
403	North Fork Kaskaskia River	35.5 sq mi (22,701 acres)	North Fork Kaskaskia River
404	Hurricane Creek	27.7 sq mi (17,753 acres)	Hurricane Creek
405	East Fork Shoal Creek	30.9 sq mi (19,820 acres)	Shoal Creek
43	Witt, IL (raingage)	--	East Fork Shoal & Hurricane Creeks
44	Shattuc, IL (raingage)	--	Lost Creek

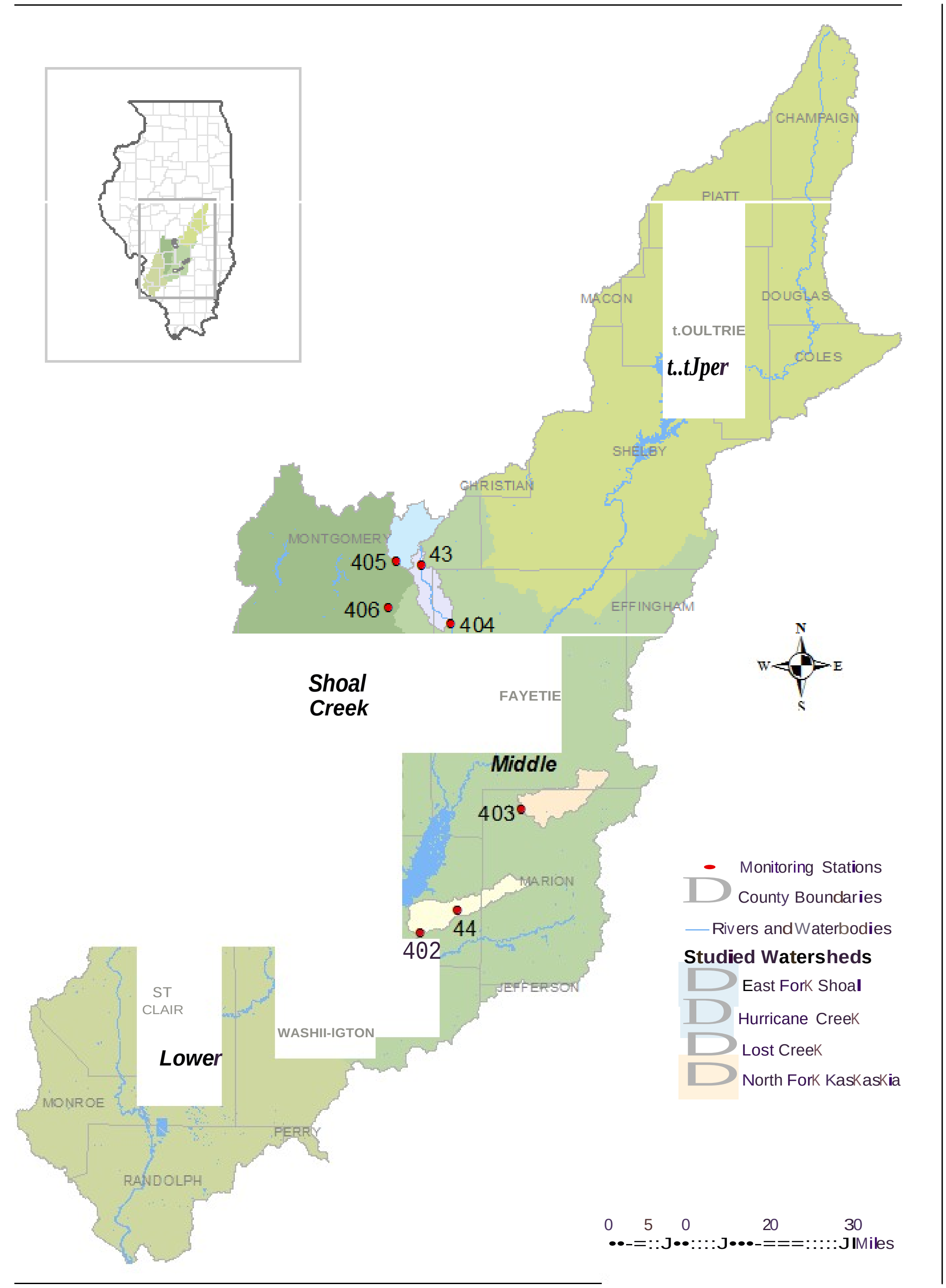


Figure 3-1. General location of monitoring stations in the Kaskaskia River watershed

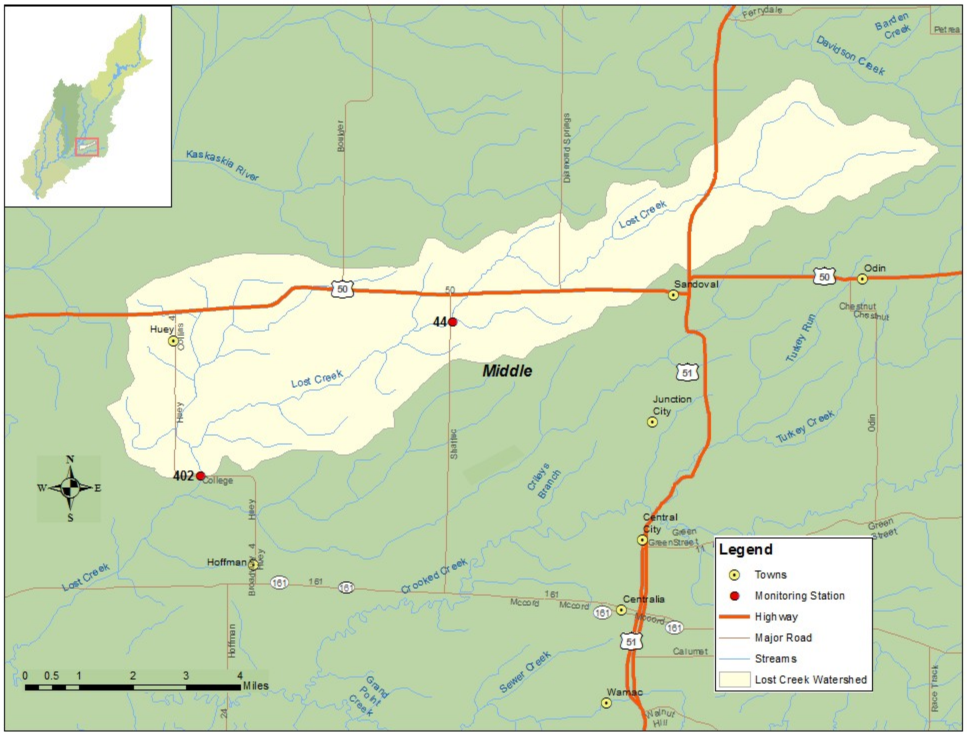


Figure 3-2. Detailed location of monitoring stations in Lost Creek (402) watershed

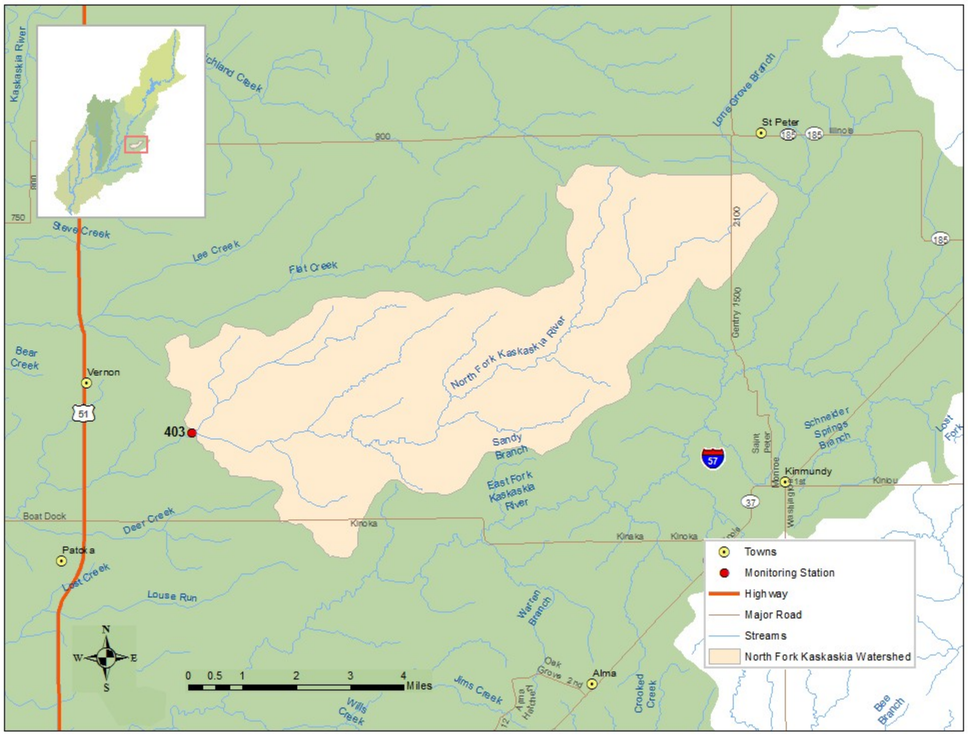


Figure 3-3. Detailed location of monitoring station in North Fork Kaskaskia River (403) watershed

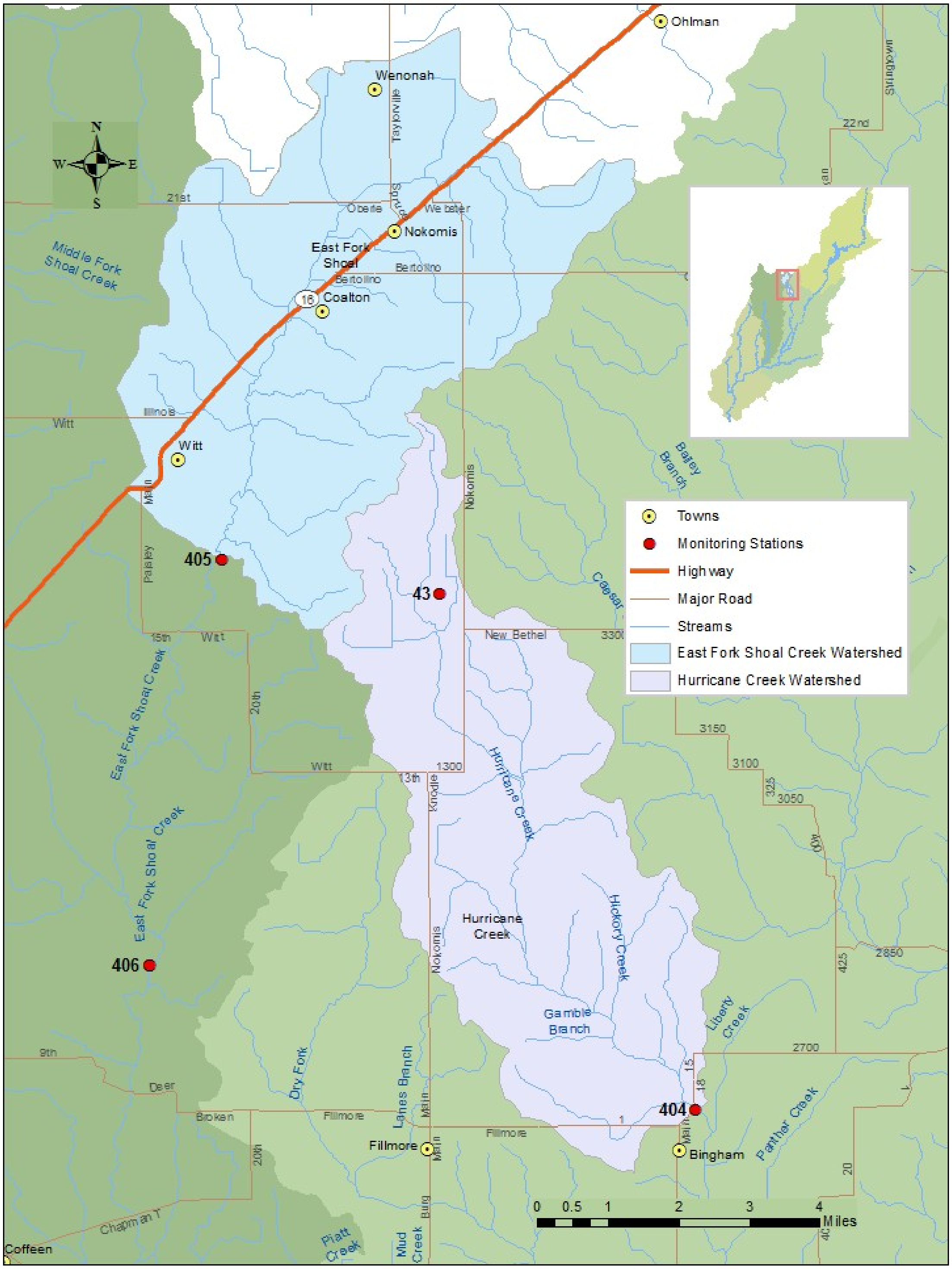


Figure 3-4. Detailed location of monitoring stations in Hurricane (404) and East Fork Shoal Creek (405) watersheds

Each of the four monitoring stations are instrumented with a Campbell Scientific CR850 datalogger, CS476 radar water level sensor, ISCO automatic water sampler, cell modem, antenna, solar panel, and batteries. All instruments, except the ISCO sampler, are housed in a stainless steel shelter to protect them from weather and vandalism. The ISCO sampler is housed in a modified 55-gallon steel drum with a hinged lid for access. The two raingages are instrumented with a modified Belfort weighing-bucket raingage, Campbell Scientific CR200 datalogger, cell modem, antenna, solar panel, and battery. The shelter and instrument configurations of the four streamgage monitoring stations are shown in Figure 3-5 and raingage stations in Figure 3-6. All data is retrieved from the station dataloggers via cell modem every hour to ISWS computer databases.

Figure 3-5. Streamgage monitoring stations in Kaskaskia River Basin: a) Lost Creek, b) North Fork Kaskaskia River, c) Hurricane Creek, and d) East Fork Shoal Creek

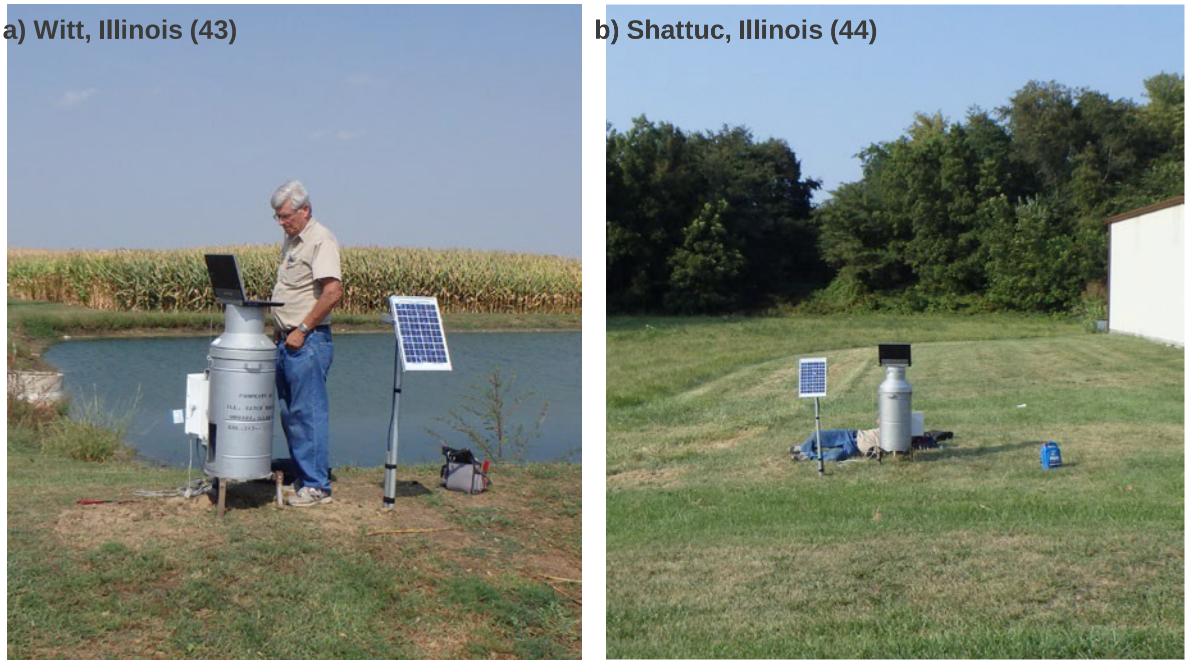


Figure 3-6. Raingage stations in Kaskaskia River Basin: a) Witt, Illinois (43) and b) Shattuc, Illinois (44)

Stream Stage and Flow

The “stage” of a stream is the measurement of the water surface of a stream from an arbitrary datum. The stage record is collected continuously and makes it possible to determine the volume of water carried by a stream past a streamgaging station. Through the application of a stage-discharge rating curve, the continuous stage is converted to streamflow. Streamflow data are generated from the 15-minute stage record at a streamgaging station. The stage data are converted to discharge (streamflow) by applying a stage-discharge calibration curve. The calibration is developed by taking several detailed field measurements of the streamflow at known stages.

Methods used in this study for determining stream discharge follow established USGS procedures as outlined by Rantz (1982a, 1982b). Stream discharge is determined by measuring the mean velocity along a stream cross section. Each vertical represents the velocity of a flow area (substation), which is defined as the sum of half the distance between verticals by the water depth at the vertical. At each vertical the velocity is sampled at 20 and 80 percent of the total depth (for total depths ≥ 2.5 feet) or at 60 percent of the total depth (for total depths < 2.5 feet). The average of the 20 and 80 measurements or the single 60 percent measurement is assumed to be the mean velocity for that subsection. Each subsection discharge is calculated by multiplying the average velocity by the flow area, and then the sum of all the subsections equals the total discharge of the stream cross section. Every discharge is then plotted against the corresponding stage at which the discharge measurement occurred. After sufficient measurements have been collected, a curve is developed to express the relationship between stage and discharge. Using this stage-discharge curve, the stage data files are then converted to discharge. The discharge data can then be used to develop nutrient and sediment load data.

All data are compiled in to what is referred to as "water years", which begins on October 1st and ends September 30th of the following year. The year delineation is associated with the close of the period. For example, water year 2014 (WY2014) begins October 1, 2013 and ends September 30, 2014. The process of collecting a sufficient number of streamflow measurements to adequately develop a stage-discharge calibration takes time. This usually takes 1-2 water years into a monitoring study. Sufficient measurements have been acquired to develop the calibration and streamflow values and nutrient and sediment loads are computed for this progress report.

Sediment and Nutrient Data

Sediment Data

Suspended sediment samples are collected either manually or by ISCO automated pump sampler. The suspended sediment sampling methods used in this study followed established USGS procedures as outlined by Edwards and Glysson (1999) and FISP (1952). The manual sampling method used depth-integrating samplers for all but the shallowest conditions. The second method used to collect suspended sediment samples was the ISCO automated pump sampler. The programming of the CR850 datalogger controls the ISCO sampling schedule. This program allows automated sampling during high-flow events and is triggered by changes in stage over time. Manual suspended sediment samples were taken at all four stations during weekly station visits and during storms when possible.

Suspended sediment concentration (SSC) data and streamflow (discharge) for all stations are shown in figures 3-7 and 3-8 for WY2016. Summary statistics for SSC samples can be found in table 3-2. Figures showing sediment concentration and discharge for previous water years can be found in Appendix A. As can be seen in the figures, suspended sediment concentrations are highly variable throughout a year depending on the climatic conditions and location of the stations in the watershed. The distance between monitoring stations ranges from 10 to 45 miles and subject to rainfall and storm variability and tracking through the region. It is also evident that sediment concentrations are the highest during storm events resulting in the transport of most of the sediment during storm events. Therefore, it is extremely important that samples are collected frequently during storm events to accurately measure sediment loads at monitoring stations. Approximately 1532 SSC samples were collected at all stations. The highest maximum SSC occurred at Lost Creek (402) at 15,704 mg/L and lowest maximum at North Fork Kaskaskia (403) with 3,456 mg/L. The mean SSC for all stations ranged from 393 to 1,206 mg/L. All stations had minimum SSC below 5 mg/L.

Nutrient Data

The nutrient data are organized into two groups: nitrogen species and phosphorous species. The nitrogen species include nitrate-nitrogen (NO_3-N), ammonium-nitrogen (NH_4-N), and total Kjedahl nitrogen (TKN). The phosphorous species include total phosphorous (TP), total dissolved phosphorous (TDP), and orthophosphate (P-ortho). Approximately 1500 samples have been analyzed for nitrogen and 1100 for phosphorus. Nitrogen and phosphorus sample results with discharge for WY2016 are shown in figures 3-9 to 3-10 and 3-11 to 3-12, respectively. A summary statistics for all stations showing the sample count, mean, median, minimum, maximum, 25th percentile, and 75th percentile are given in table 3-2. Figures showing nutrient concentrations and discharges for previous water years can be found in Appendix A.

Data for the nitrogen species at all four monitoring stations show that the dominant form of nitrogen transported by the streams is Total Kjeldahl Nitrogen (TKN). During storm events, the concentration of TKN rises significantly, exceeding the nitrate-N concentration (NO_3-N). TKN is highly correlated to suspended sediment concentrations. Ammonium-nitrogen (NH_4-N) concentrations are low at all stations except East Fork Shoal Creek (405) where maximum concentrations were nearly equal with nitrate-N concentrations. TKN maximum concentration of 21.28 mg/L was at Lost Creek (402).

As can be seen in figures 3-11 and 3-12 phosphorous species at all monitoring stations show that most of the phosphorous load is transported during storm events. Total phosphorous (t-P) concentrations are the highest during storm events and relatively low most of the time. This is very similar to that shown by sediment and thus implies high correlations between sediment and phosphorous concentrations and loads. The highest maximum t-P concentration for WY2014-16 was 6.23 mg/L at Lost Creek (402). Ortho-phosphate (oPO4-P) and total dissolved phosphorus (t-P-diss) maximum and mean concentrations at all stations are similar (table 3-2).

Figures 3-13 to 3-16 illustrate the distribution of sediment, nitrogen and phosphorus concentrations for a typical storm event on April 8-11, 2015. Note the two y-axes on the left of the plot showing concentrations for sediment (green diamonds) and the other for nitrogen/phosphorus. The right y-axis shows water discharge. The first observation is the variation in streamflow between the stations which is expected due to the spatial variation between the stations (see map in figure 3-1) and rainfall intensities. As seen in Figures 3-14 and 3-16 Hurricane (404) and East Fork Shoal (405) creeks share a watershed boundary but rainfall intensity, slope, and land cover can produced different stream discharge characteristics. This in turn can affect the carrying capacity of the streamflow resulting in variations in concentrations. All the figures support the concentration summary statistics which informed that TKN and t-P are the dominant nitrogen and phosphorus species at all stations and is similar in pattern with suspended sediment concentrations.

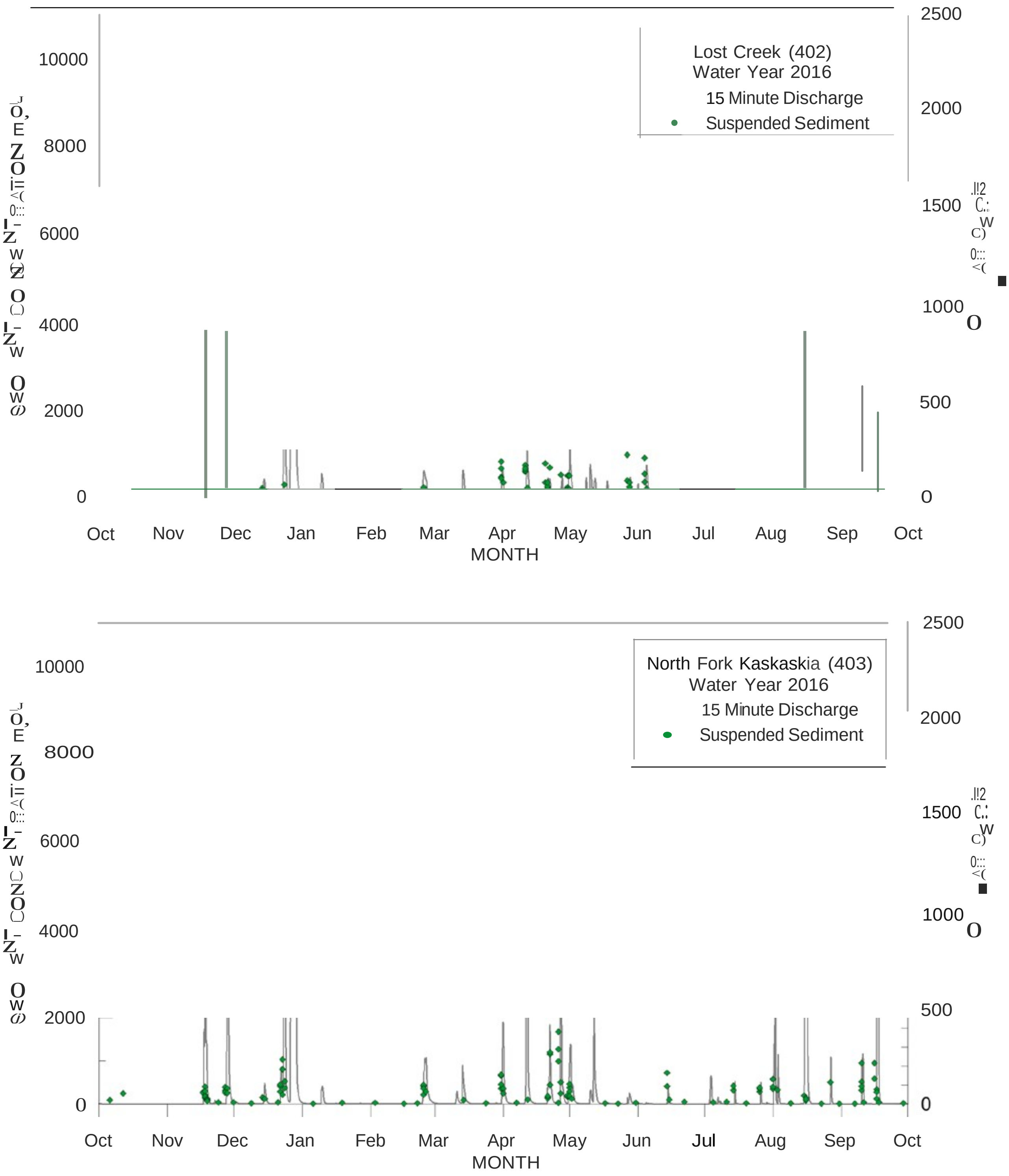
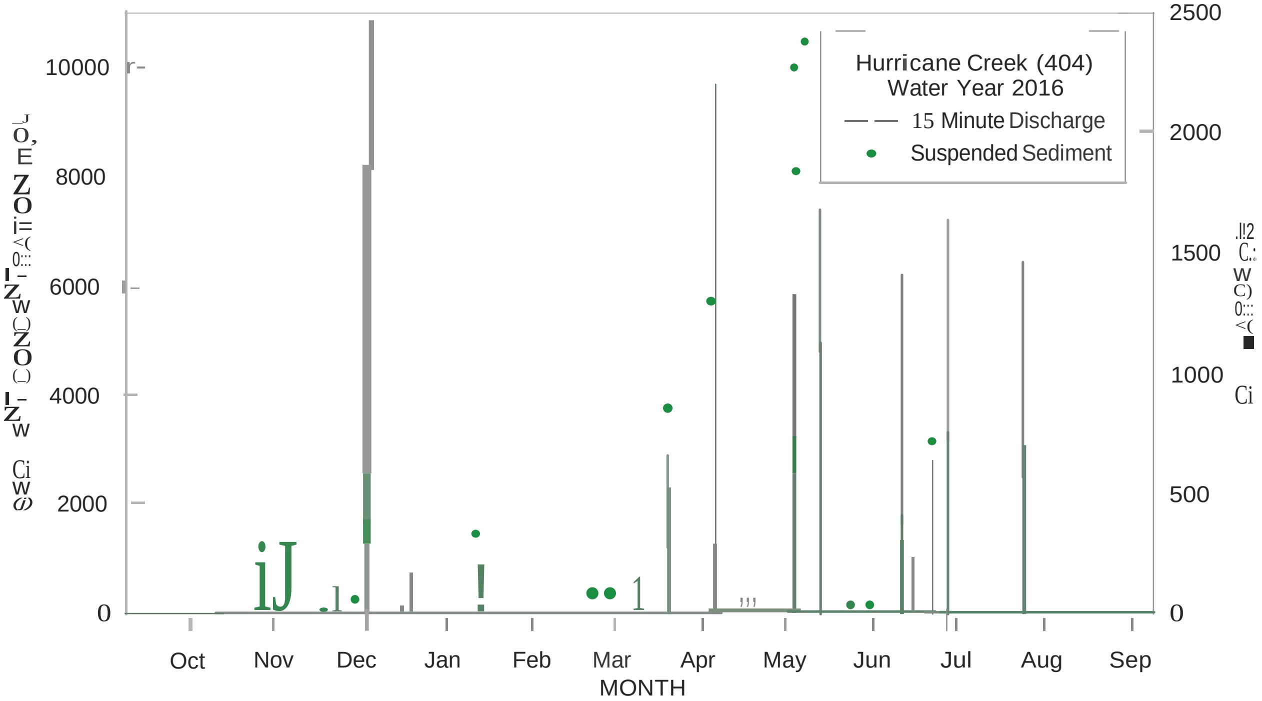


Figure 3-7. Suspended sediment concentrations and discharge for Water Year 2016: Lost Creek (402) and North Fork Kaskaskia (403)



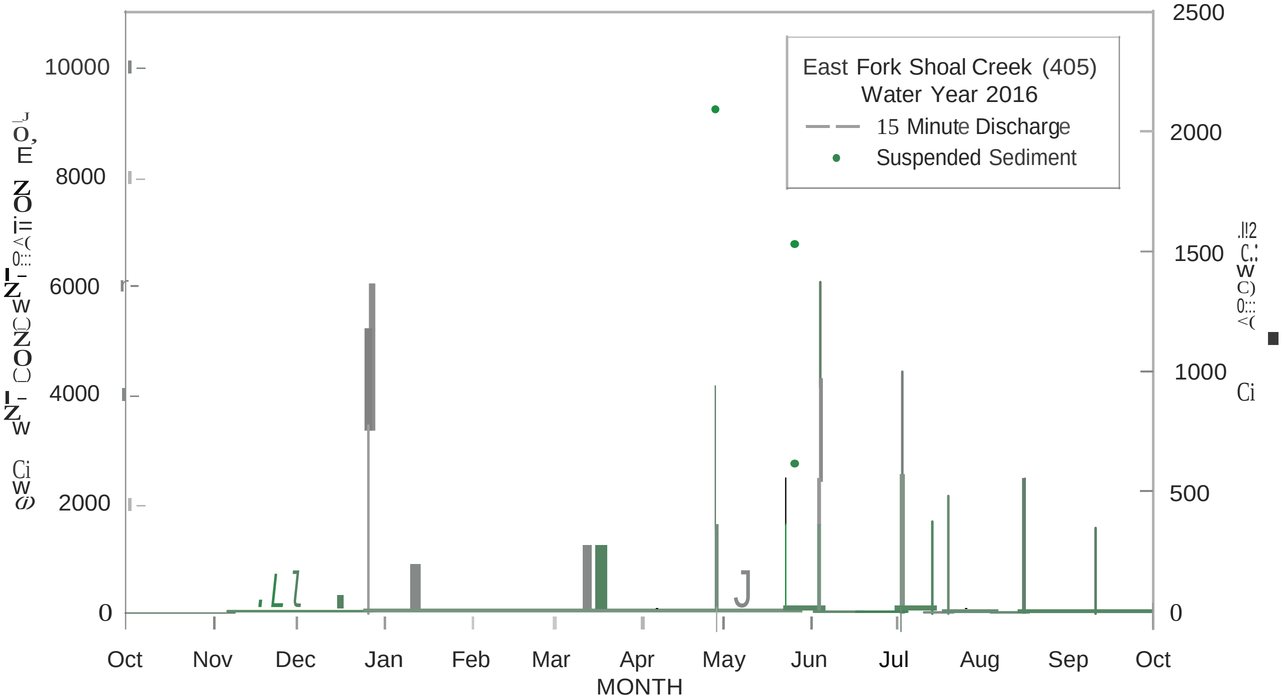


Figure 3-8. Suspended sediment concentrations and discharge for Water Year 2016:
Hurricane Creek (404) and East Fork Shoal Creek (405)

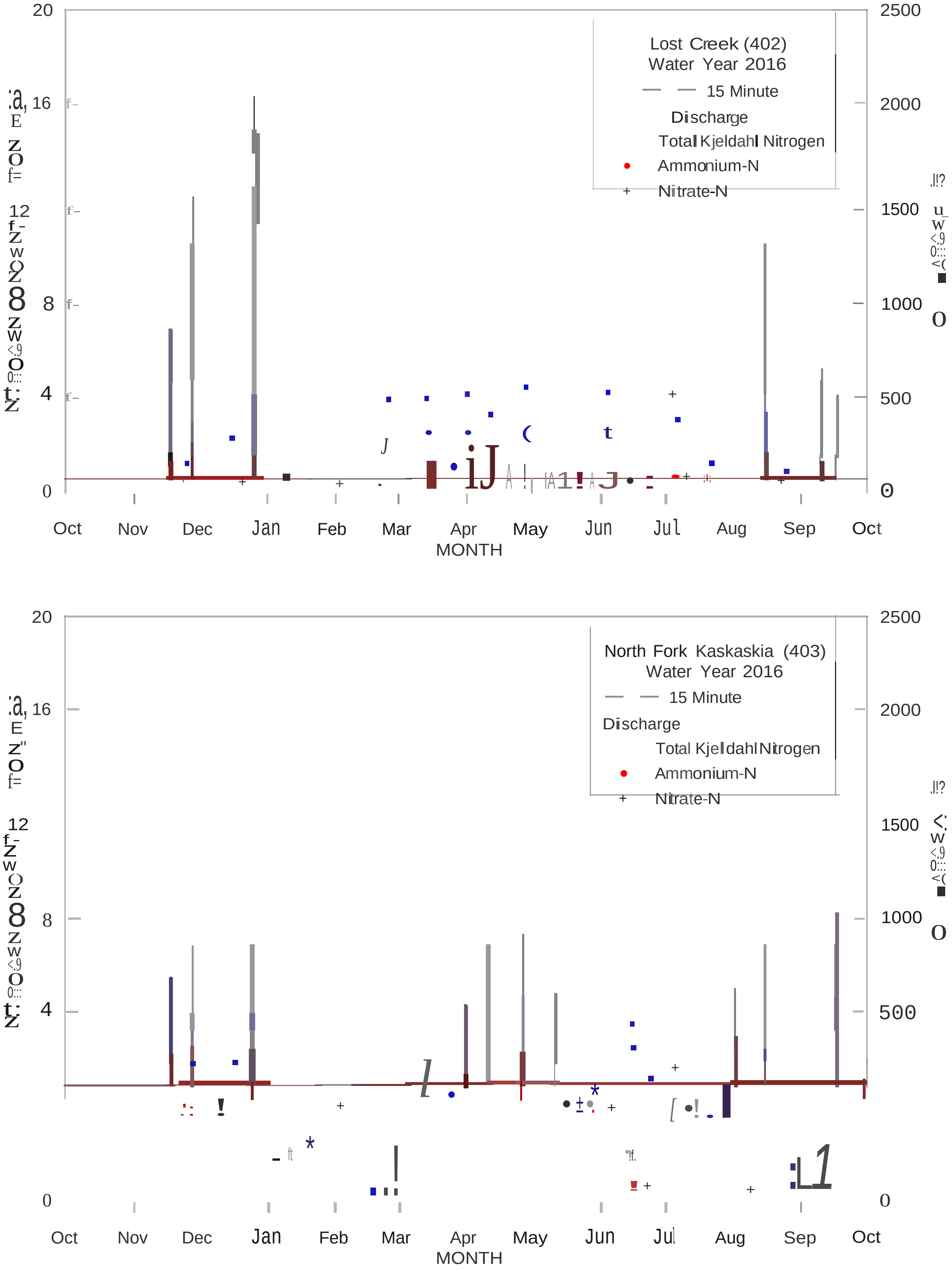


Figure 3-9. Nitrogen concentrations and discharge for Water Year 2016:
Lost Creek (402) and North Fork Kaskaskia (403)

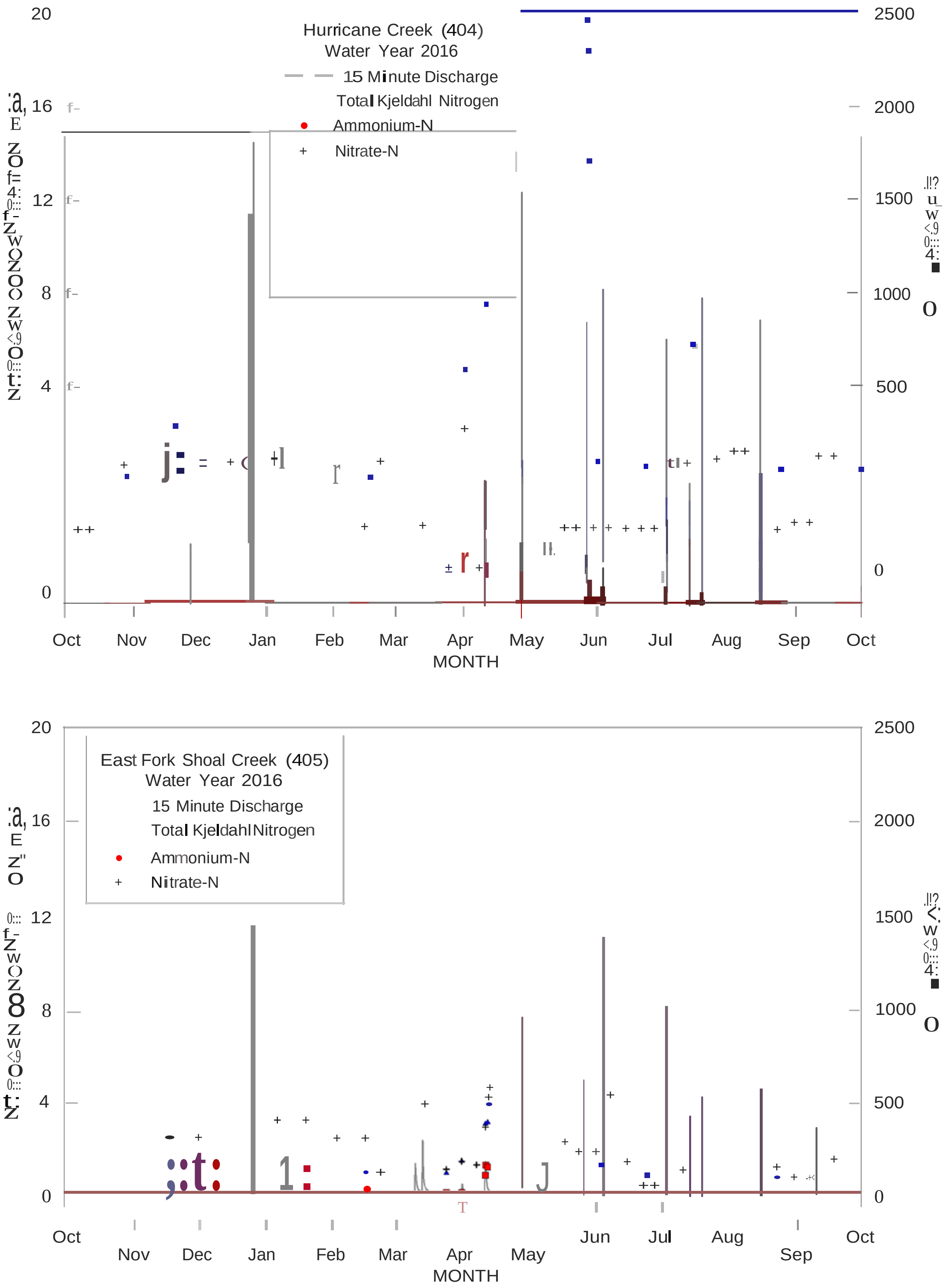


Figure 3-10. Nitrogen concentrations and discharge for Water Year 2016:

Hurricane Creek (404) and East Fork Shoal Creek (405)

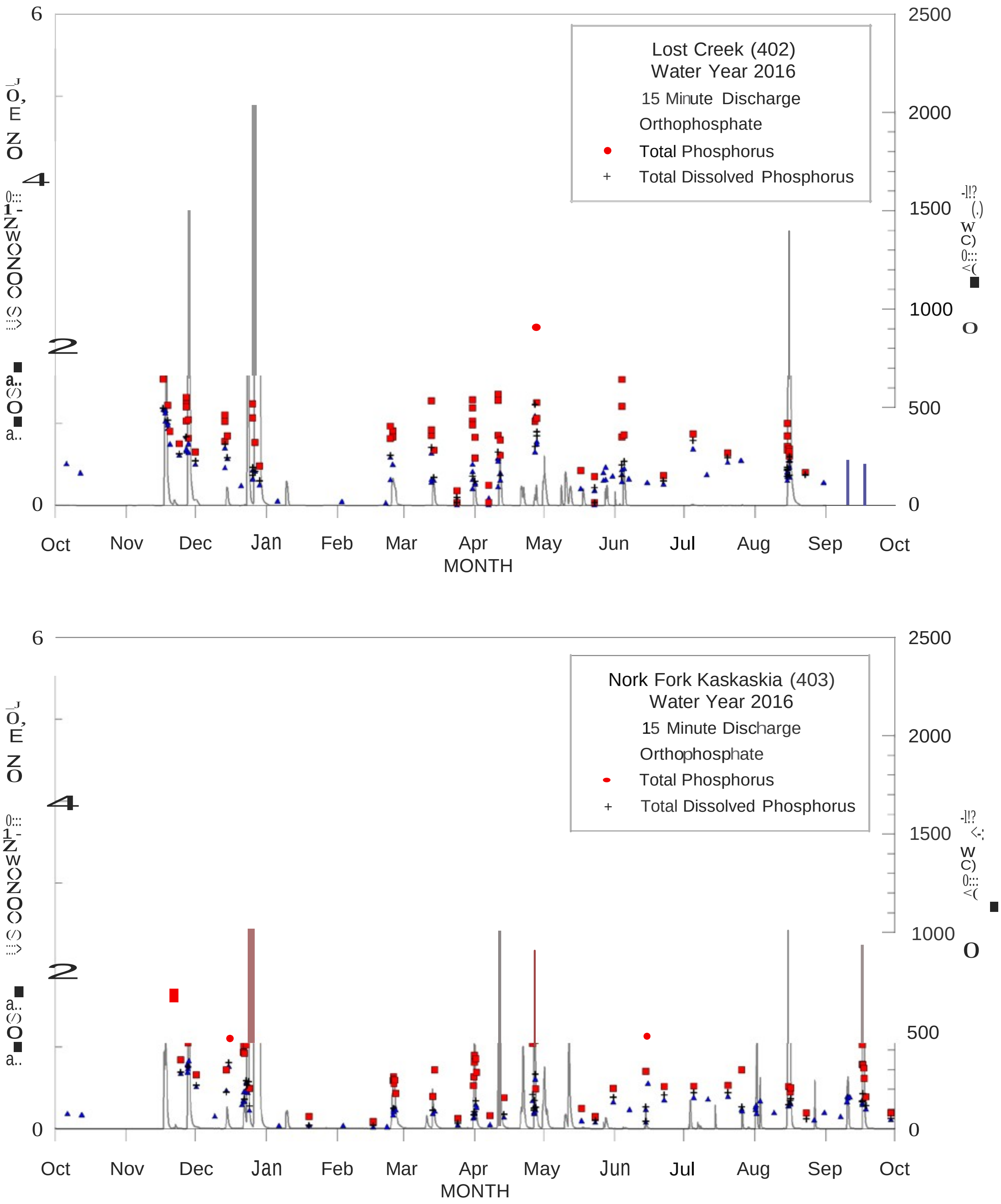


Figure 3-11. Phosphorus concentrations and discharge for Water Year 2016: Lost Creek (402) and North Fork Kaskaskia (403)

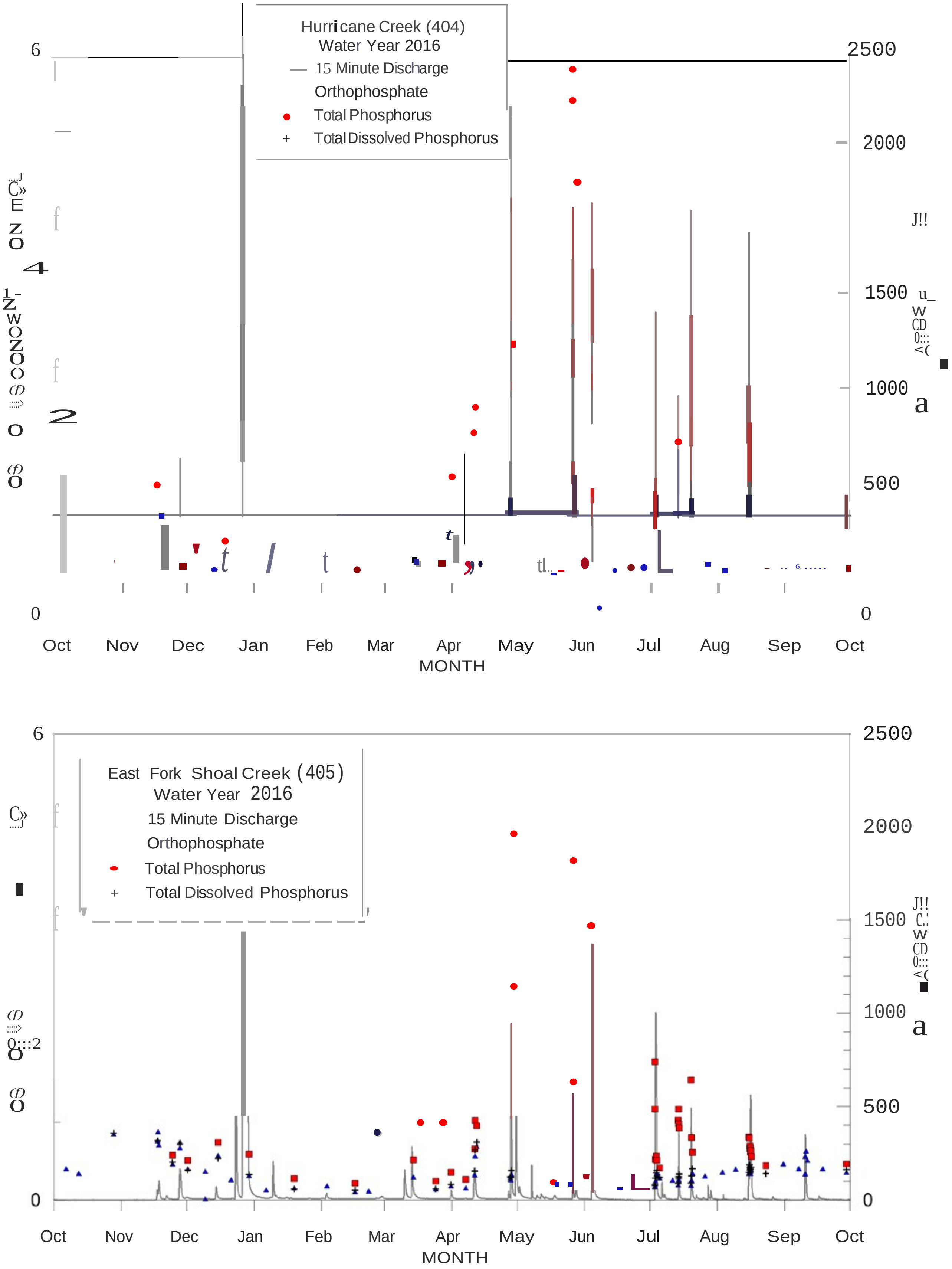
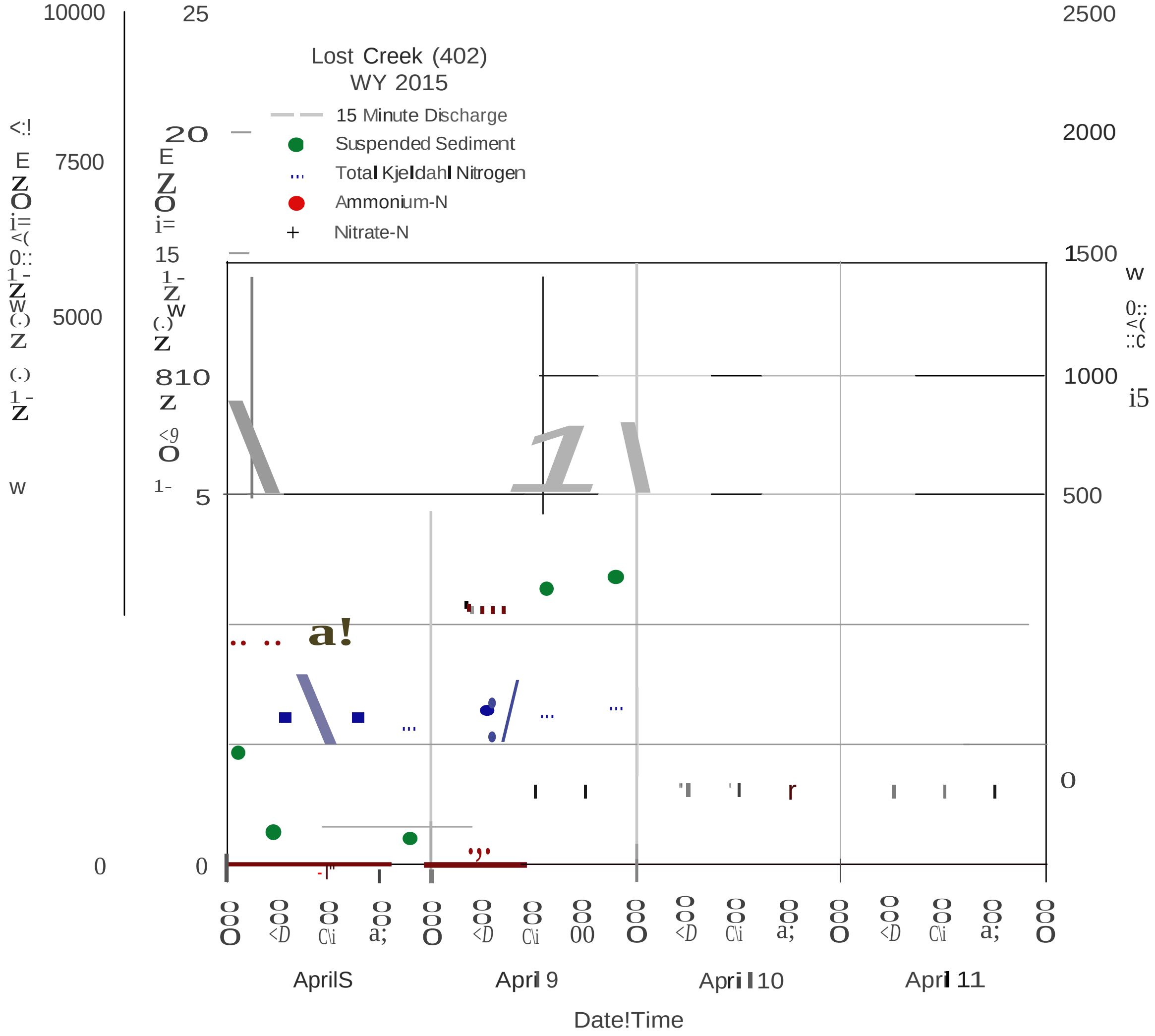
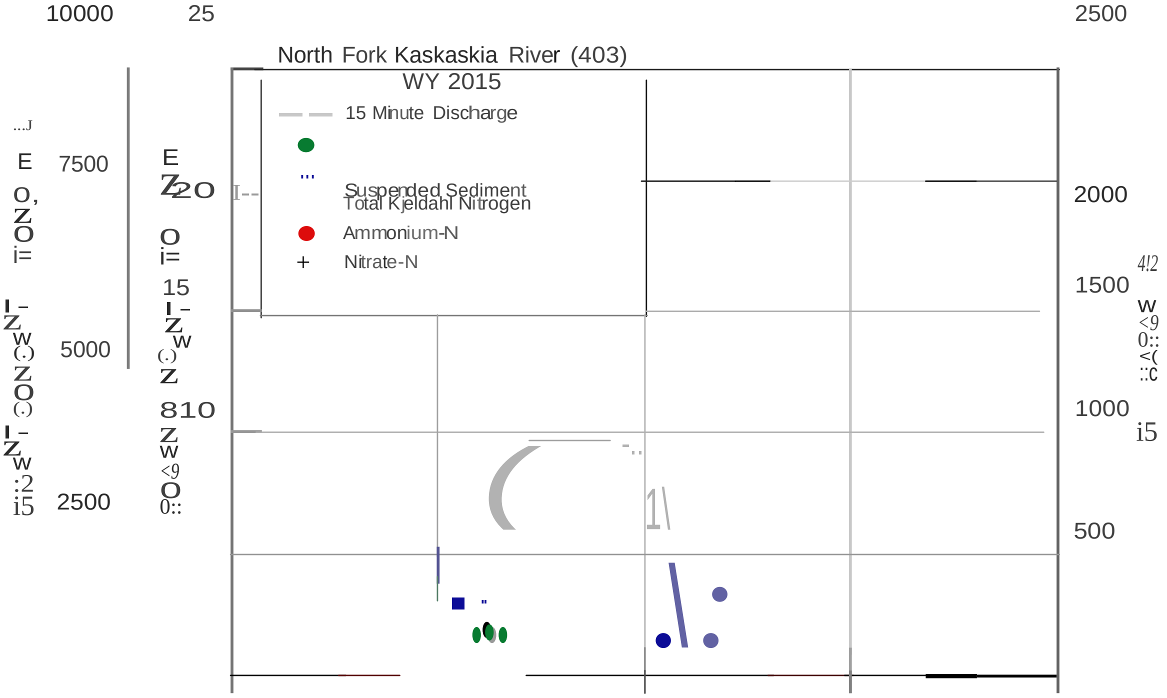


Figure 3-12. Phosphorus concentrations and discharge for Water Year 2016: Hurricane Creek (404) and East Fork Shoal Creek (405)

Table 3-2. Summary Statistics for Water Years 2014-2016 (all concentrations in mg/L).

	NO3-N	*NH4-N*	*TKN*	*t-P*	*t-P-dissolved*	*oPO4-P*	*SSC*
Lost Creek (402)							
Count	496	460	389	411	348	413	490
Mean	0.71	0.44	2.87	1.04	0.49	0.15	604
Median	0.49	0.42	2.38	0.93	0.46	0.09	249
Minimum	0.04	0.00	0.16	0.04	0.04	0.03	4
Maximum	4.90	1.30	21.28	6.23	1.41	1.24	15,704
25th Percentile	0.29	0.28	1.72	0.73	0.33	0.03	92
75th Percentile	0.88	0.56	3.25	1.21	0.61	0.18	589
North Fork Kaskaskia River (403)							
Count	368	343	259	278	231	301	389
Mean	0.61	0.34	2.42	0.82	0.38	0.12	393
Median	0.41	0.29	2.19	0.76	0.36	0.06	223
Minimum	0.04	0.00	0.16	0.04	0.04	0.03	4
Maximum	4.18	1.27	9.55	2.14	1.29	1.31	3,456
25th Percentile	0.21	0.18	1.56	0.53	0.25	0.03	63
75th Percentile	0.72	0.42	2.79	1.05	0.45	0.13	488
Hurricane Creek (404)							
Count	288	265	183	190	160	238	293
Mean	1.16	0.16	3.79	1.15	0.22	0.10	1,206
Median	1.04	0.11	2.94	0.93	0.18	0.04	521
Minimum	0.04	0.00	0.16	0.04	0.04	0.03	5
Maximum	6.96	0.78	19.70	5.74	0.81	1.27	10,462
25th Percentile	0.46	0.06	1.77	0.47	0.09	0.03	62
75th Percentile	1.51	0.20	5.15	1.51	0.29	0.08	1,505
East Fork Shoal Creek (405)							
Count	359	338	276	282	244	310	360
Mean	1.60	0.45	3.54	1.21	0.51	0.38	682
Median	1.45	0.37	2.89	1.01	0.41	0.08	263
Minimum	0.04	0.00	0.68	0.21	0.11	0.03	3
Maximum	7.08	1.55	16.26	4.72	1.53	7.09	11,897
25th Percentile	0.62	0.27	1.89	0.70	0.31	0.03	32
75th Percentile	2.26	0.59	4.19	1.52	0.72	0.42	739


Lost Creek (402)
WY 2015
15 Minute Discharge
● Suspended Sediment
Total Kjeldahl Nitrogen
● Ammonium-N
+ Nitrate-N
10000
7500
5000
0
25
20
15
10
5
0
2500
2000
1500
1000
500
0
April 8
April 9
April 10
April 11
Date/Time


North Fork Kaskaskia River (403)
WY 2015
15 Minute Discharge
● Suspended Sediment
Total Kjeldahl Nitrogen
● Ammonium-N
+ Nitrate-N
10000
7500
5000
2500
25
20
15
10
2500
2000
1500
1000
500

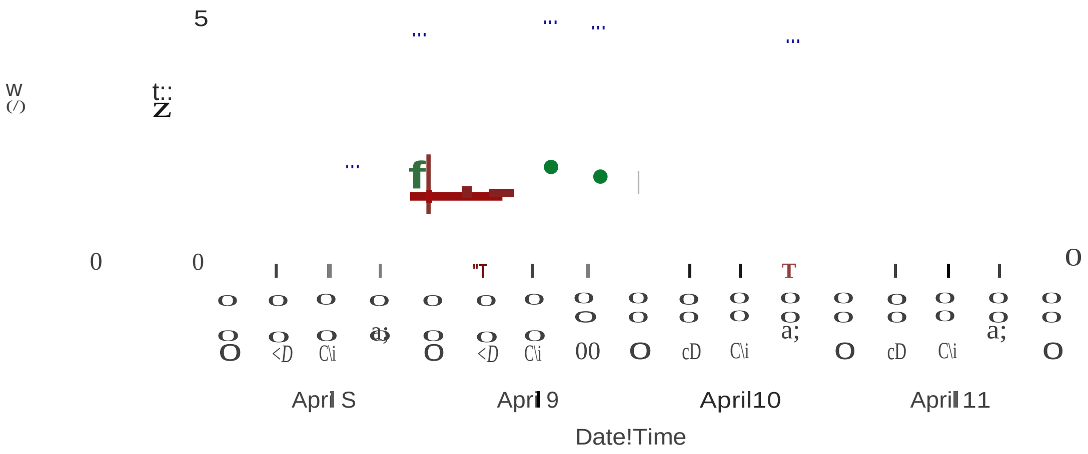
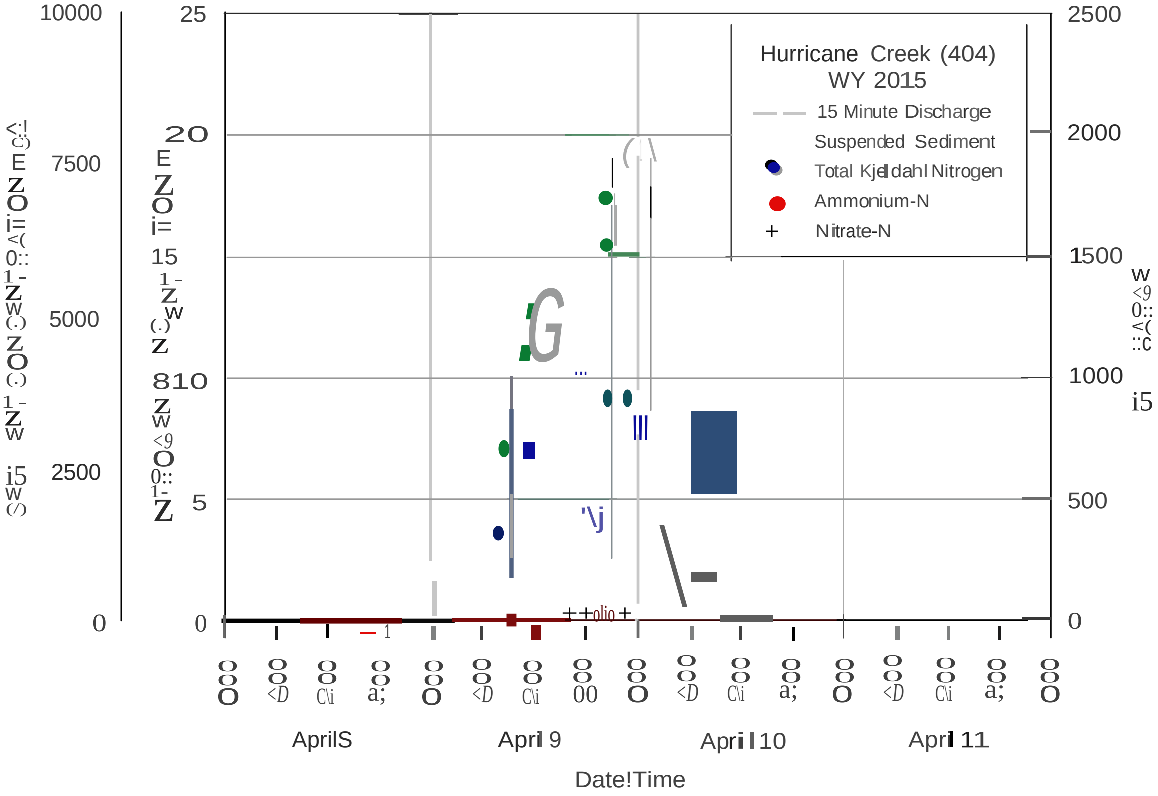


Figure 3-13. Sediment and nitrogen concentrations during April 8-11, 2015 event at Lost Creek (402) and North Fork Kaskaskia River (403).


Hurricane Creek (404)
WY 2015
15 Minute Discharge
Suspended Sediment
Total Kjeldahl Nitrogen
Ammonium-N
Nitrate-N
10000
7500
5000
2500
0
25
20
15
10
5
0
2500
2000
1500
1000
500
0
April 8
April 9
April 10
April 11
Date/Time

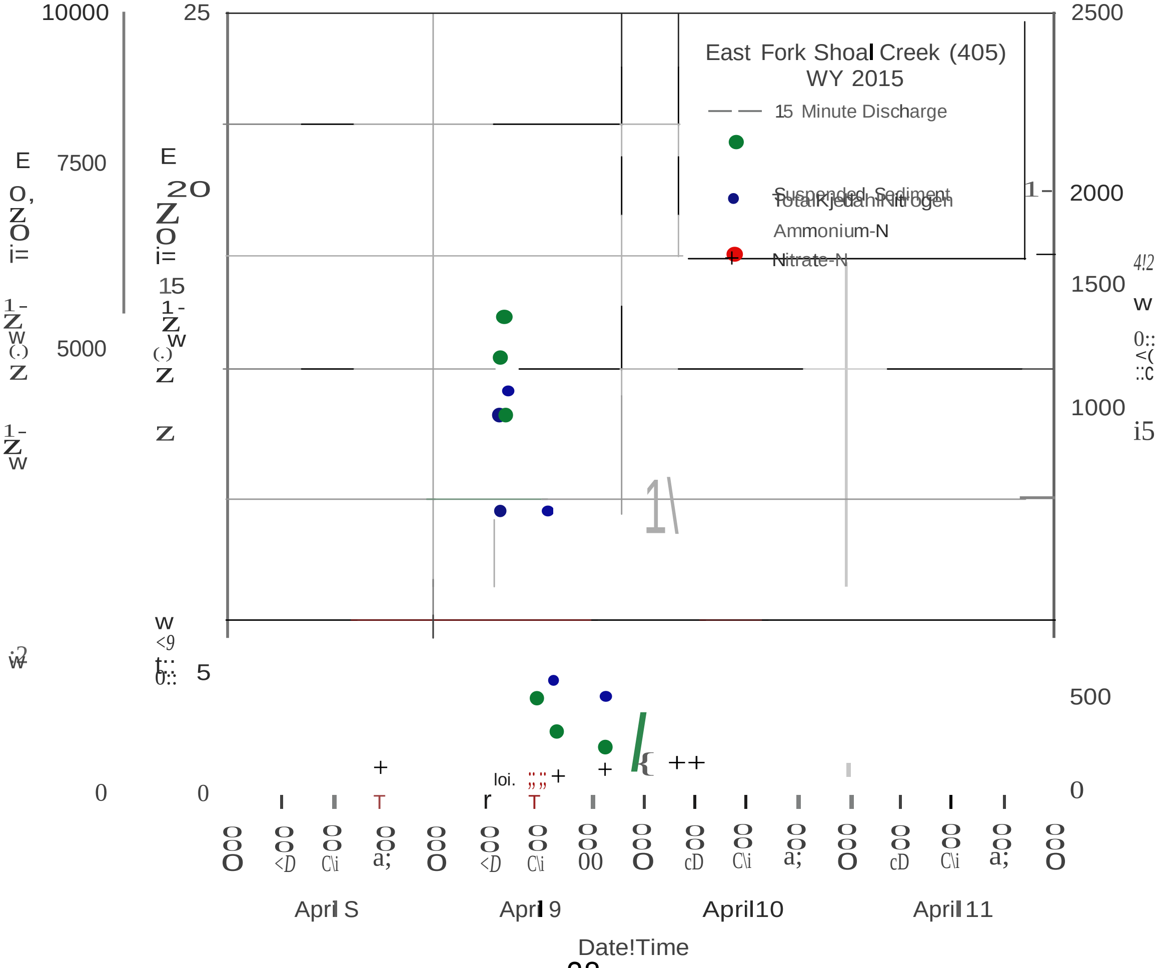
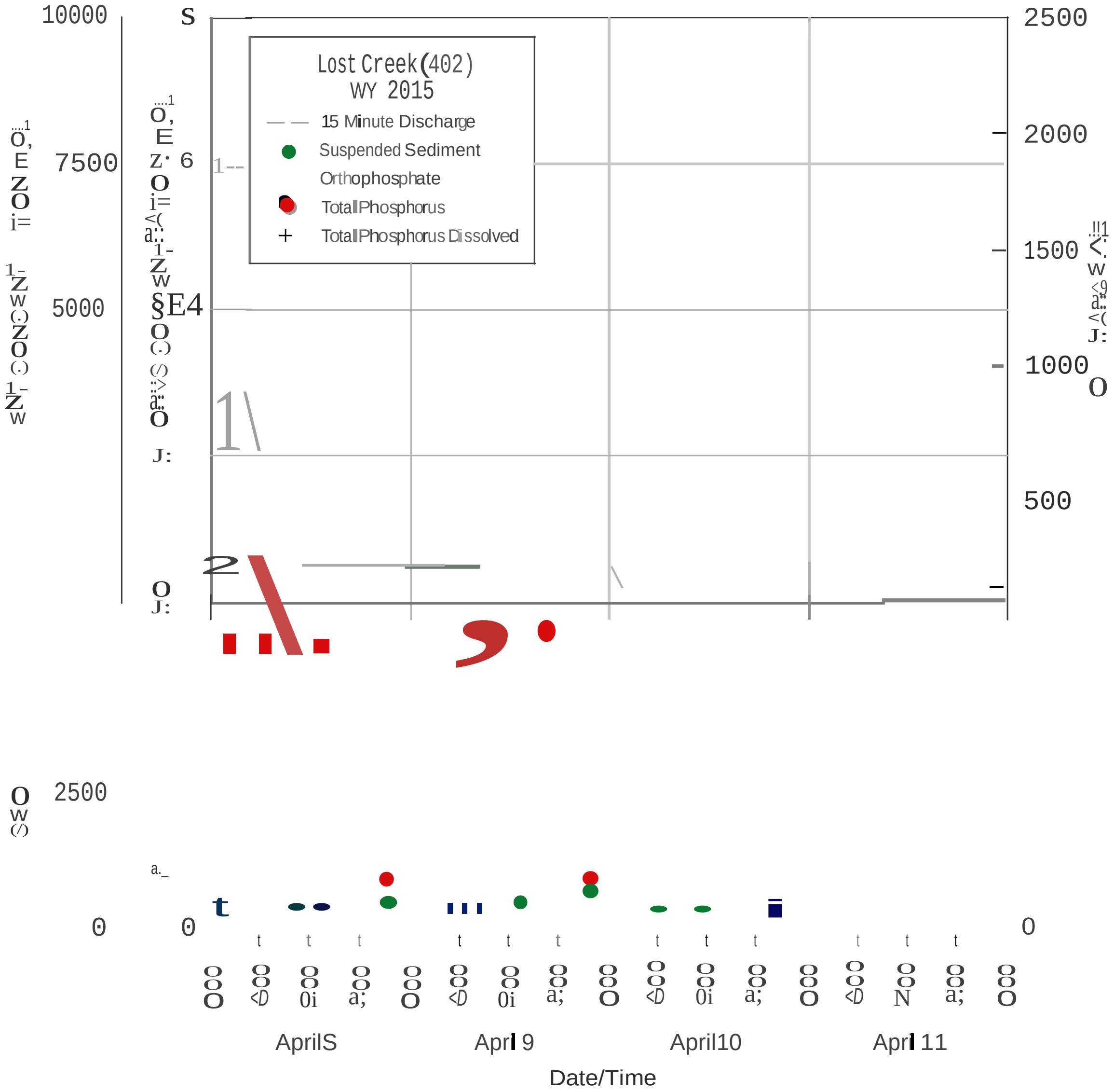
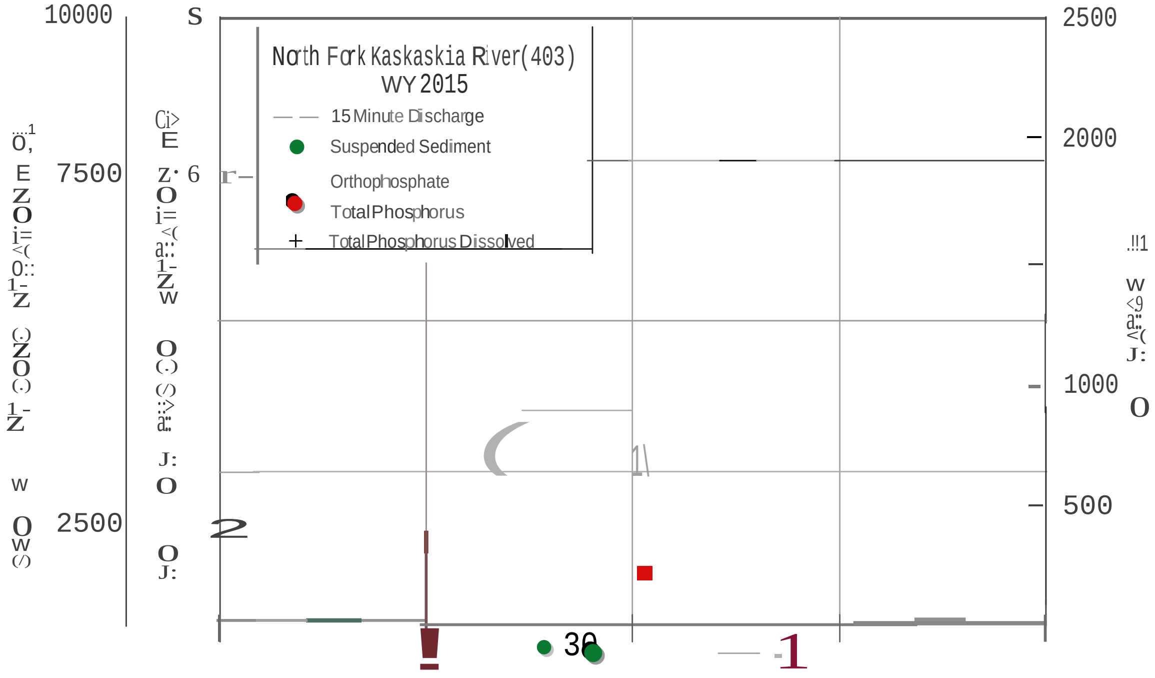

East Fork Shoal Creek (405)
WY 2015
15 Minute Discharge
Suspended Sediment
Total Kjeldahl Nitrogen
Ammonium-N
Nitrate-N
10000
7500
5000
0
25
20
15
5
0
2500
2000
1500
1000
500
0
April 8
April 9
April 10
April 11
Date/Time

Figure 3-14_ Sediment and nitrogen concentrations during April 8-11, 2015 event at Hurricane Creek (404) and East Fork Shoal Creek (405)_


Lost Creek (402)
WY 2015
15 Minute Discharge
Suspended Sediment
Orthophosphate
Total Phosphorus
Total Phosphorus Dissolved
10000
7500
5000
2500
0
2500
2000
1500
1000
500
0
April 8
April 9
April 10
April 11
Date/Time


North Fork Kaskaskia River (403)
WY 2015
15 Minute Discharge
Suspended Sediment
Orthophosphate
Total Phosphorus
Total Phosphorus Dissolved
10000
7500
2500
2500
2000
1000
500

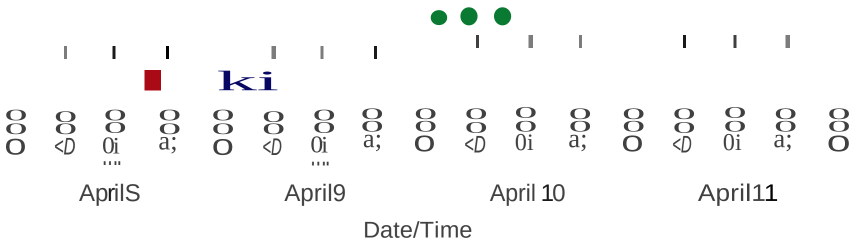


Figure 3-15. Sediment and phosphorus concentrations during April 8-11, 2015 event at Lost Creek (402) and North Fork Kaskaskia River (403).

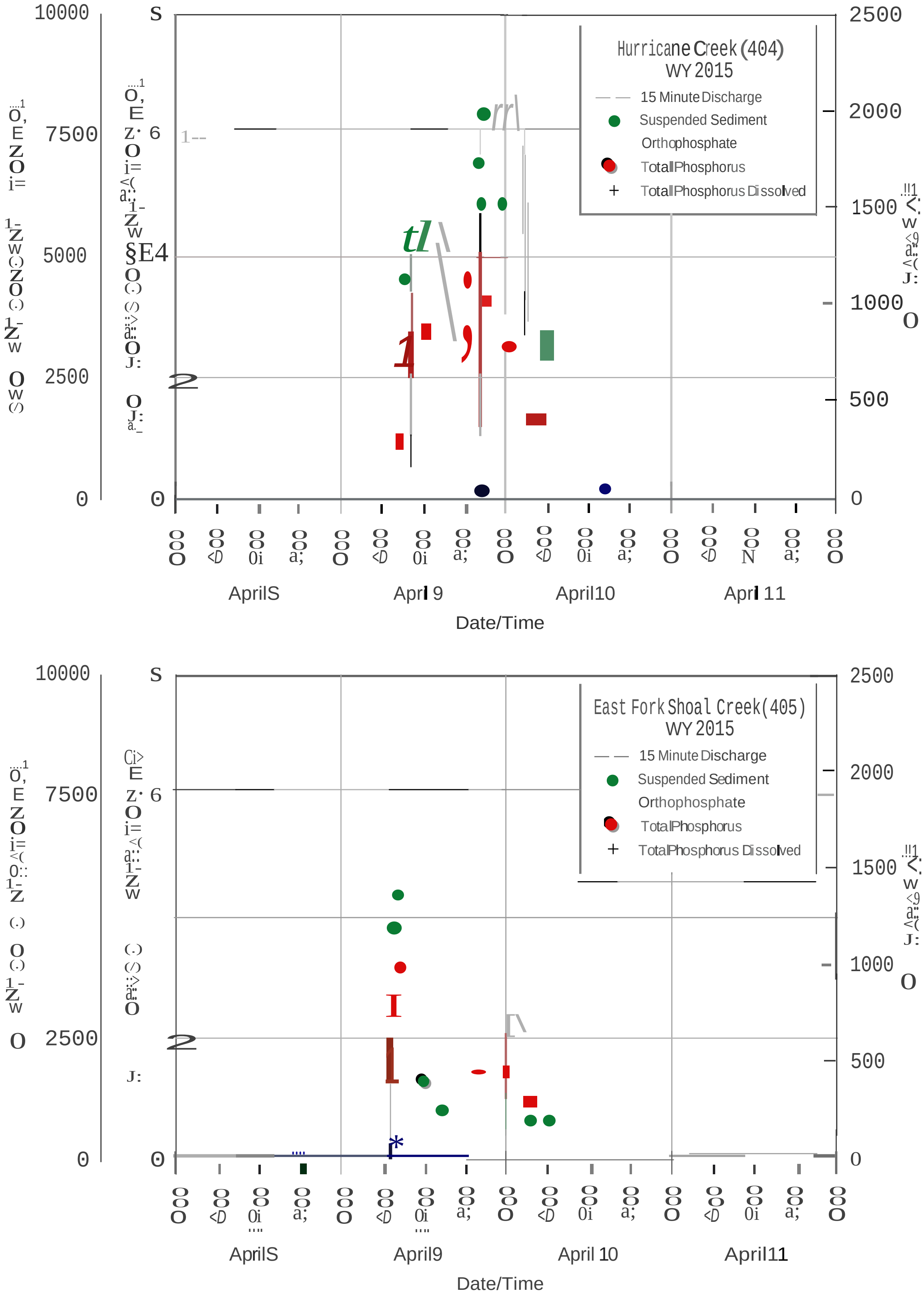


Figure 3-16. Sediment and phosphorus concentrations during April 8-11, 2015 event at Hurricane Creek (404) and East Fork Shoal Creek (405).

Sediment and Nutrient Yields

The collection of sediment and nutrient concentrations, as well as stream discharges, makes it possible to compute the load of sediment of nutrients being transported out of a watershed as measured at a monitoring station. The load is the mass of sediment or nutrients over a determined period of time. However, to compare loads between watersheds in terms of the mass per unit area, the monthly sediment and nutrient yields were computed by dividing the total annual load with the drainage area in acres for each of the monitoring stations. The yield results for all stations during WY2014-2016 are provided in tables 3-3 through 3-6 for suspended sediment, nitrate-N, TKN, and total phosphorus, respectively. The monthly yield at all stations during WY2016 for sediment and total phosphorus is shown in figure 3-17 and nitrate-N and TKN in figure 3-18. It should be noted that suspended sediment yields are presented in tons per acre (tons/ac) while nitrate-N, TKN, and total phosphorus are presented in pounds per acre (lbs/ac). Figures showing monthly sediment and nutrient yields for previous water years can be found in Appendix B.

Monthly sediment yields for WY2014-16 ranged from a low of 0.0 to 1.49 tons/acre where Hurricane Creek (404) had the highest yield (table 3-3). Hurricane Creek (404) had the highest annual yield, whereas the other three monitoring stations were much lower and similar in magnitude. As presented earlier, Lost Creek (402) had the highest recorded suspended sediment concentration, however, Hurricane Creek (404) had the highest mean and 75th quartile concentrations of all the stations. For Water Year 2016, Hurricane Creek (404) is transporting the equivalent of nearly 5 tons of suspended sediment per acre.

During WY2014-2106 monthly nitrate-N yields varied from a low of 0.00 lbs/acre at several stations to a high of 3.05 lbs/acre for East Fork Shoal Creek (405) in June 2015 (table 3-4). The highest annual nitrate-N yield for WY2015 was 5.21 lbs/acre at East Fork Shoal Creek (405) with with Lost Creek (402) next at 2.34 lb/acre. Monthly TKN yields (table 3-5) during WY2014-16 were generally higher than nitrate-N yields at all stations. Except for North Fork Kaskaskia (403) all stations had their highest monthly TKN yields in WY2016 and over 4 lbs/acre. Monthly total phosphorous yields varied from near zero lbs/acre to a high of 3.85 lbs/acre for East Fork Shoal Creek (405) in June 2015. East Fork Shoal Creek (405) usually had the highest monthly yields for all but only a few months during WY2014-16. This station had a WY2016 annual total phosphorus yield of 10.65 lbs/acre, almost double the annual load of the other stations.

Annual sediment and total phosphorus yields are presented in figure 3-19 and nitrate-N and TKN in figure 3-20 for Water Years 2014 through 2016. Water Year 2014 is a partial year while WY2015 and WY2016 are full monitoring years. Although WY2014 annual yields were generally lower due to a partial monitoring year, patterns between the stations are similar between all three years. Annual sediment yields were significantly higher at Hurricane Creek (404) as shown in figure 3-19a and East Fork Shoal Creek (405) had the highest total phosphorus annual yields seen in figure 3-19b. Figure 3-20a shows that Hurricane Creek (404) and East Fork Shoal Creek (405) tended to have higher annual nitrate-N yields than the other two stations. Annual TKN yields, figure 3-20b, do not show as much of a pattern between stations, although East Fork Shoal Creek (405) was higher than other stations except in WY2016. North Fork Kaskaskia (403) always had the lowest annual yield of all the stations in all three years.

Table 3-3. Suspended Sediment Yield in tons/acre for Kaskaskia Monitoring Stations

		Suspended Sediment Yield (tons/ac)			
	Month	*402*	*403*	*404*	*405*
WY2014	Jan 2014	0.00			
	Feb 2014	0.01	0.00	0.00	0.05
	Mar 2014	0.01	0.00	0.00	0.00
	Apr 2014	0.00	0.13	0.69	0.24
	May 2014	0.14	0.02	0.00	0.02
	June 2014	0.00	0.00	0.10	0.07
	July 2014	0.01	0.00	0.00	0.00
	Aug 2014	0.00	0.00	0.00	0.00
	Sept 2014	0.03	0.05	0.00	0.01
WY2015	Oct 2014	0.03	0.00	0.22	0.04
	Nov 2014	0.00	0.00	0.01	0.01
	Dec 2014	0.00	0.05	0.10	0.02
	Jan 2015	0.05	0.00	0.01	0.01
	Feb 2015	0.00	0.01	0.01	0.00
	2015 Mar	0.00	0.09	0.40	0.06
	Apr 2015	0.12	0.07	1.20	0.14
	May 2015	0.17	0.11	0.03	0.11
	June 2015	0.09	0.19	1.08	0.27
	July 2015	0.24	0.00	0.00	0.00
	Aug 2015	0.03	0.00	0.00	0.00
	Sept 2015	0.00	0.02	0.00	0.00
WY2016	Oct 2015	0.03	0.00	0.00	0.00
	Nov 2015	0.00	0.09	0.05	0.01
	Dec 2015	0.10	0.21	1.35	0.03
	Jan 2016	0.32	0.00	0.01	0.00
	Feb 2016	0.00	0.03	0.02	0.00
	Mar 2016	0.01	0.04	0.01	0.01
	Apr 2016	0.01	0.20	1.49	0.12
	May 2016	0.04	0.03	1.04	0.03
	June 2016	0.03	0.01	0.34	0.07
	July 2016	0.01	0.01	0.49	0.04
	Aug 2016	0.00	0.08	0.20	0.01
	Sept 2016	0.06	0.07	0.00	0.00
***WY2014**		0.19	0.20	0.80	0.40
WY2015		0.75	0.55	3.07	0.64
WY2016		0.62	0.76	5.01	0.33

[*-partial water year]

Table 3-4. Nitrate-N Yield in lbs/acre for Kaskaskia Monitoring Stations

		Nitrate-N Yield (lbs/ac)			
	Month	*402*	*403*	*404*	*405*
WY2014	Jan 2014	0.10			
	Feb 2014	0.10	0.00	0.03	0.25
	Mar 2014	0.00	0.00	0.32	0.09
	Apr 2014	0.48	0.44	2.34	1.00
	May 2014	0.08	0.26	0.40	0.40
	June 2014	0.04	0.05	0.46	0.69
	July 2014	0.00	0.00	0.01	0.00
	Aug 2014	0.10	0.01	0.02	0.00
	Sept 2014	0.06	0.06	0.01	0.01
WY2015	Oct 2014	0.01	0.00	0.12	0.11
	Nov 2014	0.03	0.00	0.09	0.16
	Dec 2014	0.37	0.24	0.49	0.48
	Jan 2015	0.03	0.03	0.28	0.25
	Feb 2015	0.03	0.03	0.15	0.11
	Mar 2015	0.31	0.25	0.88	0.60
	Apr 2015	0.25	0.05	0.31	0.29
	May 2015	0.72	0.64	1.28	1.10
	June 2015	1.16	0.48	2.28	1.89
	July 2015	0.19	0.00	0.12	0.12
	Aug 2015	0.01	0.00	0.18	0.00
	Sept 2015	0.09	0.01	0.09	0.01
WY2016	Oct 2015	0.00	0.00	0.03	0.00
	Nov 2015	0.00	0.53	0.41	0.30
	Dec 2015	0.59	0.23	2.00	3.05
	Jan 2016	0.38	0.02	0.22	0.72
	Feb 2016	0.03	0.33	0.17	0.29
	Mar 2016	0.19	0.08	0.17	0.94
	Apr 2016	0.08	0.52	1.88	2.18
	May 2016	0.28	0.19	0.38	0.95
	June 2016	0.31	0.04	0.27	1.10
	July 2016	0.11	0.12	0.60	1.08
	Aug 2016	0.01	0.17	0.06	0.14
	Sept 2016	0.21	0.21	0.07	0.13
***WY2014**		0.98	0.82	3.59	2.43
WY2015		3.21	1.73	6.26	5.13
WY2016		2.19	2.45	6.27	10.89

[*-partial water year]

Table 3-5. TKN Yield in tons/acre for Kaskaskia Monitoring Stations

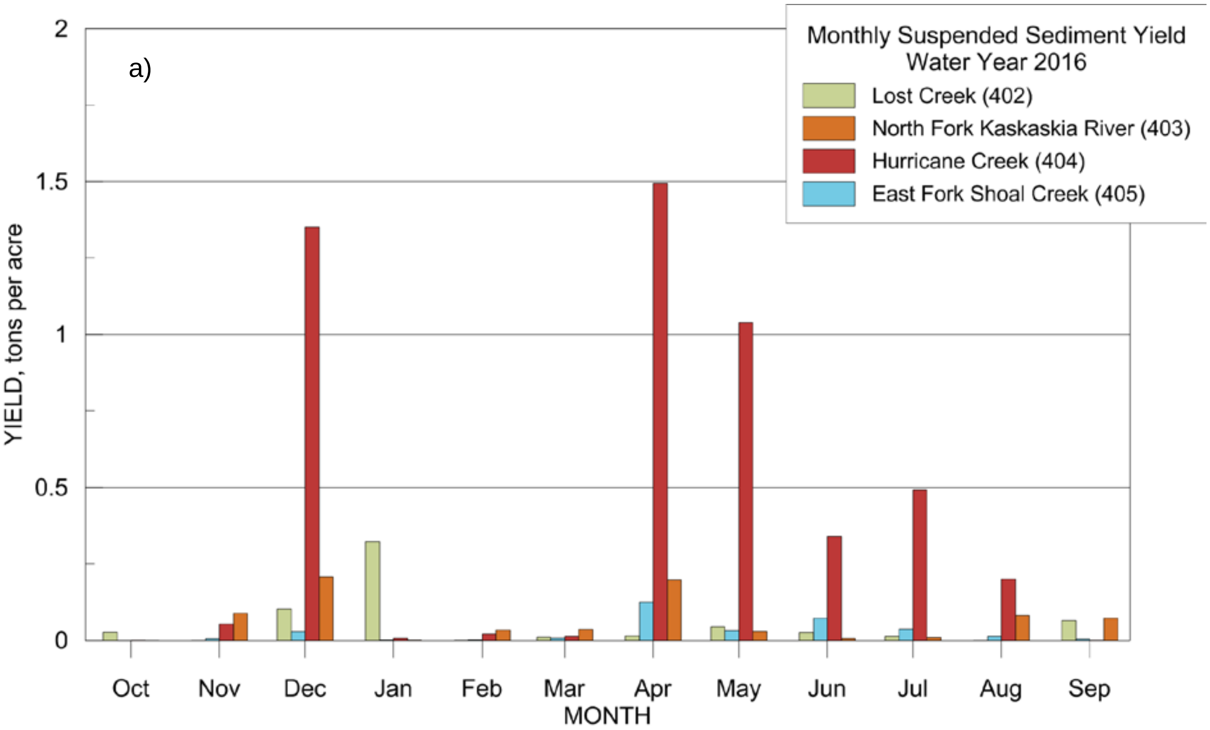
		Total Kjeldahl Nitrogen (lbs/ac)			
	Month	*402*	*403*	*404*	*405*
WY2014	Jan 2014	0.17			
	Feb 2014	0.34	0.00	0.00	1.45
	Mar 2014	0.00	0.00	0.07	0.29
	Apr 2014	1.72	1.82	2.06	3.87
	May 2014	0.10	0.28	0.24	0.78
	June 2014	0.10	0.06	0.46	1.39
	July 2014	0.00	0.00	0.00	0.00
	Aug 2014	0.33	0.03	0.01	0.00
	Sept 2014	0.36	0.40	0.00	0.12
WY2015	Oct 2014	0.10	0.01	0.72	1.29
	Nov 2014	0.16	0.01	0.07	0.48
	Dec 2014	1.39	0.91	0.49	1.04
	Jan 2015	0.14	0.13	0.13	0.47
	Feb 2015	0.10	0.10	0.03	0.17
	Mar 2015	1.69	1.01	1.03	1.74
	Apr 2015	2.27	0.87	2.26	2.58
	May 2015	1.62	1.29	0.27	2.17
	June 2015	3.27	1.75	2.59	4.89
	July 2015	0.55	0.01	0.02	0.16
	Aug 2015	0.06	0.00	0.02	0.01
	Sept 2015	0.39	0.10	0.01	0.03
WY2016	Oct 2015	0.01	0.00	0.01	0.00
	Nov 2015	2.18	0.66	0.38	0.32
	Dec 2015	4.02	1.07	3.48	2.83
	Jan 2016	0.08	0.03	0.12	0.36
	Feb 2016	0.38	0.25	0.05	0.13
	Mar 2016	0.34	0.26	0.16	0.28
	Apr 2016	0.61	1.31	7.67	4.08
	May 2016	0.59	0.25	4.62	2.10
	June 2016	0.18	0.04	1.61	2.35
	July 2016	0.01	0.07	2.31	1.57
	Aug 2016	1.26	0.37	1.03	0.49
	Sept 2016	0.79	0.55	0.02	0.12
***WY2014**		3.12	2.59	2.85	7.92
WY2015		11.75	6.19	7.66	15.02
WY2016		10.45	4.84	21.46	14.63

[*-partial water year]

Table 3-6. Total Phosphorus Yield in tons/acre for Kaskaskia Monitoring Stations

		Total Phosphorus Yield (lbs/ac)			
	Month	*402*	*403*	*404*	*405*
WY2014	Jan 2014	0.08			
	Feb 2014	0.09	0.00	0.00	1.24
	Mar 2014	0.00	0.00	0.01	0.12
	Apr 2014	0.63	0.61	0.60	2.97
	May 2014	0.03	0.07	0.05	0.49
	June 2014	0.04	0.01	0.12	0.99
	July 2014	0.00	0.00	0.00	0.00
	Aug 2014	0.16	0.01	0.00	0.00
	Sept 2014	0.16	0.13	0.00	0.11
WY2015	Oct 2014	0.04	0.00	0.23	1.14
	Nov 2014	0.10	0.01	0.03	0.58
	Dec 2014	0.79	0.46	0.18	1.00
	Jan 2015	0.06	0.06	0.04	0.36
	Feb 2015	0.03	0.03	0.03	0.08
	Mar 2015	0.51	0.32	0.28	1.06
	Apr 2015	0.72	0.24	0.72	1.89
	May 2015	0.56	0.38	0.08	1.50
	June 2015	1.20	0.54	0.82	3.85
	July 2015	0.18	0.01	0.01	0.15
	Aug 2015	0.02	0.00	0.01	0.01
	Sept 2015	0.18	0.04	0.00	0.05
WY2016	Oct 2015	0.00	0.00	0.00	0.00
	Nov 2015	1.25	0.91	0.18	0.38
	Dec 2015	1.82	0.87	1.15	2.10
	Jan 2016	0.03	0.02	0.04	0.20
	Feb 2016	0.08	0.12	0.01	0.08
	Mar 2016	0.09	0.15	0.06	0.31
	Apr 2016	0.24	0.76	2.20	2.71
	May 2016	0.22	0.15	1.40	1.17
	June 2016	0.07	0.03	0.50	1.87
	July 2016	0.00	0.06	0.72	1.24
	Aug 2016	0.53	0.30	0.33	0.45
	Sept 2016	0.23	0.35	0.01	0.15
***WY2014**		1.19	0.85	0.78	5.91
WY2015		4.39	2.08	2.44	11.67
WY2016		4.57	3.69	6.59	10.65

[*-partial water year]



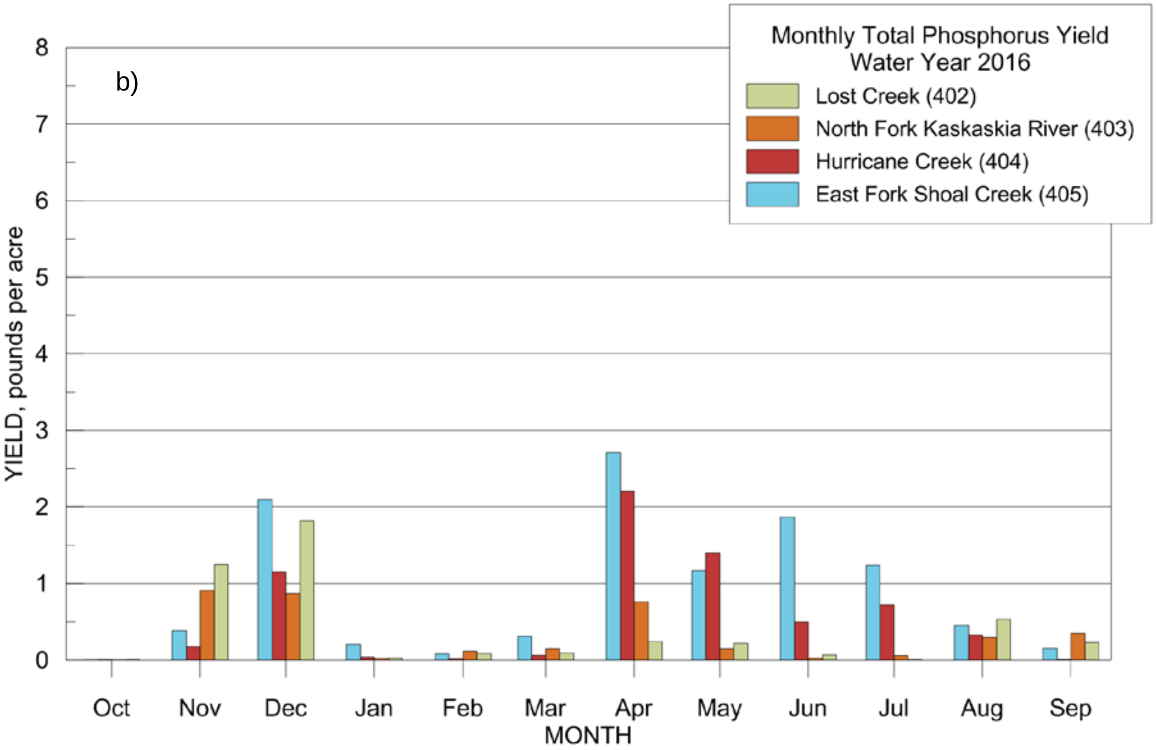


Figure 3-17. Monthly yields for all stations during Water Year 2016:
a) Suspended Sediment (tons/acre) and b) Total Phosphorus (lbs/acre)

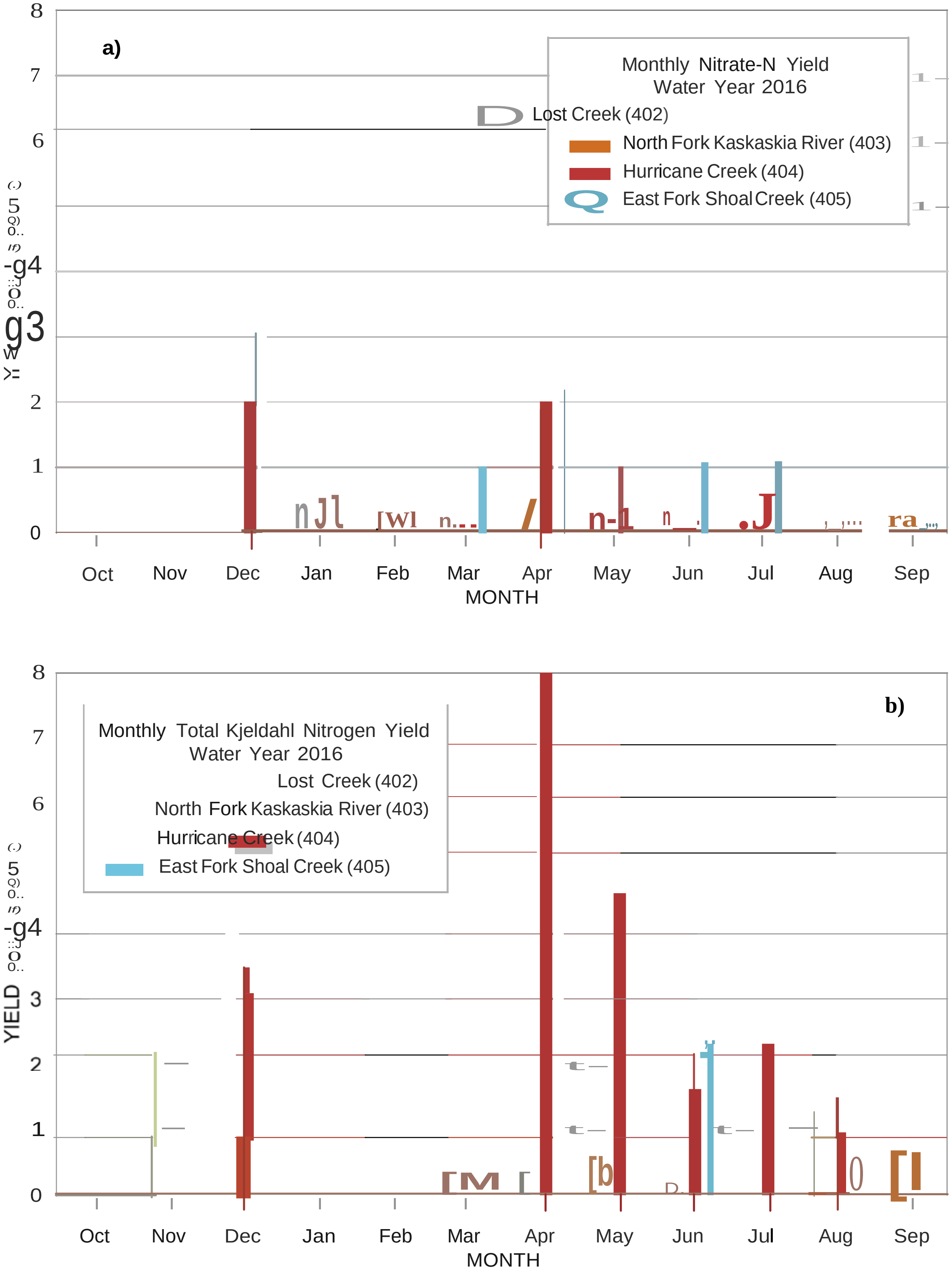
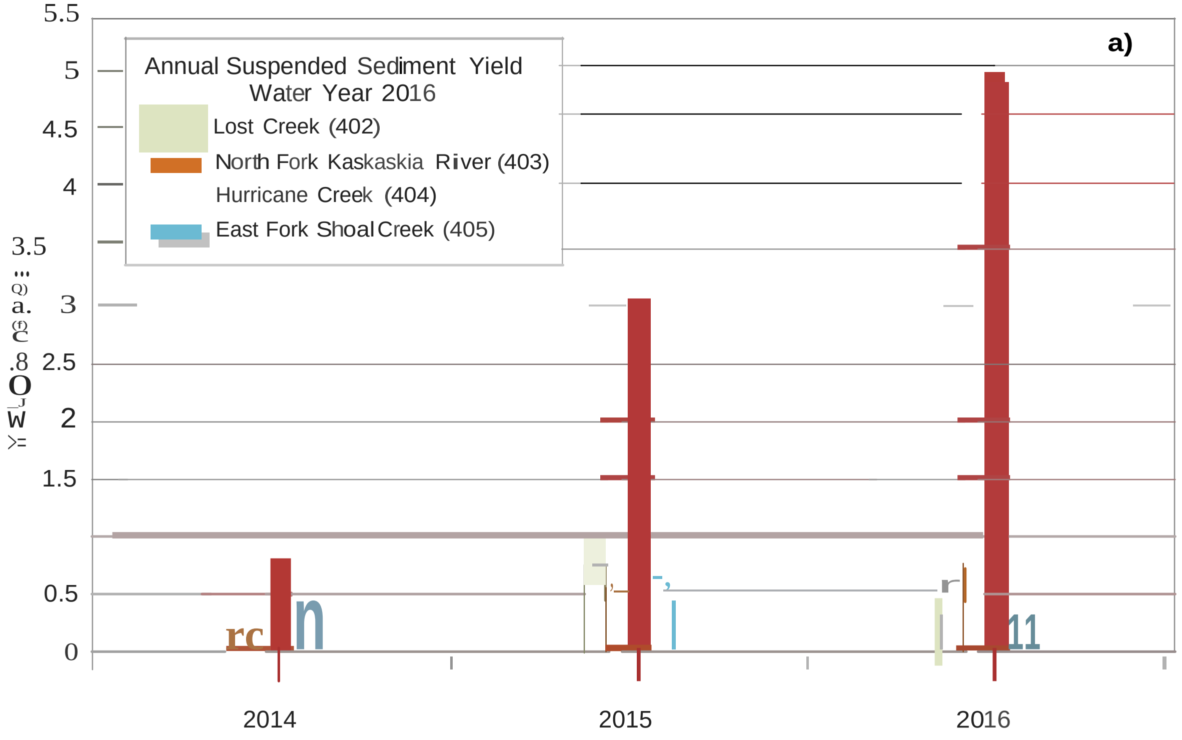


Figure 3-18. Monthly yields for all stations during Water Year 2016:
a) Nitrate-N (lbs/acre) and b) Total Kjeldahl Nitrogen (lbs/acre)



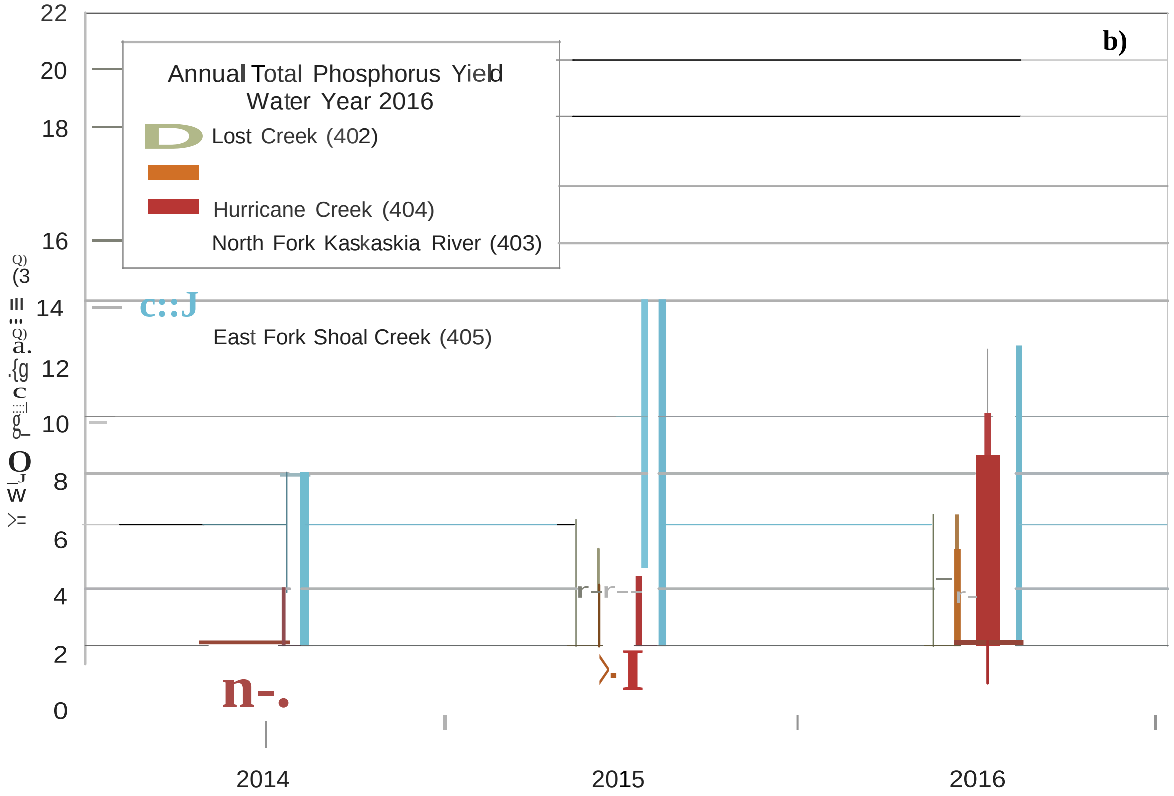
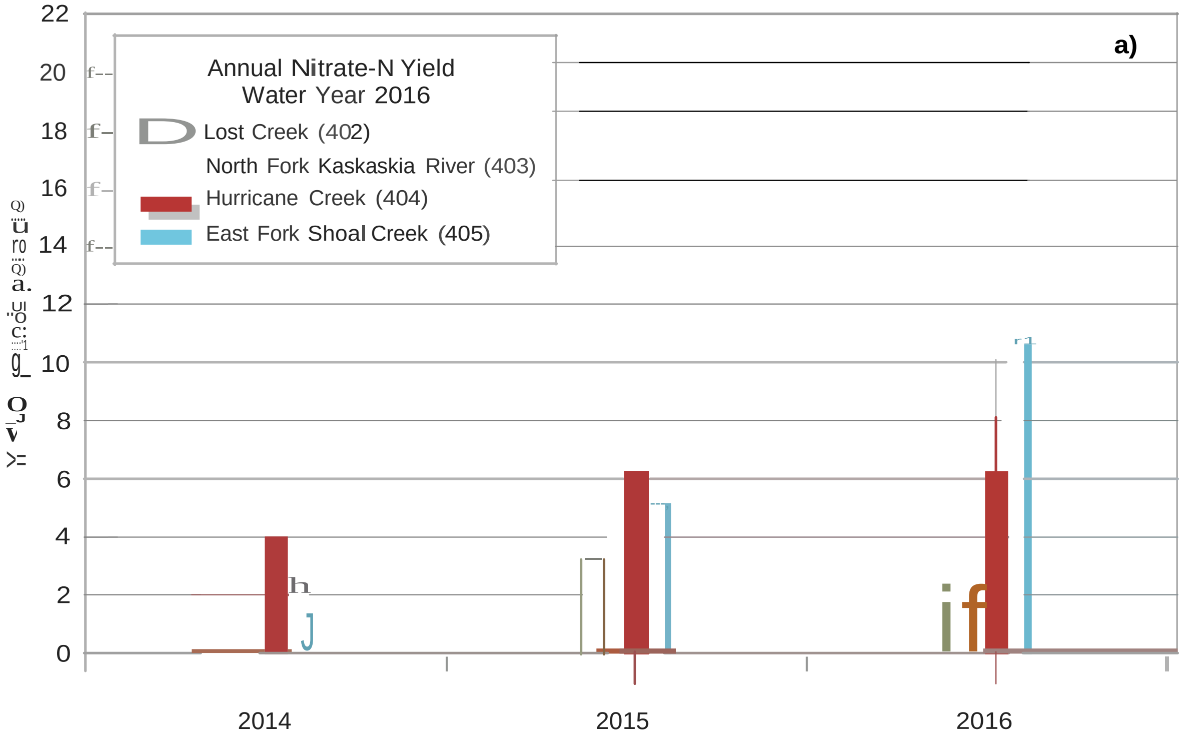
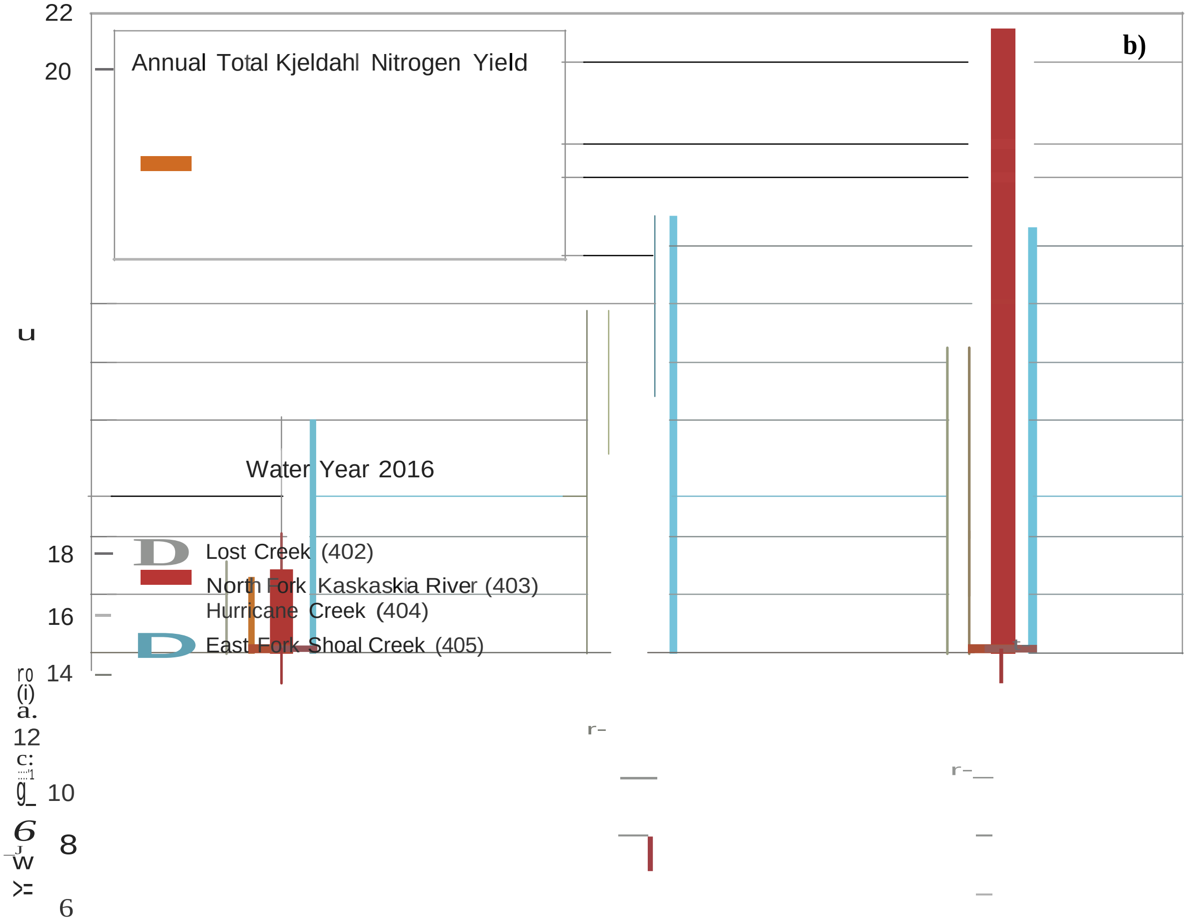


Figure 3-19. Annual yields for all stations during Water Years 2014-2016: a) Suspended Sediment (tons/acre) and b) Total Phosphorus (lbs/acre)


a)
Annual Nitrate-N Yield
Water Year 2016
Lost Creek (402)
North Fork Kaskaskia River (403)
Hurricane Creek (404)
East Fork Shoal Creek (405)
22
20
18
16
14
12
10
8
6
4
2
0
2014
2015
2016


b)
Annual Total Kjeldahl Nitrogen Yield
Water Year 2016
Lost Creek (402)
North Fork Kaskaskia River (403)
Hurricane Creek (404)
East Fork Shoal Creek (405)
22
20
18
16
14
12
10
8
6

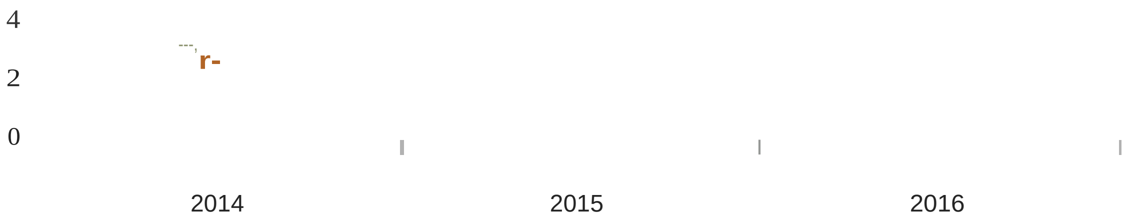


Figure 3-20. Annual yields for all stations during Water Years 2014-2016: a) Nitrate-N (lbs/acre) and b) Total Kjeldahl Nitrogen (lbs/acre)

4. Land Cover and Conservation Practices

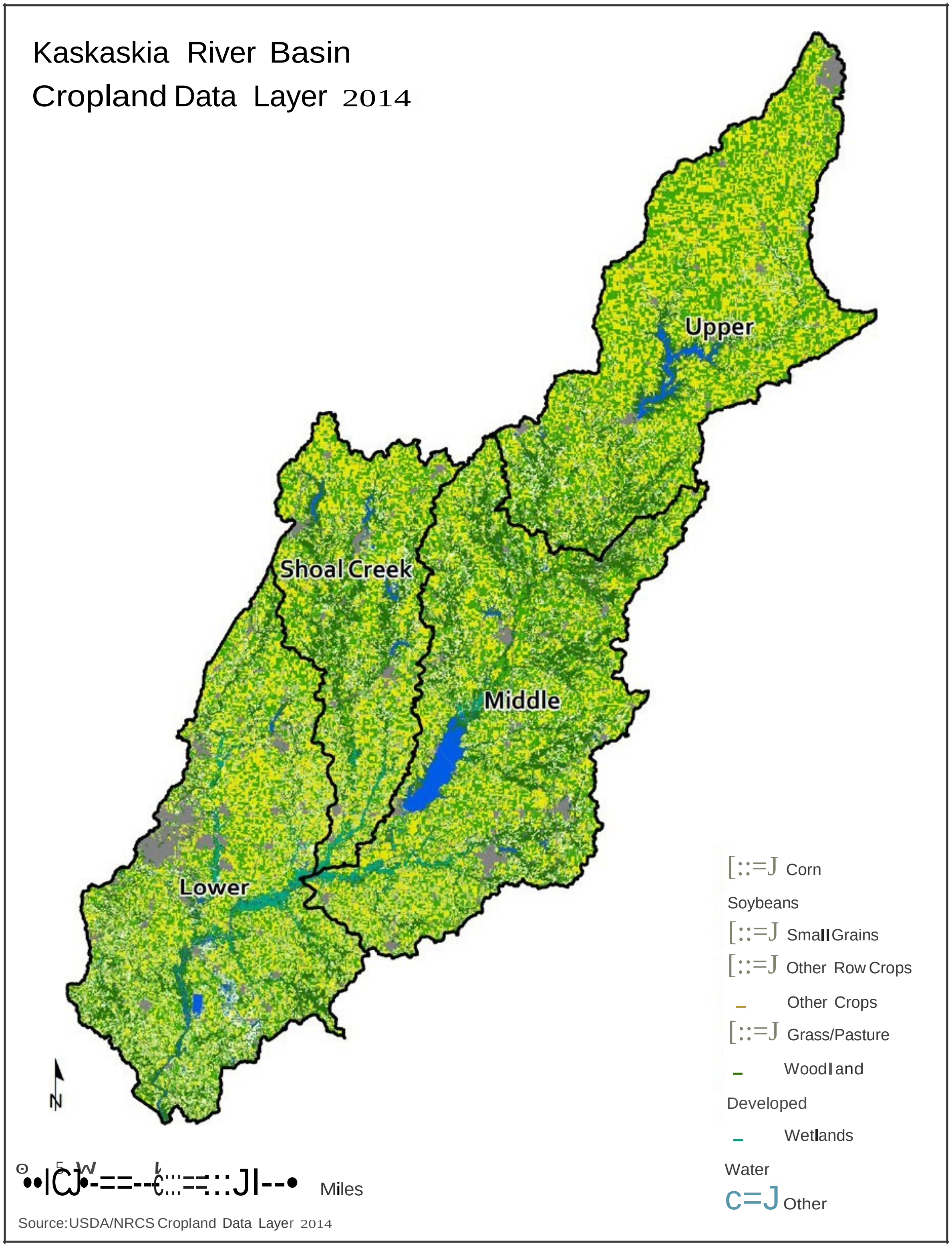
Land Cover

The distribution of 2014 land cover and croplands in the Kaskaskia River Basin are illustrated in Figure 4-1 and graphically summarized in Figure 4-2. The data is provided by the National Agricultural Statistics Service (NASS). In general, Figure 4-1 illustrates areas in agriculture production as represented by bright yellow and green colors, whereas woodlands, grassland, and wetlands in lighter greens and blues. Developed, urban types of areas are in gray. The Upper sub-watershed is dominated by agriculture production, the Middle sub-watershed is relatively equal between agriculture and all other land covers, and Shoal Creek and Lower sub-watersheds have agriculture in the flat upland areas and woodland, grassland, and wetlands predominantly in the stream valleys. Figure 4-2 shows land cover in decreasing order of percent area of the Illinois River Basin. Approximately 61 percent of the Kaskaskia River watershed area is in agriculture production, 16, 11 and 9 percent in woodlands, grassland, and developed areas, respectively.

As seen in Figure 4-3, these are the same dominant land covers in the four monitored watersheds with some variations. For many of these land covers the monitored watersheds appear to pair up. Lost Creek (402) and East Fork Shoal Creek (405) watersheds have agriculture production ranging from 74-78 percent while North Fork Kaskaskia (403) and Hurricane Creek (404) watersheds have lower agriculture percent areas (62-63%). This pattern is similar to developed urban-type land areas. The relationship reverses between the paired watersheds for grass/pasture/open lands and woodlands where North Fork Kaskaskia (403) and Hurricane Creek (404) watersheds have 13-14 and 17-20 percent, respectively. Lost Creek (402) and East Fork Shoal Creek (405) watersheds have 8 and 4-6 percent area in grass/pasture/open lands and woodlands, respectively.

Figure 4-4 illustrates the distribution of Conservation Reserve Program (CRP) areas throughout the Kaskaskia River watershed and counties. Based on a visual inspection, a few observations can be made. A majority of CRP areas are in close proximity to streams and waterbodies. Middle and Shoal Creek sub-watersheds appear to have higher concentrations of CRP acres than the other two sub-watersheds. The Upper sub-watershed is less dense but CRP seems to be evenly distributed. The Lower sub-watershed is similar to the Upper except Clinton and Marion Counties are denser.

The USDA National Agriculture Statistics Service (NASS) land cover data has been available since 1999. In 2006 an evaluation of the usefulness of the crop data layers for annual land cover information in Illinois was undertaken by the Illinois State Geological Survey (ISGS) and NASS. Based on inherent errors associated with satellite data, irreparable mechanical problems with older multispectral imagery satellites and land cover classification methods used to interpret that imagery, new enhanced CDL protocols were established in 2007 for Illinois. Consequently, land cover misclassifications were identified prior to the new protocol, which became more apparent when evaluating the land cover in the monitored watersheds (figure 4-5): Lost Creek (402), North Fork Kaskaskia River (403), Hurricane Creek (404), and East Fork Shoal Creek (405). Therefore, any changes in land cover will be evaluated for this report beginning in 2007 through 2013 which is the most currently available NASS CDL data.



Source: USDA/NRCS Cropland Data Layer 2014

Figure 4-1. Types of land cover in Kaskaskia River Basin

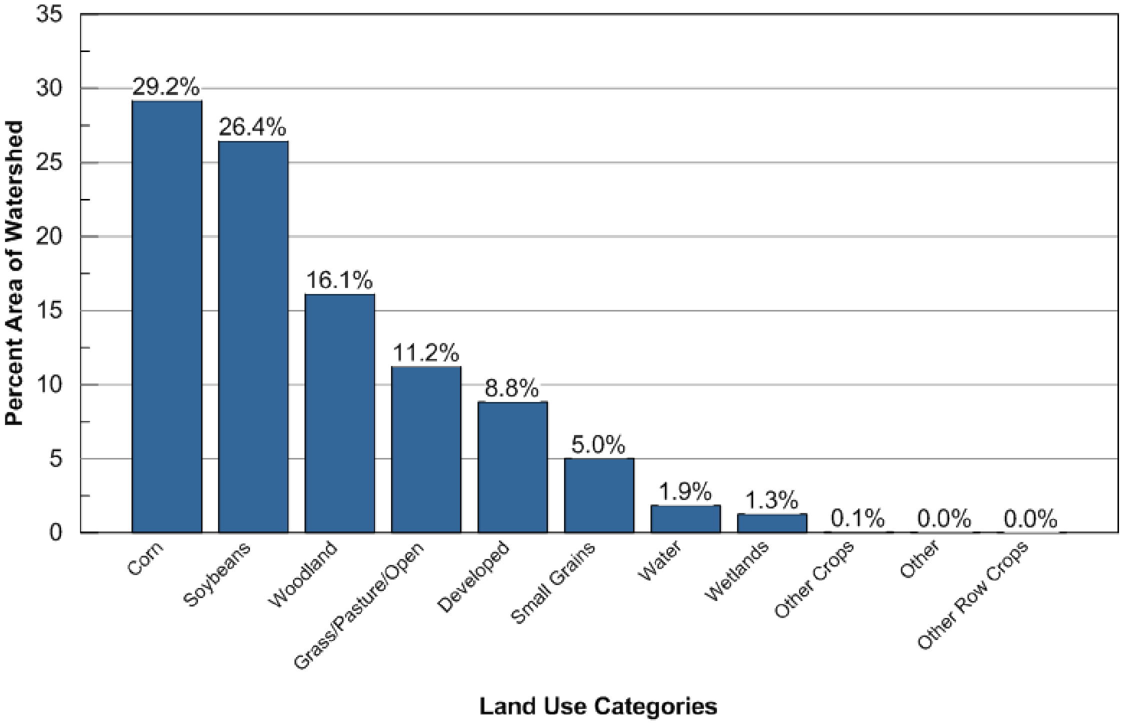


Figure 4-2. Percent watershed area of types of land cover in Kaskaskia River Basin (NASS, 2014)

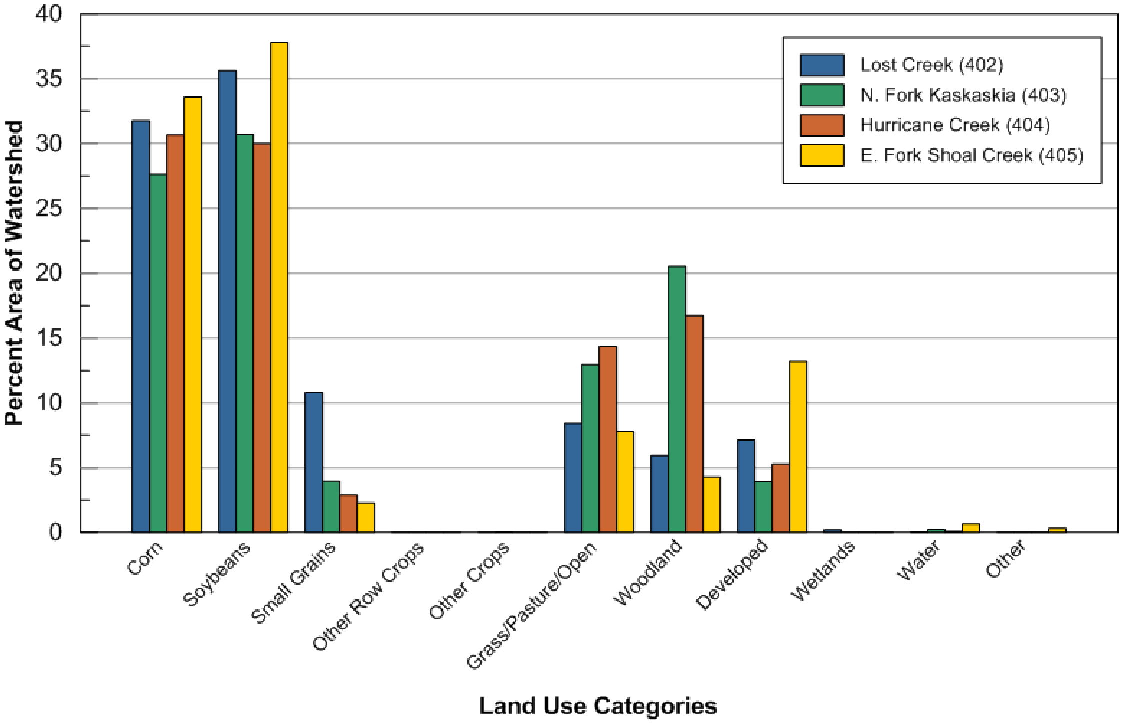


Figure 4-3. Percent watershed area of types of land cover in four monitored watersheds in Kaskaskia River Basin (NASS, 2014)

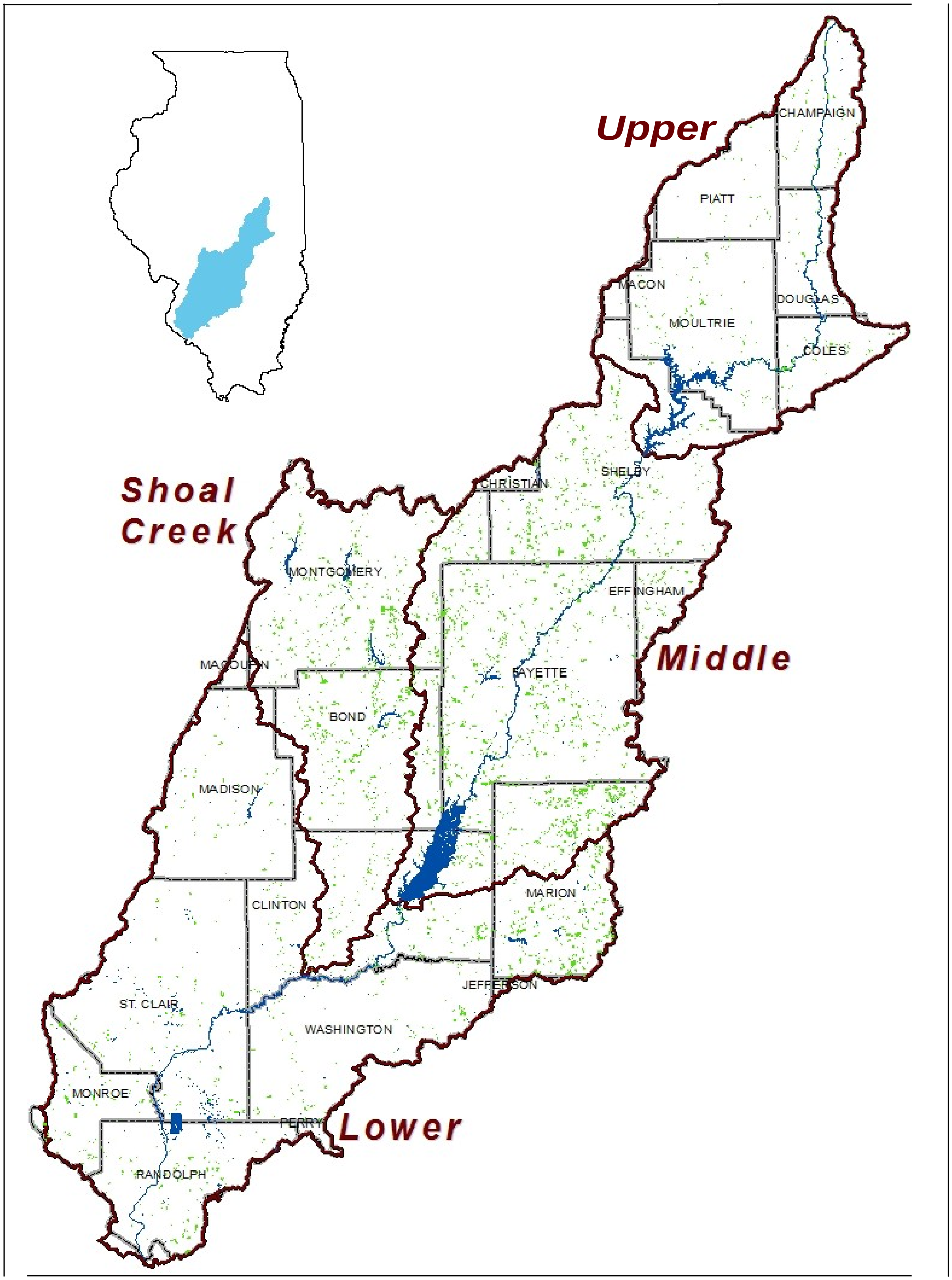


Figure 4-4. Conservation Reserve Program (CRP) in Kaskaskia Basin

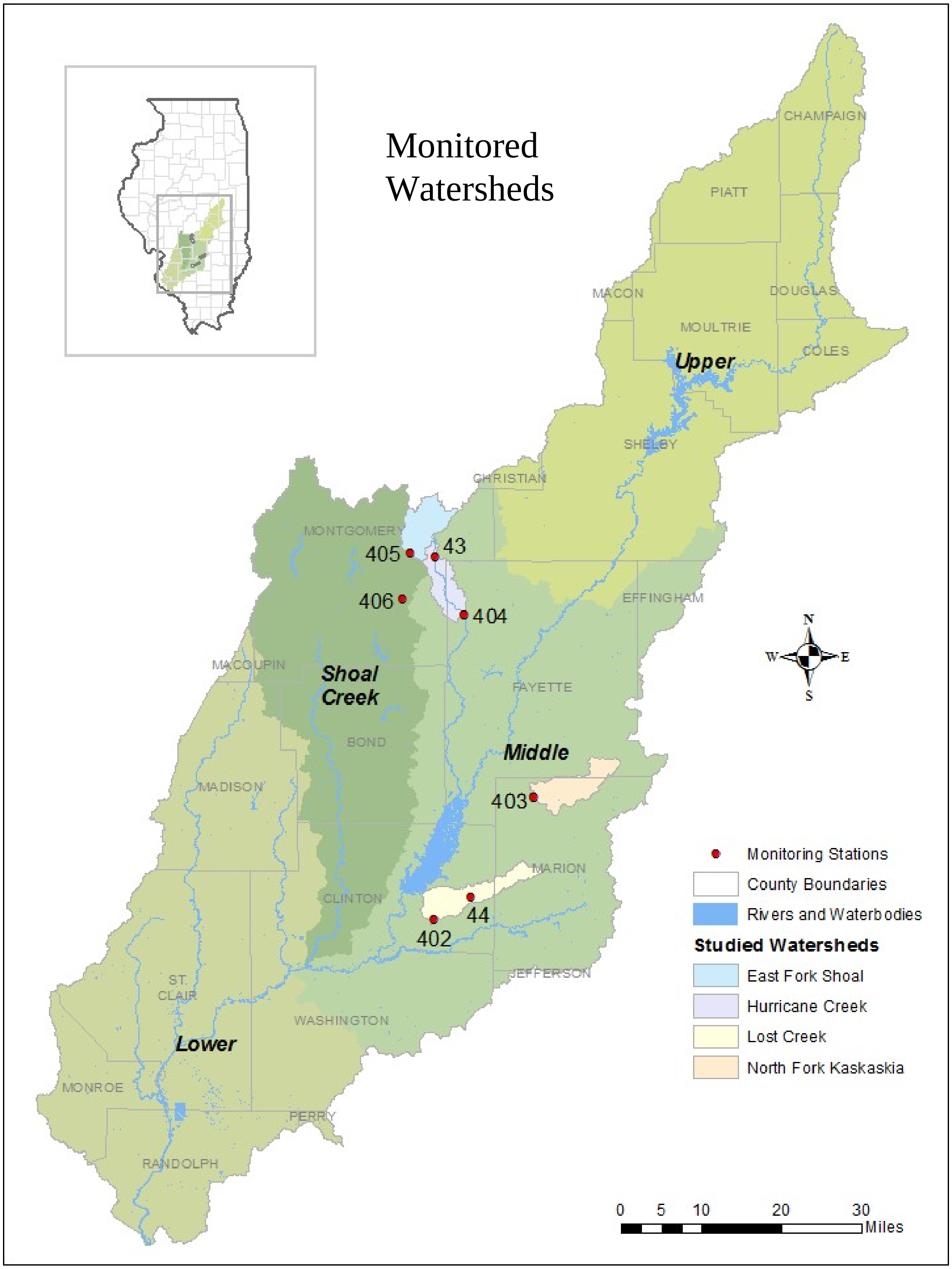


Figure 4-5. Locations of watersheds being monitored for hydrology, sediment and nutrients.

The four monitored watersheds have somewhat different ratios of land cover types. The Panther and Cox Creek watersheds in the Spoon River watershed have 53 and 73 percent area in agriculture and 47 and 27 percent in non-agriculture land covers, respectively (table 4-1). The main difference is Panther Creek has over 20 percent more land in forest/shrubland than Cox Creek, due to a large portion of the watershed lies in the Panther Creek State Conservation Area. Agriculture land cover is 44 and 56 percent in Court and Haw Creeks, respectively, while the non-agriculture area is the inverse. North Creek watershed, a tributary of Court Creek, has a larger portion of land area in forest/shrubland than Haw Creek. Figure 4-6 illustrates the percent change in total watershed acres between 2007 and 2013 for six generalized land cover categories in each of the four monitored tributary watersheds in the Kaskaskia River Basin. Agriculture land covers were categorized into Corn, Soybeans, Double Crop with Soybeans and Other Cropland, as well as summed in one category identified as Agriculture. Non-agriculture land covers were categorized into Grassland and Forest/Shrubland, and summed as Non-Agriculture. All four watersheds had a 5 percent reduction in Double Crop with Soybeans and non-agricultural land cover area (Grasslands and Forest/Shrubland) between 2007 and 2013. An increase in agricultural land cover area (Corn and Soybeans) ranged from 2 to nearly 7 percent occurred on all four watersheds. Lost, Hurricane, and East Fork Shoal Creek watersheds had marked percent increases in soybean acres and North Fork Kaskaskia watershed had an increase of corn greater than soybeans. The Hurricane Creek watershed experiences the largest decrease in non-agriculture land cover mostly occurring with losses in grasslands. Grasslands decreased on the average of 3.5 percent over all four monitored watersheds.

Table 4-1. 7-year average (2007-2013) percent acres of land cover area by watershed

	ISWS Station Number			
	402	*403*	*404*	*405*
Corn	33	26	30	31
Soybeans	38	30	28	32
Other Crops	1	1	1	1
Grasslands	16	20	22	18
Forest/Shrubland	8	22	18	14
Developed, Barren, Open Space, Water, Wetlands	4	1	2	4
AGRICULTURE	72	57	59	64
NON-AGRICULTURE	28	43	41	36

Figures 4-7 to 4-10 show the changes in each land cover for each year between 2007 and 2013. For this report, NASS Cropland Data Layer (CDL) categories for the monitored watersheds were combined into 6 general land cover categories: 1) corn, 2) soybean, 3) other cultivated crops, 4) grassland, 5) forest/shrubland and 6) developed, barren, open space, water

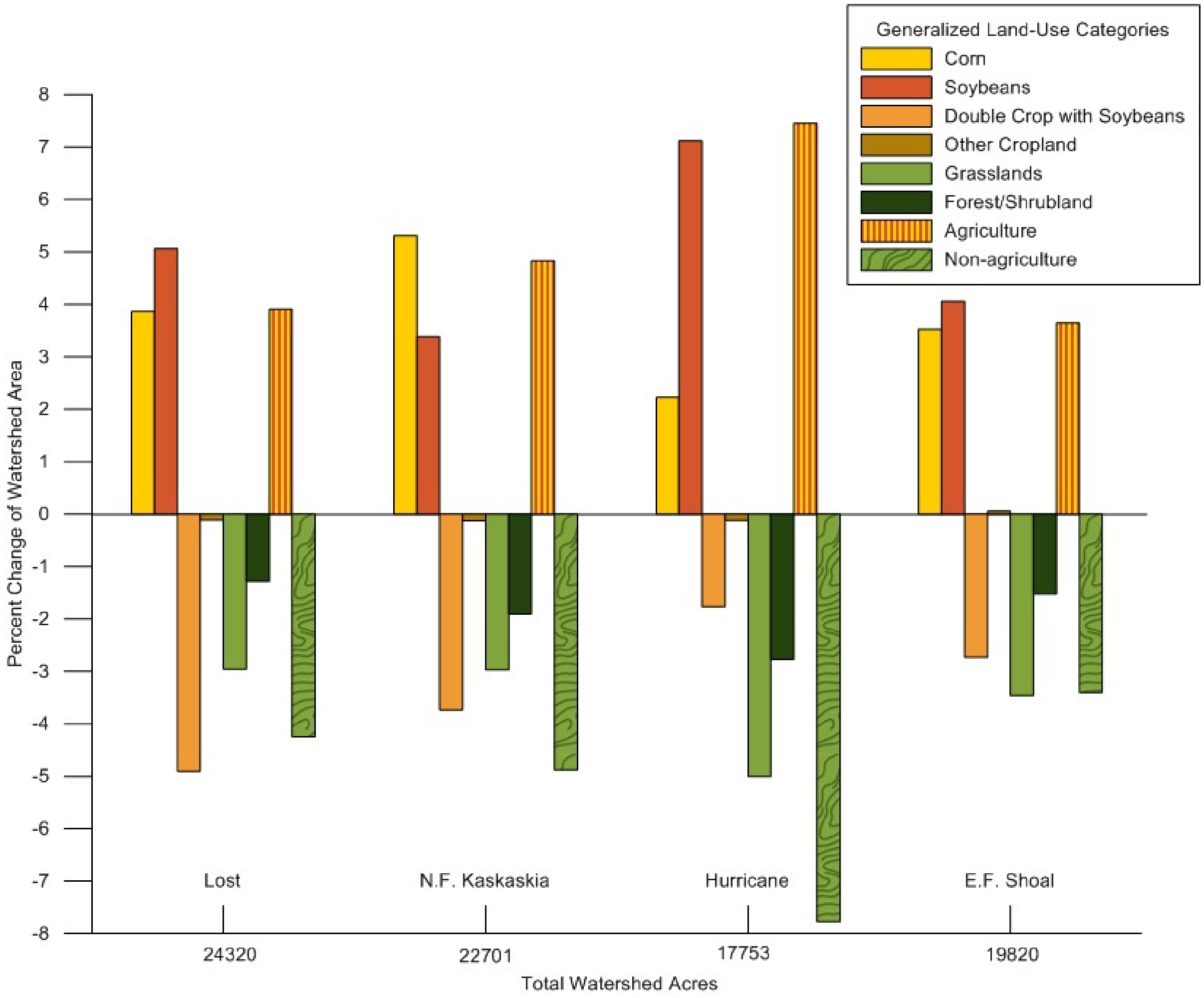


Figure 4-6. Kaskaskia River Basin Watersheds: Percent Change in Generalized NASS Land-Use from 2007-2013.

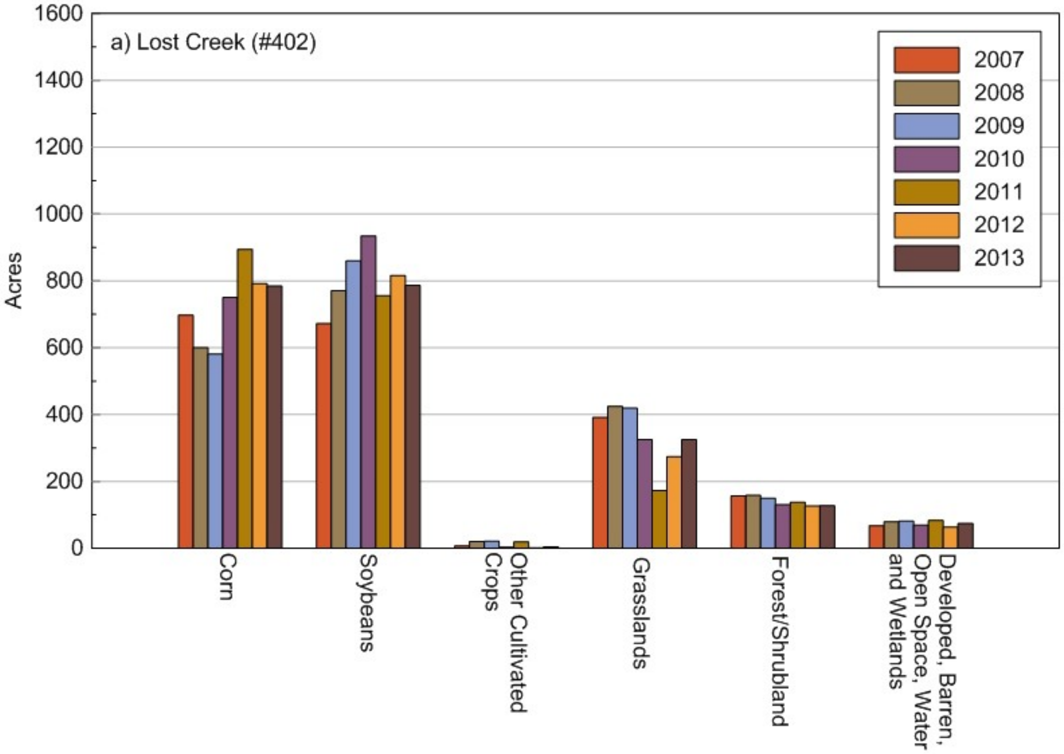


Figure 4-7. Lost Creek watershed from ISWS Station 402: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

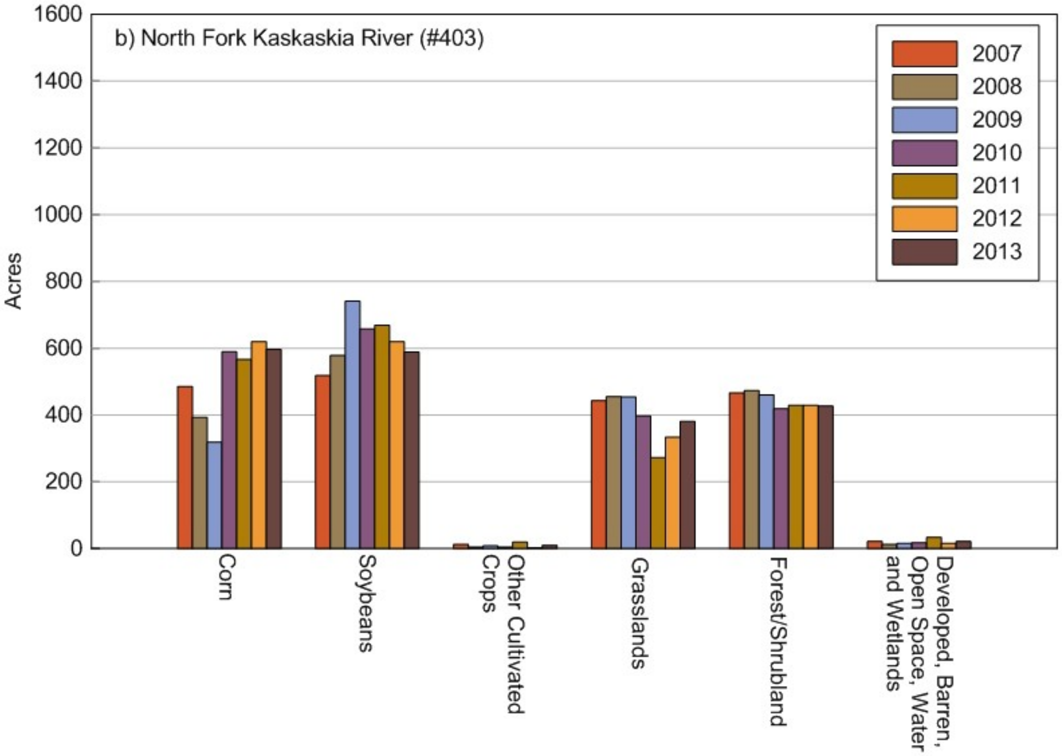


Figure 4-8. North Fork Kaskaskia River watershed from ISWS Station 403: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

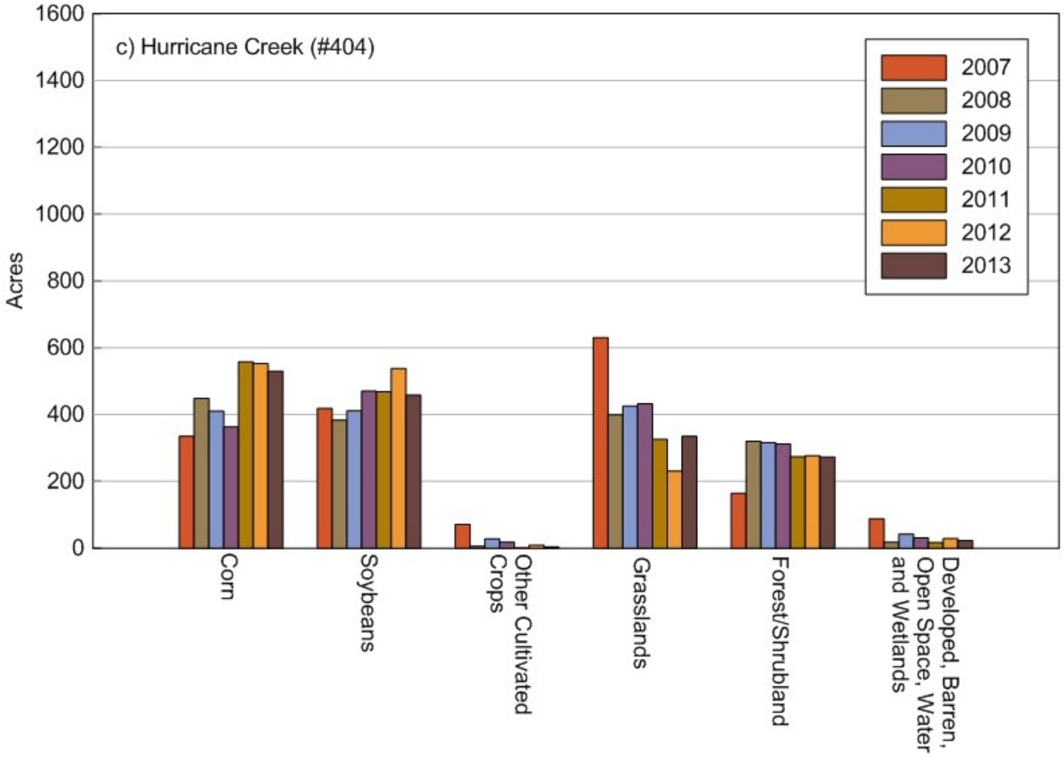


Figure 4-9. Hurricane Creek watershed from ISWS Station 404: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

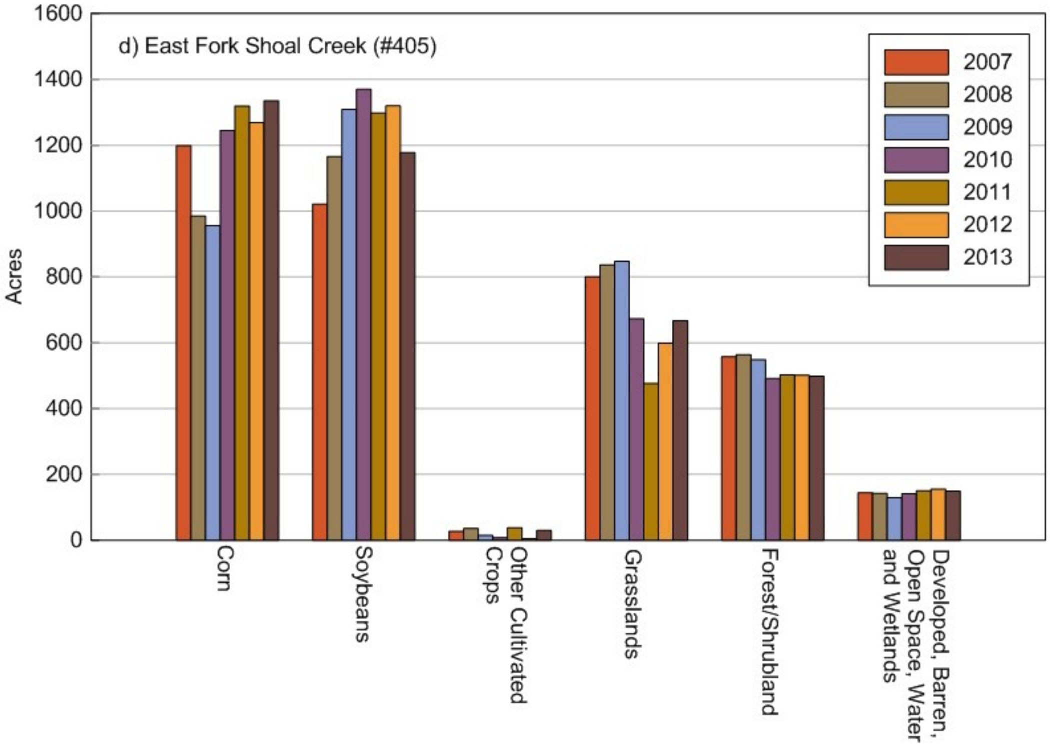


Figure 4-10. East Fork Shoal Creek watershed from ISWS Station 405: Generalized NASS Cropland Data Layer Acreage Totals: 2007-2013.

and wetlands. Land cover area changes between years is represented in acres. Therefore, some watersheds may appear to have greater changes in acreage from year to year but may only represent a small percentage of the watershed depending on the total watershed acres. Lost Creek watershed (figure 4-7) acres varied for corn, soybeans, and grasslands with corn and soybeans increasing in acres when comparing 2007 and 2013. All other land covers remained constant over the 7-year period. North Fork Kaskaskia watershed (figure 4-8) saw similar variability as Lost Creek watershed in most corn, soybeans, and grasslands acreage. Only minor increases in acres for forest/shrubland. North Fork Kaskaskia has equal acres in Grasslands and forest/shrubland, as well as slightly more Soybean acres than Corn. Lost Creek has the lowest acres of forest/shrubland of the four watersheds. Hurricane Creek (figure 4-9) appeared to have a significant decrease in Grasslands and Developed land covers and increase in Forest/shrubland from 2007 to 2008. . Finally, East Fork Shoal Creek (figure 4-10) exhibits the same annual variability in land cover acres between 2007 and 2013 as the other three monitored watersheds. Lost Creek and East Fork Shoal Creek watersheds have the most agriculture land covers of the four monitored watersheds, whereas North Fork Kaskaskia and Hurricane Creek watersheds are more evenly distributed of Corn, Soybean, Grassland, and forest/shrubland land covers. All four watersheds have extremely low acres devoted to other cultivated crops.

Conservation Practices

There has been a significant increase in the implementation of conservation practices in Illinois in recent years with CREP making a major contribution. Figure 4-11 shows the location of approved Illinois CREP contracts from the state of Illinois as of 2014. With this type of information it will be possible to identify areas where there has been significant participation in the CREP program and where changes in sediment and nutrient delivery should be expected. The information will provide important input data to the watershed models that are being developed to evaluate the impact of CREP practices.

There are many conservation practices implemented through the watersheds as a result of federal and state conservation reserve programs. In order to evaluate watershed monitoring efforts, knowing the when and what conservation practices are implemented in the watershed is important. Figures 4-12 to 4-15 are show the cumulative acres of conservation practices installed in the four monitored watersheds from 1999 through 2015. The order by which the practices are listed in the legend represent, from the largest to smallest, the sum of the acres by practice from 1999-2015. The most popular conservation practice is filter strips in Lost Creek and East Fork Shoal Creek watersheds, which are the two watershed with more percent agriculture land cover. Hurricane Creek and East Fork Shoal Creek favored upland bird habitat buffers. The two watersheds identified with higher percent area of woodland and grass/pasture/open lands (North Fork Kaskaskia River and Hurricane Creek) favored permanent wildlife habitat, upland bird buffers, new and existing grasses/legumes, and SAFE-wildlife enhancement conservation practices. North Fork Kaskaskia and Hurricane Creek watersheds have the most variety of practices installed.

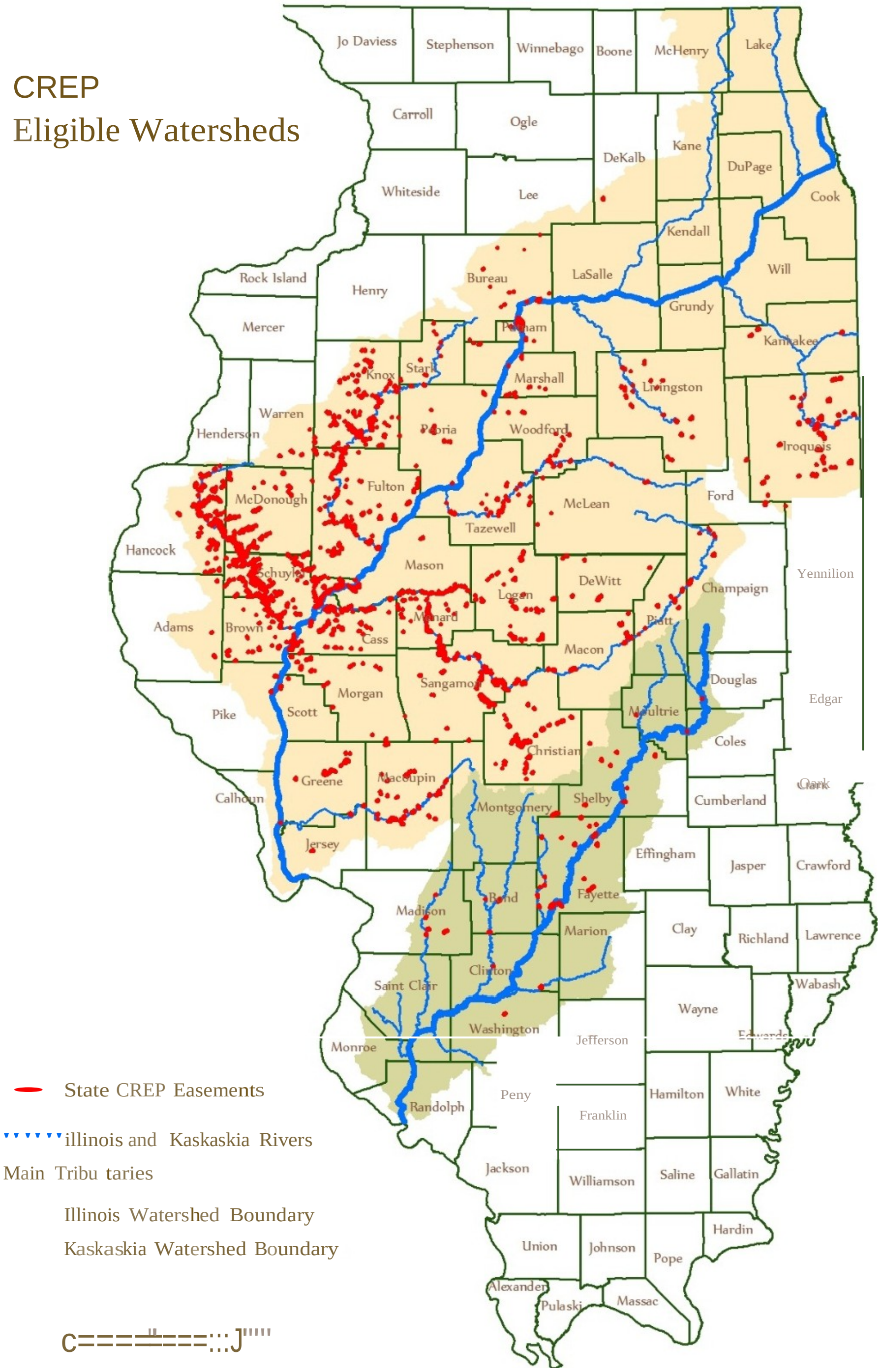


Figure 4-11. State CREP contract locations (IDNR, 2015).

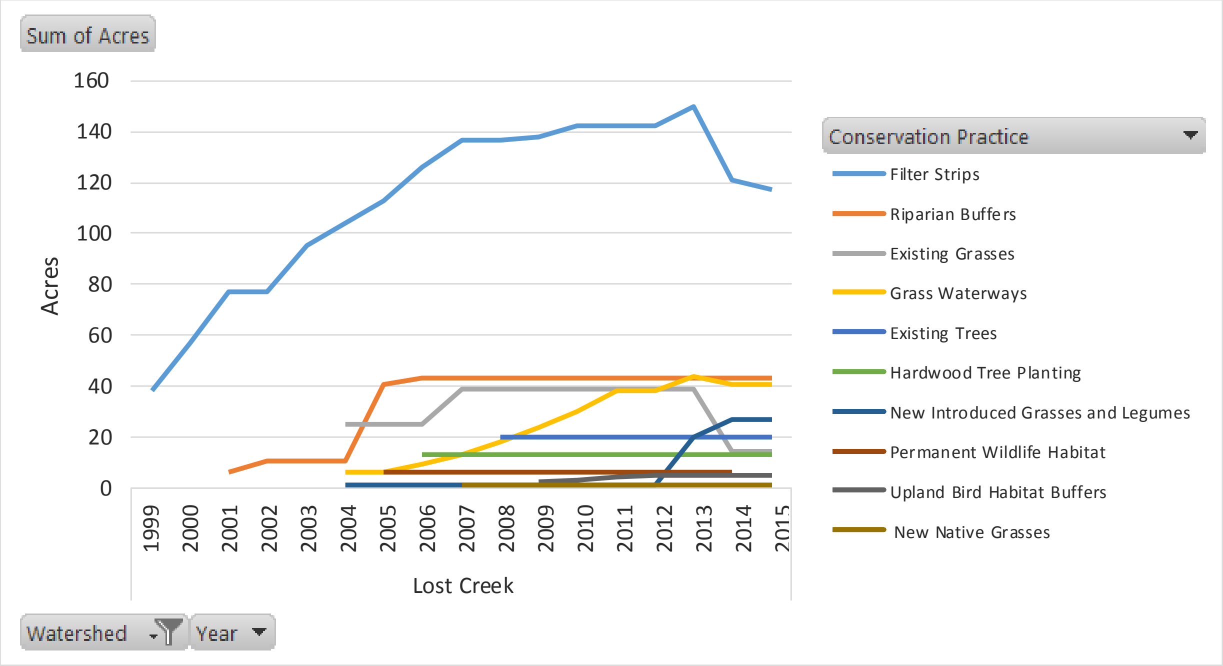


Figure 4-12. Cumulative acres of conservation practices installed in Lost Creek watershed at monitoring station ISWS #402 from 1999-2015.

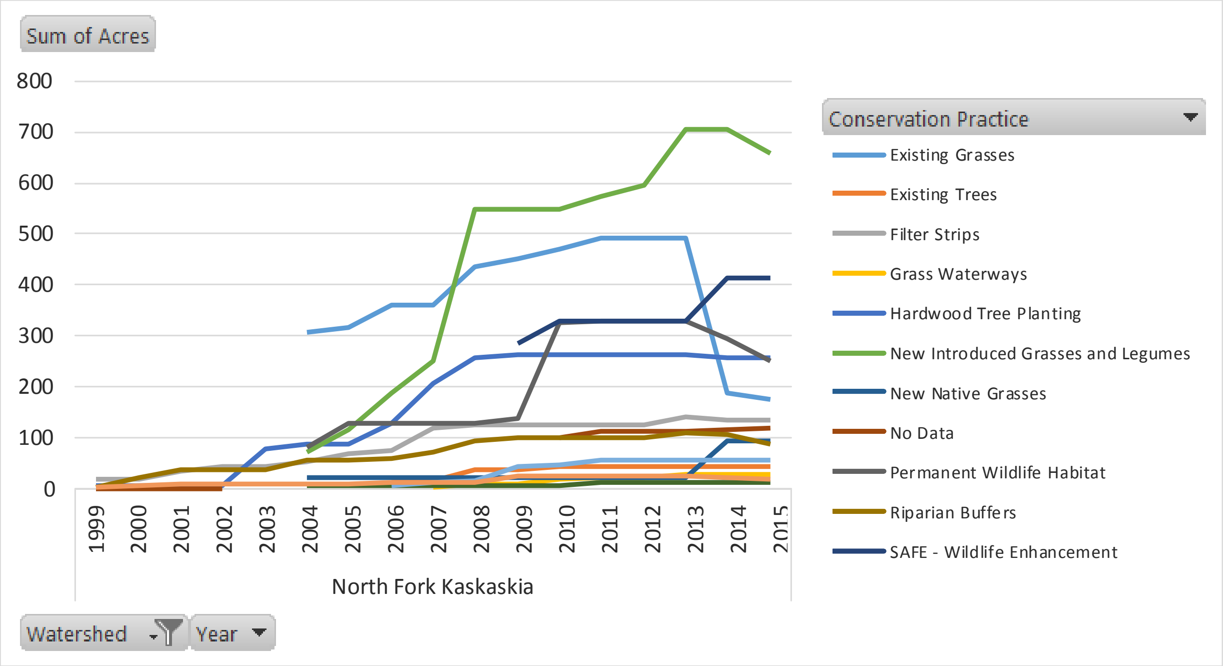


Figure 4-13. Cumulative acres of conservation practices installed in North Fork Kaskaskia River watershed at monitoring station ISWS #403 from 1999-2015.

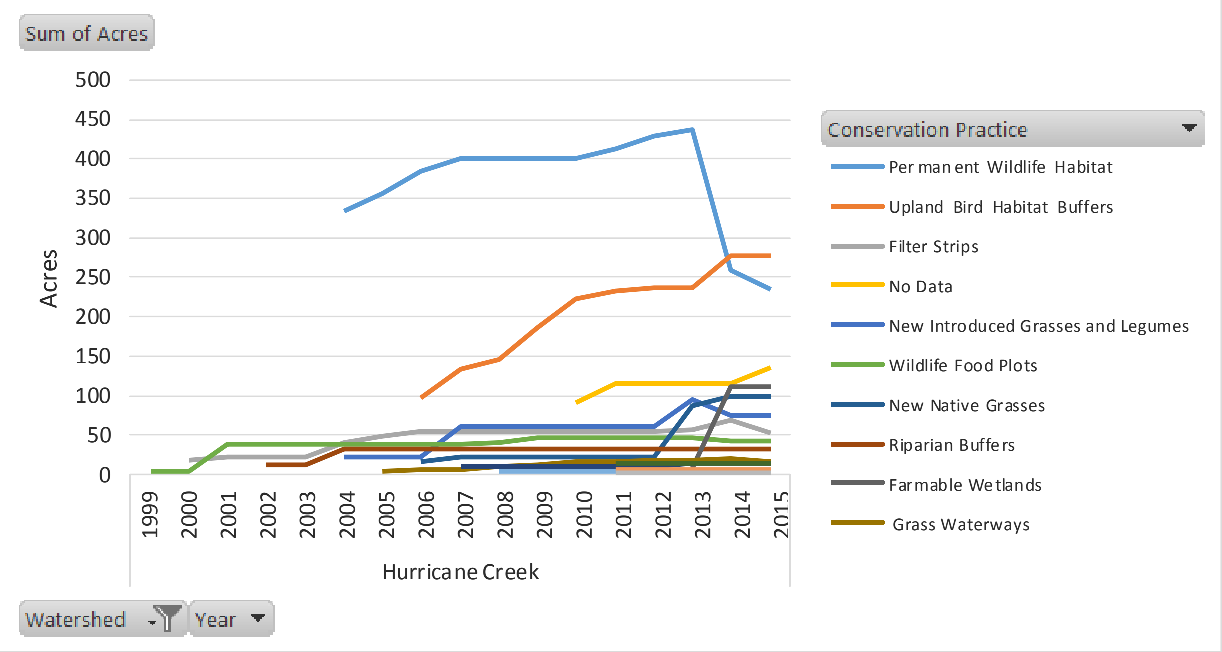


Figure 4-14. Cumulative acres of conservation practices installed in Hurricane Creek watershed at monitoring station ISWS #404 from 1999-2015.

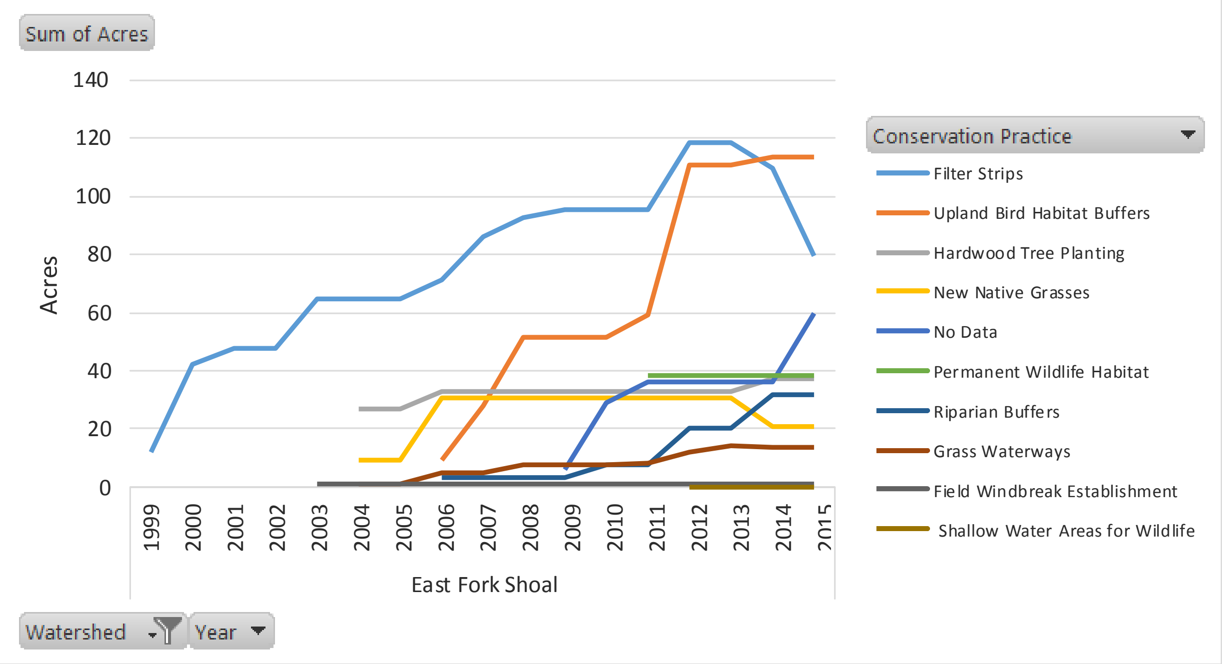


Figure 4-15. Cumulative acres of conservation practices installed in East Fork Shoal Creek watershed at monitoring station ISWS #405 from 1999-2015.

5. Summary and Conclusions

The Conservation Reserve Enhancement Program (CREP) was initiated as a joint federal/state program with the goal of improving water quality and wildlife habitat in the Illinois and Kaskaskia River basins. Based on numerous research and long-term data in the Illinois River basin, the two main causes of water quality and habitat degradations in major river corridors were known to be related to sedimentation and nutrient loads. Based on this understanding, the two main objectives of the CREP were to reduce the amount of silt and sediment entering the main stem of the Illinois and Kaskaskia Rivers by 20 percent; and to reduce the amount of phosphorous and nitrogen loadings to by 10 percent. To assess the progress of the program towards meeting the two goals, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) are developing a scientific process for evaluating the effectiveness of the program.

The monitoring and data collection component consists of a sediment and nutrient watershed monitoring program for selected sub-watersheds within the Kaskaskia River basin and also to collect and analyze land use data throughout the basin. Currently available data is insufficient to monitor long-term trends especially in small watersheds where changes can be observed and quantified more easily than in larger watersheds. To fill the data gap and to generate reliable data for small watersheds, the Illinois Department of Natural Resources funded the Illinois State Water Survey to establish a monitoring program to collect precipitation, hydrologic, sediment, nutrient and land cover data for selected small watersheds in the Kaskaskia River basin that will assist in making a more accurate assessment of sediment and nutrient delivery.

The four small watersheds selected for intensively monitoring sediment and nutrient in the Kaskaskia River basin are located within the Crooked Creek, North Fork Kaskaskia River, Hurricane Creek and Shoal Creek watersheds. In addition, two continuous recording raingages were established near the monitored watersheds. Lost Creek (402) is a tributary of Crooked Creek which, in turn is a direct tributary of the Kaskaskia River with its confluence downstream of Carlyle Reservoir. The Carlyle Reservoir is a U.S. Army Corps of Engineers impoundment on the Kaskaskia River. The North Fork Kaskaskia River (403) and Hurricane Creek (404) are direct tributaries of the Kaskaskia River and discharge directly into the upstream end of Carlyle Reservoir. East Fork Shoal Creek (405) is a tributary of Shoal Creek, the largest direct tributary of the Kaskaskia River, with its confluence downstream of Carlyle Reservoir.

After assessing and evaluating many physical, geological, biological, land cover and CRP program data and information, as well as impacts of the 2012 drought, four intensive monitoring stations were selected and the sediment and nutrient monitoring network was established for the 2014 water year (October 2013-September 2014). The WY2014 started in one of the coldest winters recorded in the region for some time. This was followed by a particularly wet spring and summer. Water Year 2015 (October 2014-September 2015) also had a particularly cold winter followed by a wet spring but did not continue very far into the summer months as happened the previous year. Water Year 2016 had several intense storms, particularly December 2015 and May 2016 which resulted in much higher annual yields than the other two monitoring years. Nitrogen and phosphorus species concentrations more associated with particulate forms (TKN, t-P) were higher than concentrations of the dissolved forms (NO_3-N and TDP). Suspended sediment concentrations were higher in watersheds with higher percent area devoted to agriculture production or higher upland slopes. However, suspended sediment yield results indicate that the highest yield of the 4 monitoring stations is from Hurricane Creek (404) which has the highest slope of the four watersheds. Nitrate-N and total phosphorus yields were highest in East Fork Shoal Creek (405) and TKN yield was highest in Lost Creek (402), Hurricane Creek (404) and East Fork Shoal (405). All stations experienced maximum concentrations of sediment and/or nutrients throughout the monitoring period, except North Fork Kaskaskia (403) which consistently had the lowest maximum concentrations.

6. References

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7. Appendix

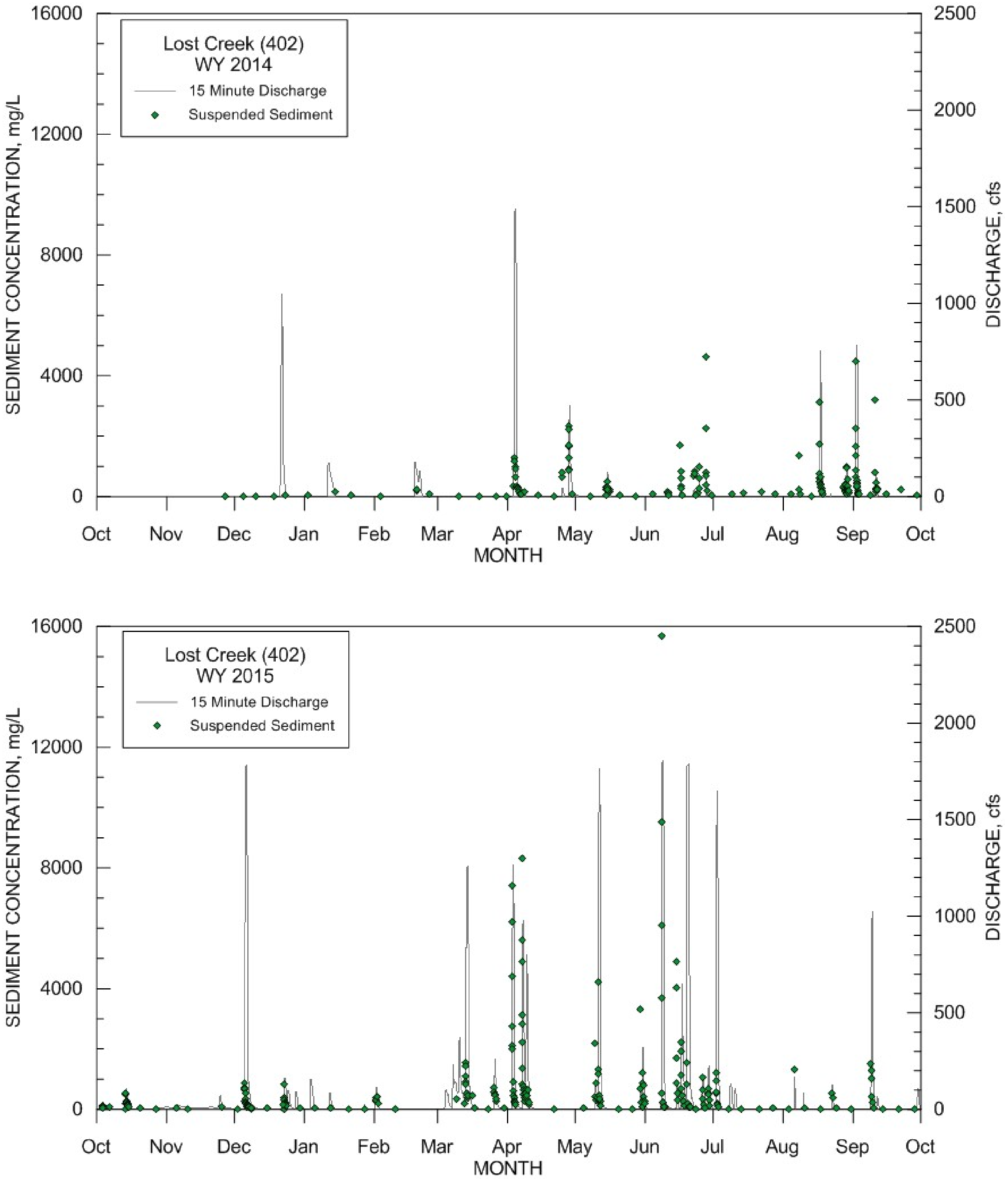
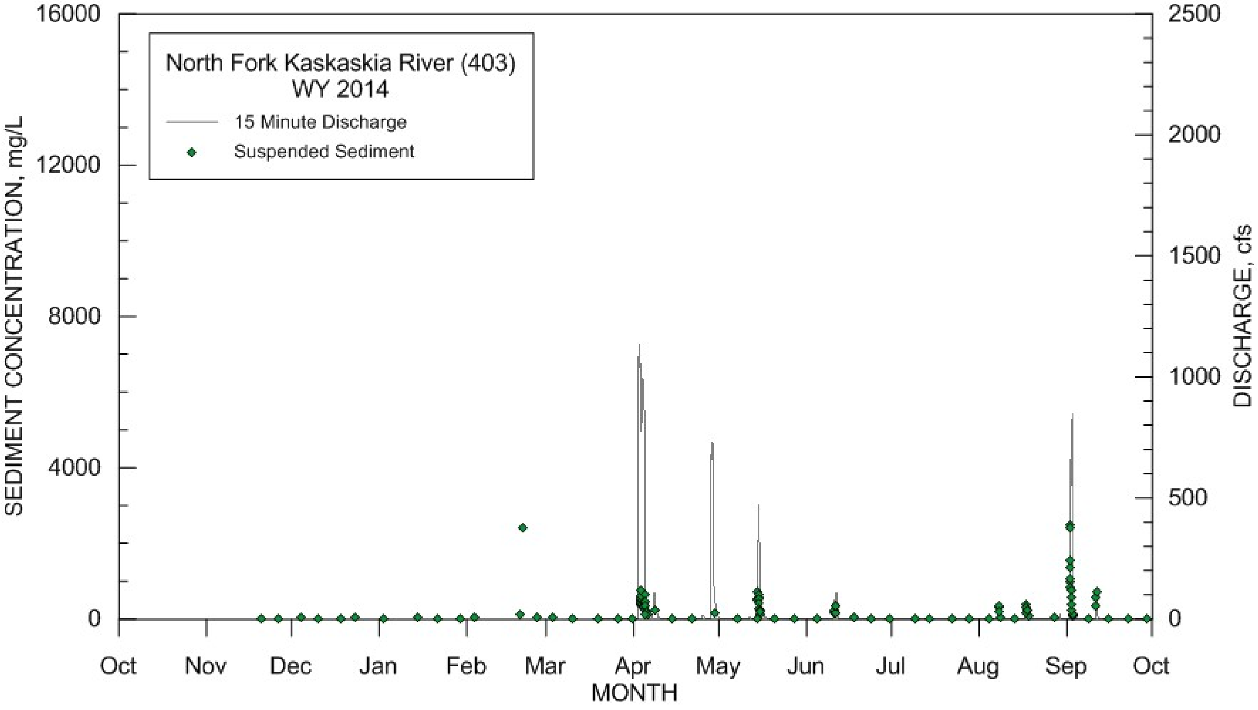


Figure A-1. Suspended sediment concentrations and discharge at Lost Creek (402): Water Year 2014 and Water Year 2015



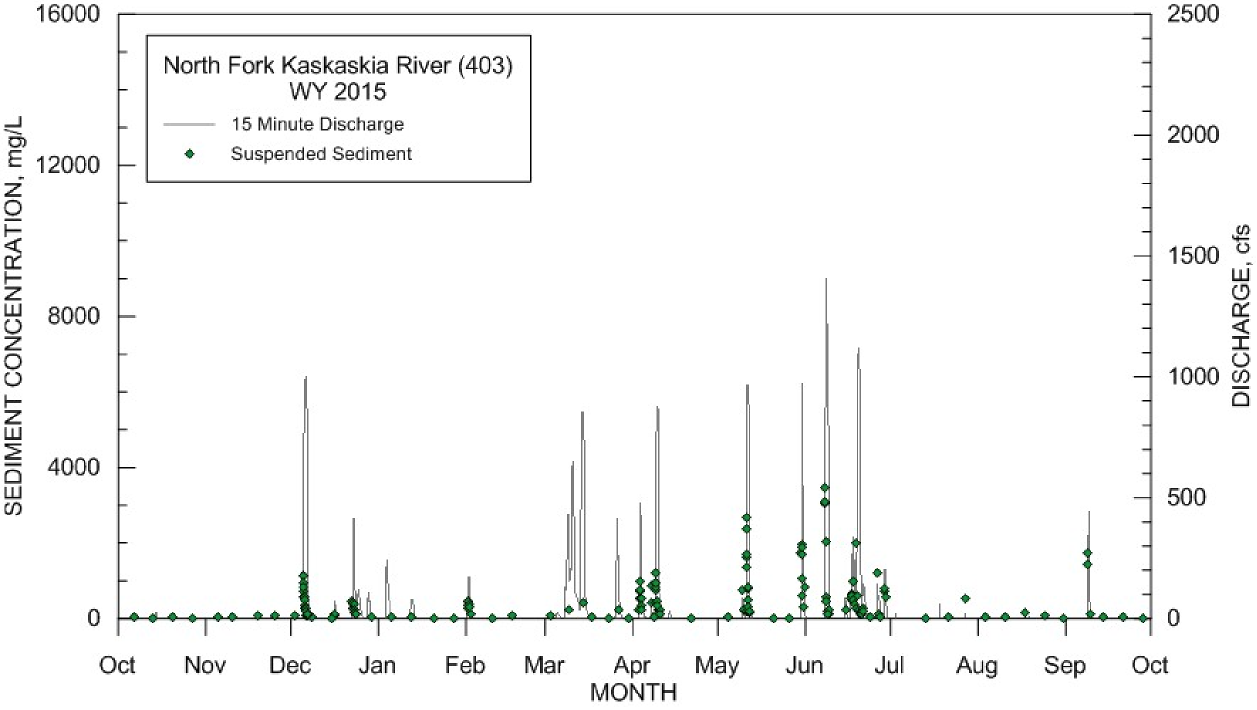
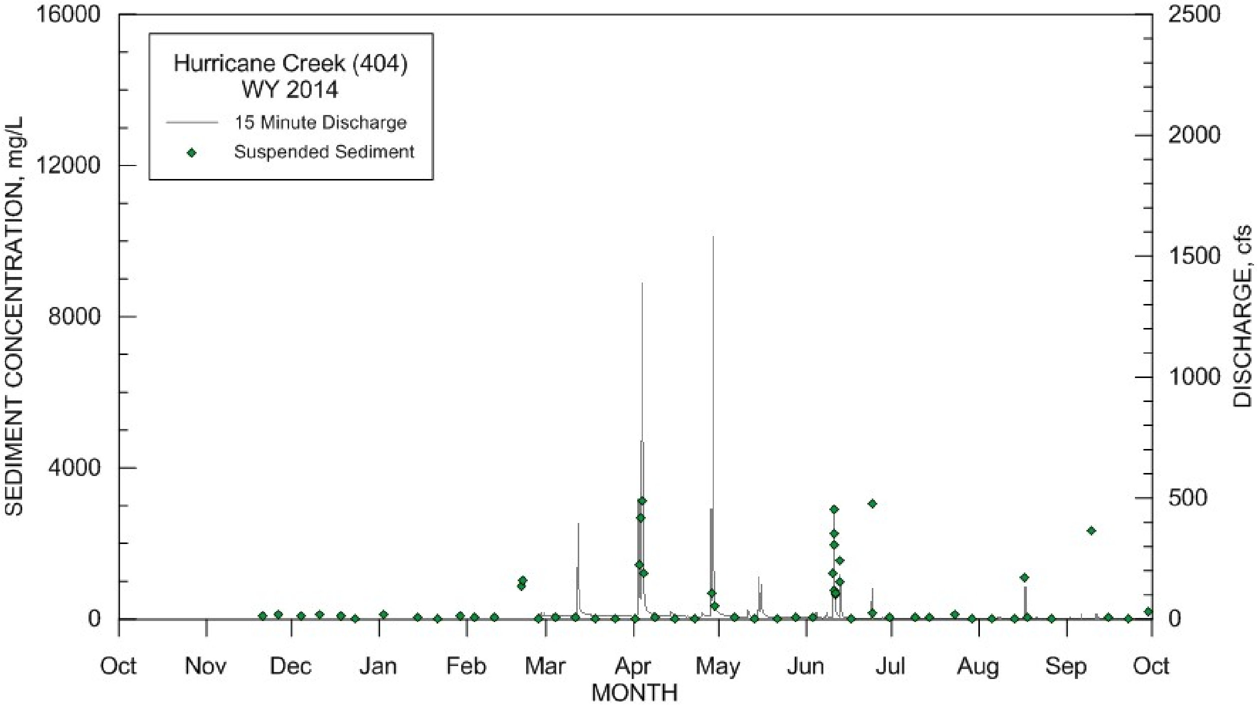


Figure A-2. Suspended sediment concentrations and discharge at North Fork Kaskaskia River (403): Water Year 2014 and Water Year 2015



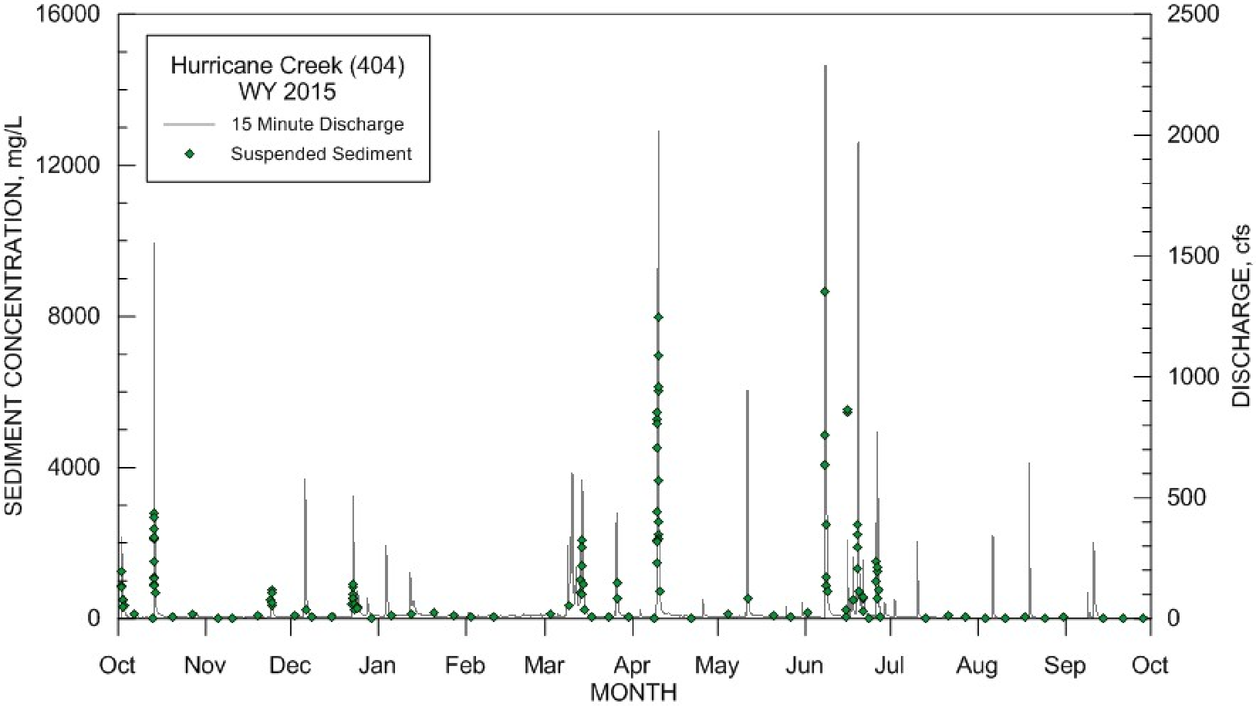
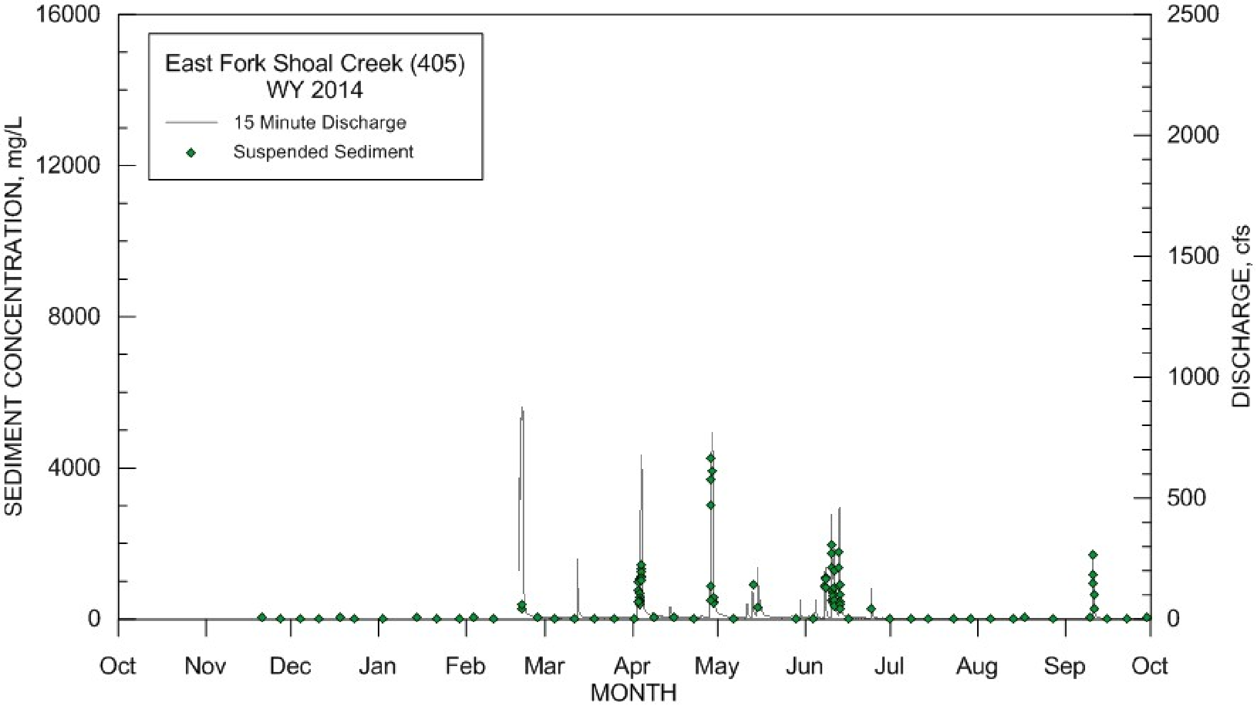


Figure A-3. Suspended sediment concentrations and discharge at Hurricane Creek (404): Water Year 2014 and Water Year 2015



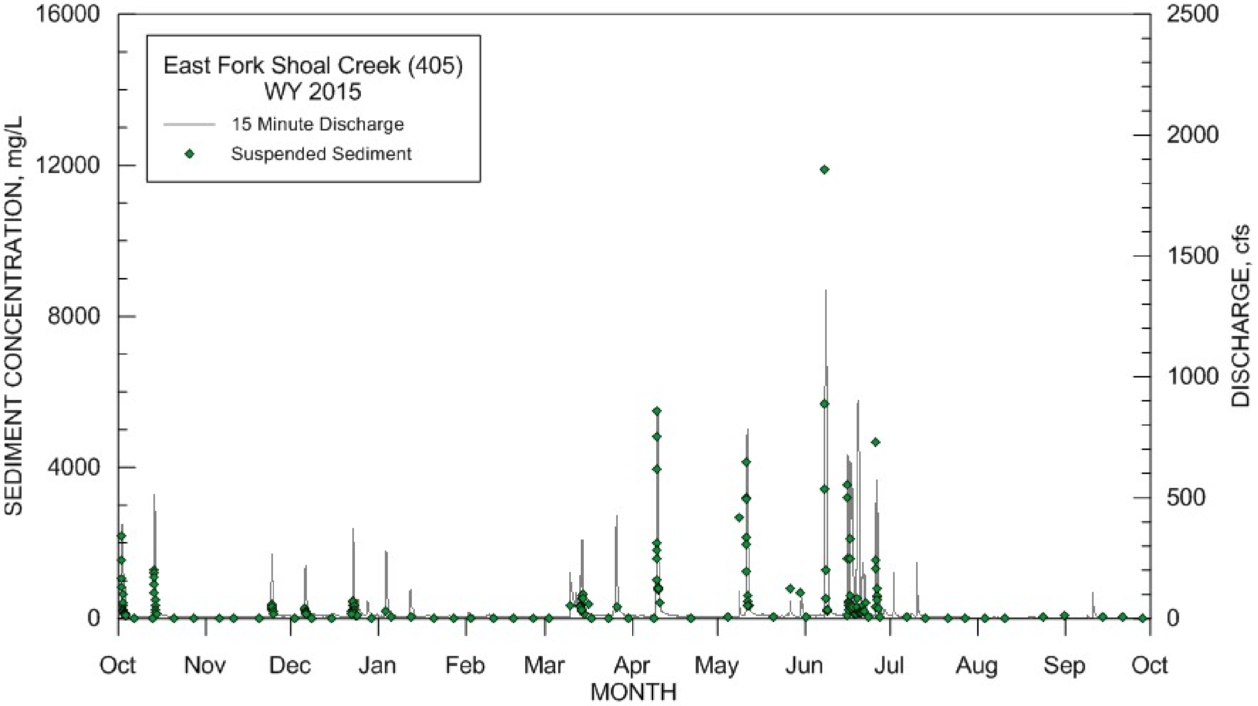
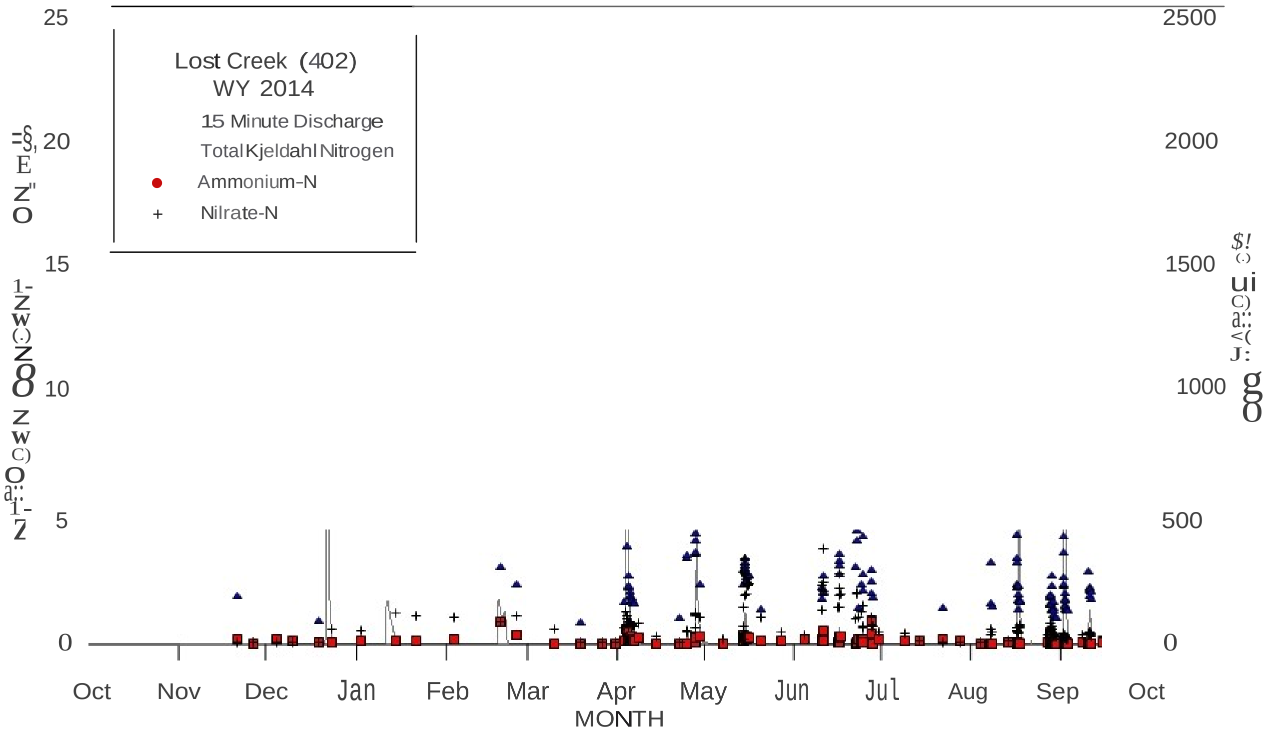
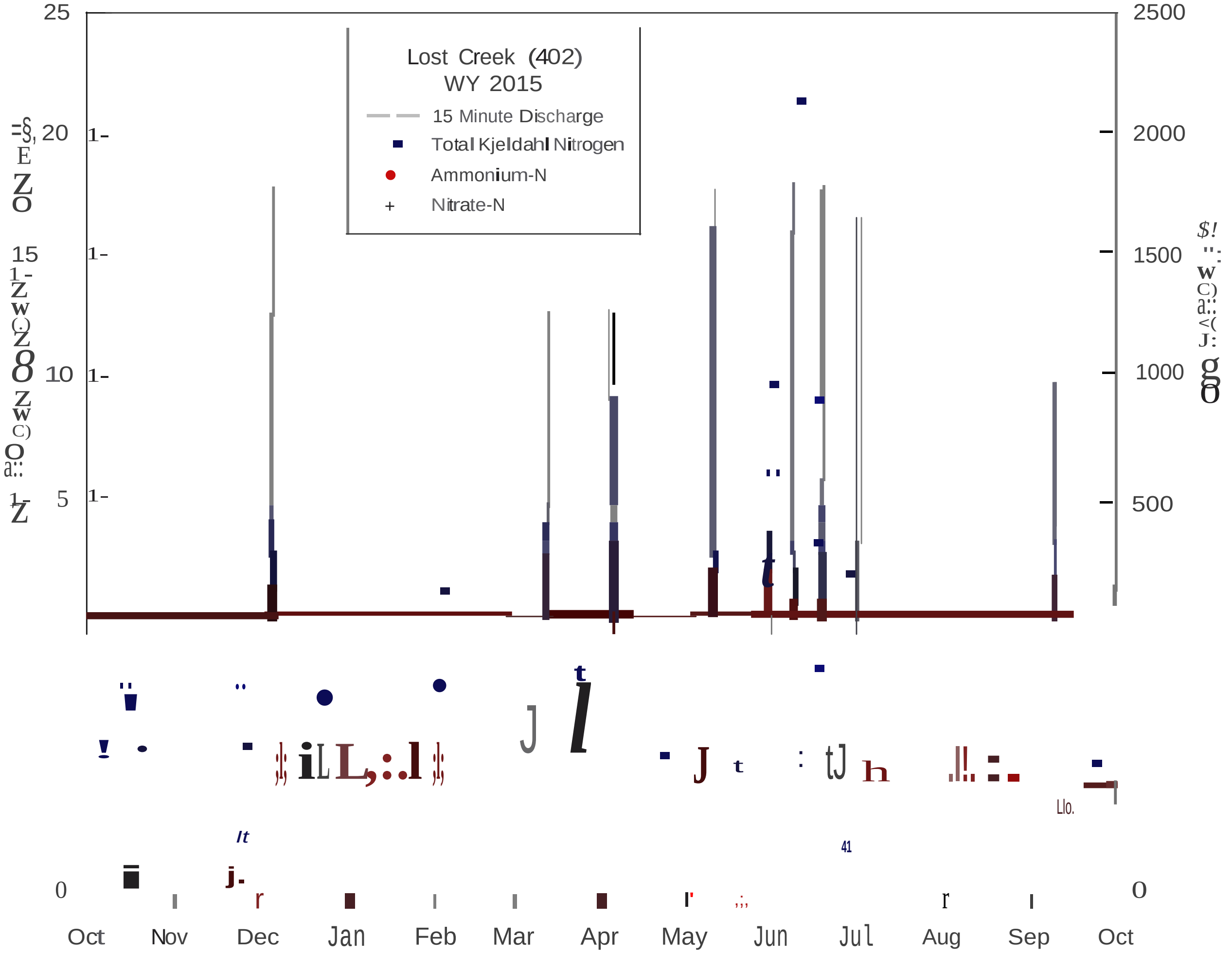


Figure A-4. Suspended sediment concentrations and discharge at East Fork Shoal Creek (405): Water Year 2014 and Water Year 2015


Lost Creek (402)
WY 2014
15 Minute Discharge
Total Kjeldahl Nitrogen
● Ammonium-N
+ Nilrate-N
25
20
15
10
5
0
2500
2000
1500
1000
500
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
MONTH


Lost Creek (402)
WY 2015
15 Minute Discharge
Total Kjeldahl Nitrogen
● Ammonium-N
+ Nitrate-N
25
20
15
10
5
0
2500
2000
1500
1000
500
0
Oct
Nov
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MONTH

Figure A-5. Nitrogen concentrations and discharge at Lost Creek (402): Water Year 2014 and Water Year 2015

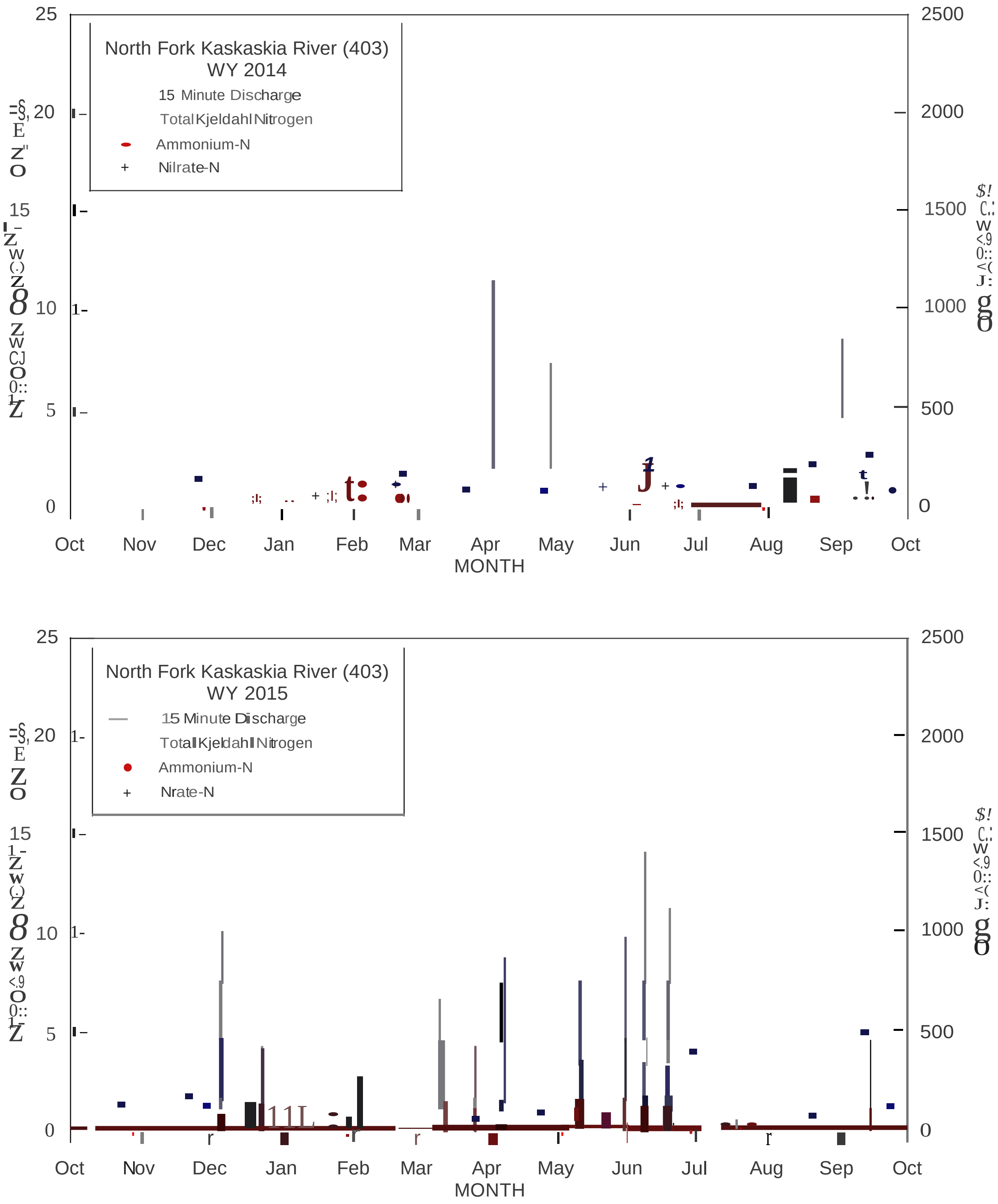


Figure A-6. Nitrogen concentrations and discharge at North Fork Kaskaskia River (403): Water Year 2014 and Water Year 2015

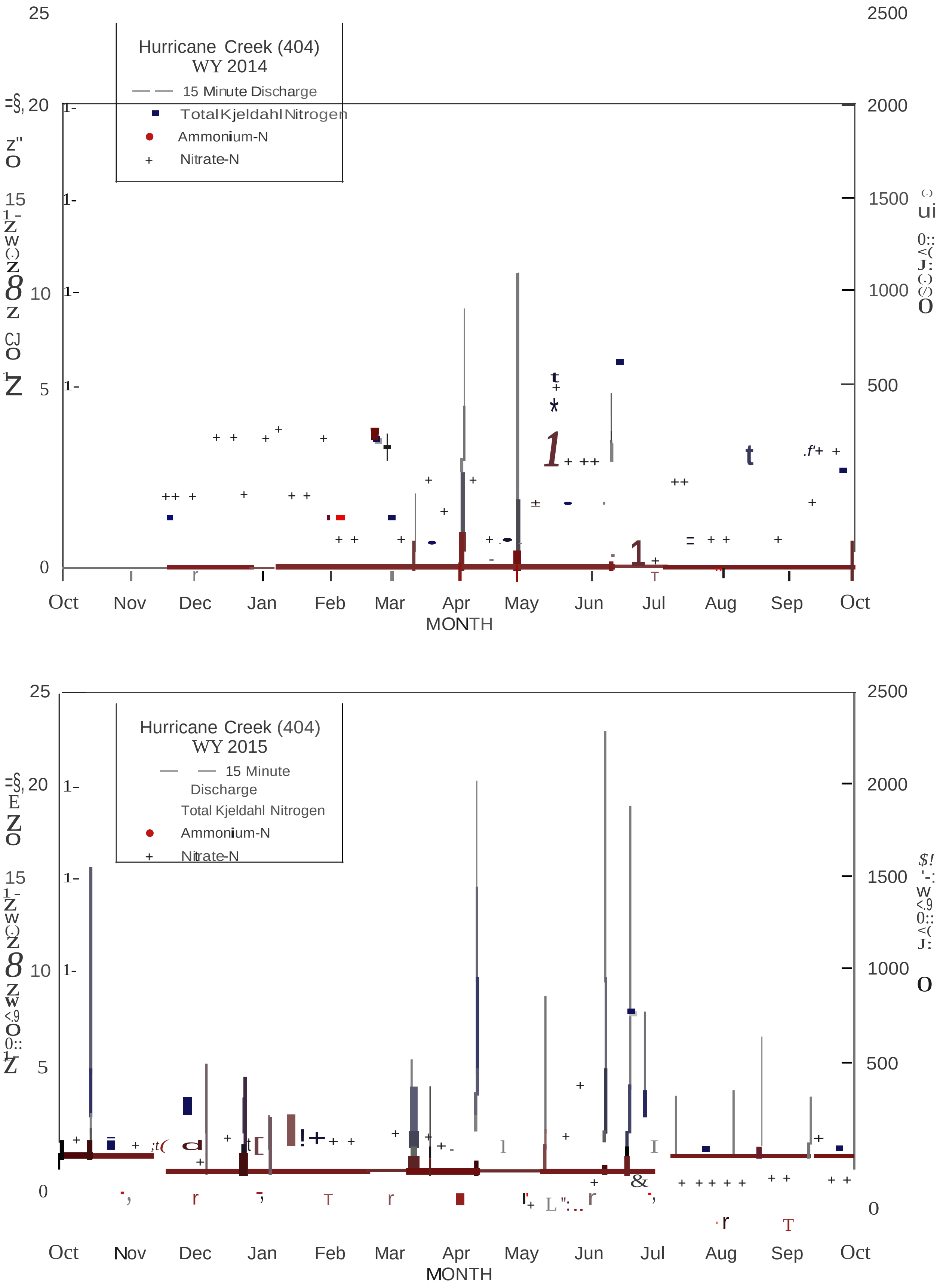


Figure A-7. **Nitrogen concentrations and discharge at Hurricane Creek (404):**

Water Year 2014 and Water Year 2015

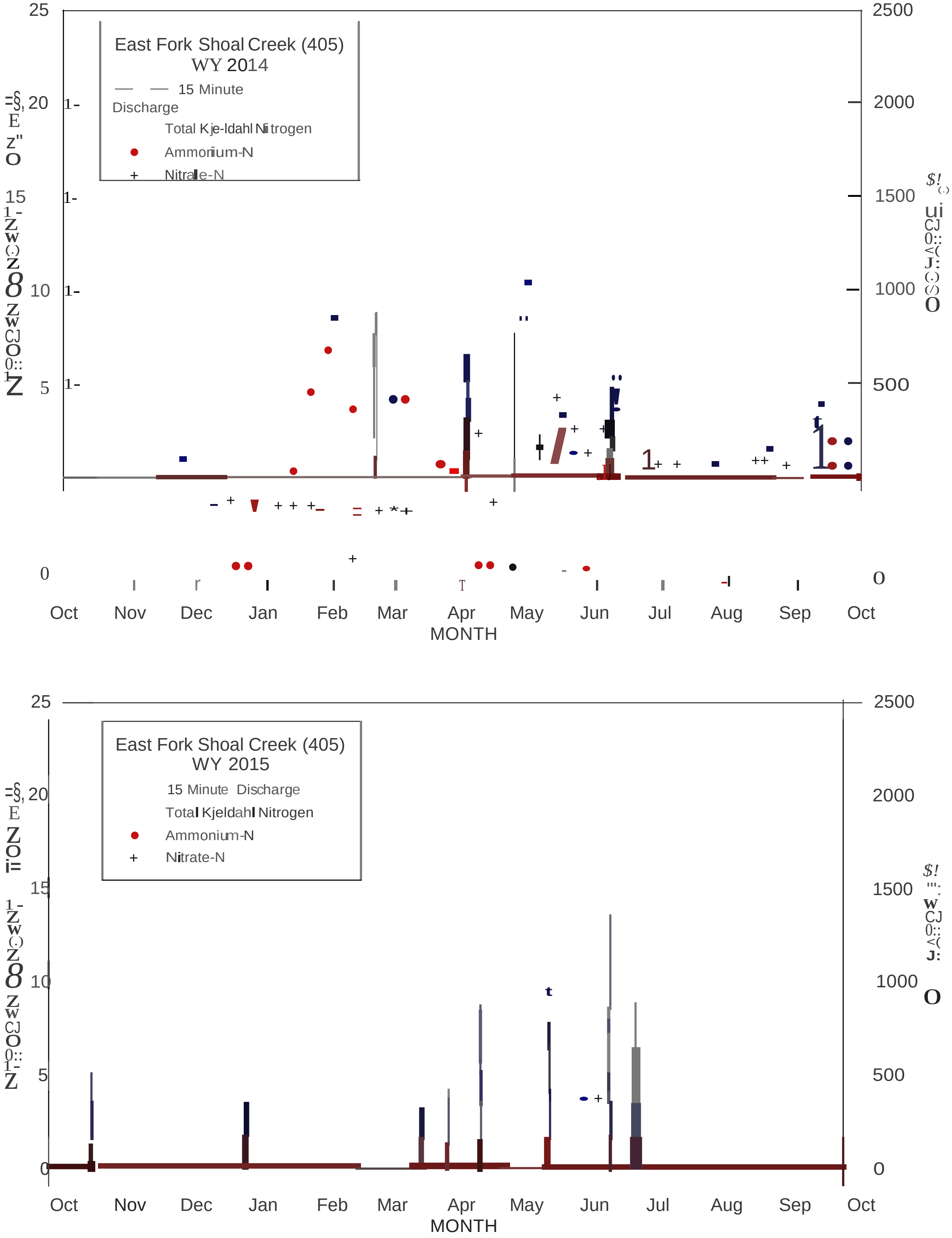
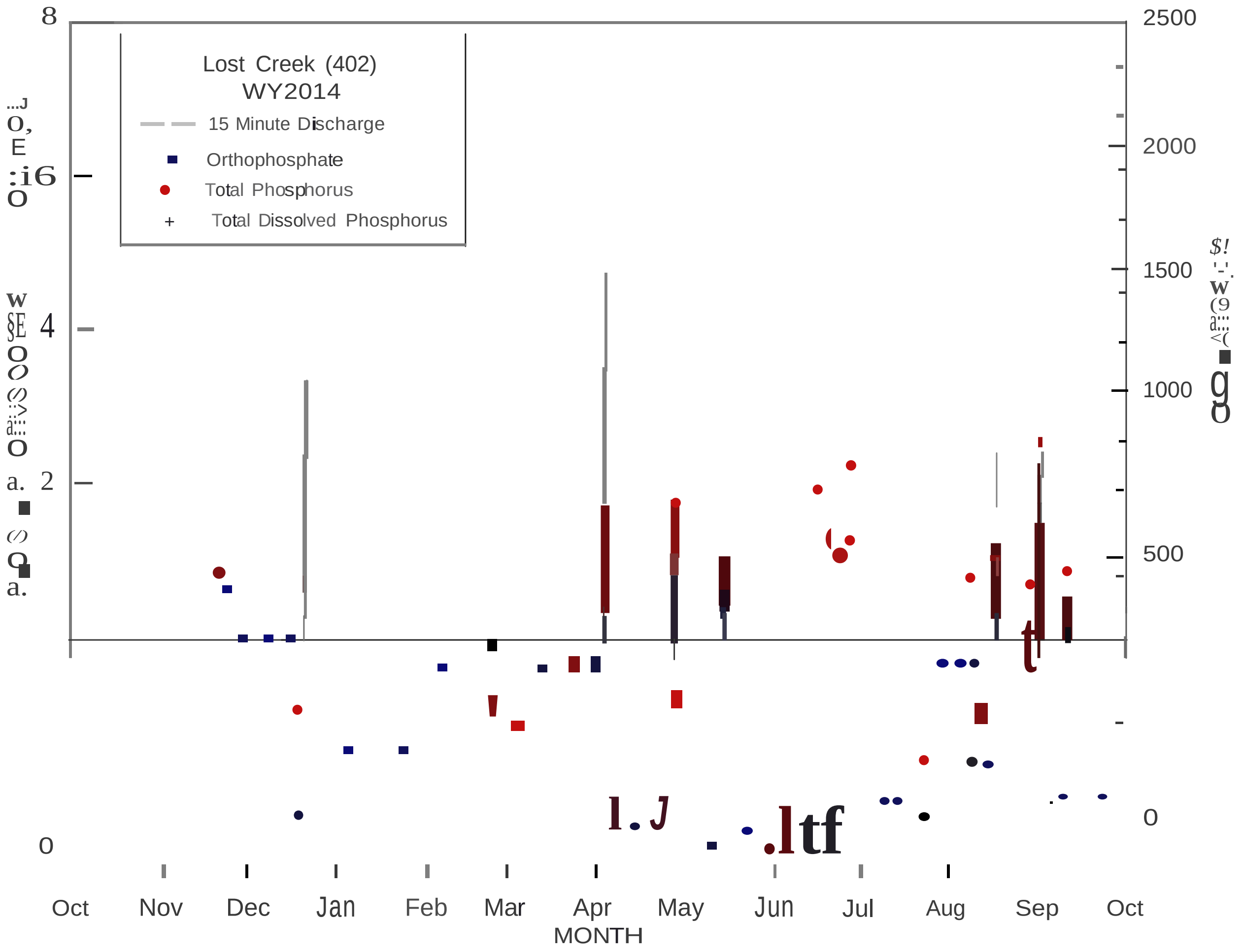


Figure A-8. Nitrogen concentrations and discharge at East Fork Shoal Creek (405): Water Year 2014 and Water Year 2015


Lost Creek (402)
WY2014
15 Minute Discharge
Orthophosphate
Total Phosphorus
Total Dissolved Phosphorus
8
6
4
2
0
2500
2000
1500
1000
500
0
Oct
Nov
Dec
Jan
Feb
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May
Jun
Jul
Aug
Sep
Oct
MONTH

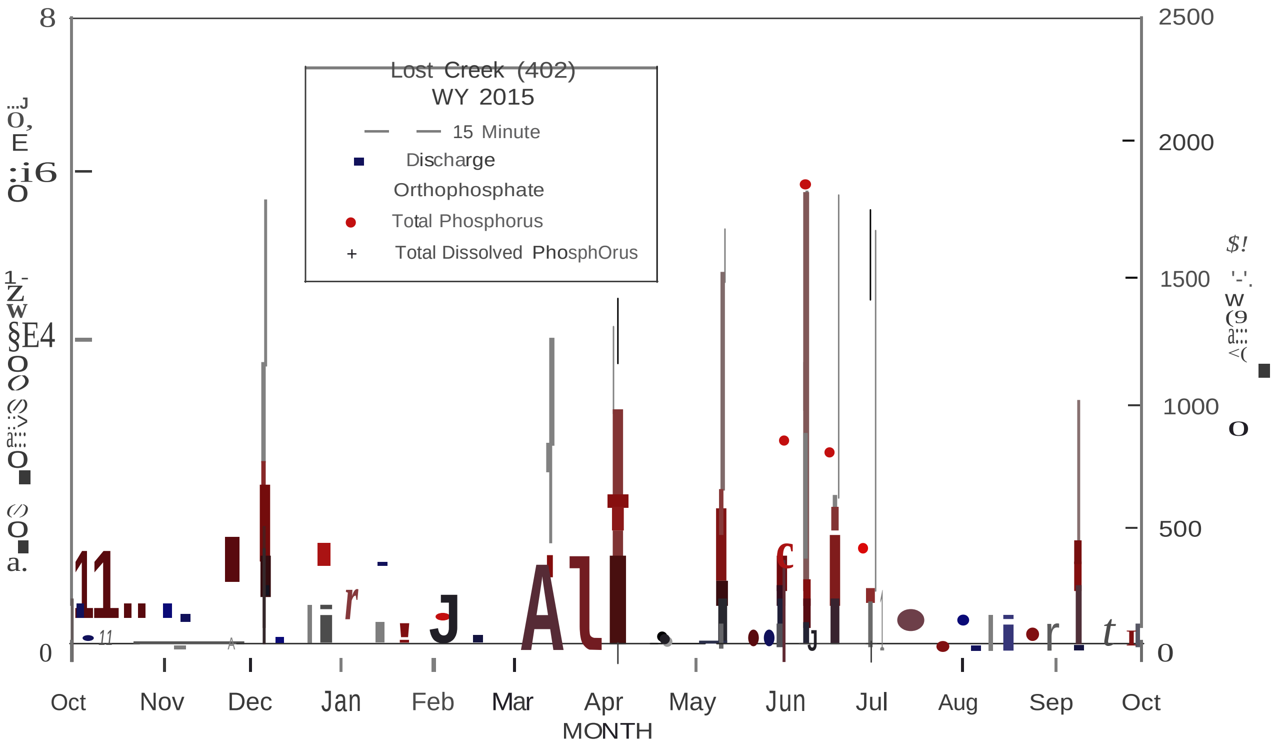
Lost Creek (402)
WY 2015
15 Minute
Discharge
Orthophosphate
Total Phosphorus
Total Dissolved PhosphOrus
8
6
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Figure A-9. Phosphorus concentrations and discharge at Lost Creek (402): Water Year 2014 and Water Year 2015

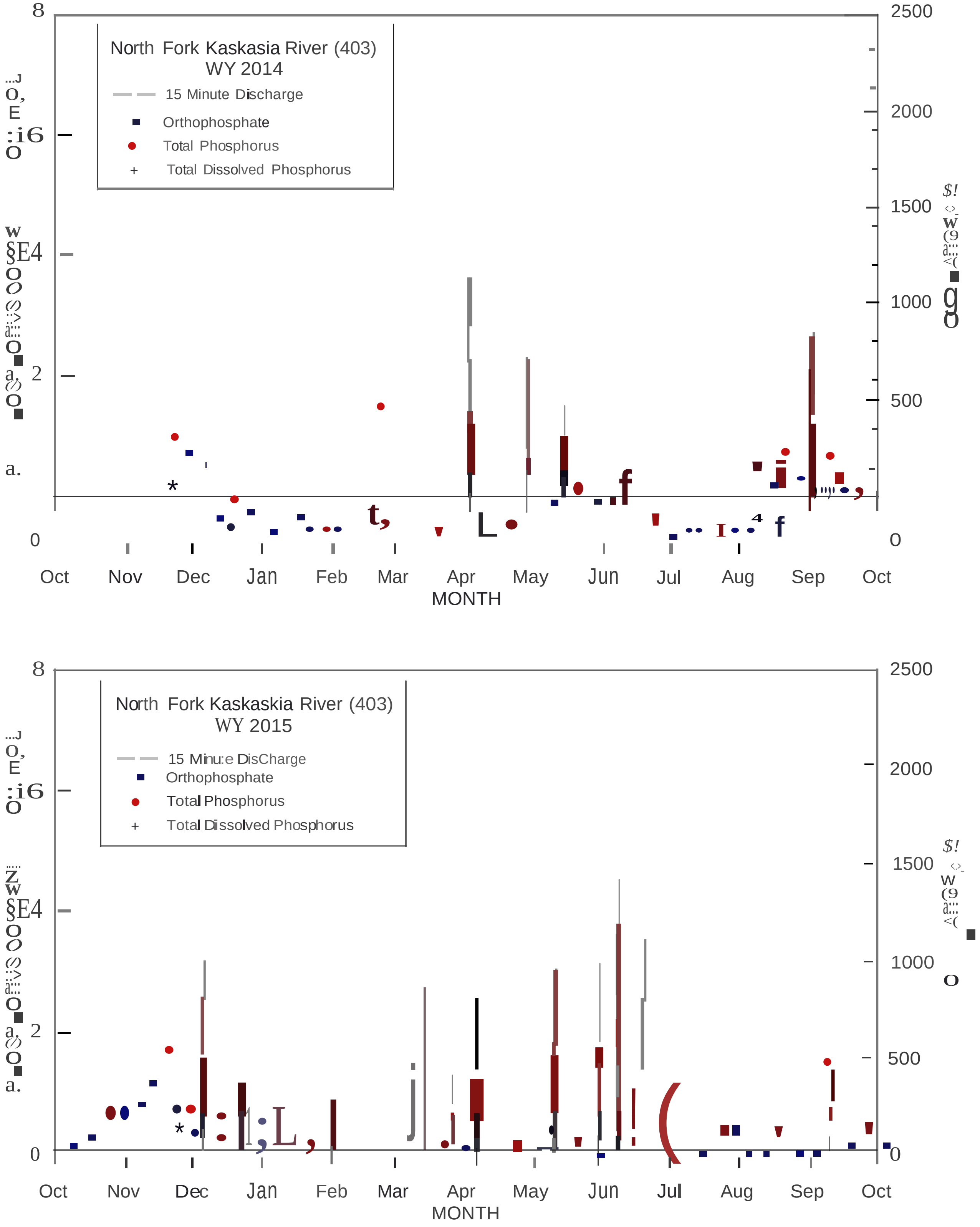


Figure A-10. Phosphorus concentrations and discharge at North Fork Kaskaskia River (403): Water Year 2014 and Water Year 2015

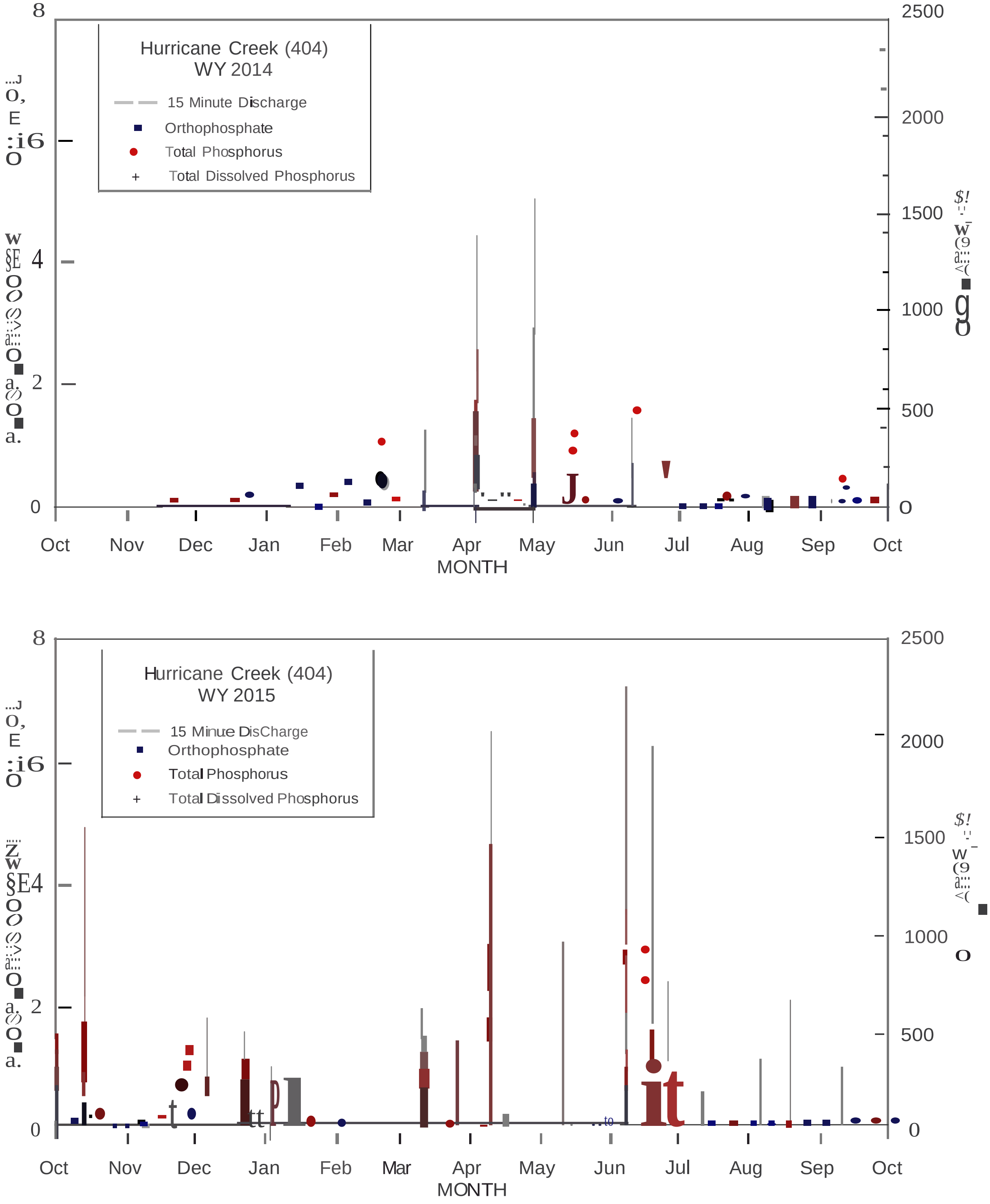
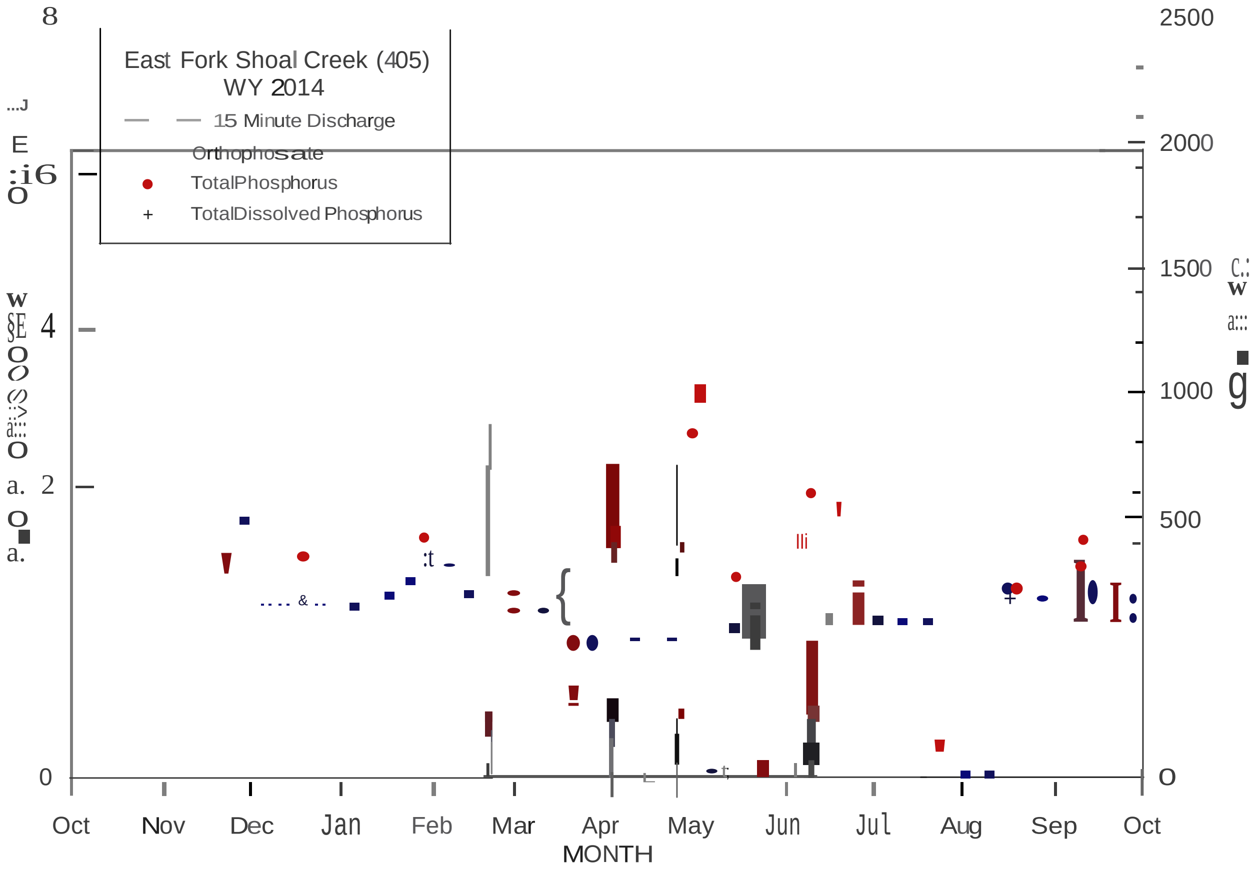


Figure A-11. Phosphorus concentrations and discharge at Hurricane Creek (404): Water Year 2014 and Water Year 2015


East Fork Shoal Creek (405)
WY 2014
15 Minute Discharge
Orthophosphate
Total Phosphorus
Total Dissolved Phosphorus
8
4
2
0
2500
2000
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500
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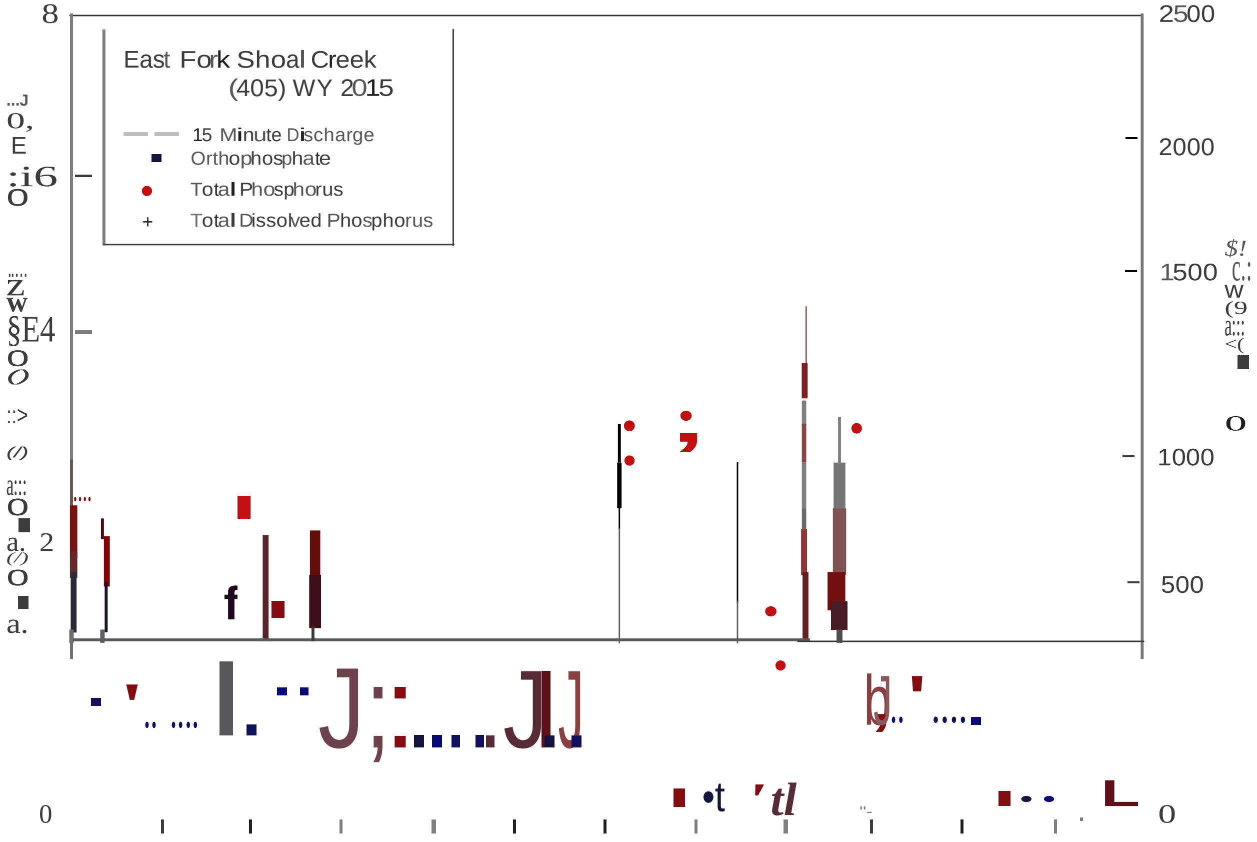
MONTH


East Fork Shoal Creek
(405) WY 2015
15 Minute Discharge
Orthophosphate
Total Phosphorus
Total Dissolved Phosphorus
8
2
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2500
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Oct
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Jul Aug Sep Oct

Figure A-12. Phosphorus concentrations and discharge at East Fork Shoal Creek (405): Water Year 2014 and Water Year 2015

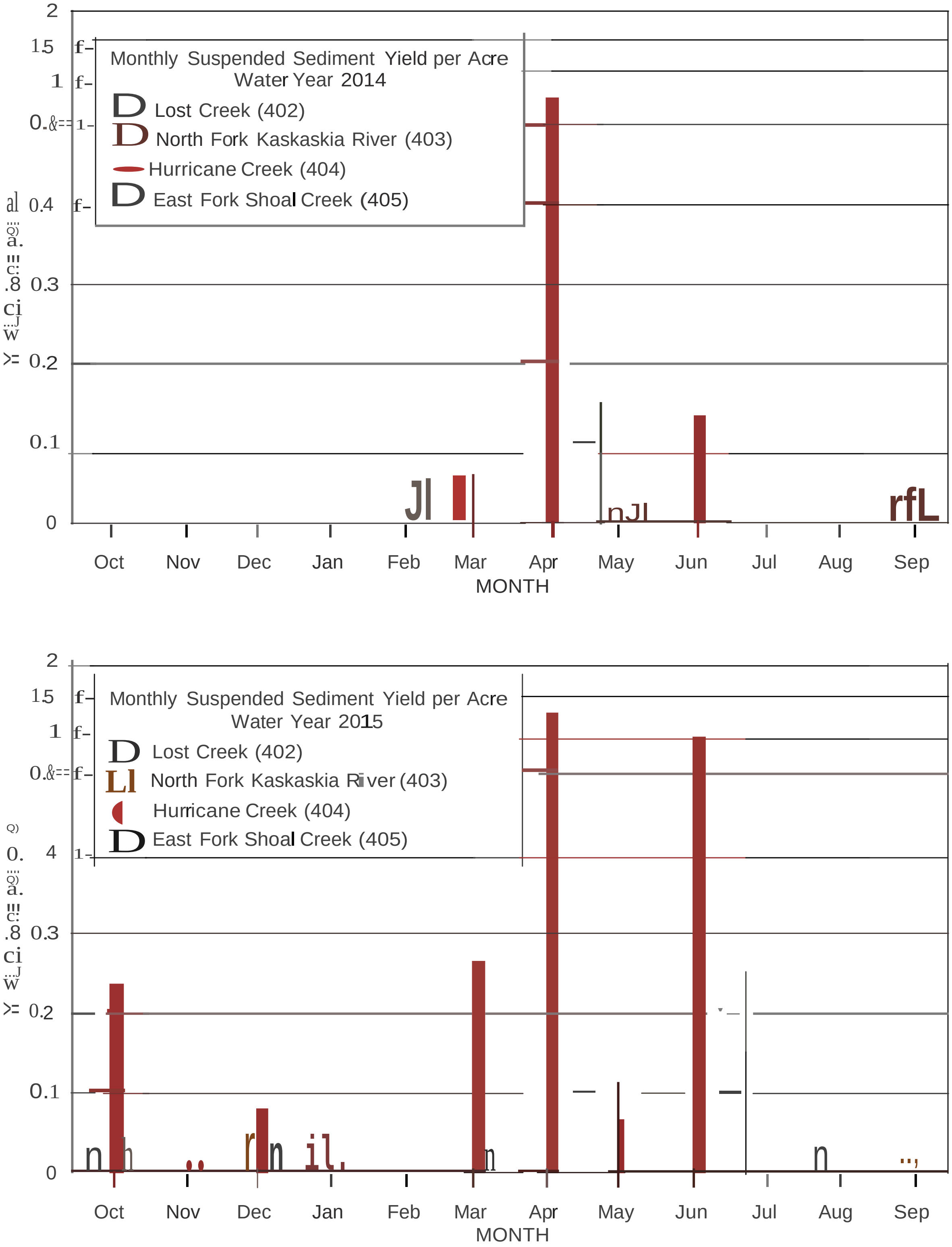
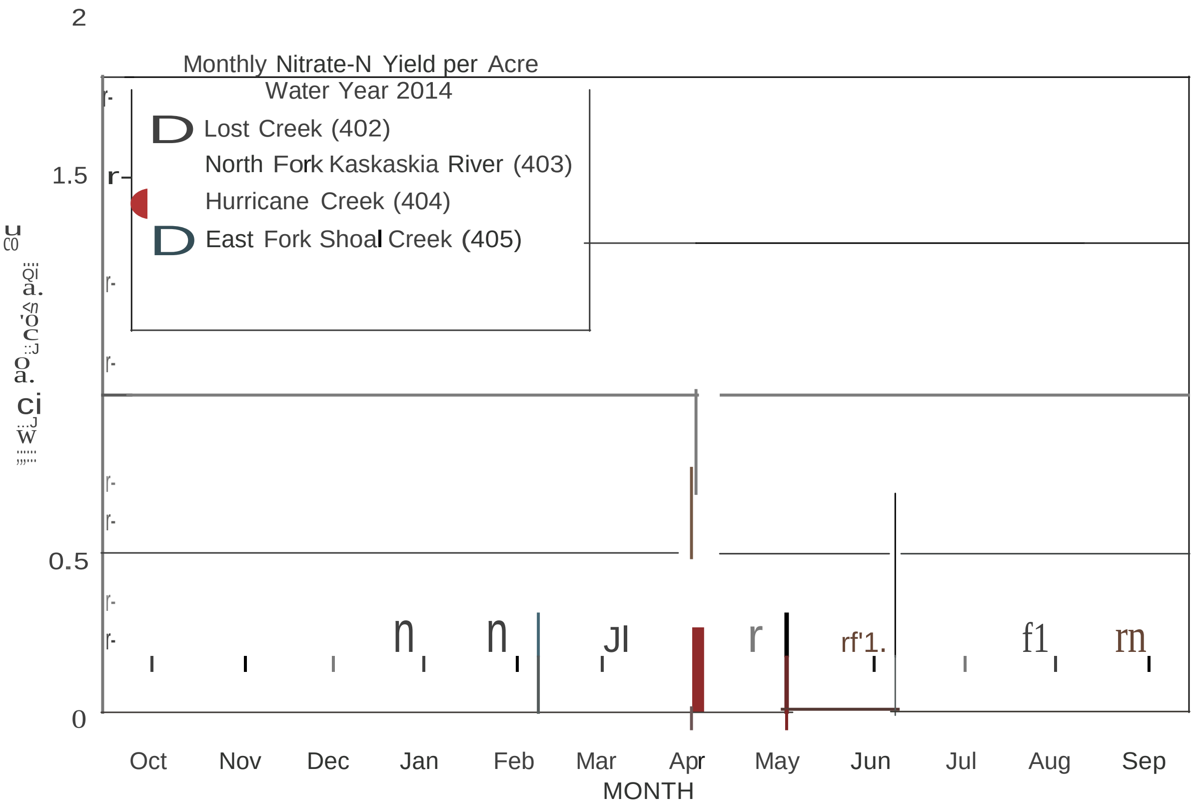


Figure B-1. Monthly sediment yield (tons/acre) for all stations during WY2014-2015



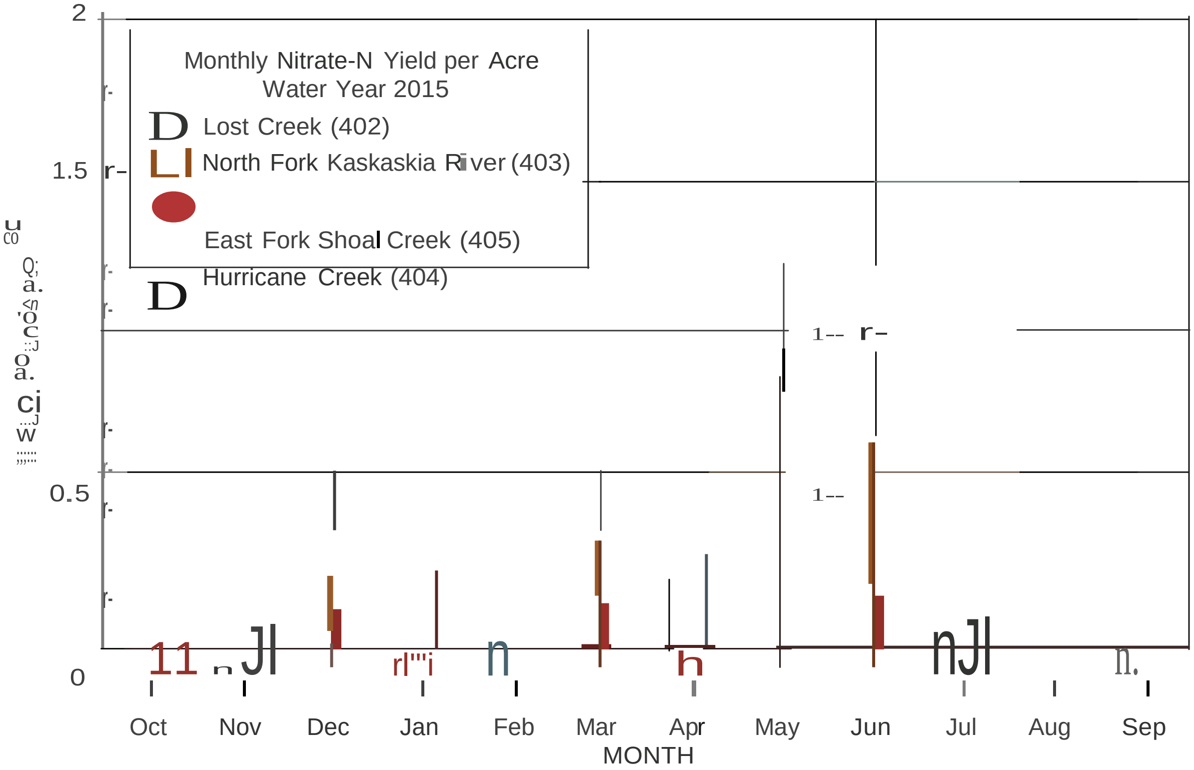


Figure 8-2. Monthly nitrate-N yield (tons/acre) for all stations during WY2014-2015

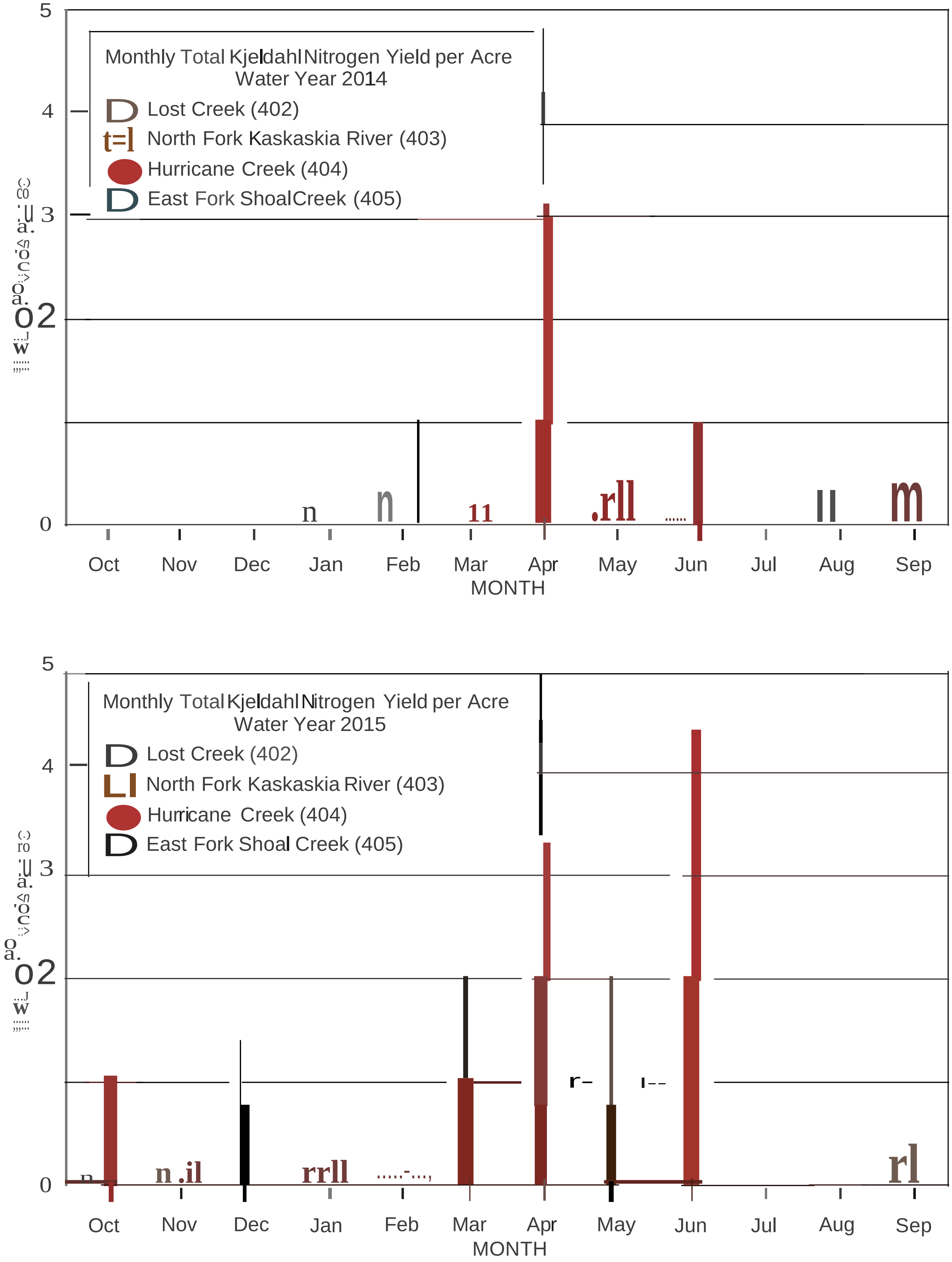


Figure B-3. Monthly TKN yield (tons/acre) for all stations during WY2014-2015

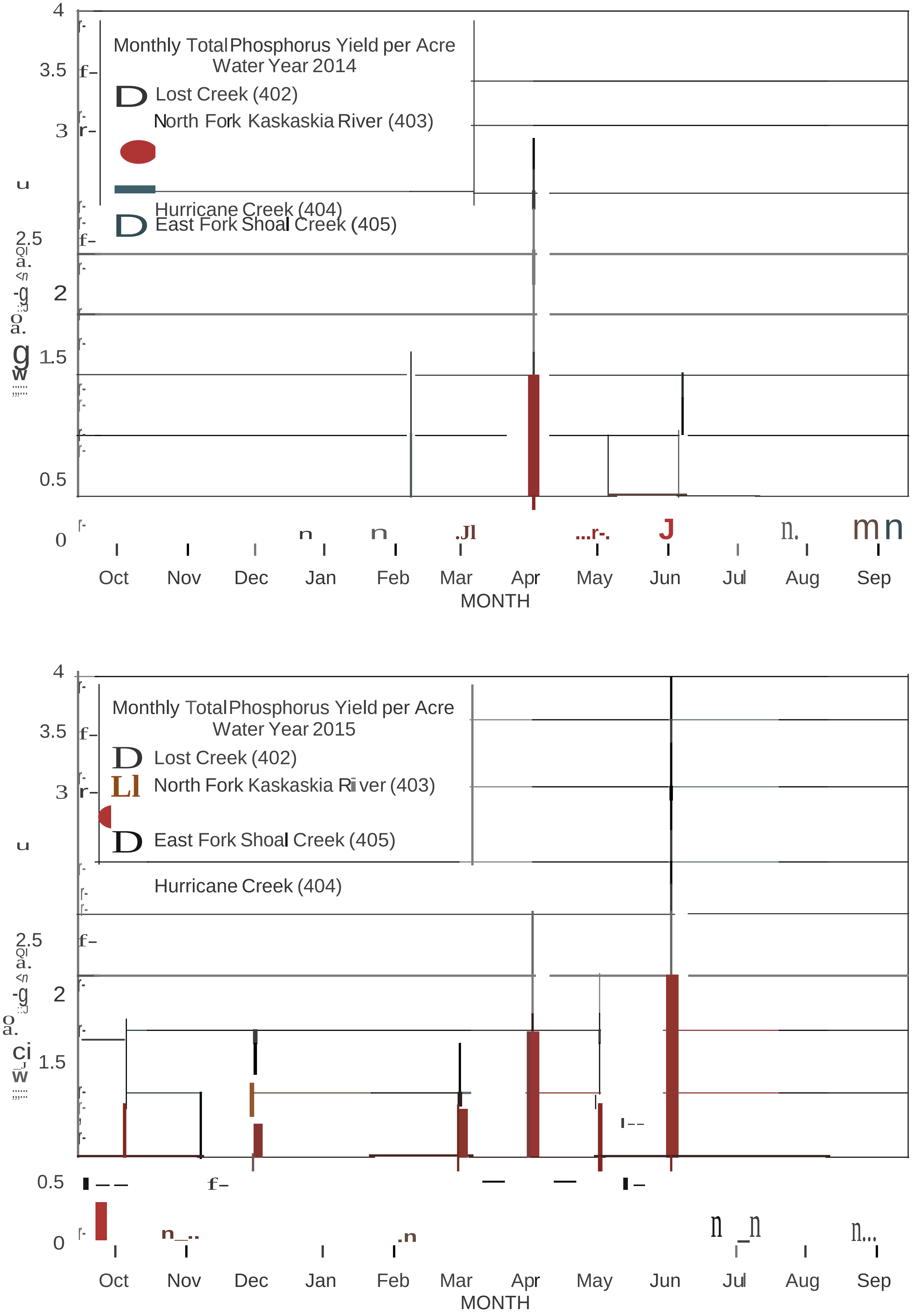


Figure B-4. Monthly total phosphorus yield (tons/acre) for all stations during WY2014-2015

Appendix D

Establishing an Aquatic Monitoring Program to Assess the Goals of the Illinois Conservation Reserve Program in the Kaskaskia River Basin

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SECTION 1 – STREAM MONITORING FOR THE CONSERVATION RESERVE ENHANCEMENT PROGRAM

The Conservation Reserve Enhancement Program in Illinois

Illinois Conservation Reserve Enhancement Program (CREP; est. 1998 Illinois River, 2010 Kaskaskia River) was developed with the United States Department of Agriculture (USDA) to improve water quality by reducing sediment and nutrient loading to water bodies and to enhance wildlife habitat for Threatened and Endangered Species by providing financial incentives for private landowners to take highly erosive agricultural lands out of production. Illinois CREP has physiochemical goals to reduce silt and sedimentation along with phosphorus and nitrogen associated with runoff from agricultural lands. In addition, Illinois CREP aims to increase bird populations and native fish and mussels stocks dependent on sensitive lands and their associated waters (State of Illinois 2010). As part of this cooperative agreement between the State of Illinois and the USDA the State has been given the responsibility to conduct a monitoring and assessment program to measure the success of these efforts. With the opening of the Kaskaskia River to CREP enrollments in 2010 the Illinois Department of Natural Resources' Division of Private Lands and Watersheds has expressed an interested in developing a monitoring program focused on assessing the aquatic biological goals of the Illinois CREP.

Need for a Stream Monitoring Program

The CREP program has two goals relevant to streams: Reduce sediment loading by 20% and phosphorus and nitrogen loading by 10% in the mainstem Illinois and Kaskaskia Rivers, and increase the native fish and mussel stocks by 10% in the Illinois and Kaskaskia Rivers. Monitoring and assessment during the past two decades have mainly focused on the physiochemical goals of CREP in the Illinois River. Watershed monitoring and analysis of existing water quality data have allowed estimates of overall sediment and nutrient loading for the entire basin (Demissie et al. 2004) and more detailed estimates for several sub-watersheds (Demissie et al. 2001, State of Illinois 2010). Biological monitoring in CREP areas has included implementation monitoring of CREP enrolled lands (State of Illinois 2010) and basin-wide surveys of fish and macroinvertebrates (IEPA 2010, Molano-Flores 2002) and mussels (Shasteen et al. 2013). With the opening of the Kaskaskia River to CREP enrollments in 2010 the Illinois Department of Natural Resources' Division of Private Lands and Watersheds expressed an interest in developing a monitoring program focused on assessing the aquatic biological goals of the Illinois CREP.

A monitoring program must be sufficiently robust that it can quantify changes in the assessment metrics and separate treatment effects (e.g., density of CREP in watershed) from regional and temporal background noise (e.g., land use changes, species introductions). Important potential covariates are urban and agricultural land use (point and non-point discharges), altered flow regimes (watershed modifications and climate change), and land use change. Since biological monitoring alone is unable to identify individual stressors or assess impacts of specific alterations in stream water quality (or a changing climate) these characteristics must also be monitored. Existing monitoring programs such as the IEPA Ambient Water Quality Network (27 active Stations in Kaskaskia Watershed), IDNR/IEPA Intensive Basin Survey, and River Watch that routinely measure many physical, chemical, and biological attributes of Illinois' waterbodies were designed to report current site conditions rather than identify trends associated with changes in land use practices. One basic approach to develop a monitoring program to address these issues includes a combination of fixed station and randomly selected sampling sites that would include the full range of conditions within the river system. Fixed sampling sites can be used to address year-to-year variation and identify long-term temporal trends in stream characteristics at individual locations. Randomly selected sampling sites can be used to identify relationships between stream characteristics and landscape characteristics (including density of conservation lands) and also to identify basin-wide temporal trends in stream characteristics. Both fixed and random sites can be used to evaluate an "increase" in fish and mussel stocks in relation to the CREP.

The Illinois State Water Survey (ISWS) has engaged in monitoring of sediment and nutrient loading in the Illinois River basin since 2000 and the Kaskaskia River basin since 2014. Accordingly, the focus of the monitoring program described in this report is the characterization of biota within the Kaskaskia River basin.

SECTION 2 – DESCRIPTION OF THE KASKASKIA RIVER BASIN

Geographical and Physical Characterization of the Basin

The Kaskaskia River basin encompasses approximately 14,885km^2 (10.2% of Illinois land area) and is the second largest basin in Illinois (Southwestern Illinois RC&D 2002). The basin boundaries include all or parts of 22 counties and the urban areas of Champaign, Vandalia, Highland, Centralia, Sparta and Belleville. The mainstem river originates in Champaign County northwest of Champaign and flows southwest to the Mississippi River near Ellis Grove in Randolph County, a distance of approximately 520km. There are 5391 confluence to confluence stream segments in the Kaskaskia River basin that flow for a total of 38,810km (1:100,000 resolution linework), and approximately 95% of those segments are wadeable (stream order ≤4, Figure 1).

The mainstem river is impounded by two Army Corps of Engineers flood-control reservoirs (Carlyle Lake and Lake Shelbyville) with a total surface area of approximately 150km^2, and ten additional reservoirs on tributaries to the Kaskaskia River with a surface area of at least 1km^2 (Figure 1). The downstream most 58km of the mainstem Kaskaskia River, between the Mississippi River and Fayetteville, was straightened to create a navigation channel suitable for barge traffic.

The Kaskaskia River basin is subdivided into four United States Geological Survey HUC8s (hydrologic unit code, a hierarchical classification system that groups catchments by similarities in geology and geography); the Upper Kaskaskia, Middle Kaskaskia, Shoal Creek and Lower Kaskaskia (Figure 1). As these HUC8s vary with respect to land use, geology and biota, they are a useful resolution for describing patterns within the basin and characterizing streams at a resolution finer than the entire basin.

Two ecoregions are present within the boundaries of the Kaskaskia River basin: the Central Corn Belt Plaines and the Interior River Valleys and Hills (Level III regions, Omernik 1987). The Central Corn Belt Plaines occurs in the upper third of the basin (Figure 2) and is typified by loam and clay soils deposited during glaciations. The topography is generally flat and much of the landscape has been converted to agriculture. Historic vegetation communities were comprised of prairie and oak-hickory forest. Many of the region's streams have been heavily modified to speed drainage (Wiken et al. 2011). The Interior River Valleys and Hills ecoregion occurs in the southern two-thirds of the basin and exhibits greater topographic diversity than the Central Corn Belt Plains in the form of river bluffs and more developed stream valleys and river floodplains. The upland soils are comprised of loam and clay, but lowlands are dominated by river deposits like sand and gravel. Historic vegetation was dominated by forest. Much of this ecoregion has been converted to cropland or pastureland, but less so than the Central Corn Belt Plains (Wiken et al. 2011).

Land cover (USDA 2002) in the Kaskaskia River basin is predominately agriculture (71%) with some forest (16%), urban (9%), wetland (2%) and grassland (1%) cover (Figures 3 - 6). Land cover amongst the four subbasins varies; the upper subbasin is 80% agriculture, while the other three subbasins range between 65% and 70%agriculture. The middle subbasin has the greatest proportion of forest land cover (21%) followed by the Shoal Creek (18%), Lower (15%) and Upper (10%) subbasins. Urban land is most dense in the Lower subbasin (12%) while the remaining subbasins are between 8% and 9% urban land. Approximately 80% of the Kaskaskia River basin is comprised of disturbed land (the sum of agriculture and urban land use), and the Upper subbasin has the highest amount (88%) followed by the Lower (80%), Shoal Creek (79%) and Middle (74%) subbasins (Figure 7). Approximately 63% of local catchments (the area draining to a confluence to confluence stream segment) are ≥50% disturbed land, 34% of local catchments are ≥75% disturbed land and 12% are ≥90% disturbed land(Figure 8).

Existing Physicochemical and Biological Characterizations

Several existing stream habitat and biotic evaluations have been completed by Illinois State Agencies, Universities or other research groups that can be utilized to characterize the Kaskaskia River basin. The majority use stream biota in their assessments, but landscape characteristics are used by some. Evaluations described here are limited to those occurring within the past ten years and those with relevance to CREP conservation objectives.

The National Fish Habitat Partnership (NFHP) conducted an effort to assess stream disturbance within the United States (Esselman et al. 2011). The resulting disturbance rating method was based on landscape characteristics including land use, population density, and presence of roads, dams, mines and point-source outfalls and streams were placed into a five-point scale ranging from very low to very high habitat degradation. The greatest number of local catchments in the Kaskaskia River basin fall into the “moderate” disturbance category (39%; Table 1, Figure 9), and 35% of local catchments are rated “high” or “very high.” The Upper HUC8 subbasin has the greatest proportion of “high” or “very high” disturbance streams (62%) and is nearly double that of the next most degraded HUC8 (Lower, 32%).

An evaluation of Illinois stream biodiversity (Bol et al. 2007) identified high quality (“biologically significant”) streams based on an assessment of biological diversity (species richness) and integrity (intactness relative to a reference condition). Data from fish, mussel, benthic macroinvertebrate and crayfish collections were used to classify streams. Diversity and integrity were each scored on a five-point (A, B, C, D, E) scale and biologically significant streams included those with multiple taxonomic groups that achieved an “A” rating. Biological diversity scores were calculated for eighty stream reaches in the Kaskaskia River basin (Figure 10). The majority of reaches received a “B”, “C” or “D” rating (26%, 44%, and 23%, respectively); five streams (6%) were rated “A” and one (1%) was an “E”. Seventy-two stream reaches were evaluated for biological integrity (Figure 11) and the majority were “B” (39%) or “C” (39%). Five reaches (7%) were rated as “A” or “D” and six (8%) were “E.” Fifteen stream reaches obtained biologically significant status (Figure 12). The Shoal Creek HUC8 contained the largest number of biologically significant stream reaches (6) and the greatest total stream length under this designation.

The Illinois Department of Natural Resources (IDNR) and Illinois Environmental Protection Agency (IEPA) provided recommended revisions to the dissolved oxygen standard for streams (IDNR and IEPA 2006). This effort included identification of stream segments likely to have high dissolved oxygen concentrations based on distribution of aquatic organisms that are sensitive to dissolved oxygen minima (Rankin 2004). In the Kaskaskia River basin there are 283 confluence-to-confluence stream segments suggested for enhanced protection based on this elevated dissolved oxygen concentration assessment (Figure 12).

The IEPA has identified Illinois streams which have experienced or are expected to experience a decline in water quality (Short, Personal Communication 2015). These streams fall into at least one of two categories: 1) Streams that have maintained a use support (as evaluated through monitoring) but have shown a declining trend, or 2) Streams that are within an area experiencing rapid land use change which is expected to result in a declining trend. The IEPA has designated these streams as priority streams for protection. The Kaskaskia River basin contains four priority streams for protection, and all are within the Upper Kaskaskia HUC8 (Figure 12).

Existing Physical and Biological Survey Data

Water quality monitoring and biological surveys have been occurring in the Kaskaskia River basin for decades. Data from these activities collected in the years immediately preceding the initiation of this study were gathered to aid basin characterization.

The IEPA completed nearly 3000 nitrogen, phosphorus and turbidity analyses at 745 locations between 2006 and 2011 in the Kaskaskia River basin (Figure 13). These variables may be useful for evaluating impacts to stream water quality in an agriculturally dominated watershed, like the Kaskaskia. These variables also are similar to those selected for this monitoring program (Section 3) and can provide additional spatial and temporal data coverage.

The IDNR has surveyed fish communities at 90 locations since 2007 (Figure 13) using standardized procedures (Illinois Department of Conservation 1994). Most of these surveys have been conducted as part of the IDNR/IEPA joint Basin Surveys, while some of those on the mainstream river are surveyed biennially. Basin Survey locations were sampled in 2007 and 2012 (some locations were sampled in both years, others in only one). Fish surveys for this study (Section 3) follow IDNR procedures, and the two datasets are complementary.

The IEPA also evaluated instream habitat using the Qualitative Habitat Evaluative Index (QHEI, Ohio Environmental Protection Agency 2006) at 94 locations in the Kaskaskia River basin during the 2007 and 2012 during Basin Surveys. The QHEI provides a qualitative index of habitat characteristics and is sometimes viewed as a measure of biological potential. Seventy of the locations where QHEI scores are available also have associated IDNR fish surveys.

The Illinois Natural History Survey (INHS) completed mussel surveys at 96 locations in the Kaskaskia River basin between 2009 and 2012 (Shasteen et al. 2013, Figure 13). Mussels were collected using a standard four person-hour search. Seventy of the mussel surveys have corresponding IEPA QHEI scores taken during 2007 or 2012 Basin Surveys, 64 locations have fish and mussel survey information, and 64 locations have fish, mussel and QHEI information.

Species of Conservation Concern

The Kaskaskia River basin contains several species of fish and mussels that meet criteria for conservation concern (IDNR 2015). Four species of fish, including one that is state threatened, are listed as Species in Greatest Conservation Need (Table 2, Figure 14). Each of these species are listed because of their rarity and because their habitats are rare or vulnerable to degradation (IDNR 2015). Seven mussel Species in Greatest Conservation Need also are present in the basin (Table 2, Figure 14). Two of these are state threatened and one is both state and federally endangered. Five of the species are listed as SGCN under the rarity criterion, five are declining, two have rare or vulnerable habitat requirements and one exhibits additional vulnerabilities related to distribution patterns.

Status of Conservation Land Programs

Several private lands conservation programs are active within the Kaskaskia River basin and may provide benefits to streams through reduced sedimentation and nutrient loading, improved instream habitat and promoting a less disturbed hydrologic regime. The Natural Resource Conservation Service (NRCS) administers the Agricultural Conservation Easement Program (ACEP) to preserve the function and wildlife benefits associated with wetlands. In 2012, 38 ACEP wetland parcels totaling 16.2 km^2 were present in the basin. The United States Department of Agriculture (USDA) offers assistance programs to encourage private lands owners to plan and implement conservation activities. The USDA Environmental Quality Incentives Program (EQIP) offers financial and technical assistance to aid land owners for implementing a wide range of projects for improving soil characteristics, water quality and wildlife habitat. Access to EQIP parcel locations and characteristics is restricted to us, and therefore EQIP presence in the Kaskaskia River basin has not been quantified. There are 39 Illinois Nature Preserves and Land and Water Reserves totaling 56.3km^2 in the basin. Preserves and Reserves are designated to protect the natural characteristics within their boundaries. Assuming the two programs do not overlap, the total land area in ACEP, Nature Preserves and Land and Water Reserves is approximately 0.5% of the Kaskaskia River basin.

The largest private lands program in the Kaskaskia River basin is the Conservation Reserve Program (CRP). CRP provides incentives to land owners to remove environmentally sensitive lands from agricultural production and place them into an approved conservation practice. CRP has been active in the Kaskaskia River basin for more than 30 years. At initiation of this monitoring program (2012) there were 28,228 CRP parcels totaling 645km^2 in the Kaskaskia River basin (4% of the land area) with a mean parcel size of 0.05km^2 (Figure 15). Mean CRP parcel size is 0.06, 0.09, 0.08 and 0.02km^2 for the Upper, Middle, Shoal Creek and Lower HUC8 subbasins, respectively. Density of CRP within a local catchment provides an ecologically meaningful measure of conservation land use relative to a stream segment Allan, et al. 1997). In the Kaskaskia River basin nearly half (48%) of local catchments have no CRP, and 93% of local catchments have 10% or less of their area (Figure 16) enrolled in the program. The frequency distribution of CRP density varies amongst the four HUC8 subbasins (Figures 17-20); the Lower Kaskaskia has the highest proportion of local catchments with no CRP (68%) and those with <10% CRP (97%), while the Middle Kaskaskia has the lowest proportion (34% with no CRP and 89% with <10% CRP). CRP density within the total upstream catchment of a stream segment reflects a similar pattern (Figure 21); 29% of upstream catchments have no CRP and 98% <10% of their area enrolled. At the initiation of this monitoring program no CREP contracts had been completed, and therefore no CREP parcels were present in the Kaskaskia River basin.

SECTION 3 – MONITORING OBJECTIVES AND PROCEDURES

Monitoring Goal and Objectives

The goal of this monitoring program is to provide a characterization of Kaskaskia River basin stream reaches at a time when CREP program enrollments are opening within the basin. This program will provide a baseline from which change can be measured as the CREP program matures and thereby provide a means for evaluating any potential for increase in fish and mussel stocks. Within this context, study objectives are:

1. Evaluate chemical, physical and biological status of streams. This portion of the program will be used to determine current status and assess trends over time in stream biodiversity throughout the Kaskaskia River Basin accounting for regional and system-wide variation.
2. Evaluate status of streams with sensitive species. This portion of the program will assess temporal trends in the characteristics of sensitive populations in areas of conservation concern.
3. Assess locations with concurrent monitoring programs for long-term trend evaluation. Information from these fixed locations will track temporal changes in biological communities as private lands program initiatives mature.

Survey locations and measures were selected to support study objectives.

Survey Site Selection and Procedures

Physicochemical and biological characteristics evaluated during this monitoring program were selected for relevance to the CREP objectives of reduced sediment and nutrients and improved fish and mussel stocks. Some of these characteristics provided direct evaluations of CREP objectives (e.g., nitrate nitrogen concentration, fish assemblage survey) while others provide a surrogate through which an objective may be indirectly evaluated (e.g., substrate metrics in habitat indices that may relate to sedimentation). Unless otherwise noted monitoring surveys occurred during summer low flow conditions to adhere to existing sampling protocols (e.g., IDNR Basin Surveys) and index periods (e.g., Smogor 2000).

Survey effort was divided between the three monitoring objectives and survey location selection procedures were intended to provide relevant information for each objective. A stratified random procedure was employed to select survey locations for a basin-wide characterization streams (Objective 1). Locations were evenly divided amongst the four HUC8 subbasins (stratum 1) and then divided into size and local catchment CRP density strata (strata 2 and 3; Figure 22). There were two size classes: class 1 streams were those reaches with link magnitudes (link is the sum of first order streams upstream of the target segment) between 2 and 20, and class 2 streams had link magnitudes between 11 and 50 (based on 1:100,000 streamlines). Reaches with link magnitudes of one were not included in the selection procedure to reduce the likelihood that selected locations would be dry during the summer survey period, and the link 50 maximum was an approximation of the upper limit of wadeability. In the Kaskaskia River basin 1619 stream segments (30% of all segments) were in class 1 and 571 (11%) were in class 2. Local catchment CRP density was divided into five classes: class 1 was <1%, class 2 was 1 - <5%, class 3 was 5 - <10%, class 4 was 10 - <20%, and class 5 was ≥20%. As no CREP lands were present in the basin at study initiation, CRP was selected as a surrogate conservation land program through which impacts of CREP can be estimated. The HUC8 and size strata facilitate a distribution of survey locations along the environmental gradients present within the Kaskaskia River basin, while the CRP density stratum provides information along a conservation land use gradient. Water quality, habitat, fish and benthic macroinvertebrates were evaluated at Objective 1 locations, and each location was surveyed once during the study (Figure 23).

Streams designated as both BSS and enhanced DO (Figure 12) were considered for monitoring as sensitive species locations (Objective 2). Survey locations were placed in groups of three and arranged longitudinally along a series of bridges or other access points (Figure 23). Water quality, habitat and benthic macroinvertebrates were evaluated at these locations, and surveys were repeated in each study year.

Long-term trend monitoring (Objective 3) was conducted in 2015 and 2016 at the four Illinois State Water Survey (ISWS) CREP monitoring stations (Figure 23). Water quality, habitat, fish and benthic macroinvertebrates were evaluated at these locations.

Additional survey locations were targeted specifically to supplement graduate student research projects. Many of these were streams with high (≥10%) local catchment CRP density (Figure 23). Others surveys improved distribution of locations along environmental gradients of interest or increased spatial density of survey locations.

Temperature Evaluation

Continuous temperature recorders were deployed at a subset of survey locations in an effort to characterize summer thermal regime throughout the Kaskaskia River basin. Stream thermal regime has been shown to impact fish species distribution (Magnuson et al. 1979) and community composition (Lyons et al. 2009), and temperature maxima can be influenced by riparian characteristics (Hinz et al. 2011). Mean daily July temperature, mean maximum daily July temperature and mean daily temperature range were calculated for each temperature record. Multiple linear regression coupled with Akaike's Information Criterion (AIC) also was used to estimate thermal characteristics at unsampled reaches within the Kaskaskia River basin (Figures 25-27).

Water Quality Measures

Eight measures, which are both biologically relevant and which might reflect the land use gradient within an agriculturally dominated watershed, were selected to evaluate water quality at survey locations. Dissolved oxygen, specific conductance, temperature and pH were measured using a Hach HQ40d Portable Multi-Meter, while nitrate nitrogen, total reactive phosphorus, ammonia nitrogen and turbidity were measured using a Hach DR900 Colorimeter with Test-N-Tube kits. In addition to measurements taken during regular sampling visits, water quality was evaluated following harvest (November) at a subset of locations in 2013 and 2014.

Habitat Evaluations

Habitat characteristics were evaluated using the Illinois Habitat Index (IHI, Sass et al. 2010) and the Qualitative Habitat Evaluation Index (QHEI, Ohio Environmental Protection Agency 2006). The IHI is comprised of five metrics which reflect landscape disturbance. Index scores range from 5 to 24 and high scores reflect greater disturbance. The QHEI evaluates habitat characteristics thought to be relevant to fish. The QHEI uses seven metrics, the sum of which corresponds to one of four qualitative categories.

Benthic Macroinvertebrate Surveys

Summer benthic macroinvertebrates were collected using the IEPA 20-jab procedure (IEPA 2011). Jabs were divided in proportion to available habitat. Collected invertebrates were preserved in ethanol, sorted in the laboratory, and transported to EcoAnalysts, Inc. (Moscow, ID) for identification and enumeration. Spring macroinvertebrates from the Orders Ephemeroptera, Plecoptera and Trichoptera (EPT) were collected using Critical Trends Assessment Program (CTAP) methods (Molano-Flores 2002). Many EPT emerge prior to summer, so spring EPT surveys may supplement summer surveys by providing additional information for these sensitive taxa. Collected EPT were preserved in the field and identified and enumerated in the laboratory by Eric South (UIUC graduate student) under the direction of Dr. R.E. DeWalt (INHS Project Co-PI).

Fish Surveys

Fish surveys followed IDNR Basin Survey procedures (Illinois Department of Conservation 1994) using either a DC backpack electrofishing unit (LR-20, Smith Root) or a 30-foot electric seine powered by a 120 volt generator. Collected fish were identified and enumerated on site and returned to the stream. Fish assemblages were qualified using the Index of Biotic Integrity (IBI, Smogor 2000). The IBI categorizes fish assemblages into five categories by summarizing ten diversity and trait-based metrics.

SECTION 4 – SUMMARY OF SURVEY EFFORTS AND EVALUATION OF OBJECTIVES

Survey events with at least one biological and one physicochemical evaluation occurred at 139 locations (Table 3, Figure 23). When spring EPT collection and fall water quality evaluations are included with low flow survey events, 265 data collection efforts were completed.

In general, metrics selected for a monitoring program to evaluate spatiotemporal patterns should be broad enough to be relevant across the whole system, sensitive enough that changes can be detected through space and time, and be repeatable through time. Metric used in this study were selected to meet these criteria and to advance the overall monitoring goal of evaluating the relationship between stream characteristics and private lands programs. Evaluated characteristics were summarized at the whole-basin and HUC8 subbasin scales. HUC8s provide a convenient mechanism to account for spatial differences in land use and geology that occur within the Kaskaskia River basin. To retain analytical resolution for each objective, evaluations were completed for each objective in Section 4 using appropriate data (e.g., Objective 1 evaluated using data from randomly selection locations) and in Section 5 all data from this monitoring program were combined with those from external sources (e.g., IDNR Basin Surveys) to expand the spatiotemporal extent of basin characterizations. Reporting monitoring results with this dual analytical design ensures the spatiotemporal resolution of each Objective is retained while basin characteristics are also evaluated.

Objective 1: Basin-Wide Characterization Survey Events

Ninety-four locations were surveyed for basin-wide characterization (Objective 1) (Table 3, Figure 23). Spatial distribution (HUC8 stratum) was roughly equal with 22 to 25 surveys in each HUC8 (Table 4). Survey efforts occurred more frequently at small (size class 1) streams with low CRP density (CRP classes 1-3) due to the limited availability and accessibility of large streams with high CRP density. Fish were collected at most (84) locations and those without fish samples had spring or summer (or both) macroinvertebrate collections to fulfill the biological component for a survey event. Sixty-eight spring EPT surveys occurred. Water quality measures were taken at 33 basin-wide survey locations in fall and at 84 locations during summer surveys. Habitat was evaluated during each survey where fish or summer macroinvertebrates were collected, but not when spring macroinvertebrates were the only biota collected.

Water Quality

Mean dissolved oxygen, conductivity, pH, ammonia, reactive phosphate and turbidity were higher in fall, while nitrate was lower, although the ranges of values for both seasons largely overlap (Table 5). Dissolved oxygen, pH and ammonia have General Use Water Quality Standards (IEPA 2012), and an alternative benchmark intended for use in lakes can be used as a substitute Standard until a standard is developed for streams. Standards were exceeded for dissolved oxygen during 16% of survey events, 4% for ammonia (chronic Standard only), 92% for reactive phosphate and not violated for pH (Table 6).

Physical Habitat

QHEI scores ranged from 21 to 77.5 with a mean of 51.2 (Table 7). Approximately 27% of survey locations were in the impaired category, 45% in the moderate category, 27% in the good category and 1% in the excellent category. As a group, basin-wide survey locations scored lowest on the Riffle-Run metric (26% of the maximum possible metric score) and highest on the Channel Morphology and Gradient metrics (64% of maximum possible metric score for both). IHI scores spanned the entire index range (5-24) with a mean of 18.3 (Table 8). Relative to the maximum, basin-wide locations score lowest on the Woody Debris metric (66%) and highest on the Buffer and Bare Bank and Substrate metrics (83% and 84%, respectively). If the index score range is broken into quartiles (e.g., <9.75 is the lowest quartile of possible scores), 49% of survey locations are in the highest score quartile, 33% in the third quartile and only 18% in the lowest two quartiles.

Benthic Macroinvertebrates

Nearly 22,000 benthic macroinvertebrates were identified from surveys conducted at basin-wide locations from the summer samples. Mean estimated abundance per sample was 1521 individuals (range: 146-6465) and mean number of taxa was 37.9 (range: 17-53). Although Class Insecta comprised most of the identified individuals (87%), eight additional Classes were present with Malacostraca (a group of crustaceans, 8%), Bivalvia (mussels, 2%), Gastropoda (snails, 2%) and Clitellata (Oligochaete worms, 2%) each contributing at least two percent to the total individuals. Individuals from the Order Diptera (flies) dominated basin-wide locations at 69% of the total individuals, while Trichoptera was the second most abundant Order at 6% of the total. EPT taxa were 16% of the total individuals and the mean number of EPT per sample was 3.0.

Spring EPT surveys resulted in 5244 individuals collected from 53 species. Mean abundance per location was 125.7 (range: 0-544) and mean species richness was 5.8 (range: 0-16). Ephemeropterans were most abundant, comprising 77% of individuals collected, and Plecopterans least abundant at 3%. *Caenis latipennis* (Ephemeroptera), *Cheumatopsyche sp.* (Trichoptera) and *Acerpenna pygmaea* (Ephemeroptera) were the most common species making up 21%, 18%, and 14% of the total individuals collected, respectively.

Fish

Fifty-three fish species were recorded from basin-wide characterization locations. Mean fish species richness was 12.9 (range: 1-24) and mean abundance was 342.4 (range: 3-2181). Because fish survey effort is proportional to stream size, it may be more appropriate to report standardized values. Mean species richness per 100m was 12.5 (range: 0.9-28.9) and mean abundance per 100m was 359.8 (range: 2.9-2467). The three most frequently occurring species were Green Sunfish (*Lepomis cyanellus*, recorded at 93% of survey locations), Creek Chub (*Semotilus atromaculatus*, 82%) and Bluntnose Minnow (*Pimephales notatus*, 76%). The most abundance species were Creek Chub (15% of the total combined catch of all basin-wide surveys), Red Shiner (*Notropis lutrensus*, 13%) and Sand Shiner (*Notropis stramineus*, 13%). The three species with the highest mean proportional density are Creek Chub (21%), Green Sunfish (8%) and Central Stoneroller (*Campostoma anomalum*, 7%).

Mean IBI score for basin-wide characterization locations was 35.0 with a range of 13 to 55 (Table 9). No locations were scored in the highest IBI category (moderately high), while 3%, 22%, 65%, and 9% were in the very low, low, moderately low and moderate categories, respectively. On average, these locations scored highest in the tolerant species (5.2 of the maximum score of 6), proportion generalist feeders (4.5) and number of native species (4.1) metrics. The lowest scores were observed in the number of intolerant species (an average of 0.7 of the maximum score of 6) and number of sucker species (2.2) metrics.

Objective 2: Sensitive Species Survey Events

Twelve of the fifteen sensitive species locations (Objective 2) were surveyed in each study year, and one trio was surveyed in both 2013 and 2014 (Table 4). Spring EPT were collected at each location in 2014 and 2015. Fall water quality measurements were taken at all locations in 2013 and at nine locations in 2014.

Water Quality

Mean dissolved oxygen, conductivity, pH, ammonia and turbidity were higher in fall, nitrates were lower and reactive phosphorus was not measurably different from the summer samples (Table 5). Dissolved oxygen exceeded the Standard in 5% of samples, reactive phosphate 0.91 of samples and Standards were not violated for pH and ammonia (Table 6).

Physical Habitat

QHEI scores ranged from 35.5 to 71 with a mean of 56.0 (Table 7). No sensitive species locations scored in the excellent QHEI category, while 5% were impaired, 66% were moderate and 29% were good. Collectively, sensitive species locations scored lowest on the Riffle-Run metric (32%) of the maximum metric score) and highest on the Channel Morphology metric (71%). IHI scores ranged from 13 to 24 with a mean of 19.4 (Table 8). Half of the sensitive species locations had IHI scores in the highest quartile of possible scores, 45% in the third quartile and 5% in the second quartile. These locations scored high relative to the maximum in the Substrate Ratio (94%) and the Buffer and Bare Bank metrics (93%).

Benthic Macroinvertebrates

One hundred eighty-eight taxa and 13,742 individuals were identified from summer macroinvertebrate surveys at sensitive species locations. Mean species richness of identified individuals was 47.5 (range: 30-61) and mean estimated abundance in the samples was 3344 (range: 353-9255). Class Insecta was 94% of the total individuals and Malacostraca was 4% (all other taxa were <0.01). Dipterans were 58%, Trichopterans 16%, Ephemeropterans 14%, Amphipods 3%, Coleopterans (beetles) 2%, Odonates (dragonflies and damselflies) 2% and fourteen other taxa had less than 1% of identified individuals. EPT taxa were a combined 31% of identified individuals.

Spring EPT surveys at sensitive species locations collected 834 individuals from 26 taxa. Mean abundance was 259 (range: 7-773) and richness was 14.5 (range: 1-22) per location. Ephemeropterans were 57% of the collected individuals, Tricopterans 30% and Plecopterans 13%. *Cheumatopsyche sp.* was the most numerous taxa (18% of the individuals) followed by *Perlesta sp.* (Plecoptera, 13%), *Caenis latipennis* (12%) and *Nectopsyche candida* (Tricoptera, 10%).

Summer macroinvertebrate surveys at sensitive species locations included 37 of the 82 species sensitive to low dissolved oxygen concentrations (IDNR and IEPA 2006). Spring EPT surveys recorded nine of these sensitive species, two of which were not found during summer surveys. No mussel species sensitive to low dissolved oxygen concentrations were recorded near sensitive species locations during recent surveys conducted by the INHS (Shasteen et al. 2013). Fish surveys had been completed at three sensitive species locations during the most two recent IDNR Basin Survey events (2007 and 2012), and one contained two species sensitive to low dissolved oxygen concentrations.

Summer macroinvertebrate samples were processed in both 2013 and 2014 at 14 of the 15 sensitive species locations. Mean change in species richness between years was 21% (range: 1-126%) and mean change in estimated abundance was 183% (range: 6-658%). There was no obvious pattern with regards to which year resulted in the highest richness or abundance as half of the locations were higher in 2013. Higher richness and abundance occurred in the same year at nine of the thirteen (69%) locations where both values could be calculated.

Objective 3: Long-Term Trend Survey Events

Long-term locations were surveyed in 2014 and 2015 following their establishment by the ISWS (ISWS 2015; Table 4). Water quality measurements were taken in three of the four locations in fall 2014. Spring EPT were collected at one location in 2014 and two locations in 2015.

Water Quality

Seven summer and three fall water quality measurement events occurred between 2014 and 2015. Dissolved oxygen, reactive phosphate and turbidity were higher in fall, conductivity and nitrates higher in summer and there was no seasonal difference observed for pH or ammonia (Table 5). No Standards were exceeded for pH or ammonia, but dissolved oxygen was below the Standard in 20% of events and reactive phosphate above the Standard in 90% of samples (Table 6).

Physical Habitat

Mean QHEI score for long-term trend locations was 51.8 with a range of 31 to 71.5 (Table 7). If the mean score is calculated using the 2014 and 2015 evaluations, two long-term trend locations were within the moderate category and one each in the impaired and good categories. Relative to the maximum score, the highest scoring metric was Channel Morphology (66% of the maximum possible score) and the lowest was Riffle and Run (28%). Mean IHI score was 19.8 and the range was 16 to 24. If 2014 and 2015 scores are averaged, two locations were in the third quartile and two in the fourth quartile. Long-term trend locations scored highest relative to the maximum score in the Substrate Ratio metric (100%) and lowest in the Riffle metric (60%).

Benthic Macroinvertebrates

Mean summer macroinvertebrate species richness was 42.8 (range: 38-48) and mean abundance per sample was 2599 (range: 1092-4358). Eighty-nine taxa from seven Classes were identified. Class Insecta was most abundant (88% of identified individuals) followed by Bivalvia (5%), Clitellata (3%) and Gastropoda (2%). Dipterans were the most abundant Order (57%) followed by Ephemeroptera (27%) and Veneroida (mussels which include Asian Clams, 5%). All other Orders comprise less than five percent of the total identified individuals. EPT taxa were 20% of identified individuals although no Plecopterans were observed.

Mean species richness for spring EPT surveys was 5.7 (range: 4-7) and mean abundance was 115 (range: 105-125). A total of twelve taxa were identified. Ephemeropterans comprised 76% of the total identified individuals and Trichopterans and Plecopterans were 24% and <1%, respectively. *Caenis latipennis* (34% of the identified individuals), *Acerpenna pygmaea* (31%) and *Cheumatopsyche sp.* (22%) were the numerically dominant taxa.

Fish

Electrofishing surveys occurred at three long-term trend locations in 2014 and 2015; however, one location was too deep to wade. Twenty-nine fish species and 2564 individuals were collected. Mean species richness 16.8 (range: 15-21) and mean abundance was 427 (range: 128-1323) while mean standardized richness was 11.0 per 100m (range: 6.0-15.4) and mean standardized abundance was 567 per 100m (range: 29-2366). Bigmouth Shiner (*Notropis dorsalis,* 16% of total individuals), Silverjaw Minnow (*Ericymba buccata,* 14%) and Sand Shiner (*Notropis stramineus,* 10%) were the most abundant species. Blackstripe topminnow (*Fundulus notatus*), Bigmouth Shiner and Green Sunfish had the highest mean proportional density at 9%, 8% and 8%, respectively.

Mean IBI score was 41.8 (range: 33-46). Using the mean of 2014 and 2015 surveys, all three locations score in the moderately low category. Long-term trend locations have high mean scores for the number of minnow species, number of invertivore species, proportion of generalist feeders and proportion tolerant species metrics, while they score low in the number of intolerant species metric (Table 9.)

SECTION 5 – SYNTHESIS OF MONITORING DATA AND DATA FROM EXTERNAL SOURCES

Survey procedures used during this monitoring program were standardized across location types and followed procedures used by State agencies. Therefore, combining data from each monitoring objective and from State agencies expands spatial, temporal and environmental gradient coverage. IDNR, IEPA and INHS data were combined with data collected during project monitoring activities to evaluate stream temperature, water quality, habitat, fish and mussels.

Temperature

Summer temperature was recorded at 60 stream segments for this monitoring program between 2013 and 2015 (Table 3). Thirty-four records from 27 segments within the Kaskaskia River basin were collected between 2003 and 2009 for a statewide evaluation of stream temperature (Hinz et al. 2011) and these records were added to those collected during this monitoring program. Mean daily summer (July or August) temperature was 23.4^{o}C with a range of 18.9 to 27.2^{o}C. Using thermal categories proposed by Wehrly et al. (2003) and Hinz et al. (2011), 21% of segments with records would be classified as coolwater (<22.0^{o}C), 30% as transitional (22.1-23.7^{o}C) and 49% as warmwater (>23.7^{o}C, Figure 24). Mean daily summer temperature range was 3.2^{o}C (range: 0.8-8.8^{o}C) and mean daily summer maximum was 25.1^{o}C (range: 19.3-32.1^{o}C). Multiple linear regression models selected based on Akaike Information Criterion (AIC) were used to estimate stream temperature at all Kaskaskia River basin segments using records for the 87 segments where data were available. Individual models were constructed for mean of the maximum daily summer temperature, mean of the daily summer temperature and mean daily temperature range. The pool of potential independent variables included weather (air temperature and precipitation), stream channel characteristics (size and gradient), land use (summarized at local and upstream catchment scales) and geology (summarized at local and upstream catchment scales). Simple linear regression using each independent variable was conducted first and results from these models were used to select combinations of variables for multiple linear regression analysis. Forty models were completed for each temperature measure and all models within two ΔAIC of the top model were retained (Table 10). Retained models were weighted according to their calculated likelihood values. Twenty percent (17) of temperature records were reserved for model validation. Air temperature, stream size and proportion of agricultural land use were important in nearly all models, while geology was important to some (Table 10). Mean difference between measured mean of the maximum and the associated model was 1.6°C, for the mean of the mean it was 1.2°C and for the mean range it was 1.4°C. Given these mean error values are similar to the temperature range between the three thermal categories (i.e., only 1.7°C separates cool from warm), model estimates are placed into quartiles. Quartiles were used to categorize model outputs as relationships between temperature and biota have not been evaluated for the Kaskaskia River basin; therefore, models should be used to evaluate relative thermal characteristics.

When the models were used to estimate thermal characteristics within the Kaskaskia River basin some spatial patterns emerge (Figures 25-27). The Upper HUC8 had the highest density of cooler stream reaches (Figure 25). The highest quartile of the maximum daily temperature tended to be populated by low order streams, with the highest density in the Upper HUC8 (Figure 26). Low order streams also were more numerous in the highest quartile of the daily temperature range estimates and were most dense in the Upper and Lower HUC8s (Figure 27). When quartile categories for each model are summed (lowest = 1, middle two = 2, highest = 3), mid-order streams tended to be the coolest and most stable and low order tended to be warmest and least stable (Figure 28). The Upper HUC8 has the highest density of cool and stable streams, while the Lower HUC8 has the highest density of warm and variable streams.

Water Quality

Between 1999 and 2011 the IEPA completed a combined total of 14,437 ammonia, nitrite and nitrate nitrogen, phosphorus and turbidity measurements at 247 locations for their Ambient Water Quality program. Measurements are taken approximately nine times annually at locations ranging from wadeable streams to the mainstem Kaskaskia River. Some locations are immediately downstream of permitted discharges. The mean ammonia concentration for all location and date combinations was 0.37mg/L and the range of annual means was 0.08 to 0.33mg/L (Figure 29). Mean nitrate plus nitrite concentration was 2.90mg/L with a range of annual means of 1.85 to 3.57mg/L. When nitrate was evaluated as a separate analyte it comprised 2% of the nitrate plus nitrite total making it a minor contributor to total nitrogen. Nitrate plus nitrite could therefore be considered analogous to the nitrate measurements taken during this study. The mean dissolved phosphorus concentration was 1.36mg/L with a range of annual means of 0.14 to 0.29mg/L. Mean turbidity was 52 absorption units with a mean annual range of 25 to 73. The turbidity measurement procedures used by the IEPA differ from those used in this study, but the measures were roughly equivalent.

Physical Habitat

One hundred twenty-eight QHEI evaluations were completed by the IEPA during the 2007 and 2012 Basin Survey events in the Kaskaskia River basin. Mean index score was 54.4 (Table 7) with a range of 25.5 to 83. Almost half (45%) of locations were in the moderate category, 23% in the impaired category, 29% in the good category and 4% in the excellent category. IEPA locations scored highest relative to the maximum score in the Substrate (59% of the maximum possible score) and Pool and Current (59%) metrics and lowest in the Riffle and Run (21%) metric.

When QHEI evaluations from this study and the IEPA are combined, the mean QHEI score is 52.6 (Table 7). Impaired locations comprise 27% of evaluated streams, 46% are moderate, 24% are good and 3% are excellent. The Middle, Shoal Creek and Lower HUC8s had similar QHEI scores while the Upper was about ten percent lower than the other subwatersheds (Table 11). The Upper HUC8 scored lower than the other subbasins in the Cover, Riparian, Pool and Current and Gradient metrics. The Upper HUC8 had the highest proportion of impaired locations, while the Lower had the highest proportion of good locations (Figure 30).

Benthic Macroinvertebrates

The Upper HUC8 had the highest mean number of Orders recorded per survey followed by the Middle, Shoal Creek and Lower HUC8s (Table 12). The Lower HUC8 had a lower mean number of taxa than the other HUC8s, which all had similar values. The Lower HUC8 also had the lowest mean abundance per survey followed by the Upper, Middle and Shoal Creek HUC8s.

The top five and seventeen of the top 20 most frequently occurring benthic macroinvertebrate taxa were Chironomids (Diptera; Table 13). The remaining taxa in the top 20 were one Trichopteran, one Oligochaete and one Elimid (riffle beetle). Occurrence rank for each taxa varied between HUC8s, but the top twelve taxa in the whole watershed were in the top 20 of each HUC8. Fourteen of the top 20 most abundant taxa are Chironomids, three were Ephemeropterans, while Amphipoda, Similiidae (Diptera) and Trichoptera each have one taxa in the top 20 (Table 14). HUC8 ranks for each taxon are highly variable relative to the watershed rank as only the top four taxa are in the top 20 for each HUC8.

Mean spring EPT taxa richness for the Upper, Middle, Shoal Creek and Lower HUC8s was 9.4, 7.5, 7.5 and 5.1, respectively, while mean abundance was 228, 130, 110 and 142, respectively. EPT taxa made up 20% of the total summer benthic macroinvertebrates collected. Only ten Plecopterans were collected (<1% of total), while Trichopterans were 11% of the total and Ephemeropterans were 9%.

Fish

Fifty-seven electrofishing surveys were conducted by the IDNR in 2007 or 2012 in the Kaskaskia River basin. The mean number of species recorded was 14.8 and mean abundance was 521. Standardized richness and abundance values using sample effort cannot be calculated as the necessary information is not included in the IDNR database for many surveys. Mean richness for the Upper, Middle, Shoal Creek and Lower HUC8s was 19.7, 12.7, 11.7 and 14.0, respectively. The Upper HUC8 also had the highest mean abundance (998) followed by the Middle (395), Lower (357) and Shoal Creek (132) subbasins. Mean richness and abundance was lower in 2012 (12.0 and 180, respectively) than in 2007 (18.0 and 928).

When electrofishing surveys from this study and the IDNR Basin Surveys are combined, mean fish richness is 13.8 (range: 1-39) and mean abundance is 431 (range: 3-6920). Lower mean richness and abundance values for this monitoring program is not surprising given IDNR streams were larger on average (mean link 37 for IDNR and 10 for monitoring locations). Mean richness for the Upper, Middle, Shoal Creek and Lower HUC8s was 14.8, 12.8, 13.9 and 13.2, respectively. Mean abundance for the Upper, Middle, Shoal Creek and Lower HUC8s was 540, 403, 337 and 369, respectively. The number of species recorded was greatest in the Upper HUC8 (56 species) followed by Shoal Creek (54), Middle (51) and Lower (46) HUC8s.

Considering both this study and IDNR information, Green Sunfish, Creek Chub and Yellow Bullhead (*Ameirus natalis*) are the three most frequently occurring species at surveyed locations (Table 15). Green Sunfish occurred at 91% of surveyed locations and Creek Chub and Yellow Bullhead each occurred at 73%. All of the top 20 most frequently occurring species were recorded at 29% or more of survey locations and the top eleven species were recorded from at least half of locations. Some species ranks were relatively stable across HUC8s (e.g., Green Sunfish, Creek Chub, Blackstripe Topminnow), but others varied greatly, like Creek Chubsucker (*Erimyzon oblong;* 22 rank range) and Pirate Perch

(*Aphredoderus* sayanus; 16). Bluntnose Minnow, Sand Shiner and Creek Chub were the three most abundant species over all survey locations (Table 16). These three species comprised 13%, 13% and 11% of the total individuals collected, respectively. All of the top 20 most abundant species made up at least one percent of the total individuals collected and each of the top seven species at least five percent of the total, together making up 67% of the total. The top 20 most abundant species comprised 93% of the total individuals collected. There is less abundance rank stability across HUC8s than for frequency of occurrence. For example, Striped Shiner (*Luxilus chrysocephalus*) is the twelfth most abundant species in the Upper HUC8, but was not found in the other three subbasins. The mean range of abundance ranks across HUC8s for a species is 10.5 while the mean for frequency of occurrence is 7.8.

Mean IBI score for this study and IDNR surveys is 35.7 (range: 1-59; Table 17). Most IBI scores were within the middle categories with 6% of scored locations categorized as Very Low, 18% as Low, 61% as Moderately Low, 14% as Moderate and 1% as Moderately High. The mean basin-wide score was lowest for the intolerant species and sucker species metrics (0.9 and 2.4, respectively) and highest for the tolerant species and proportion generalist feeder metrics (5.1 and 4.8, respectively). The Lower HUC8 had the highest mean IBI score, followed by the Middle, Upper and Shoal Creek HUC8s (Table 17). The Middle, Shoal Creek, and Lower HUC8s scored below 0.5 in the intolerant species metric while the Upper HUC8 scored 1.8. The Upper HUC8 scored substantially lower in the number of species and number of invertivore species metrics when compared to the other three HUC8s. The Middle and Shoal Creek HUC8s had the highest proportion of locations scored as Very Low or Low (31% and 30%, respectively) and the Shoal Creek and Upper HUC8s had the lowest proportion of Moderate or Moderately High locations (13% for both; Figure 31).

Mussels

Mussel community information is summarized from Shasteen et al. (2013). Thirty-two species of mussels were found live at survey locations, and mean species richness was 4.1 (range: 0-15). No live mussels were recorded at 23 locations (24% of locations) and an additional nine locations (9%) had only one species. Mean abundance was 36.4 (range: 0-349) per survey. Mean richness for the subbasins was 7.2, 2.1, 5.9 and 5.8 for the Upper, Middle, Shoal Creek and Lower HUC8s.

Many of the most frequently observed and most abundant species were not collected in all HUC8s (55% of top 20 species in both cases; Table 18, 19) suggesting mussel populations exhibit patchy or restricted distributions in the Kaskaskia River basin. In particular the Middle and Lower HUC8s lack many of the top 20 species of the basin. Two of the top 20 most frequently encountered species (*Tritogonia verrucosa [Pistolgrip]* and *Ligumia recta [Black Sandshell]*) and one of the top 20 most abundant species (*Tritogonia verrucosa*) are SGCN.

Mussel communities can be evaluated using the Freshwater Mussel Classification Index (MCI, IDNR 2006). The MCI uses four metrics, the sum of which places a community into one of five qualitative categories along scale ranging from four to 20. Mean MCI score for the basin 6.8 (range: 0-15) and 31% of evaluated locations were ranked Restricted, 21% Limited, 33% Moderate, 16% Highly Valued and none were Unique. Mean MCI scores for the subbasins were 7.2, 4.6, 8.5 and 7.0 for the Upper, Middle, Shoal Creek and Lower HUC8s, respectively. The Upper and Middle HUC8s had the highest proportion of locations in the Restricted category, while the Upper and Shoal Creek HUC8s had the highest proportion in the Highly Valued category (Figure 32). Overall, the frequency distribution of MCI is skewed toward the poorer categories.

SECTION 6 – SUMMARY OF GRADUATE STUDENT RESEARCH

Two University of Illinois Urbana-Champaign graduate students enrolled in Master of Science programs were funded through this project and conducted research to further understanding of aquatic communities in the Kaskaskia River basin. Their research is briefly summarized here in abstracts from their theses.

<u>Relative Importance of Conservation Reserve Programs to Mayfly, Stonefly and Caddisfly Species Richness in the Kaskaskia River Basin of Illinois – Eric South, Department of Entomology</u>

The Conservation Reserve (CRP) and Conservation Reserve Enhancement Programs (CREP), funded by federal and state government, offer farmers financial incentives to take erosive agricultural lands out of production. Within these program landscapes, several best management practices, including riparian zone easements and restoration, are used along streams and wetlands to improve habitat for riparian and in-stream species (State of Illinois 2013). This thesis investigates the efficacy of CRP and CREP lands to support assemblages of three environmentally sensitive orders, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT) in the Kaskaskia River basin, a heavily impacted, predominantly agricultural watershed in central and southern Illinois. A total of 10,522 EPT specimens were examined from 84 sites across the basin during May and June of 2013-2015. Seventy-six variables from geographic information system (GIS) and in-situ generated variables were used in an Akaike information criterion analysis (AICc) to construct a set of 13 best regression models accounting for variance in EPT basin richness. AICc importance values and hierarchical partitioning revealed five important variables associated with EPT richness: Link (number of first order tributaries), WT_Perm (soil permeability at the total catchment level), WT_Urban (urban land use at the total catchment level), Silt, and DO (dissolved oxygen). AICc showed that Link and WT_Perm have the highest importance value (1.00), followed by WT_Urban (0.99), and Silt (0.83). Individual percent contribution (*% I*) as determined by hierarchical partitioning placed DO third among these five variables. The amount of CRP/CREP land in the drainage ranked low in relative importance and *% I* contribution, suggesting that this mosaic of conservation practices may not contribute significantly to supporting highly diverse EPT assemblages.

The full document can be found at: http://hdl.handle.net/2142/90890

<u>Impacts of Voluntary Private Lands Programs on Stream Fish Diversity in the Kaskaskia River Basin, Illinois – Levi Drake, Department of Natural Resources and Environmental Science</u>

Freshwaters support over 40% of fish species diversity, as well as one-third of all vertebrate species, yet remain one of the most threatened habitats globally. Anthropogenic disturbances have caused many negative impacts throughout history, and continue to do so today. After the dust bowl we began to inch our way toward smarter management of our watersheds. This eventually spurred the development of best management practices (BMPs) to combat non-point source pollution. Voluntary private lands programs such as the Conservation Reserve Program (CRP) look to offer monetary incentives to landowners willing to implement conservation practices on their lands. Biological goals, such as increased native bird or fish populations, are sometimes included in programs like CRP and little has been done to evaluate whether those goals are being achieved or not. Sampling can often be expensive for these endeavors, so alternative measures for obtaining this information are valuable. Species distribution modeling (SDM) has provided us with a chance to gain more information about communities without additional sampling effort. I look to balance sampling efforts with species distribution modeling to investigate the effects of CRP of stream fish species richness.

In this study, I use data from two Illinois fisheries datasets in combination with modeled environmental data to predict the presence or absence of 64 fish species across the Kaskaskia River basin using random forest classification. Of the 64 modeled species, 52 SDMs met my model performance requirements (TSS>0.2). These 52 SDMs were then stacked to obtain an index of species richness across the basin, and then the species richness values were compared with observed richness of modeled species, via regression, for accuracy. The regression deviated from the ideal 1:1 line, but Theil's Inequality Coefficient indicated a very strong matchup between observed and predicted richness (U=0.012). Based on this, I concluded that my SDMs were able to provide an accurate representation of species richness when the predictions of individual species models were stacked.

I developed a novel standardization method using a house-neighborhood framework. "Neighborhoods" were built around a group of fish sampling sites in the Kaskaskia River basin, Illinois. The species richness of the neighborhood was then used to standardize species richness at fish sampling sites. It is expected that a site in a neighborhood with high species richness would have more species than a site in a neighborhood with low species richness. Standardization based on the neighborhood species richness removes this species pool effect from my models. Logit regression was then used to assess the effect of local habitat variables including CRP on species richness. Proportion of CRP lands within the local watershed for sampled sites ranged from 0% to 45.13%. Using the dredge function within the MuMIn package in R, all possible models were explored. R2 values were low across all models, ranging from R2 = 0.0915 to R2 = 0.2367. The best models (ΔAIC<2) took various combinations of in-stream habitat characteristics with large substrate consistently being ranked as one of the most important variables for species richness. The proportion of CRP lands in the local watershed was not taken as a predictor for any of the top models, while local habitat variables were found to be the most common factors influencing species richness. In conclusion, my study was unable to detect any major influence from CRP on stream fish species richness, and shows that local habitat factors are drivers of species richness when removing species pool effects from models. More rigorous targeting in the CRP implementation plans may help to increase the effect that CRP lands can have on fish species richness.

The full document is pending.

SECTION 7 –SUMMARY

The Kaskaskia River basin is a biologically diverse system with 53% of Illinois' fish species, 47% of mussel species and 22% of the total BSS length. The basin's landscape is highly disturbed, though, as 80% of the total land cover is urban or agriculture, and tied to this disturbance is a high frequency of stream channel and hydrology modification. But, approximately 939km^2 of the basin (6% of the land area) is protected through public ownership or private easements, including approximately 661km^2 (4%) in private land conservation programs.

The primary goal of this monitoring program is to provide baseline information regarding chemical, physical and biological characteristics of streams in the Kaskaskia River basin. Information from these monitoring efforts and from State agencies and Universities provide a characterization of the basin at the initiation of CREP enrollments within the basin, which may be used to evaluate temporal changes as CREP matures. Monitoring methods were selected specifically to correspond with existing survey programs (e.g. IDNR Basin Surveys) and for their repeatability as monitoring continues.

Characterization of the Kaskaskia River basin incorporated nearly 4000 evaluations of streams, including 378 habitat evaluations, 180 electrofishing events, 175 benthic macroinvertebrate surveys and 96 mussel surveys. In general, larger streams had greater fish, benthic macroinvertebrate and mussel richness. Using six quantitative and qualitative biological metrics, the Shoal Creek HUC8 had greatest diversity followed by the Upper, Lower and Middle subbasins (Table 20).

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Table 1. Proportion of Kaskaskia River basin local catchments in each NFHP disturbance category (Esselman et al. 2011).

Disturbance Rating	Kaskaskia Basin	Upper Subbasin	Middle Subbasin	Shoal Creek Subbasin	Lower Subbasin
Very Low	0.00	0.00	0.00	0.00	0.00
Low	0.18	0.08	0.23	0.20	0.19
Moderate	0.39	0.21	0.49	0.44	0.42
High	0.29	0.60	0.17	0.25	0.22
Very High	0.06	0.03	0.03	0.05	0.10

Table 2. Fish and mussel species of conservation concern recorded since 2000 in the Kaskaskia River basin. SGCN = Species in Greatest Conservation Need (IDNR 2015), ST = State Threatened, SE = State Endangered, FE = Federally Endangered.

Common Name	Scientific Name	Taxon	Conservation Status	SGCN Listing Criteria	Number of Locations Since 2000
Brown Bullhead	*Ameiurus nebulosus*	Fish	SGCN	Rare, habitat	2
Flier	*Centrarchus macropterus*	Fish	SGCN	Rare, habitat	1
Pugnose Minnow	*Opsopoeodus emiliae*	Fish	SGCN	Rare, habitat	2
Western Sand Darter	*Ammocrypta clara*	Fish	SGCN/SE	Rare, habitat	8
Black Sandshell	*Ligumia recta*	Mussel	SGCN/ST	Rare	7
Elktoe	*Alasmidonta marginaa*	Mussel	SGCN	Declining	1
Monkeyface	*Theliderma metanevra*	Mussel	SGCN	Rare, declining	2
Pistolgrip	*Tritogonia verrucosa*	Mussel	SGCN	Declining	17
Snuffbox	*Epioblasma triquetra*	Mussel	SGCN/FE/SE	Rare, declining, habitat, other vulnerabilities	1
Spike	*Eliptio dilatata*	Mussel	SGCN/ST	Rare, habitat	5
Wartyback	*Amphinaias nodulata*	Mussel	SGCN	Rare, declining	3

Table 3. Frequency of survey events and number of locations (unique stream segments) for physiochemical and biotic characterization of streams in the Kaskaskia River basin.

	Number of Survey Events					
Evaluated Characteristic	Basin-Wide Status (Obj. 1)	Sensitive Species (Obj. 2)	Long-term Trend (Obj. 3)	Student Research	Total Events	Total Segments
Temperature Regime	47	18	2	0	67	60
Water Quality	117	66	11	16	210	126
Habitat	87	42	8	34	171	159
Fish	84	0	6	34	124	110
Benthic Macroinvertebrates	78	42	8	23	151	126
Spring EPT Macroinvertebrates	68	30	3	0	101	86
Total Locations:	94	15	4	31		

Table 4. Frequency of basin-wide characterization surveys (Objective 1) within each stratum.

Stratum		HUC8 Subbasin				
Size Class	CRP Class	Upper	Middle	Shoal	Lower	Total
1	1	5	3	2	3	13
1	2	2	2	4	3	11
1	3	3	4	4	3	14
1	4	2	3	2	3	10
1	5	3	3	2	1	9
2	1	2	0	3	4	9
2	2	1	2	2	3	8
2	3	2	1	2	2	7
2	4	4	3	0	2	9
2	5	1	2	1	0	4
	Total:	25	23	22	24	

Table 5. Mean (and range) of seven water quality parameters measured at survey locations in the Kaskaskia River basin.

Location Type	Period	Dissolved Oxygen (mg/L)	Conductivity (µS/cm)	pH	Nitrate (mg/L)	Ammonia (mg/L)	React. Phosphate (mg/L)	Turbidity (AHU)
Basin-Wide	Summer	7.0 (1.1 - 13.2)	578 (96 - 857)	7.9 (7.2 - 9.0)	3.0 (0 - 16.5)	0.1 (0 - 2.5)	0.8 (0 - 7.0)	28 (1 - 177)
	Fall	8.6 (0.4 - 17.2)	663 (293 - 1202)	8.4 (7.7 - 8.8)	2.4 (0 - 9.7)	0.3 (0 - 6.4)	1.3 (0 - 10.7)	37 (5 - 153)
Sensitive Species	Summer	8.4 (5.7 - 13.4)	671 (180 - 1570)	8.1 (7.2 - 8.6)	3.4 (0.1 - 14.4)	0.1 (0 - 1.0)	0.6 (0.2 - 1.4)	24 (6 - 73)
	Fall	11.5 (1.6 - 15.6)	787 (367 - 2035)	8.3 (7.2 - 9.0)	3.1 (0 - 12.0)	0.4 (0 - 4.5)	0.6 (0 - 1.6)	28 (6 - 59)
Long-Term	Summer	7.2 (4.8-8.4)	583 (269-820)	8.0 (7.9-8.2)	3.2 (0.9-9.2)	0.1 (0-0.3)	0.5 (0-1.1)	28 (15-66)
	Fall	7.5 (1.8-16.0)	543 (369-659)	8.0 (7.8-8.5)	1.4 (0.8-2.3)	0.1 (0-0.1)	1.7 (0.3-3.2)	58 (40-84)

Table 6. Illinois Environmental Protection Agency General Use Water Quality Standards and proportion of water quality measurements exceeding those Standards (i.e., “Not Met”).

	Dissolved Oxygen (mg/L)		pH		Ammonia (mg/L)		React. Phosphate (mg/L)	
Location Type	**Standard**	**Not Met**	**Standard**	**Not Met**	**Standard***	**Not Met**	**Standard****	**Not Met**
Basin-Wide	5.0 March-July, 3.5 August-February	0.16	6.5-9.0	0	7.37/1.27	0/0.04	0.05	0.92
Sensitive Species	5.0 March-July, 3.5 August-February	0.05	6.5-9.0	0	7.37/1.27	0/0	0.05	0.91
Long-Term	5.0 March-July, 3.5 August-February	0.20	6.5-9.0	0	7.37/1.27	0/0	0.05	0.90

* First value is acute Standard and second is chronic. Values were calculated with mean pH (8.069) and mean temperature (23.0^{o}C).

** There is no reactive phosphorus Standard for most streams; however, the Standard for lakes is 0.05mg/L, which can serve as a benchmark.

Table 7. QHEI metric and index scores for survey locations in the Kaskaskia River basin. IEPA scores acquired from Bureau of Surface Water via personal data request.

	Metrics							
Location Type	Substrate	Cover	Channel	Riparian	Pool-Current	Riffle-Run	Gradient	QHEI Score
Basin-Wide	8.4	9.9	12.7	5.8	5.9	2.1	6.4	51.2
Sensitive Species	9.2	10.9	14.2	6.5	7.5	2.5	5.2	56.0
Long-Term	9.6	9.4	13.1	5.2	6.0	2.3	6.3	51.8
IEPA	11.8	11.5	11.0	5.6	7.1	1.7	5.8	54.4
All Sources	10.2	10.8	11.7	5.6	6.5	1.8	6.0	52.6
Maximum Possible Score:	20	20	20	10	12	8	10	100

Table 8. IHI metric and index scores for survey locations in the Kaskaskia River basin.

	Metrics					
Location Type	**Buffer-Bare**	**Substrate**	**Shade**	**Riffle**	**Woody Debris**	**IHI Score**
Basin-Wide	4.2	4.2	3.0	3.5	3.3	18.3
Sensitive Species	4.6	4.7	2.6	3.5	4.0	19.4
Long-Term	4.5	5.0	3.3	3.0	4.0	19.8
Maximum Possible Score:	5	5	4	5	5	24

Table 9. IBI metric and index scores for survey locations in the Kaskaskia River basin.

	Metrics										
Location Type	Number Species	Minnow Species	Sucker Species	Sunfish Species	Invertivore Species	Intolerant Species	Proportion Invertivore	Proportion Generalist	Proportion Coarse Substrate Spawners	Tolerant Species	IBI Score
Basin-Wide	3.6	4.1	2.2	3.9	3.8	0.7	3.8	4.5	3.9	5.2	35.0
Long-Term	4.8	5.2	3.0	4.3	5.5	0.5	3.5	5.3	4.5	5.1	41.8
Maximum Possible Score:	6	6	6	6	6	6	6	6	6	6	60

Table 10. Parameters and relationship (positive or negative) to modeled characteristic of temperature models for the Kaskaskia River basin.

Model	Model Parameters (Relationship)	ΔAICc	Model Weight
Mean 1	Air Temperature(+), Drainage Area(+), Riparian Agriculture(+), Watershed Soil Permeability(-)	0	0.30
Mean 2	Air Temperature(+), Drainage Area(+), Riparian Agriculture(+)	1.72	0.13
Mean 3	Air Temperature(+), Drainage Area(+), Riparian Agriculture(+), Watershed Soil Permeability(-), Local Catchment Soil Permeability(+)	1.73	0.13
Maximum 1	Air Temperature(+), Drainage Area(+), Riparian Agriculture(+)	0	0.33
Maximum 2	Air Temperature(+), Drainage Area(+), Riparian Agriculture(+), Watershed Depth to Bedrock(+)	1.67	0.14
Maximum 3	Air Temperature(+), Drainage Area(+), Riparian Agriculture(+), Watershed Soil Permeability(-)	1.73	0.14
Maximum 4	Air Temperature(+), Drainage Area(+), Riparian Agriculture(+), Precipitation(-)	1.93	0.12
Variation 1	Precipitation(-), Drainage Area(+), Riparian Agriculture(+)	0	0.26
Variation 2	Precipitation(-), Riparian Agriculture(+)	0.22	0.23

Table 11. QHEI metric and index scores for survey locations (IEPA and this monitoring program; 2007-2015) in the Kaskaskia River basin.

	Metrics							
HUC8	**Substrate**	**Cover**	**Channel**	**Riparian**	**Pool-Current**	**Riffle-Run**	**Gradient**	**QHEI Score**
Upper	10.6	9.9	11.2	5.3	5.6	1.8	5.3	49.7
Middle	10.2	10.7	12.9	6.2	6.4	1.5	6.2	54.2
Shoal Creek	9.7	11.2	13.5	5.9	7.5	2.2	5.6	55.7
Lower	9.5	11.8	11.0	5.6	7.3	2.2	6.9	54.2
Maximum Possible Score:	20	20	20	10	12	8	10	100

Table 12. Mean macroinvertebrate number of orders, number of taxa and abundance in Kaskaskia River basin HUC8s. Values are derived from collections in 2013 and 2014 from survey locations.

HUC8	Orders	Taxa	Abundance
Upper	9.9	45.2	1919
Middle	9.6	46.2	2140
Shoal Creek	8.8	46.7	3219
Lower	8.4	38.4	1324

Table 13. Rank frequency of occurrence for the top 20 most common benthic macroinvertebrate species in wadeable streams of the Kaskaskia River basin. Values are derived from collections in 2013 and 2014 from survey locations. "T" denotes a tie.

		Subbasin Rank			
Taxon	**Watershed Rank**	**Upper**	**Middle**	**Shoal**	**Lower**
Thienemannimyia gr. sp.	1	1	6	2	T-8
Tanytarsus sp.	T-2	T-6	T-1	1	T-2
Polypedilum illinoense gr.	T-2	2	7	T-3	T-1
Paratanytarsus sp.	T-3	3	T-1	T-5	T-14
Ablabesmyia mallochi	T-3	T-4	T-1	T-5	T-8
Cheumatopsyche sp.	4	T-6	T-4	T-7	T-2
Polypedilum flavum	5	T-6	T-4	T-7	T-8
Cryptochironomus sp.	6	T-4	15	T-10	T-2
Procladius sp.	7	T-6	T-10	T-7	T-14
Chironomus sp.	8	T-15	T-8	T-10	T-1
Polypedilum scalaenum gr.	T-9	T-13	T-8	13	T-2
Cladotanytarsus sp.	T-9	10	T-10	T-10	T-14
Dicrotendipes neomodestus	10	17	T-10	T-3	T-8
Phaenopsectra sp.	11	T-11	T-10	T-14	T-8
Tubificidae	12	T-11	T-10	20	T-2
Paratendipes sp.	13	T-15	T-19	T-23	T-24
Saetheria tylus	T-14	T-21	T-19	16	T-71
Rheotanytarsus exiguus gr.	T-14	T-28	T-24	T-14	T-24
Labrundinia sp.	15	18	T-16	T-27	T-14
Stenelmis sp.	16	T-21	T-31	17	T-24

Table 14. Rank abundance for the top 20 most abundant benthic macroinvertebrate taxa in wadeable stream of the Kaskaskia River basin. Values are derived from collections in 2013 and 2014 from survey locations. "T" denotes a tie.

		Subbasin Rank			
Taxon	Watershed Rank	Upper	Middle	Shoal	Lower
Cheumatopsyche sp.	1	6	3	1	4
Polypedilum flavum	2	4	2	2	5
Polypedilum illinoense gr.	3	1	4	4	13
Tanytarsus sp.	4	3	5	3	9
Cladotanytarsus sp.	5	7	1	6	40
Chironomus sp.	6	14	16	5	3
Procladius sp.	7	13	6	12	10
Paratanytarsus sp.	8	11	7	8	6
Ablabesmyia mallochi	9	11	10	10	8
Simulium sp.	10	2	17	14	18
Polypedilum scalaenum gr.	11	10	14	11	12
Thienemannimyia gr. sp.	12	9	13	13	7
Dicrotendipes neomodestus	13	22	12	9	14
Caenis sp.	14	43	9	35	1
Cricotopus bicinctus gr.	15	8	23	15	46
Tricorythodes sp.	16	18	20	7	n/a
Saetheria tylus	17	25	11	18	45
Tribelos jucundum	18	32	8	22	62
Hyalella sp.	19	19	19	17	28
Baetis intercalaris	20	27	15	16	25

Table 15. Rank frequency of occurrence for the top 20 most common fish species in wadeable streams of the Kaskaskia River basin. Values are from 2013-2015 surveys and the most recent (either 2007 or 2012) IDNR Basin Surveys. “T” denotes tied.

		Subbasin Rank			
Species	Watershed Rank	Upper	Shoal	Middle	Lower
Green sunfish	1	T-1	1	1	1
Creek chub	T-2	3	3	T-4	4
Yellow bullhead	T-2	8	2	3	3
Bluntnose minnow	4	T-1	6	7	T-5
Bluegill	5	10	4	2	2
Blackstripe topminnow	6	4	8	6	T-8
Largemouth bass	7	T-15	7	T-4	T-5
Red shiner	8	7	5	T-9	12
Central stoneroller	9	6	T-11	T-19	T-8
Johnny darter	10	5	T-11	T-13	T-13
Longear sunfish	11	T-11	14	T-9	10
White sucker	12	T-11	T-15	T-13	7
Sand shiner	13	14	T-9	T-9	11
Redfin shiner	14	T-11	T-9	T-13	T-15
Tadpole madtom	15	T-15	17	T-13	T-15
Pirate perch	T-16	17	T-20	8	T-13
Silverjaw minnow	T-16	19	T-11	T-17	26
Creek chubsucker	18	9	19	T-19	31
Suckermouth minnow	19	25	T-15	T-21	T-15
Bigmouth shiner	20	23	18	T-21	19

Table 16. Rank abundance for the top 20 most common fish species in wadeable streams of the Kaskaskia River basin. wadeable streams of the Kaskaskia River basin. Values are from 2013-2015 surveys and the most recent (either 2007 or 2012) IDNR Basin Surveys. "T" denotes tied.

		Subbasin Rank			
Species	Watershed Rank	Upper	Shoal	Middle	Lower
Bluntnose minnow	1	1	3	8	3
Sand shiner	2	2	1	5	4
Creek chub	3	5	4	2	1
Central stoneroller	4	3	8	3	2
Red shiner	5	4	2	10	5
Bigmouth shiner	6	13	9	1	9
Silverjaw minnow	7	7	5	4	11
Green sunfish	8	15	6	6	8
Bluegill	9	16	11	7	6
White sucker	10	6	14	22	7
Blackstripe topminnow	11	8	15	9	13
Johnny darter	12	10	7	12	12
Longear sunfish	13	9	16	17	10
Redfin shiner	14	11	13	21	19
Pirate perch	15	14	27	11	14
Suckermouth minnow	16	18	10	20	17
Yellow bullhead	17	22	12	15	15
Creek chubsucker	18	17	19	19	27
Striped shiner	19	12	T-54	T-52	T-47
Largemouth bass	20	25	17	18	16

Table 17. Mean metric and index scores for IBI evaluations of fish collected during this study and by the IDNR. Values are from 2013-2015 surveys and the most recent (either 2007 or 2012) IDNR Basin Surveys.

	Metric Scores										
Spatial Scale	Number Species	Minnow Species	Sucker Species	Sunfish Species	Invertivore Species	Intolerant Species	Proportion Invertivore	Proportion Generalist	Proportion Coarse Substrate Spawners	Tolerant Species	IBI Score
Kaskaskia River basin	3.5	4.0	2.4	3.8	3.7	0.9	4.0	4.8	4.2	5.1	35.7
Upper HUC8	3.0	3.6	2.4	3.5	2.8	1.8	4.5	5.1	4.9	5.1	35.6
Middle HUC8	4.1	3.8	2.4	4.2	4.4	0.0	3.6	4.7	3.2	5.3	35.7
Shoal Creek HUC8	4.0	4.9	2.2	4.0	4.1	0.3	3.7	4.0	4.0	4.8	34.6
Lower HUC8	4.1	4.5	2.4	4.3	4.6	0.4	3.5	5.1	3.6	5.1	37.6
Max. Possible Score	6	6	6	6	6	6	6	6	6	6	60

Table 18. Rank frequency of occurrence for the top 20 most frequently occurring mussel species in the Kaskaskia River basin (from Shasteen et al. 2013).

		Subbasin Rank			
Species	**Watershed Rank**	**Upper**	**Middle**	**Shoal Creek**	**Lower**
Potamilus ohiensis	1	T-6	4	T-5	1
Leptodea fargilis	2	T-11	1	3	3
Lasmigona complanata	T-3	T-1	T-5	T-7	T-6
Quadrula quadrula	T-3	T-4	T-2	T-1	N/A
Pyganodon gradis	5	T-5	T-2	T-1	N/A
Potamilus alatus	6	T-1	T-5	T-13	9
Lampsilis cardium	T-7	T-1	T-12	T-5	N/A
Strophitus undulatus	T-7	T-8	N/A	T-20	2
Truncilla truncata	9	T-8	T-12	T-9	T-4
Quadrula pustulosa	10	T-6	T-9	T-9	10
Tritogonia verrucosa	11	T-8	T-5	4	N/A
Amblema plicata	T-12	T-11	T-5	T-13	16
Fusconaia flava	T-12	T-15	N/A	N/A	N/A
Toxolasma parvum	14	T-15	T-9	T-9	T-12
Uniomerus tertalasmus	15	T-16	T-12	T-20	N/A
Lampsilis teres	16	T-17	N/A	18	T-6
Ligumia recta	T-17	N/A	N/A	N/A	T-4
Megalonaias nervosa	T-17	T-15	T-12	T-20	11
Truncilla donaciformis	T-17	T-17	N/A	T-7	N/A
Arcidens confragosus	20	T-15	N/A	T-20	T-12

Table 19. Rank abundance for the top 20 most abundant mussel species in the Kaskaskia River basin (from Shasteen et al. 2013).

		Subbasin Rank			
Species	**Watershed Rank**	**Upper**	**Middle**	**Shoal Creek**	**Lower**
Quadrula quadrula	1	2	2	2	N/A
Tritogonia verrucosa	2	10	4	1	N/A
Potamilus ohiensis	3	T-15	7	14	1
Uniomerus tertalasmus	4	1	T-16	T-20	7
Leptodea fargilis	5	6	6	4	5
Pyganodon gradis	6	11	3	3	N/A
Lampsilis siliquoidea	7	13	1	N/A	N/A
Amblema plicata	8	3	9	8	15
Lampsilis cardium	9	4	8	5	N/A
Quadrula pustulosa	10	9	5	11	4
Strophitus undulatus	11	14	N/A	T-20	2
Toxolasma parvum	12	T-7	11	12	6
Lasmigona complanata	13	T-7	10	13	9
Truncilla truncata	14	5	T-16	15	11
Potamilus alatus	15	12	12	18	3
Lampsilis teres	16	26	N/A	6	12
Fusconaia flava	17	T-17	N/A	7	N/A
Truncilla donaciformis	18	27	N/A	9	N/A
Arcidens confragosus	19	T-15	N/A	T-23	8
Obliquaria reflexa	20	N/A	N/A	10	N/A

Table 20. Biological metric rank for HUC8 subbasins.

Metric	Upper	Middle	Shoal Creek	Lower
Summer Benthic Macroinvertebrate Taxa Richness	3	2	1	4
Spring EPT Taxa Richness	1	2	3	4
Fish Species Richness	1	4	2	3
IBI Score	3	2	4	1
Mussel Species Richness	3	4	1	2
MCI Score	2	4	1	3
Mean Rank:	2.2	3.0	2.0	2.8

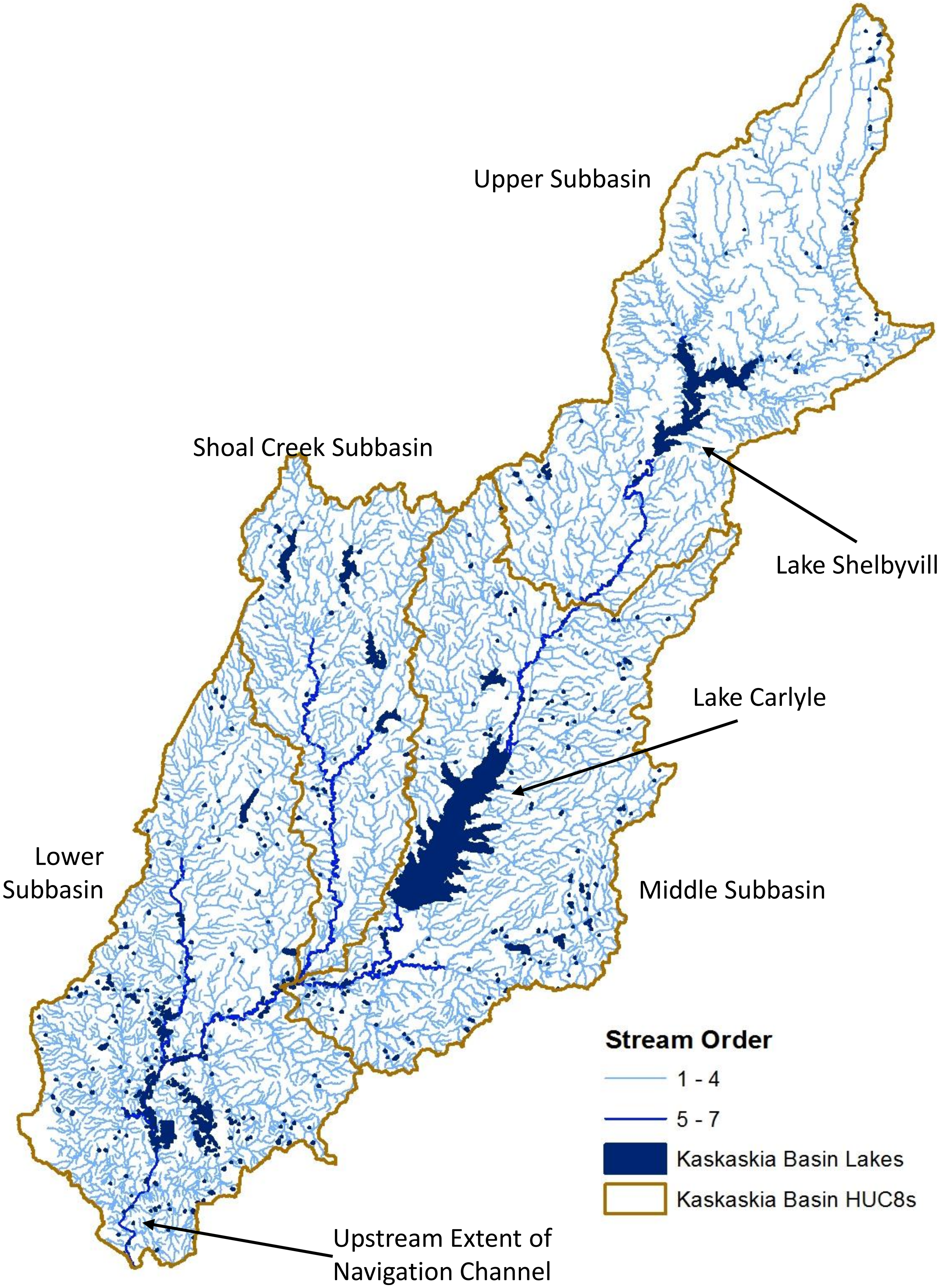

Figure 1. Kaskaskia River basin streams, lakes and HUC8 subwatershed boundaries.

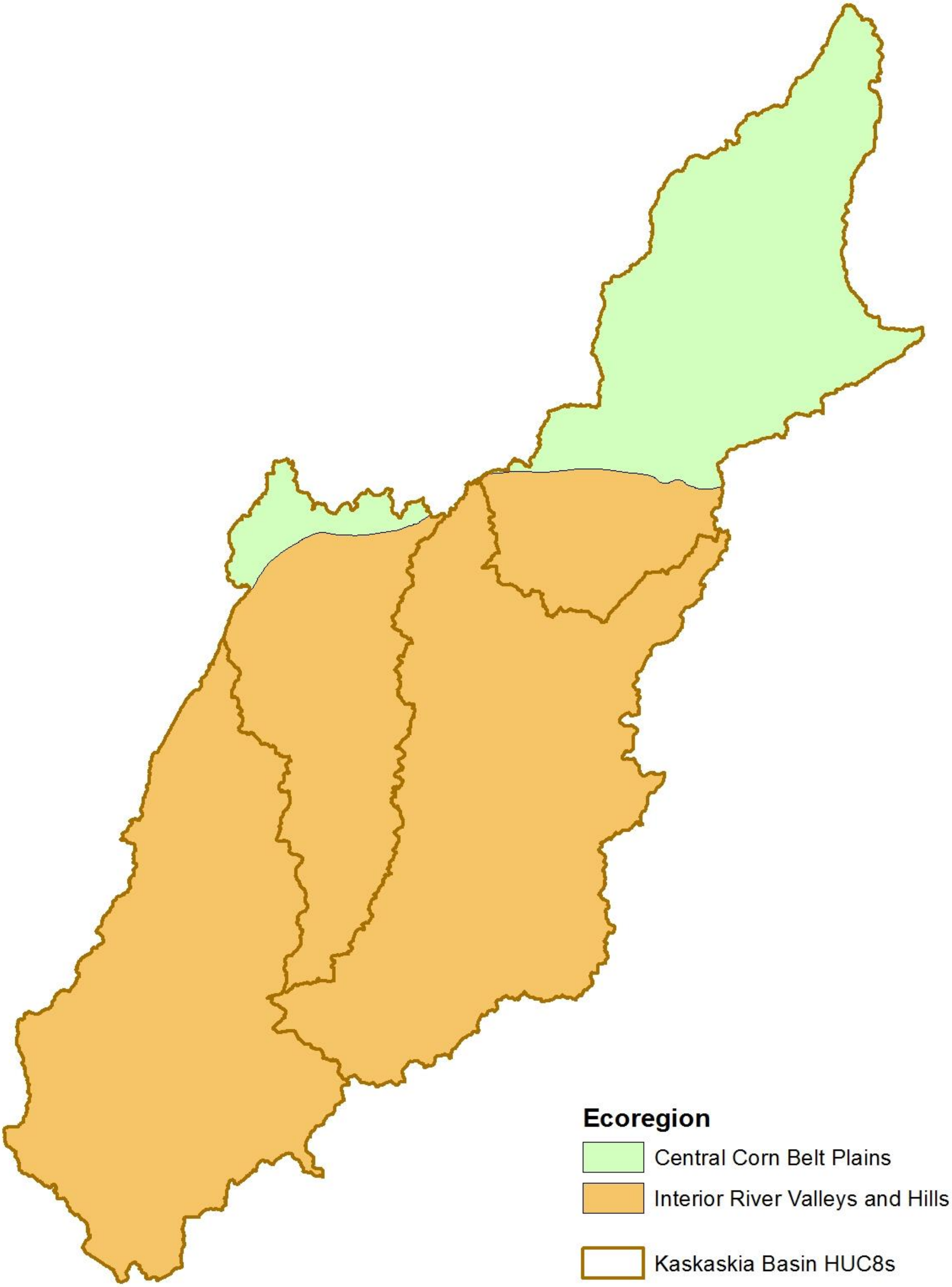

Figure 2. Ecoregions within the Kaskaskia River basin.

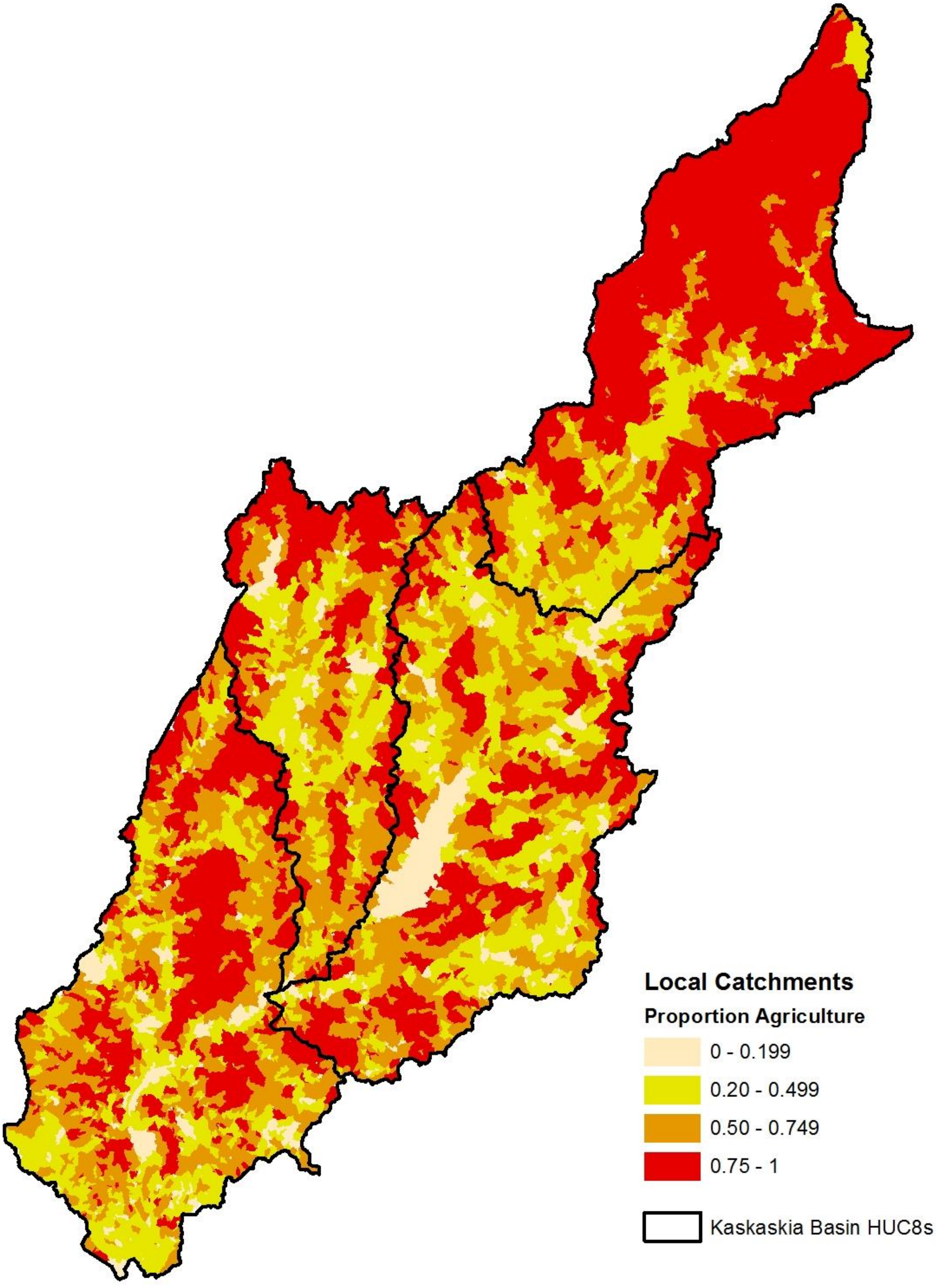

Figure 3. Density of agriculture landcover in the local catchments of the Kaskaskia River basin.

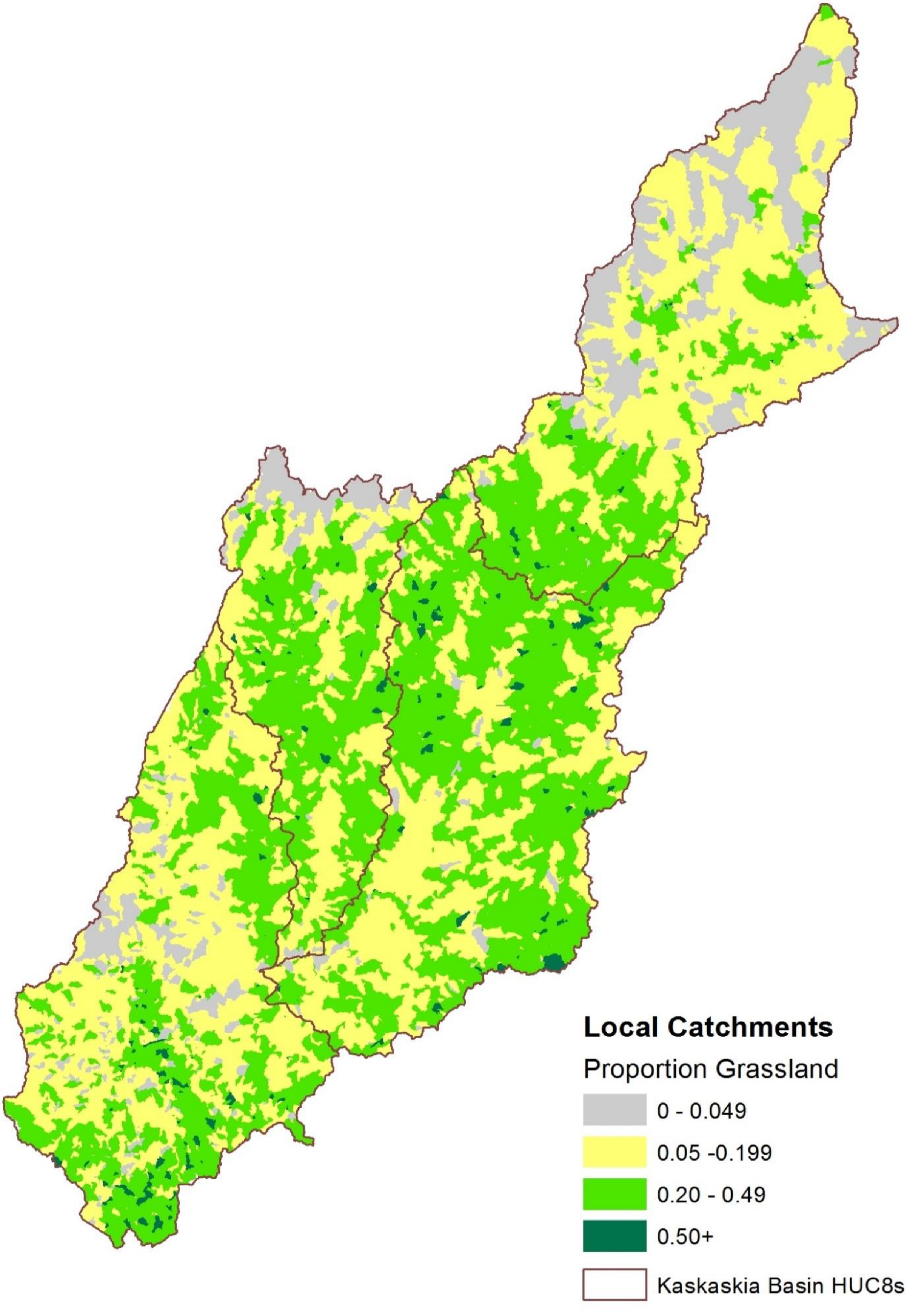

Figure 4. Density of grassland landcover in the local catchments of the Kaskaskia River basin.

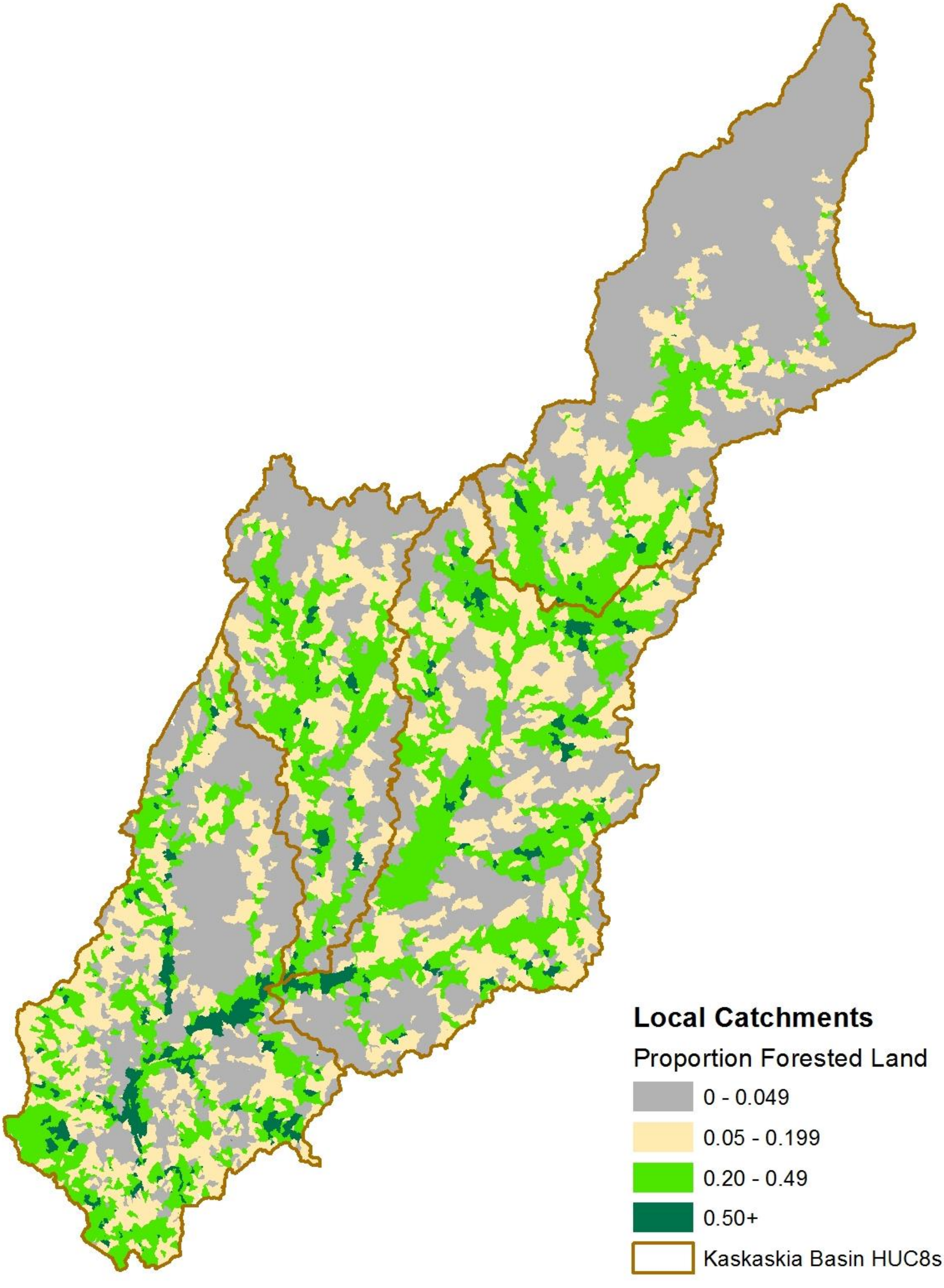

Figure 5. Density of forest landcover in the local catchments of the Kaskaskia River basin.

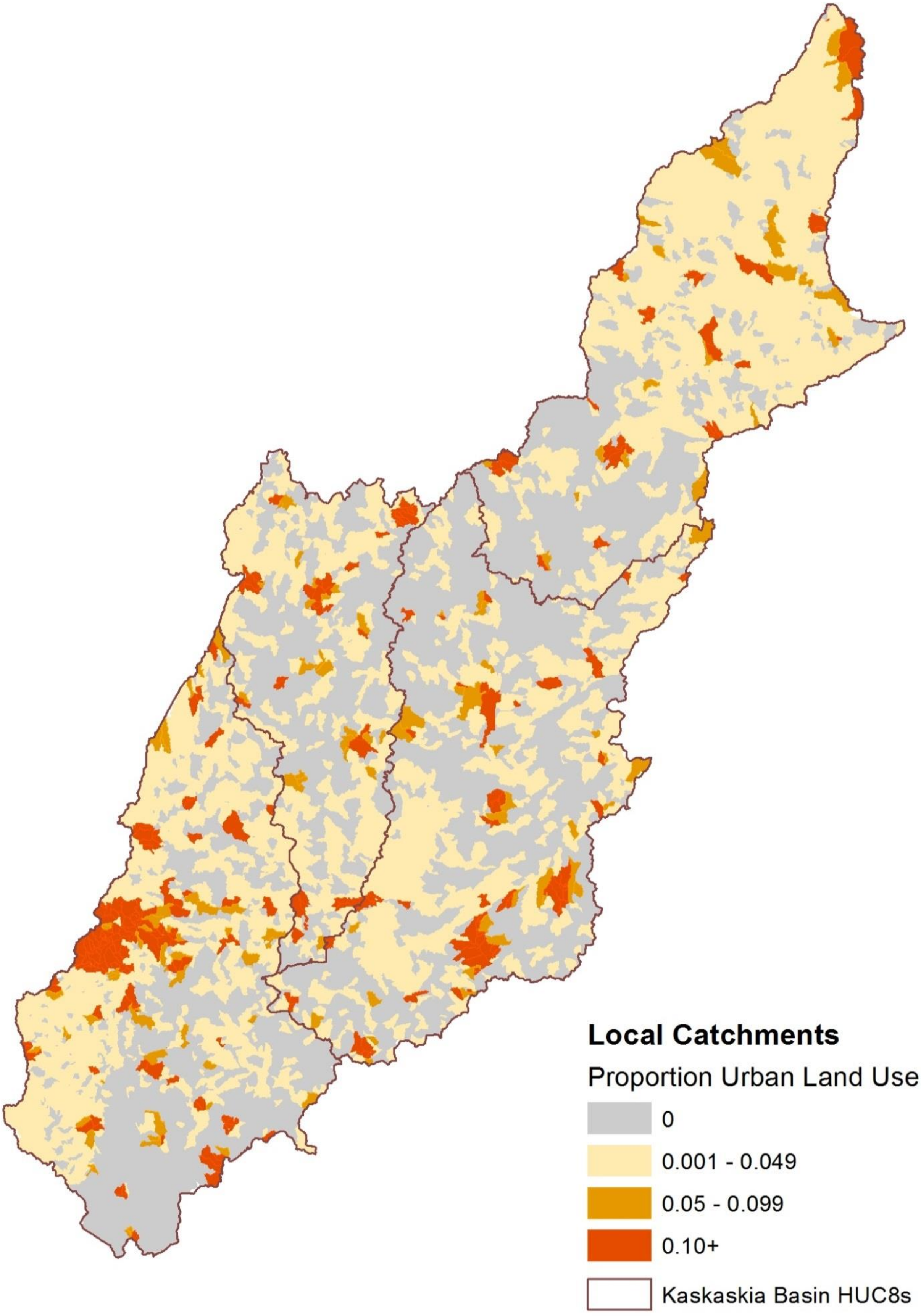

Figure 6. Density of urban landcover in the local catchments of the Kaskaskia River basin.

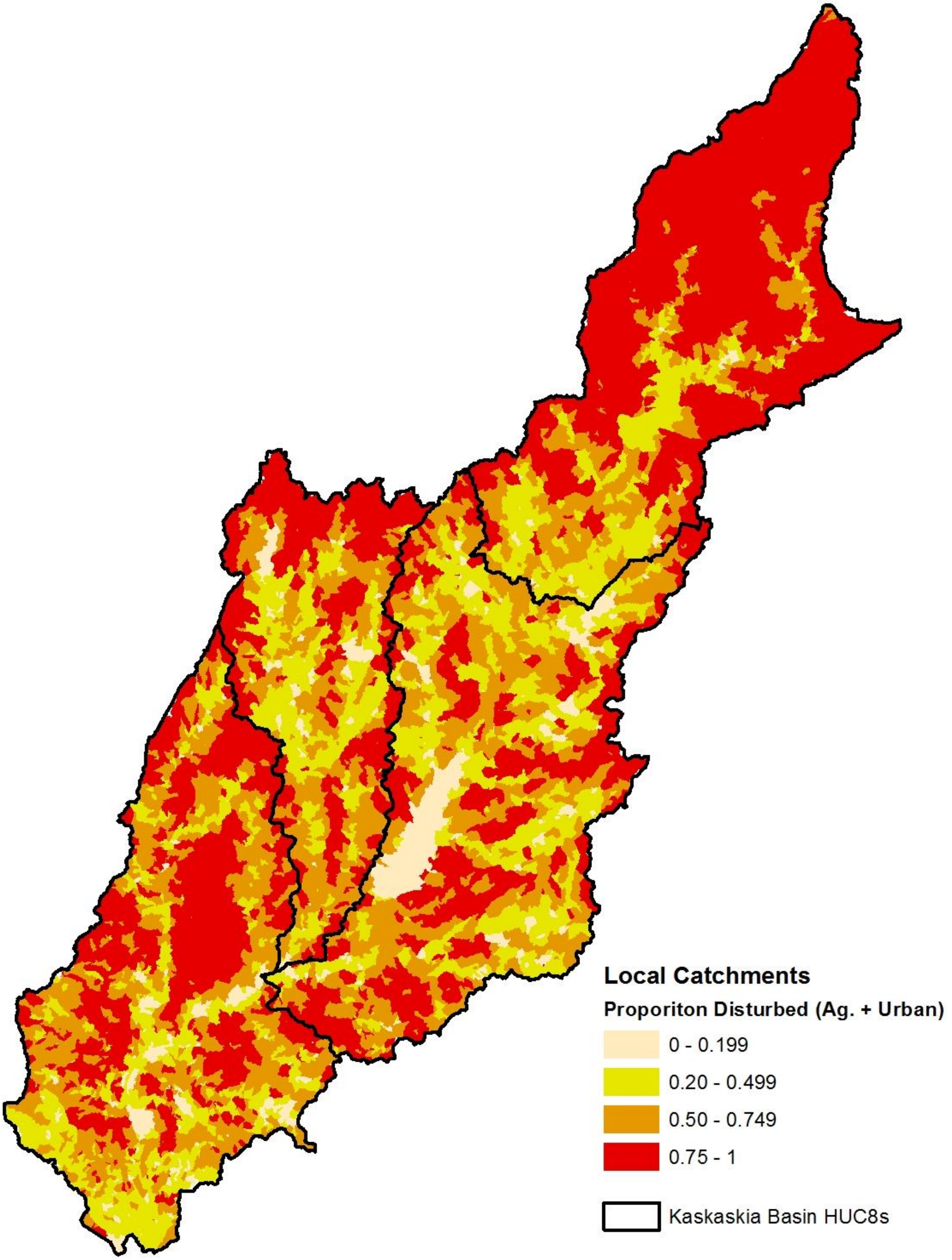

Figure 7. Density of disturbed (agriculture and urban) landcover in the local catchments of the Kaskaskia River basin.

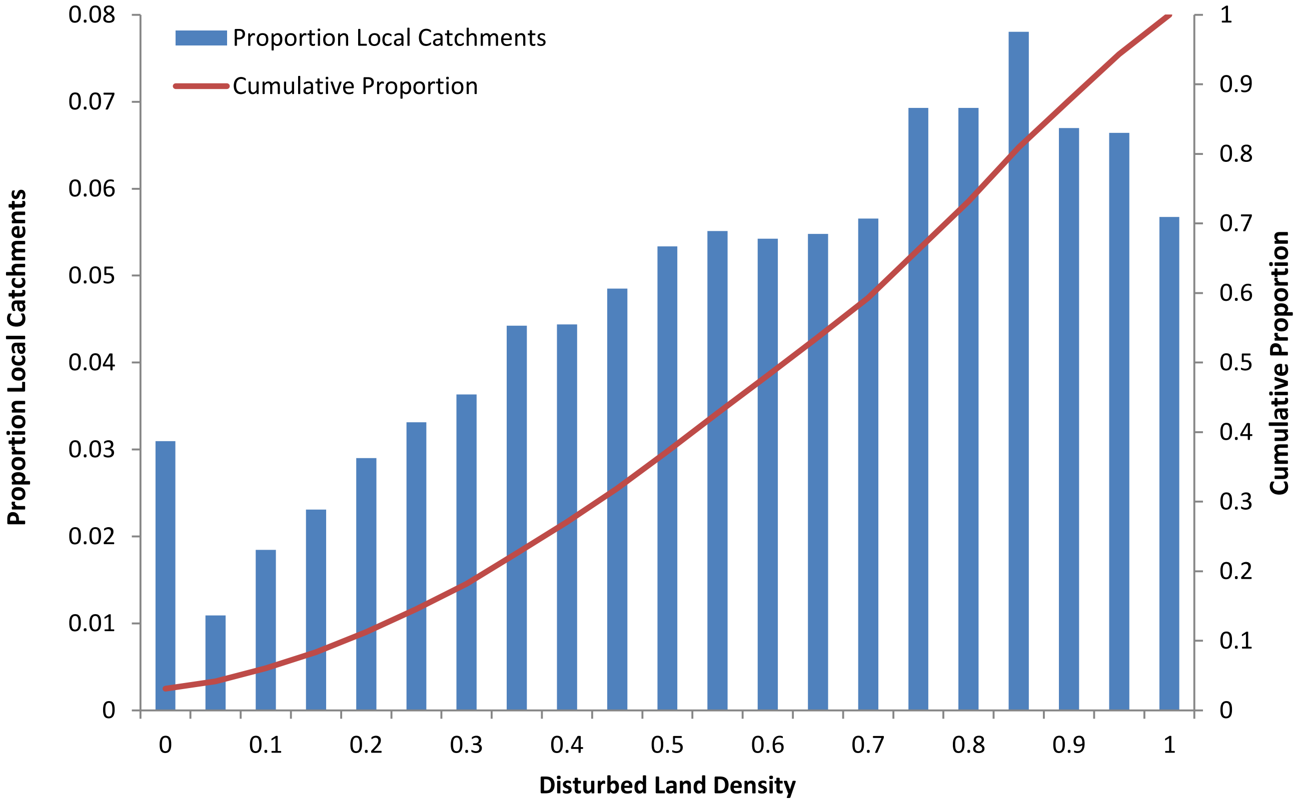

Figure 8. Density of disturbed land (agriculture or urban) in local catchments of the Kaskaskia River basin.

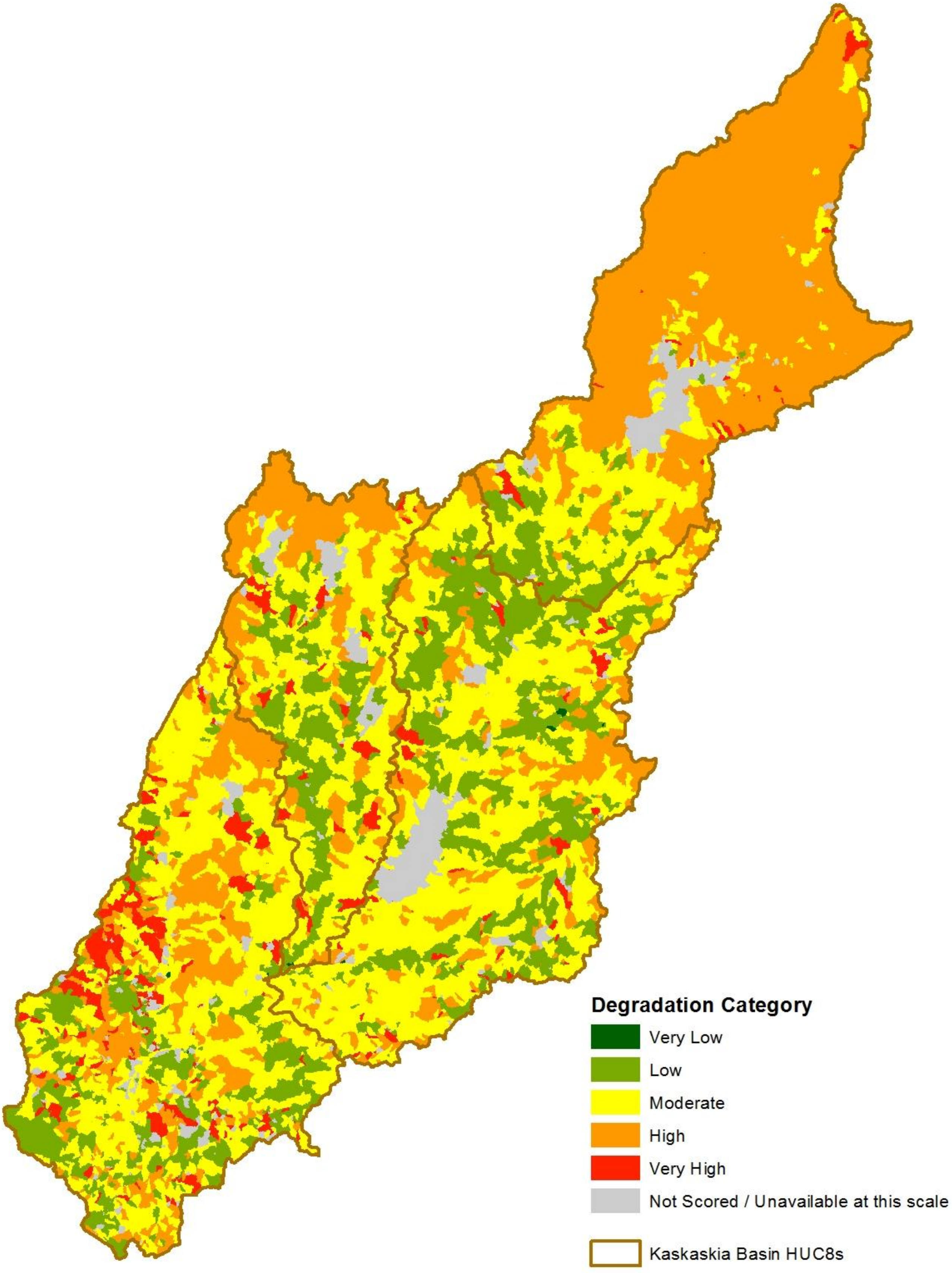

Figure 9. Estimated stream habitat degradation in the Kaskaskia River basin based on National Fish Habitat Partnership evaluations (Esselman et al. 2011).

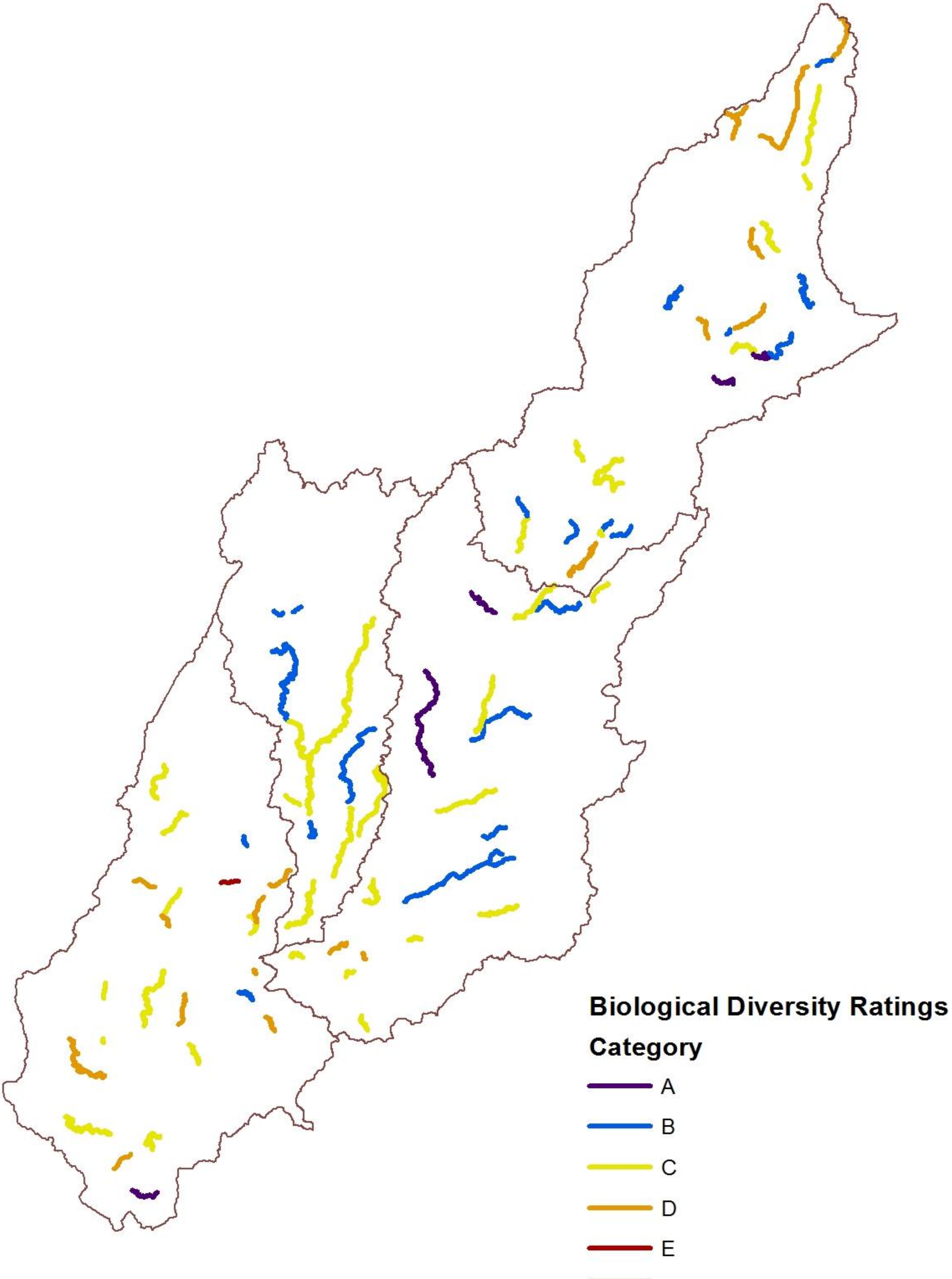

Figure 10. Biological diversity rating of streams in the Kaskaskia River basin from Bol et al. (2007).

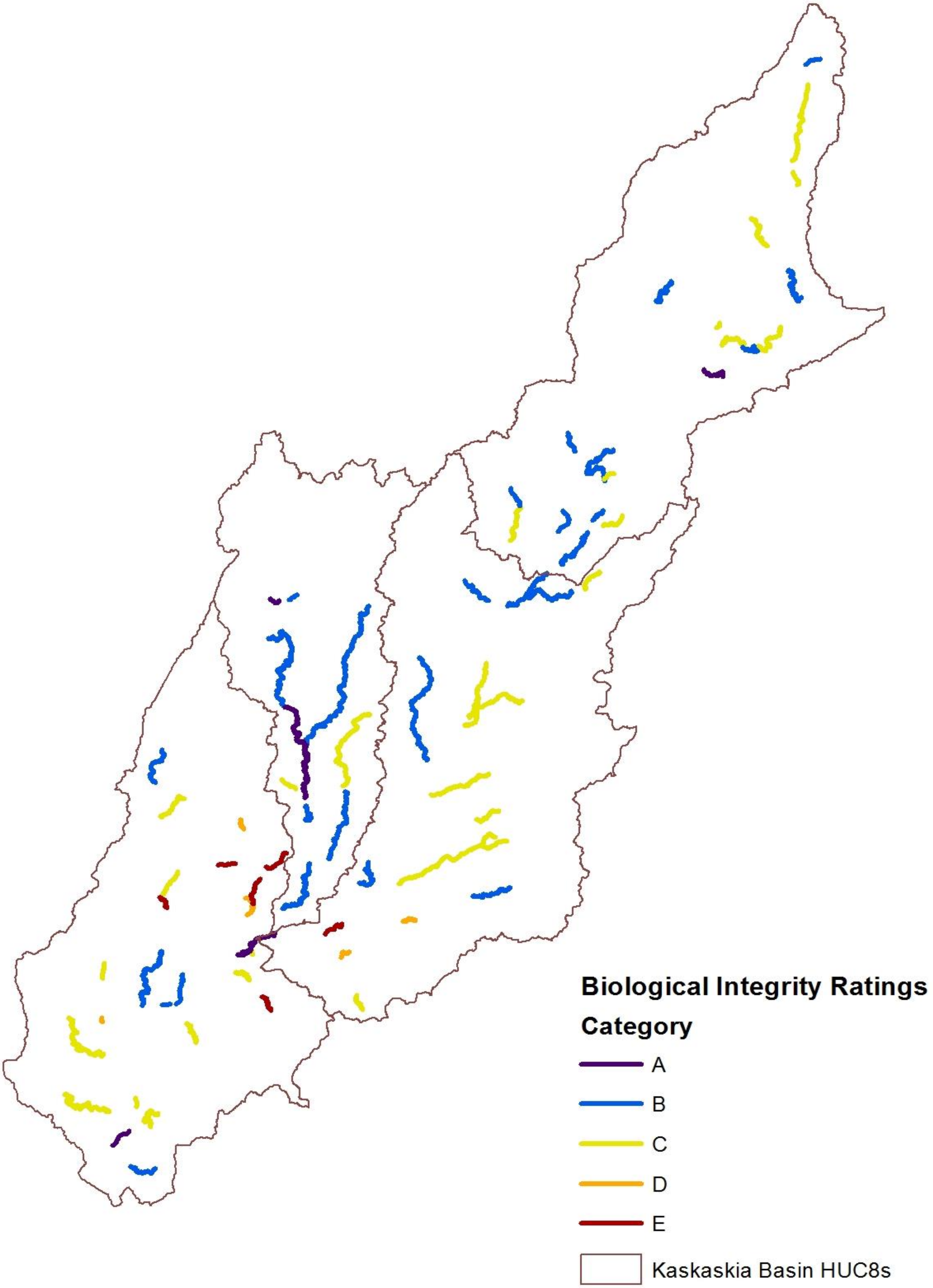

Figure 11. Biological integrity rating of streams in the Kaskaskia River basin from Bol et al. (2007).

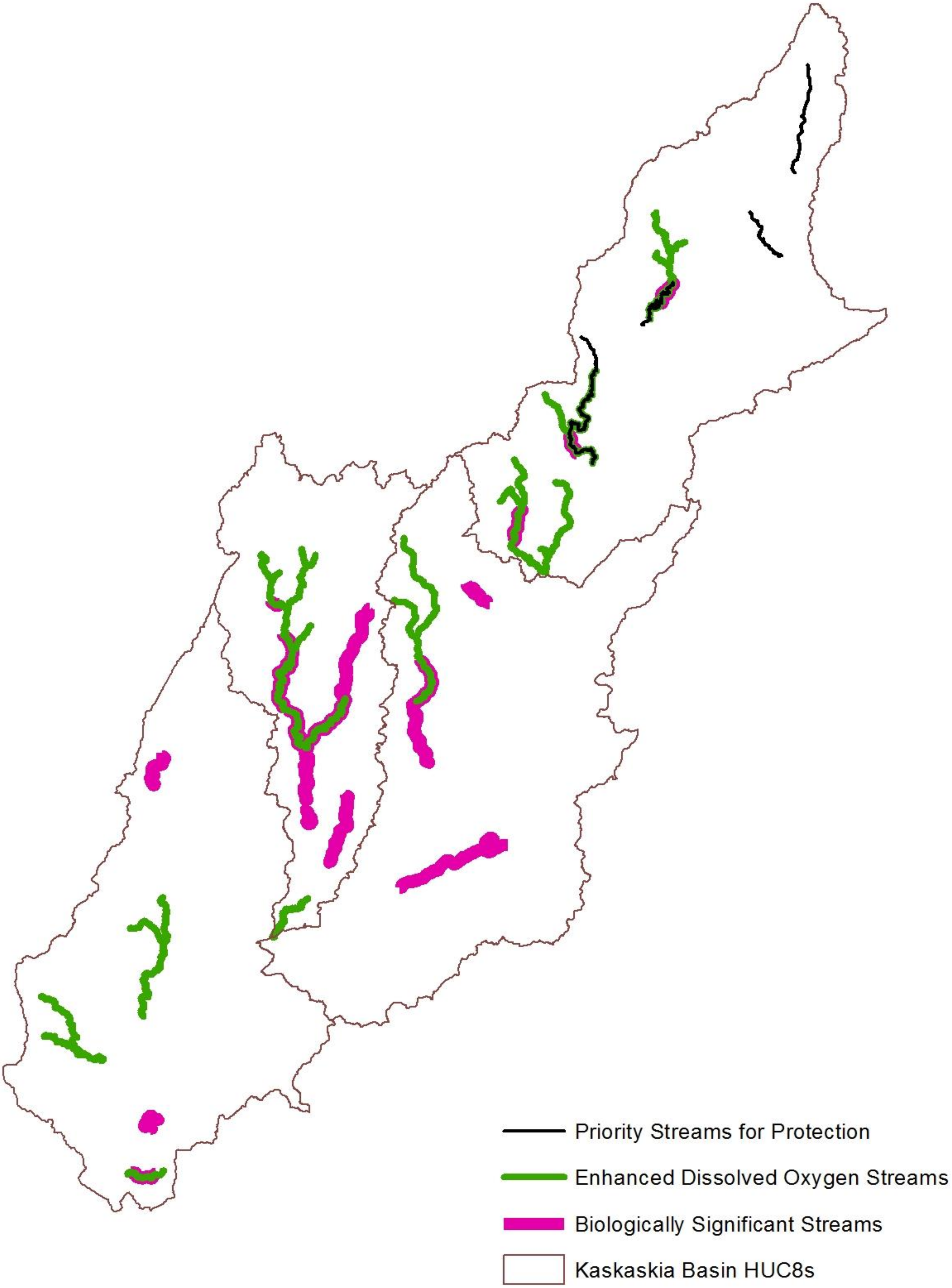

Figure 12. **Stream reaches classified as biologically significant (Bol et al. 2007), enhanced dissolved oxygen streams (IDNR and IEPA 2006) or priority streams for protection (IEPA 2011).**

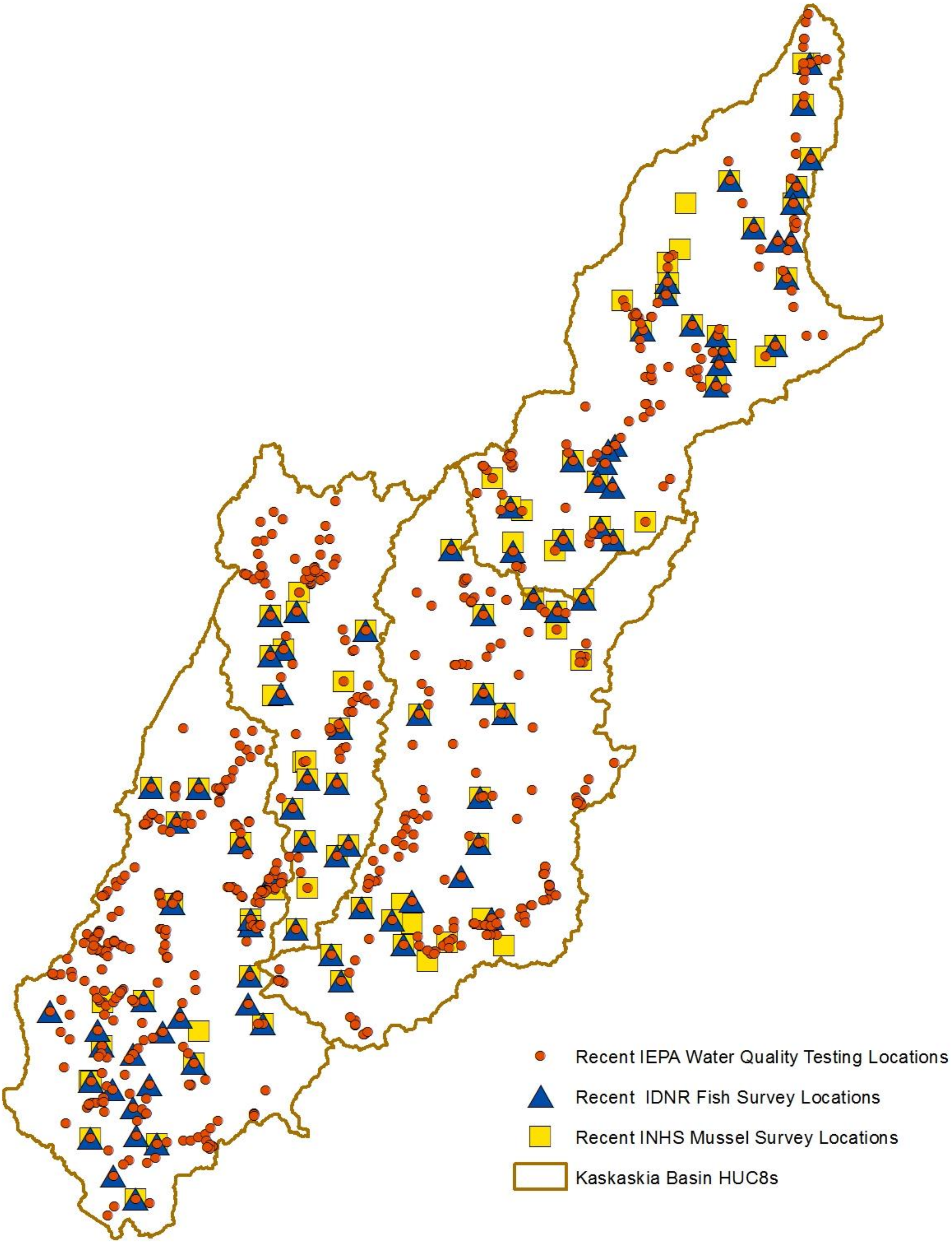

Figure 13. Location of water quality measures, fish surveys and mussel surveys completed between 2005 and 2012.

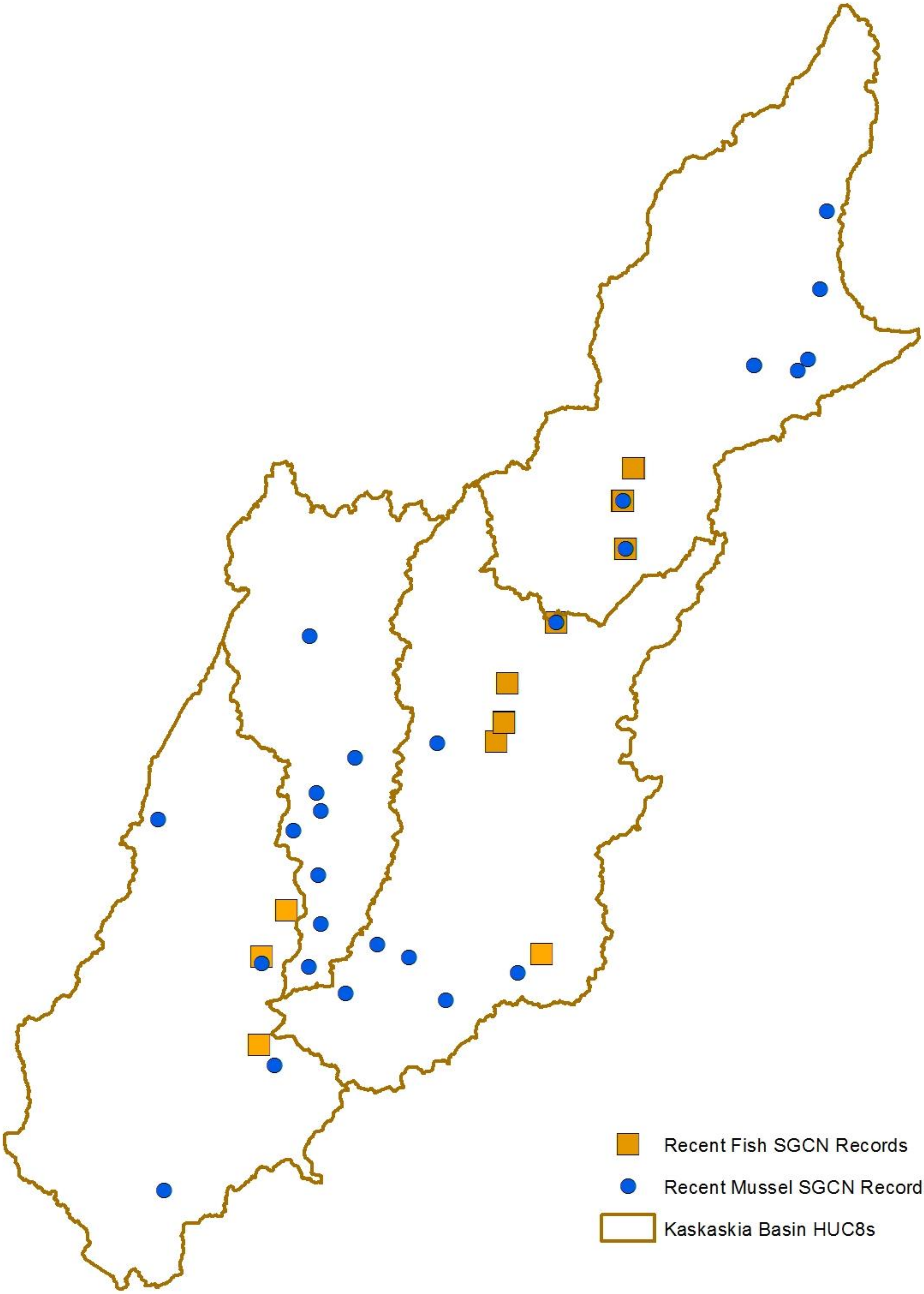

Figure 14. Location of fish and mussel Species in Greatest Conservation Need. Records are limited to those from 2000 or more recent.

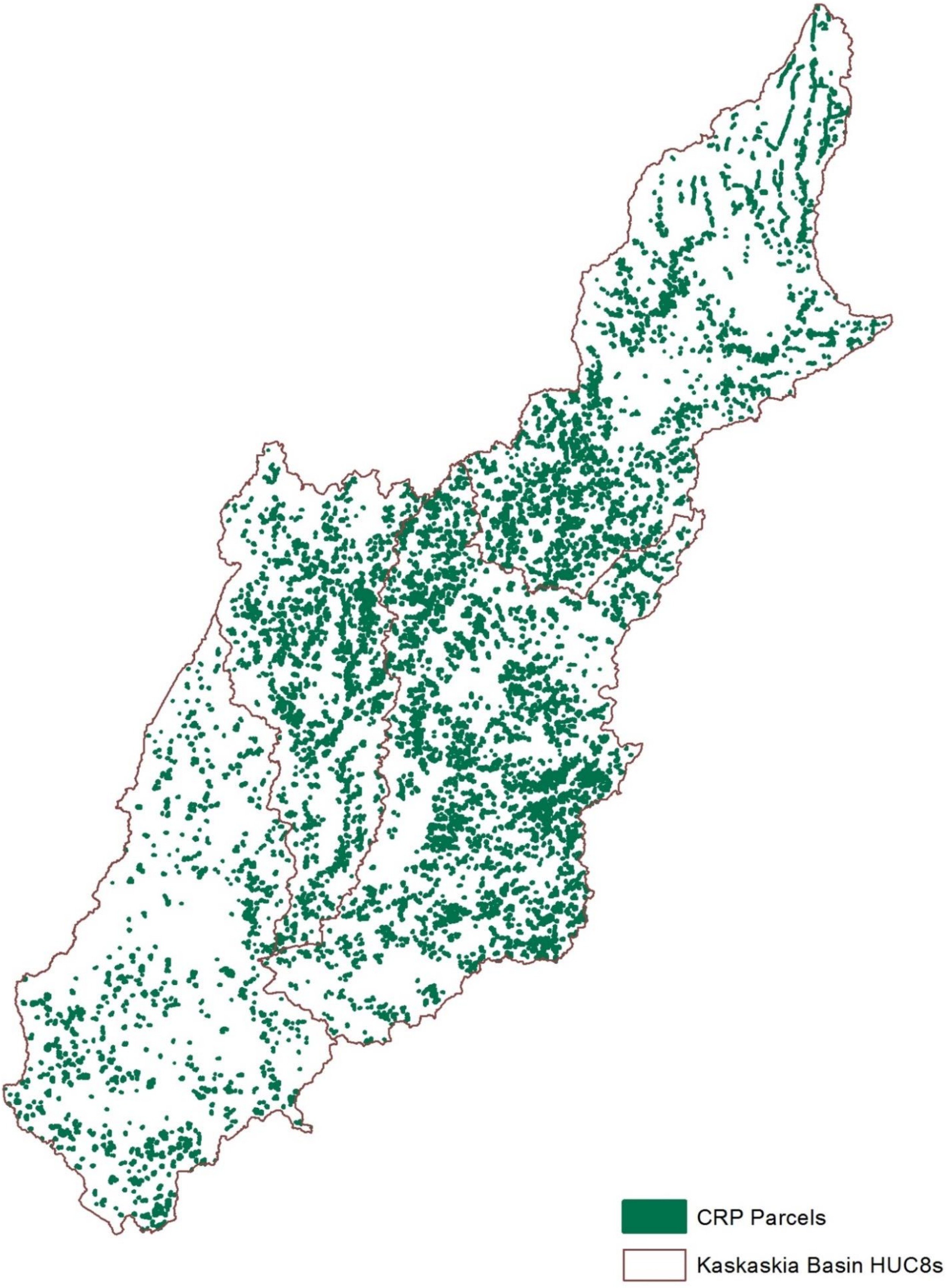

Figure 15. Locations of Conservation Reserve Program (CRP) parcels in the Kaskaskia River basin (information accessed in December 2012).

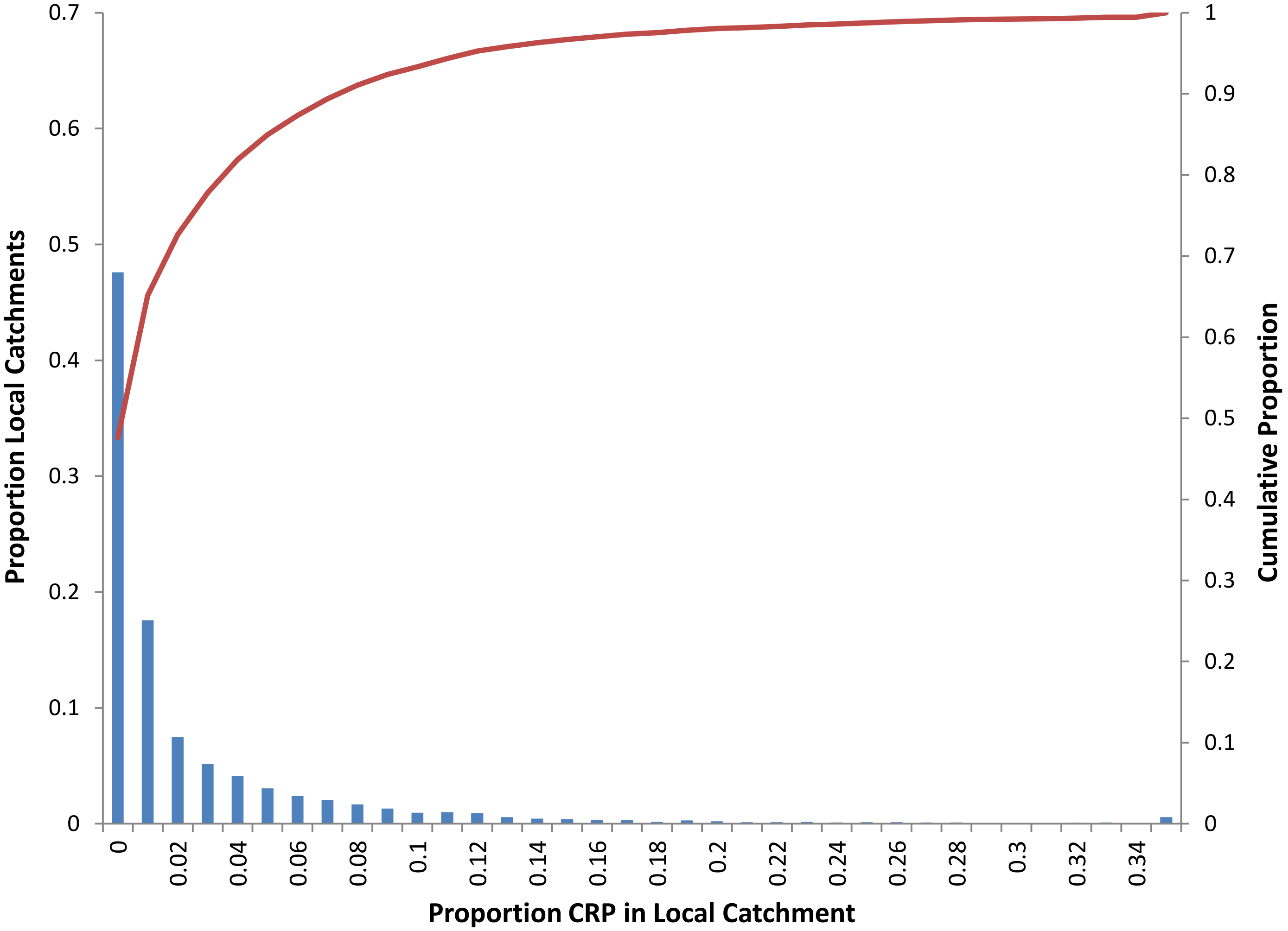

Figure 16. Proportion of Conservation Reserve Program (CRP) as total land use in local catchments in the Kaskaskia River basin.

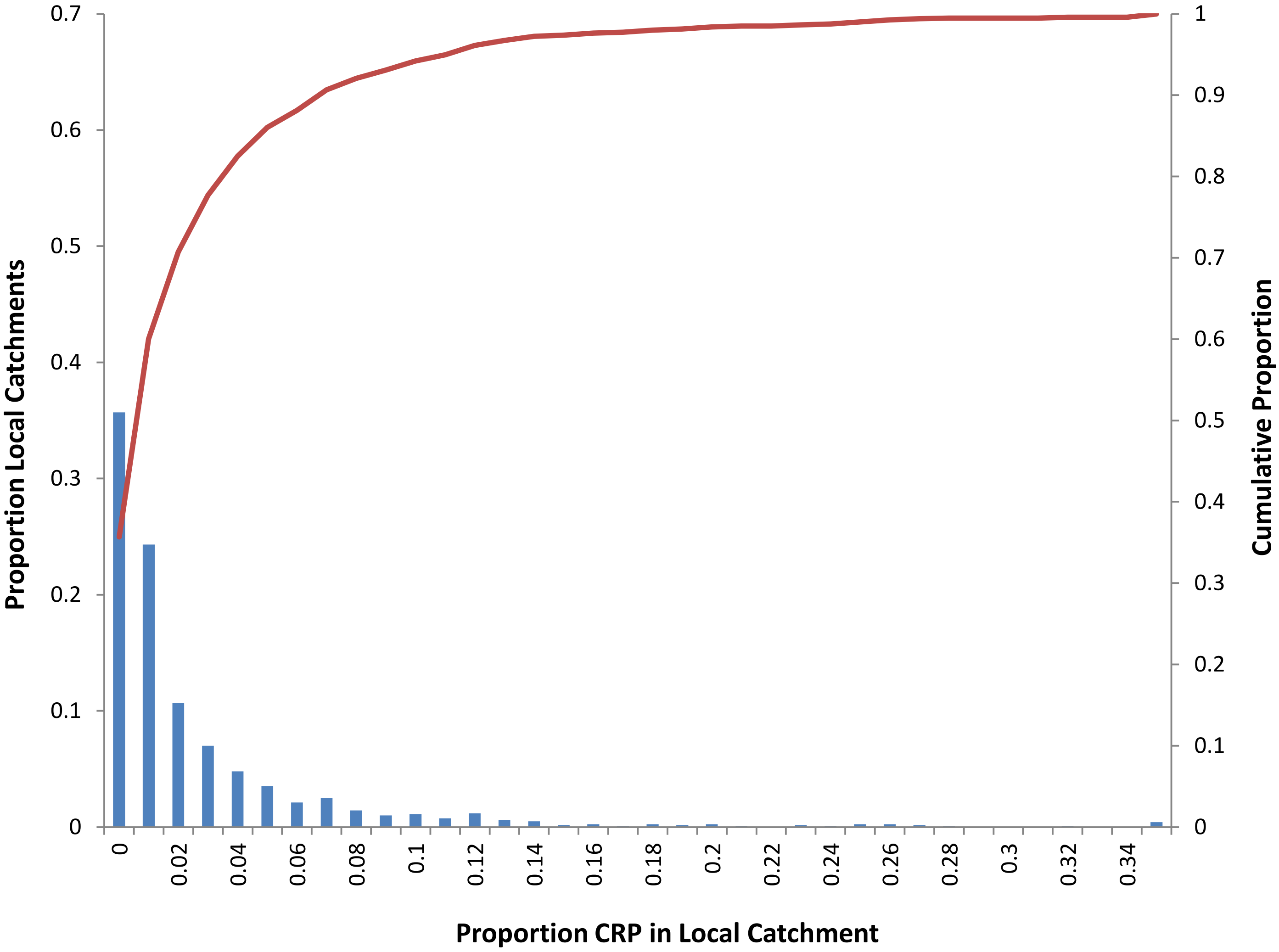

Figure 17. Proportion of Conservation Reserve Program (CRP) as total land use in local catchments in the Upper Kaskaskia subbasin.

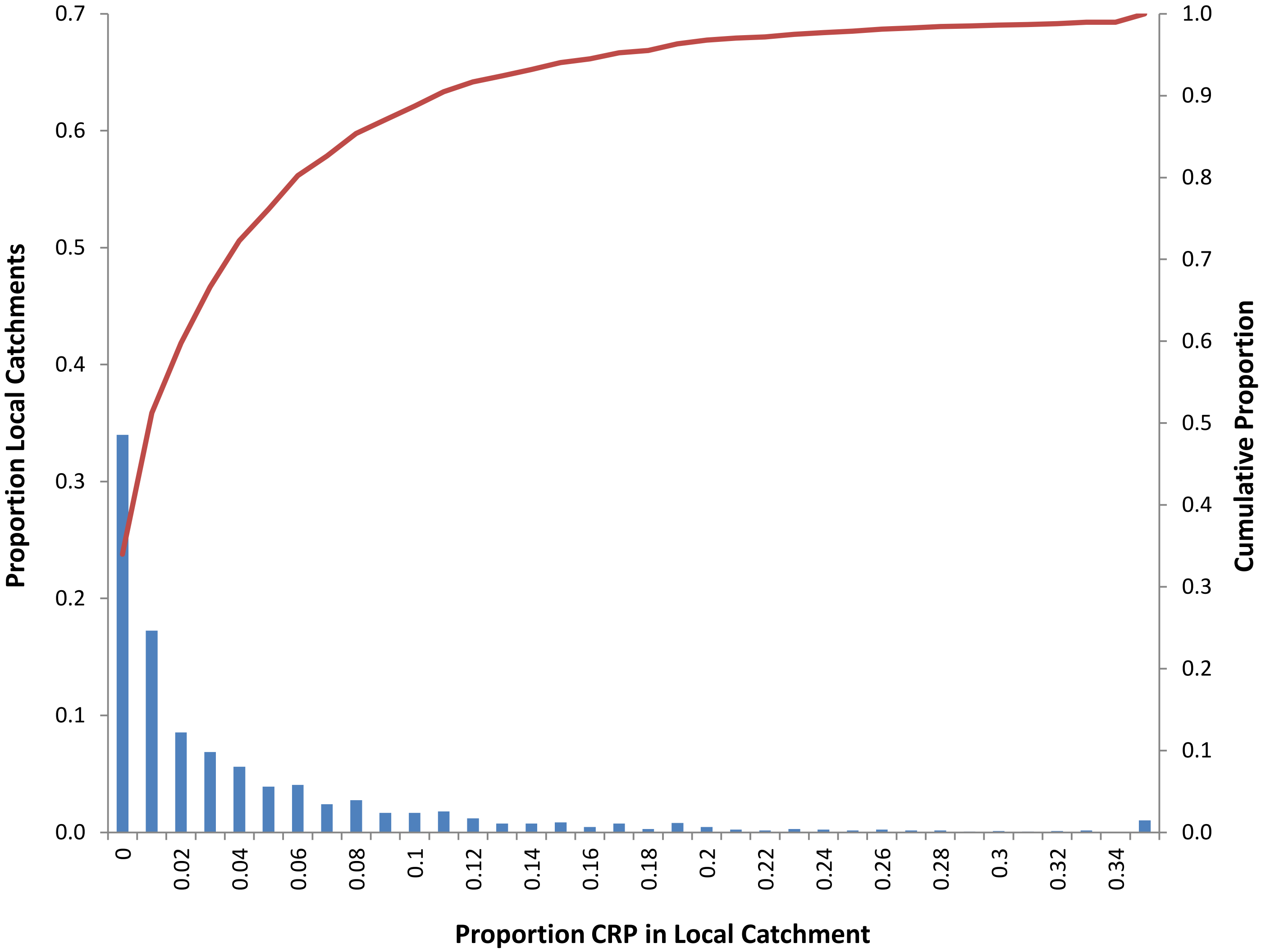

Figure 18. Proportion of Conservation Reserve Program (CRP) as total land use in local catchments in the Middle Kaskaskia subbasin.

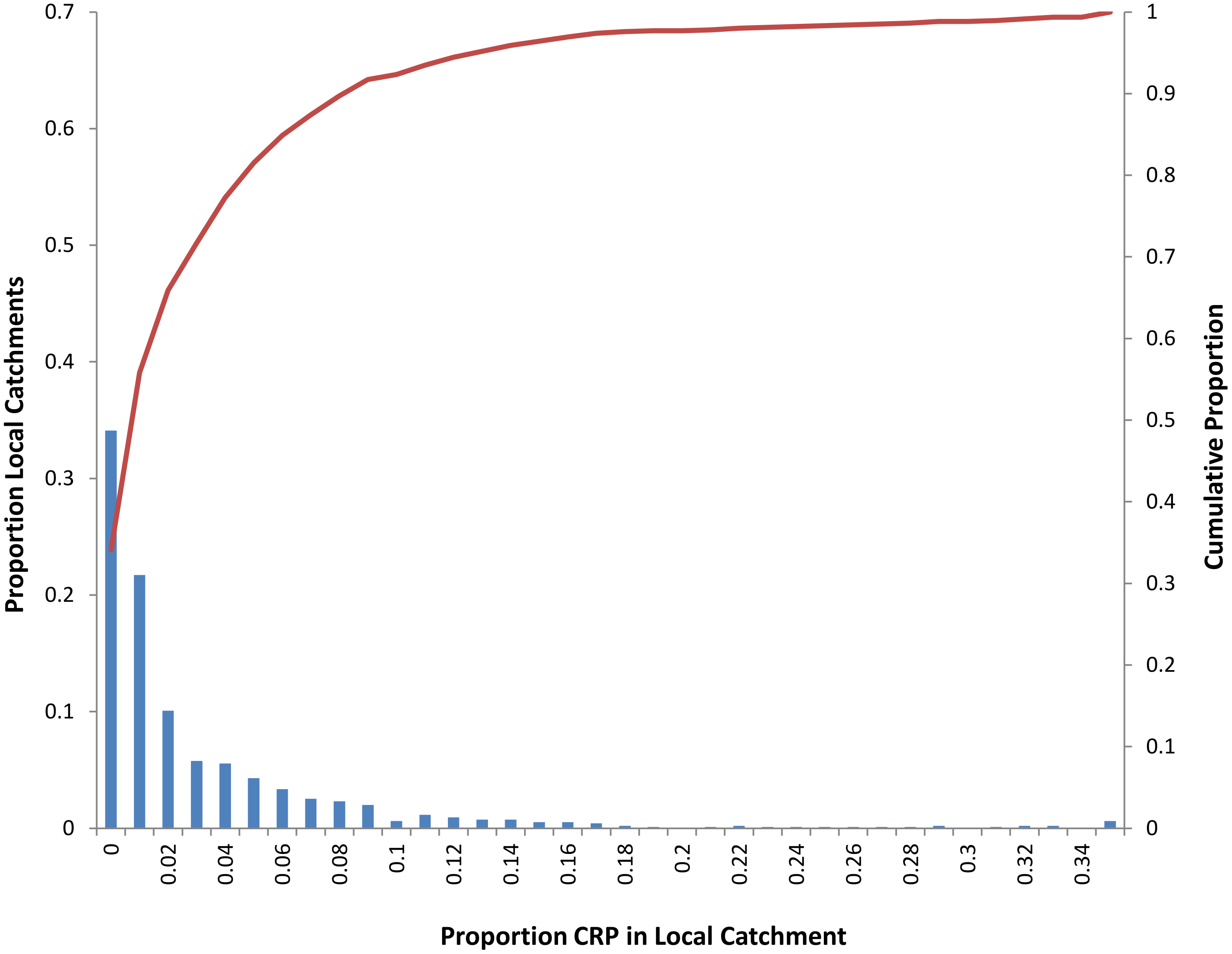

Figure 19. Proportion of Conservation Reserve Program (CRP) as total land use in local catchments in the Shoal Creek subbasin.

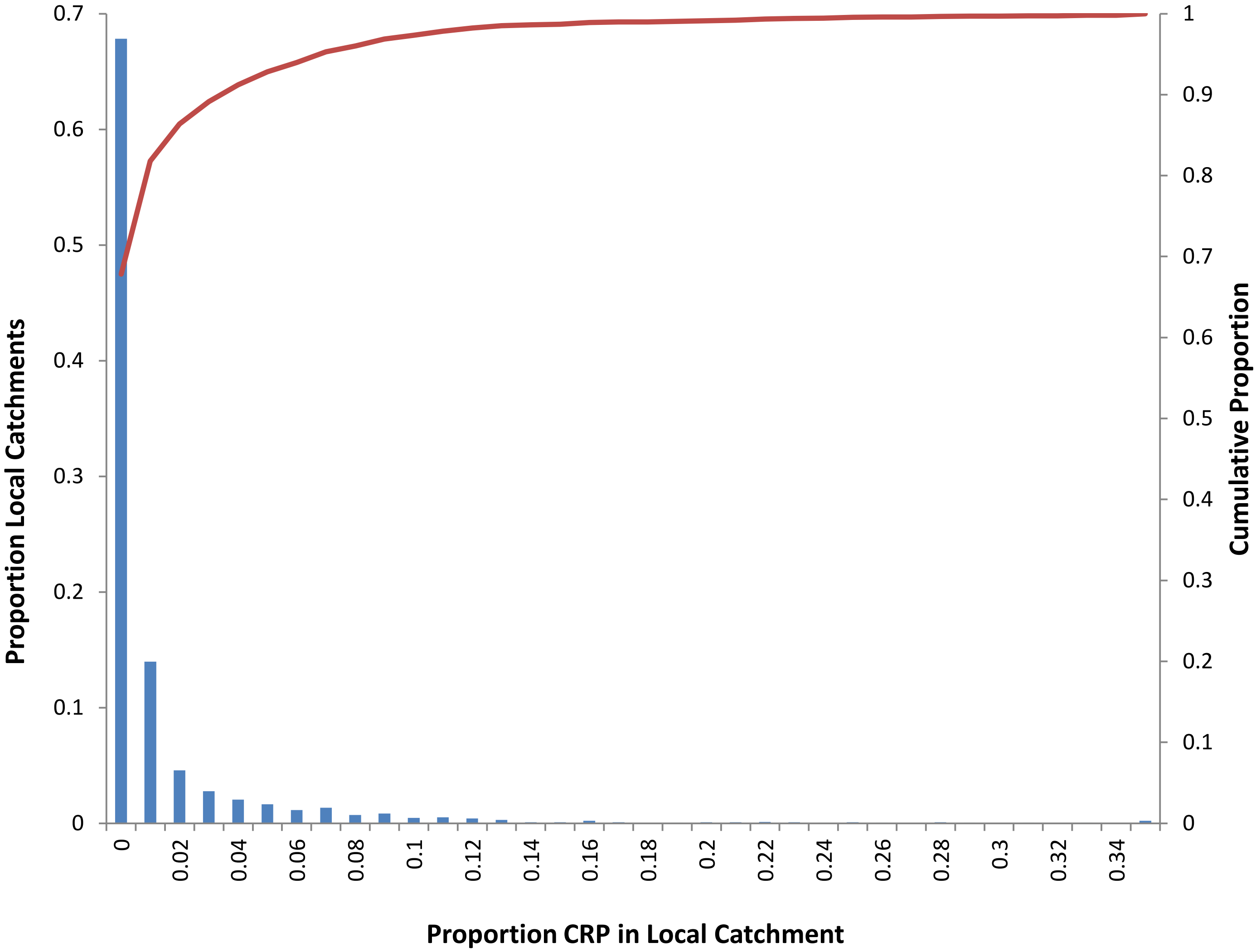

Figure 20. Proportion of Conservation Reserve Program (CRP) as total land use in local catchments in the Lower Kaskaskia subbasin.

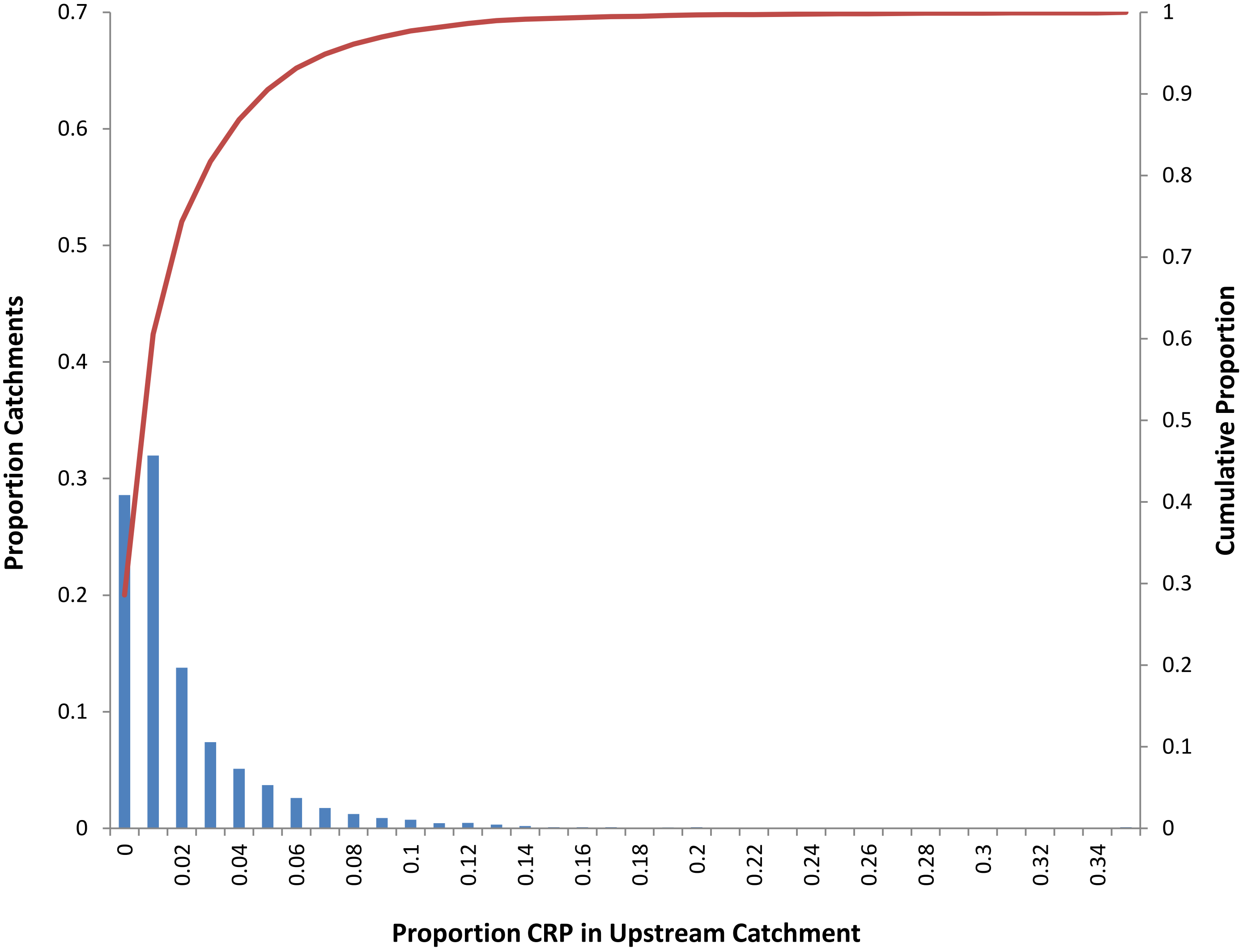

Figure 21. Proportion of Conservation Reserve Program (CRP) as total land use in upstream catchments in the Kaskaskia River basin.

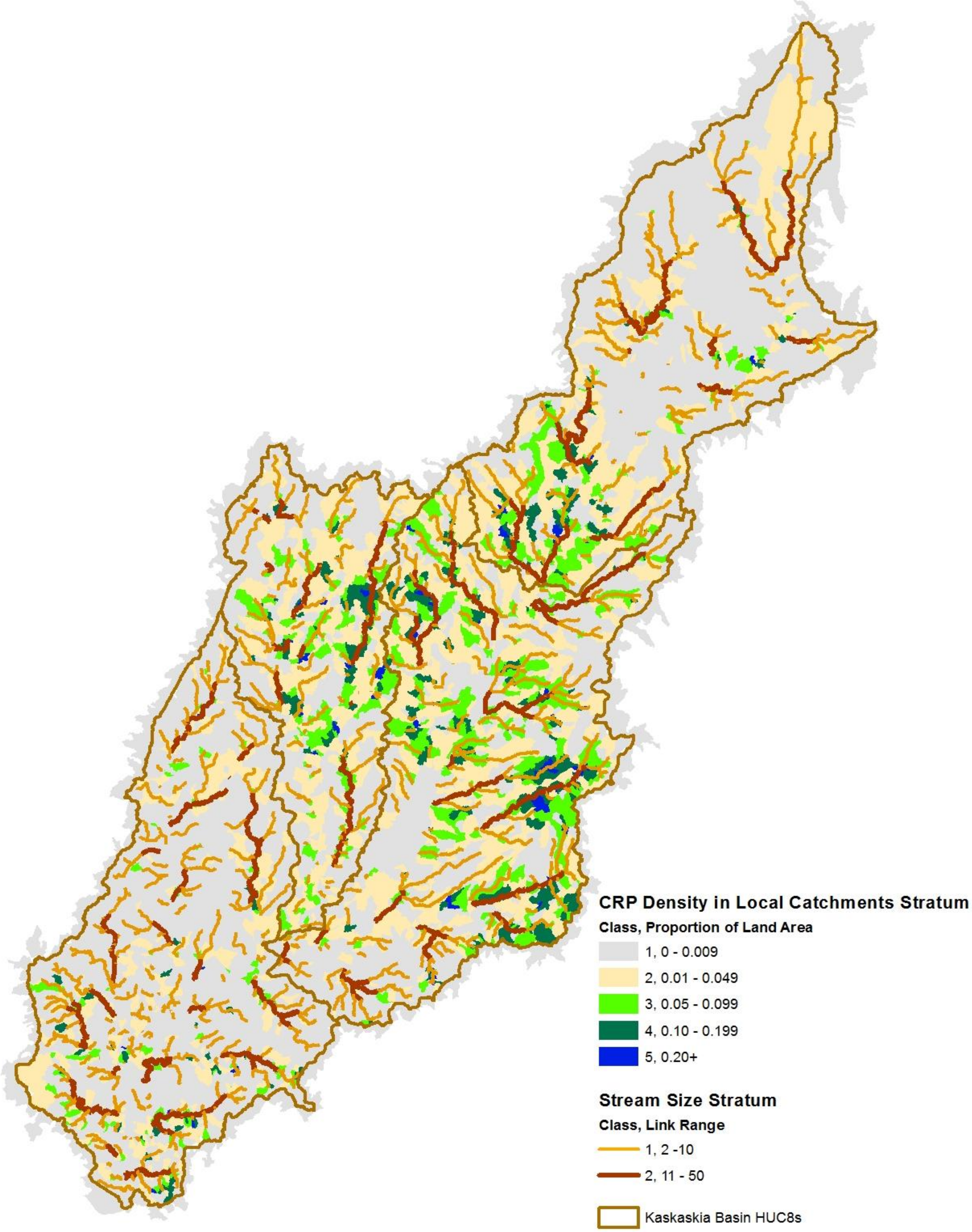

Figure 22. Survey site selection strata and classes for basin-wide stream characterizations (Objective 1). Stratum 1: HUC8; stratum 2: stream size (link number based on 1:100,000 scale linework); stratum 3: Conservation Reserve Program (CRP) density in local catchments.

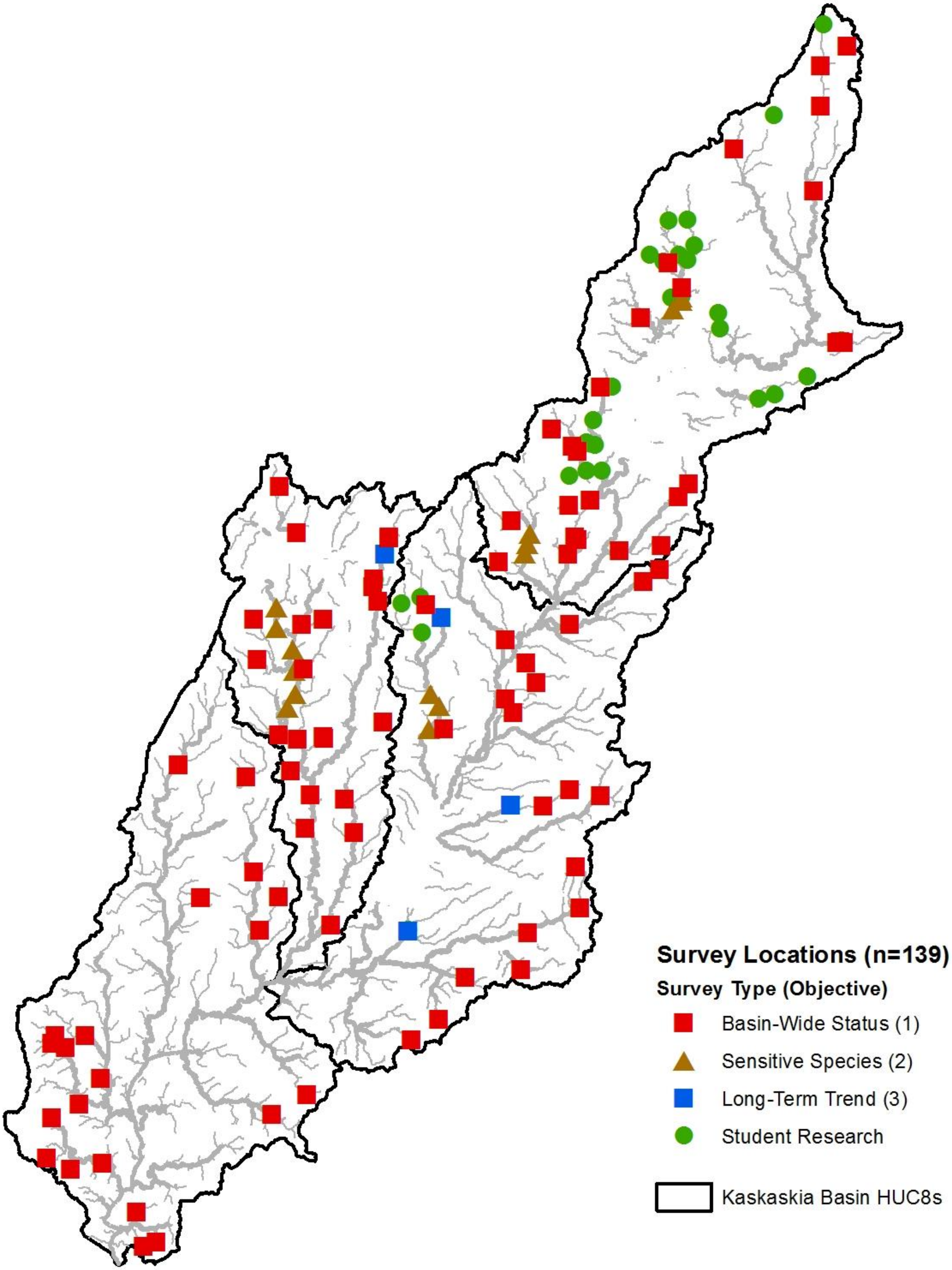

Figure 23. Survey locations and purpose.

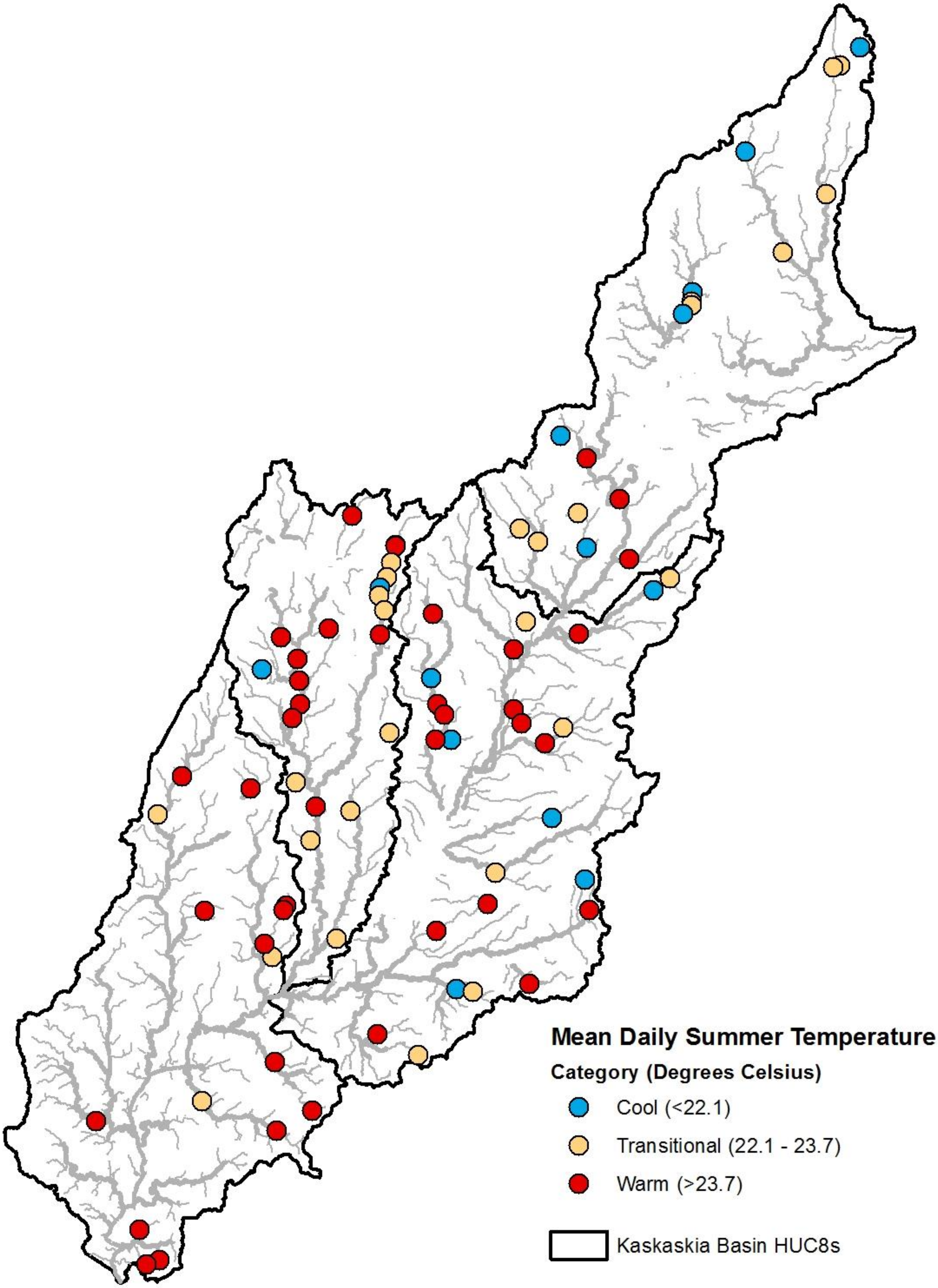

Figure 24. Location and thermal category for temperature records collected between 2003 and 2015. Mean value is displayed for locations with multiple records.

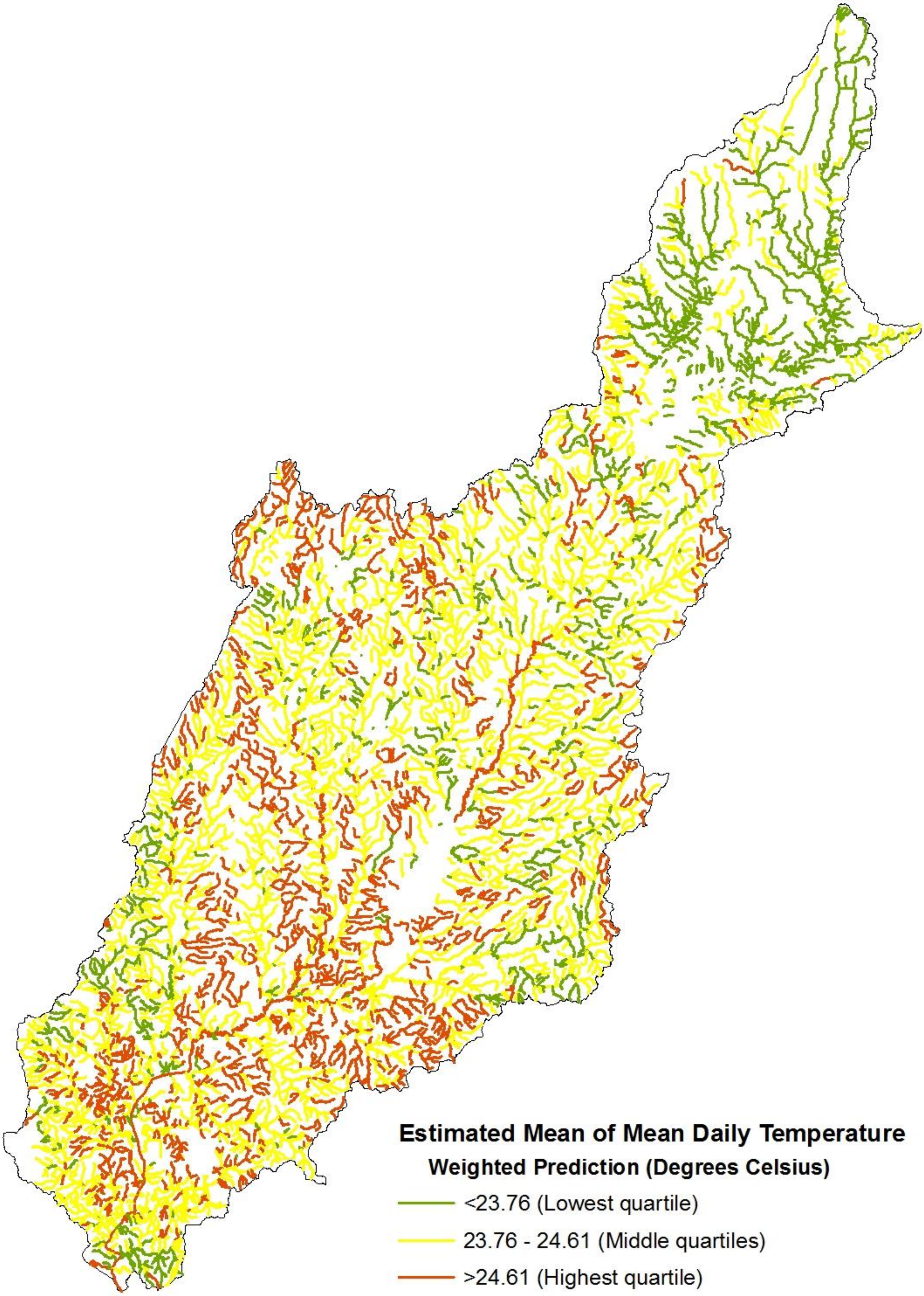

Figure 25. Mean of mean daily summer temperature estimated from multiple linear regression models.

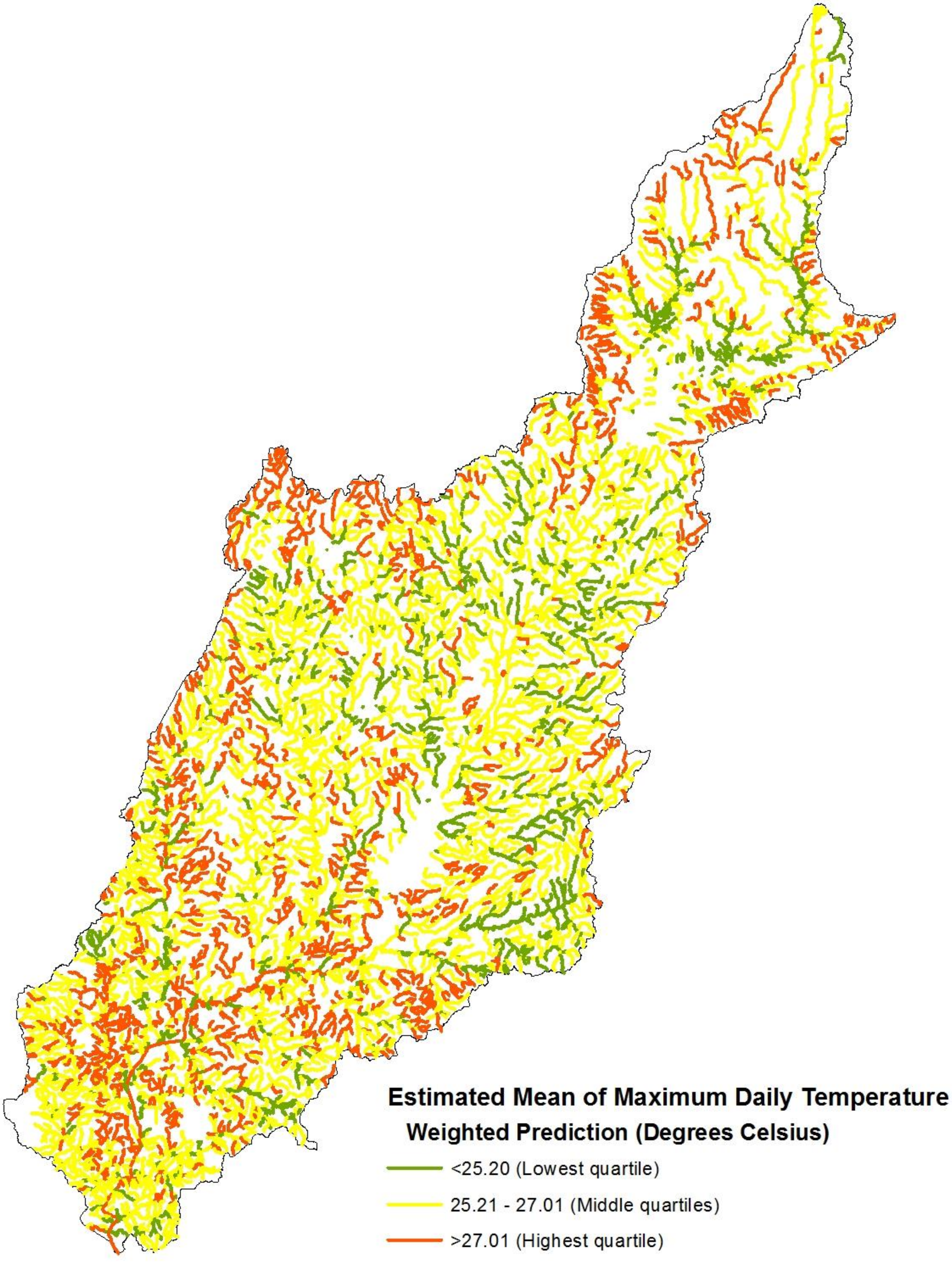

Figure 26. Mean of maximum daily summer temperature estimated from multiple linear regression models.

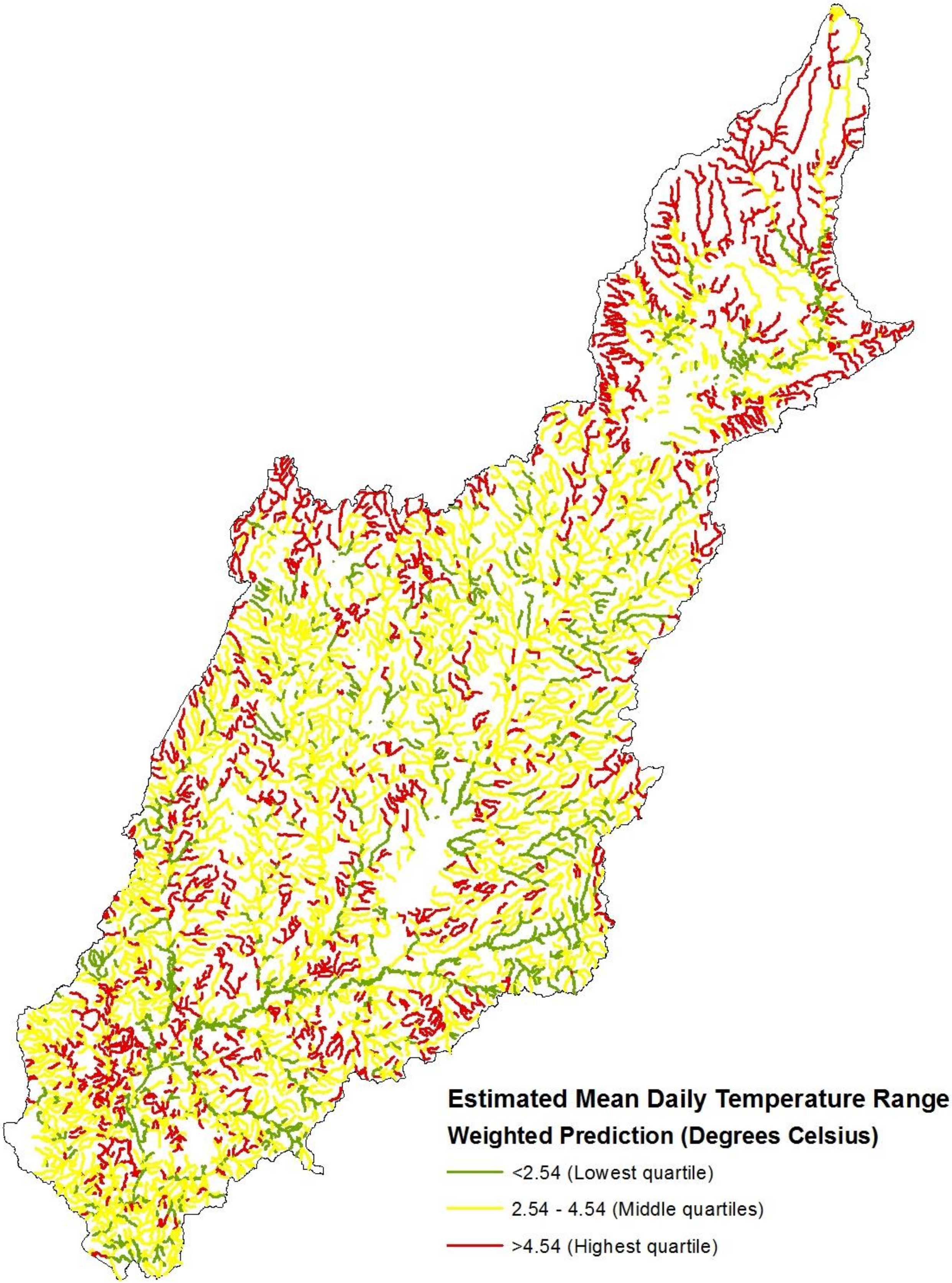

Figure 27. Mean of daily summer temperature range estimated from multiple linear regression models.

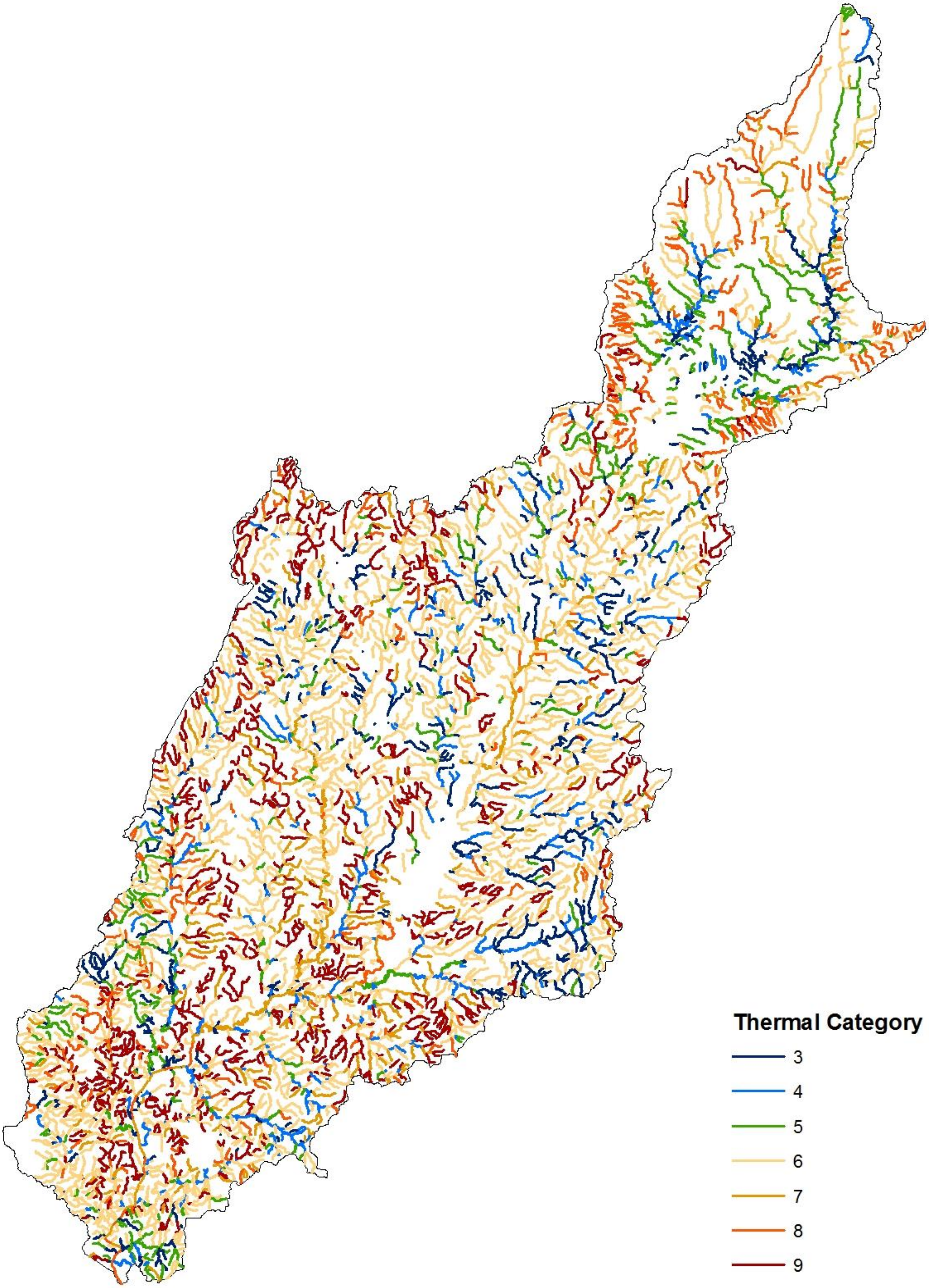

Figure 28. Combined thermal category of three temperature models. Value is sum of quartiles from models. For example, a segment in the lowest daily mean quartile, middle daily maximum quartiles and lowest daily range quartile would have a score of 4 (1+2+1).

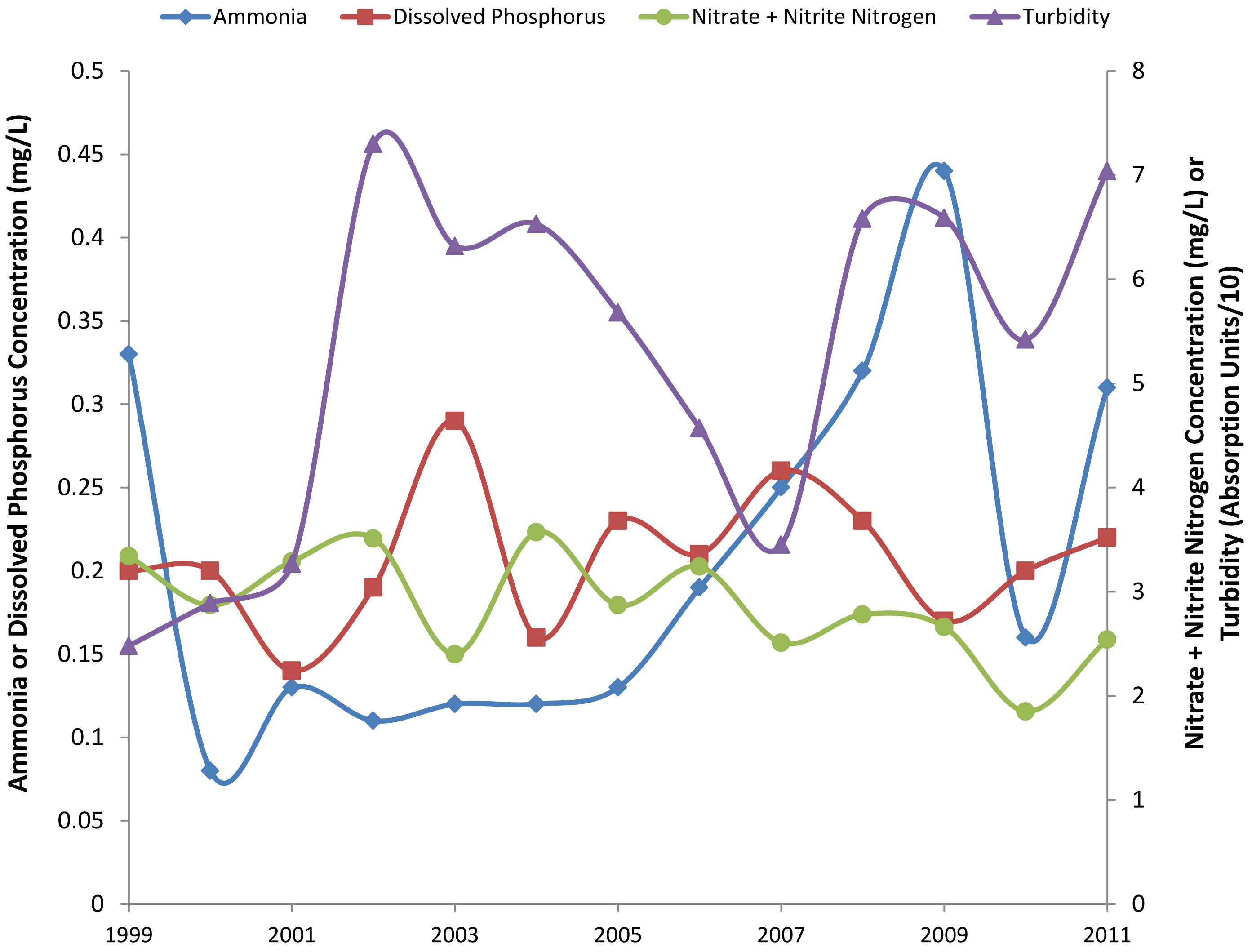

Figure 29. Mean IEPA water quality values between 1999 and 2011 in the Kaskaskia River basin.

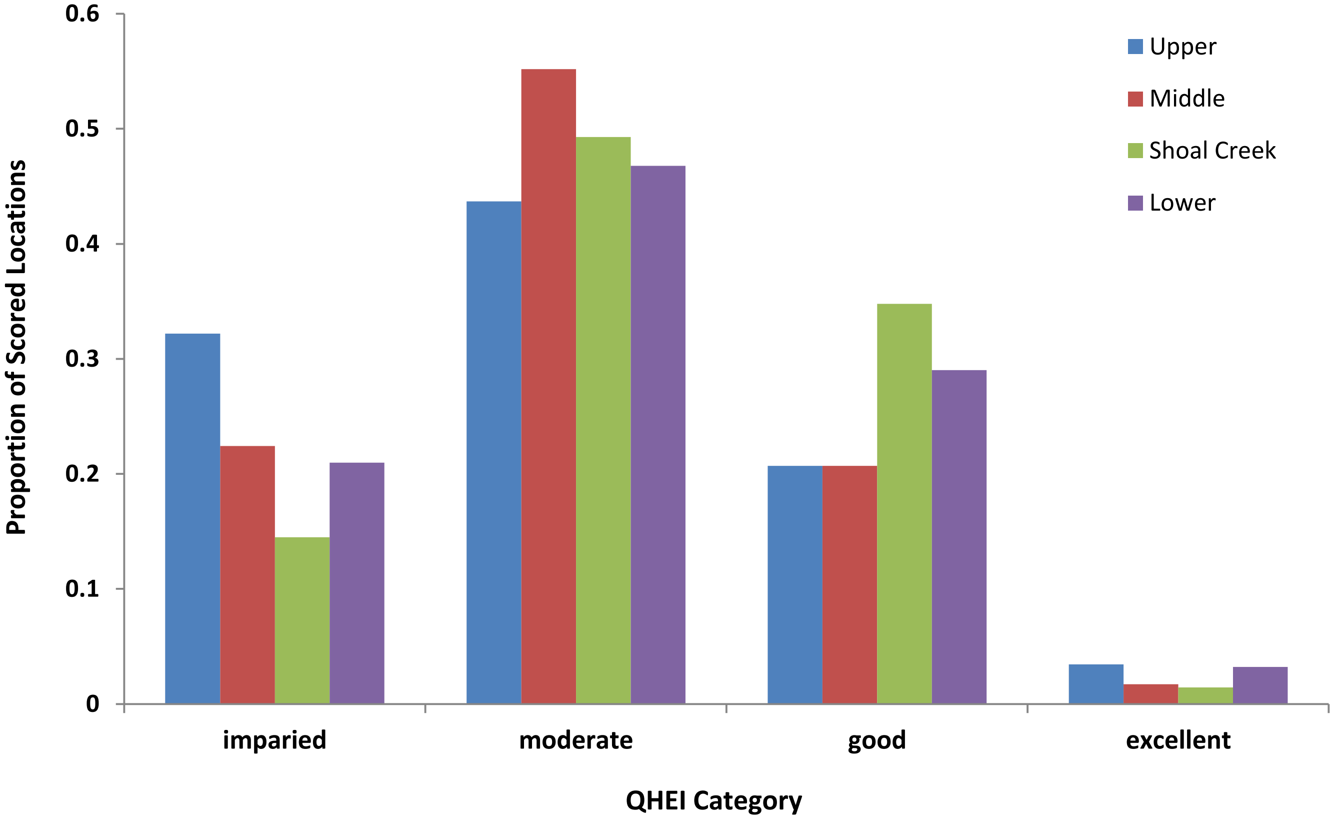

Figure 30. Proportional distribution of QHEI scores calculated between 2007 and 2015 from this study and the IEPA.

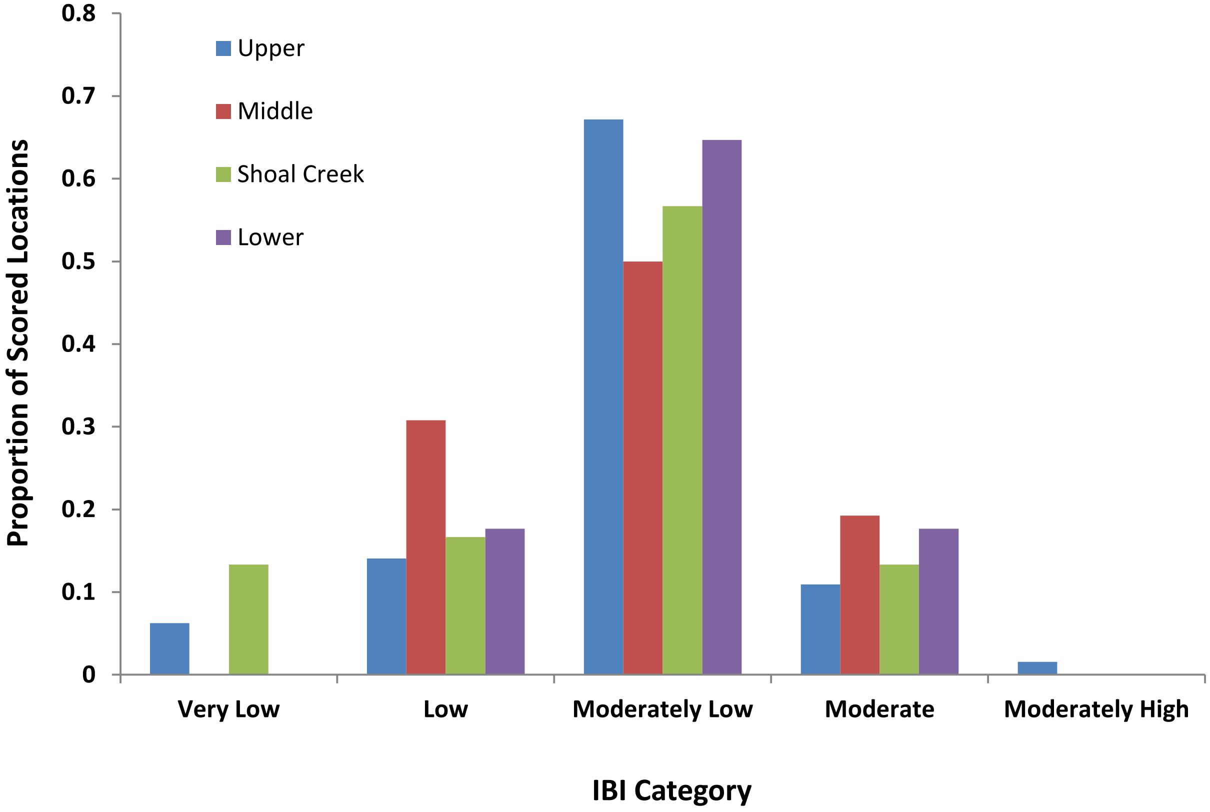

Figure 31. Proportional distribution of IBI scores calculated between 2007 and 2015 from this study and the IDNR.

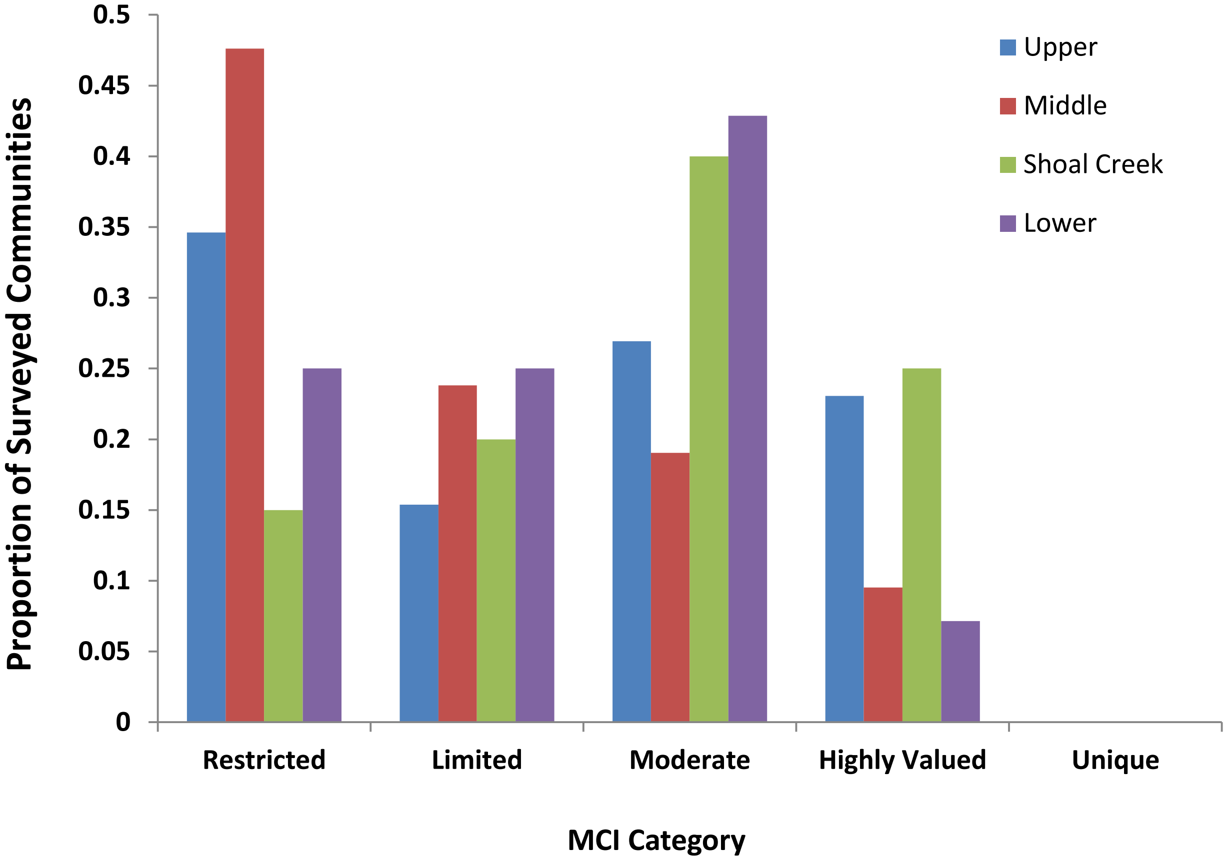

Figure 32. Proportional distribution of MCI scores (Shasteen et al. 2013).