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Evaluating the effectiveness of the Illinois River Conservation Reserve Enhancement Program in reducing sediment delivery

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Abstract The ecology of the Illinois River, a tributary of the Mississippi River, was severely degraded for several decades due to sedimentation and water-quality problems. A joint federal/state program known as the Illinois River Conservation Reserve Enhancement Program (CREP) was initiated in 1998 to restore the river. One of the major goals of the program is to reduce sediment delivery to the river by 20 percent. To assess the program's progress toward meeting that goal, the State of Illinois is developing a scientific process that includes data collection, modelling and evaluation. The baseline condition for sediment delivery was prepared based on available data collected in 1981–2000. Using that information as a baseline, it will be possible to assess and compare sediment delivery and sedimentation in the Illinois River valley for different periods after CREP implementation.

Key words conservation reserve; enhancement; Illinois River; land use; monitoring; sediment delivery; sediment load; Illinois, USA

INTRODUCTION

The Illinois River is one of the major tributaries of the Mississippi River that drains 40 percent of the State of Illinois and parts of Indiana and Wisconsin, USA (Fig 1). There was severe degradation of the river ecology for several decades due to sedimentation and water-quality problems. Currently, there are various initiatives to restore the river and its watershed. The Illinois River Conservation Reserve Enhancement Program (CREP) is a joint federal/state program to improve water quality and wildlife habitat in the Illinois River basin by protecting and restoring the flood plain corridor of the Illinois River and its tributary streams. The program was initiated in 1998 through a Memorandum of Agreement (MOA) between the US Department of Agriculture, the Commodity Credit Corporation, and the State of Illinois. Enrolment in the program began on 1 May 1998. The MOA was amended and re-authorized several times to increase acreage eligible for enrolment up to 93 890 ha (232 000 acres). From 1998 to 2004, a total of 44 863 ha (110 854 acres) enrolled in the program. A subset of that total, 29 592 ha (73 121 acres) is also enrolled in the state option for permanent easement (92%), 15-year easement contract extension (5%), and 35-year easement contract extension (3%) (State of Illinois, IDNR, 2005). Two of the four specific goals established for the program were:

– Reduce the amount of silt and sedimentation entering the mainstem of the Illinois River by 20%.

Fig. 1 Location of the Illinois River basin and its tributary watersheds.

– Reduce the amount of phosphorous and nitrogen in the Illinois River by 10%.

To assess program's progress toward meeting those two goals on sediment and nutrient delivery, the Illinois Department of Natural Resources (IDNR) and the Illinois State Water Survey (ISWS) are developing a scientific process for evaluating program effectiveness. The process includes data collection, modelling and evaluation.

MONITORING AND DATA COLLECTION

The monitoring and data collection component consists of a watershed monitoring program to monitor sediment and nutrients for selected watersheds within the Illinois River basin and also to collect and analyse land-use data throughout the river basin. Historically, there is a limited number of sediment monitoring stations within the Illinois River basin, and most of the available records are of short duration. Out of the 44 sediment monitoring stations in the watershed, only 18 stations had records longer than five years and only eight stations had records longer than 10 years. Therefore the available data and monitoring network was insufficient to monitor long-term trends, especially in small watersheds in which 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 IDNR funded the ISWS to initiate a monitoring program to collect precipitation, hydrological, sediment, and nutrient data for selected small watersheds in the Illinois River basin. These data will help provide a more accurate assessment of sediment and nutrient delivery to the Illinois River.

Sediment data

Five small watersheds within the Spoon and Sangamon Rivers sub-watersheds were selected for intensive monitoring of sediment and nutrients within the Illinois River basin. Information about the monitoring stations is provided in Table 1. Court and North Creeks are within the Spoon River watershed, while Panther and Cox Creeks are within the Sangamon River watershed. The Spoon River watershed generates the highest sediment per unit area in the Illinois River basin. The Sangamon River watershed, the largest tributary watershed to the Illinois River, delivers the largest total amount of sediment to the Illinois River. The type of data collected and the data collection methods are presented in detail in the monitoring program's first project progress report (Demissie *et al*., 2001).

Table 1 Sediment and nutrient monitoring stations established for the Illinois River CREP.

Station ID	Name	Drainage area	Watershed
301	Court Creek	172 km^2 (66.4 sq mi)	Spoon River
302	North Creek	67.4 km^2 (26.0 sq mi)	Spoon River
303	Haw Creek	143 km^2 (55.2 sq mi)	Spoon River
201	Panther Creek	42.7 km^2 (16.5 sq mi)	Sangamon River
202	Cox Creek	31.1 km^2 (12.0 sq mi)	Sangamon River

Sediment loads

Sediment concentrations and water discharges are used to compute the amount of sediment transported past monitoring stations. Based on available flow and concentration data, daily sediment loads are computed and then compiled to compute monthly and annual loads. Results of those calculations are summarized in Tables 2 and 3 for

Table 2 Summary of annual water discharges and sediment loads for the three monitoring stations in the Spoon River watershed. (To convert tonnes to tons divide by 0.9072).

	Court Creek		North Creek		Haw Creek	
Water year	*Q* (m^3 s^{-1})	Sediment load (tonnes)	*Q* (m^3 s^{-1})	Sediment load (tonnes)	*Q* (m^3 s^{-1})	Sediment load (tonnes)
2000	336	21 809	114	5 721	324	17 493
2001	626	35 803	229	13 757	563	40 651
2002	490	51 709	209	24 081	442	36 328
2003	193	17 876	86	9 365	123	4 852
2004	211	6 046	91	1 677	246	8 966

Table 3 Summary of annual water discharges and sediment loads for the five monitoring stations in the Sangamon River watershed. (To convert tonnes to tons divide by 0.9072).

	Panther Creek		Cox Creek	
Water year	*Q* (m^3 s^{-1})	Sediment load (tonnes)	*Q* (m^3 s^{-1})	Sediment load (tonnes)
2000	35	3 569	25	3 415
2001	101	8 069	80	7 908
2002	154	28 293	120	19 047
2003	45	2 424	35	1 498
2004	79	6 392	52	3 765

the five monitoring stations. The tables present the annual water discharge and sediment load for each station. As expected, annual sediment loads are highly correlated with water discharge. Thus, wetter years, 2001 and 2002, generated more sediment at all stations than drier years, 2000 and 2004. Annual sediment loads ranged from a low of 1498 tonnes (1651 tons) at Cox Creek in 2003, to a high of 51 709 tonnes (56 999 tons) at Court Creek in 2002. In terms of total annual sediment loads, larger watersheds such as, Court and Haw Creeks, consistently carry higher sediment loads than Panther and Cox Creeks. However, Panther and Cox Creeks generate more sediment than Court, North, and Haw Creeks per unit area.

LAND-USE PRACTICES

Outside of natural factors such as physical settings and climate variability, land-use practices are the main factors that affect a watershed's hydrology, erosion and sedimentation, and water quality. It is therefore important to document and analyse changes in land-use practices in a given watershed to understand and explain changes in its hydrology, water quality, and the erosion and sedimentation processes. 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 levels to improve land-use practices by implementing conservation practices throughout the watershed. The Illinois River CREP is a major state and federal initiative that has significantly increased conservation and restoration practices in the Illinois River basin.

Historical agricultural land-use practices and recent conservation efforts, including CREP, are briefly discussed in the following paragraphs.

Historical agricultural land-use trends in Illinois

To provide a historical perspective to changes in land-use practices in the Illinois River basin, the authors compiled and analysed historical land-use data from different sources for the whole state. The earliest land-use data are based on the Illinois Agricultural Statistics (IAS) records. The IAS data shows that in 1866 approximately 23% of the state's land area was in agricultural crop production. In 2003, agricultural production increased to 65% of the state's land.

As can be seen in Fig. 2, there are two periods of significant changes in crop production. From 1866 through to the 1920s, crop production increased by 57%, mostly due to a significant increase in the acreage of small grain (wheat, oats, and hay). The other change occurred in the 1920s when the small grain acreage supplanted that for soybeans. Essentially, from that period to the present, a steady reversal in acreage occurred such that currently soybean acreage is the same as that for small grains in the 1920s. From the 1920s to 2003, the total land area in crop production increased by 35% in Illinois. Dominant crops were corn and small grains in 1866, whereas corn and soybeans (row crops) accounted for 93% of the total crop acreage in 2003. During the period of record (1866–2003), corn acreage remained fairly steady at 3.72 million ha (9.2 million acres). Acreage peaked to 4.69 million ha (11.6 million acres) in 1976 and was almost at that level (4.53 million ha or 11.2 million acres) in 2003.

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. The IDNR has

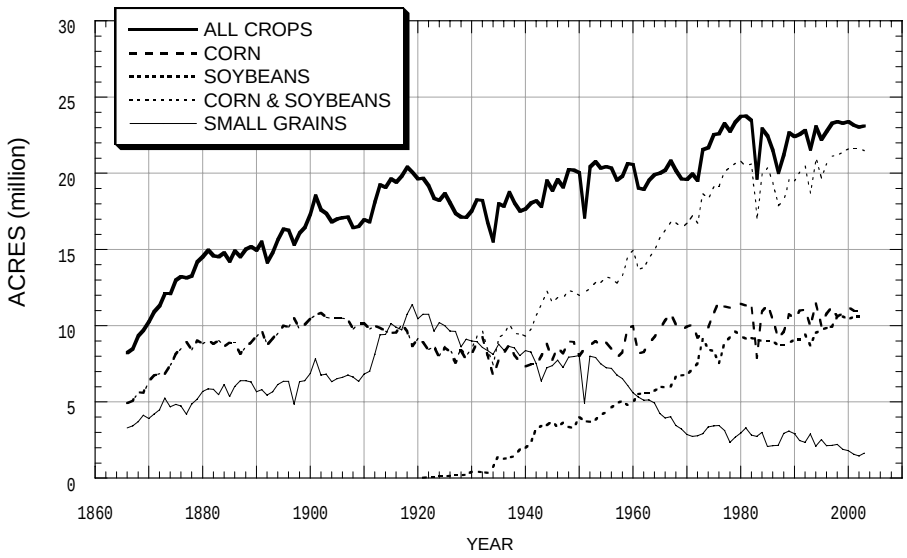

Fig. 2 Land-use trends in Illinois (one acre = 0.405 ha).

established different programs to document and track conservation practices in Illinois. The major initiative is known as the Illinois Conservation Practices Tracking System (ICPTS), which includes development of "a comprehensive database documenting the precise location, nature, and planned duration of conservation practices being implemented through Illinois CREP as well as other conservation incentive programs within the Illinois River basin" (State of Illinois, IDNR, 2005).

Figure 3 shows site locations with approved Illinois CREP contracts from the USDA and State of Illinois for the 1998–2003 period. As shown in Fig. 3, conservation areas are located along stream corridors within the river basin. With the ICPTS, it will be possible to identify areas of significant participation in the CREP program in which changes in sediment and nutrient delivery should be expected. The information will provide important input data for watershed models being developed to evaluate the impact of land-use changes on sediment and nutrient delivery.

Model development and application

The ISWS has been developing a watershed model for the Illinois River basin in support of the Illinois River Ecosystem project. In the initial phase, a hydrological model of the entire Illinois basin was 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 US Environmental Protection Agency's BASINS 3.0 modelling system. The Hydrologic Simulation Program – FORTRAN or HSPF (Bicknell *et al*., 2001), which is part of the BASINS modelling system, 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 ISWS has been developing the sediment transport and water-quality capabilities of the HSPF model for the Illinois River basin.

Assessment and evaluations

Methods used to assess current and future conditions and to evaluate progress of the Illinois River CREP toward meeting goals set for reducing sediment and nutrient delivery to the Illinois River will rely on data being collected in the Illinois River basin and watershed models being developed to complement the data. For sediment delivery, the baseline condition prepared was based on available data collected in 1981–2000 (Demissie *et al*., 2004). The sediment budget estimate for the Illinois River for the 1981–2000 period is shown in Fig. 4.

The figure shows the average annual sediment delivery from tributary streams to the Illinois River. The estimate was based on data collected at some tributary streams and regression equations developed based on available data in the basin. In summary, the estimated sediment budget for the 1981–2000 period shows that tributary streams delivered an average of 9.98 million tonnes (11.0 million tons) of sediment to the

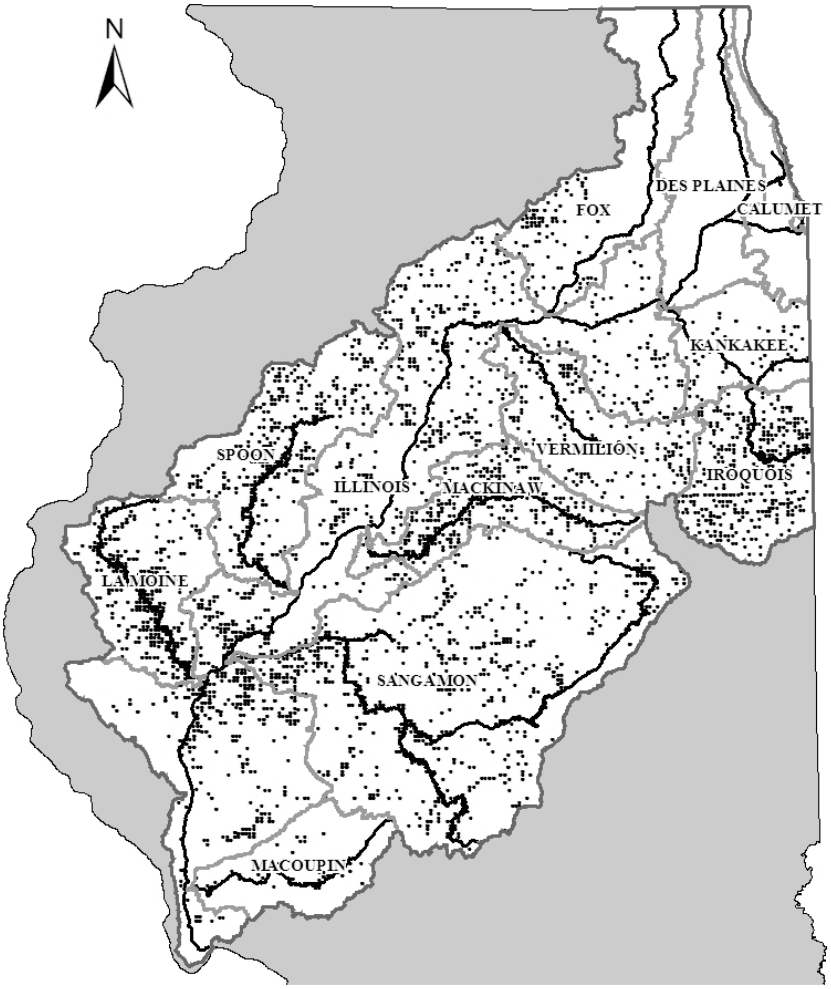

Fig. 3 Location of CREP conservation easement contracts within the Illinois River Basin.

Illinois River valley per year. The measured sediment load in the Illinois River at Valley City, 99 km (61.3 miles) upstream of the junction of the Illinois River with the Mississippi River, averaged 4.44 million tonnes (4.9 million tons) per year. This left about 5.53 million tonnes (6.1 million tons) or 55% of the estimated sediment to be delivered from tributary streams for deposition within the valley every year. As shown in Fig. 4, most of the sediment flows into LaGrange Pool from the Spoon, Sangamon, LaMoine, and Mackinaw Rivers. The Spoon River delivers the most sediment per unit area of any major tributary to the Illinois River. The Vermilion and Kankakee Rivers contribute significant sediment into the Peoria and Dresden Pools, respectively. In general, the Lower Illinois River receives much more sediment than the Upper Illinois River. It should, however, be noted that Fig. 4 is a cumulative sediment budget for the whole Illinois River valley. Sediment entrapment and thus deposition within each pool could not be calculated for each pool from available data. Therefore, only the estimated total sediment deposition within the Illinois River valley is shown at Valley City.

Having this information and data for the 1981–2000 period will enable assessment and comparison of sediment delivery and sedimentation in the Illinois River valley for

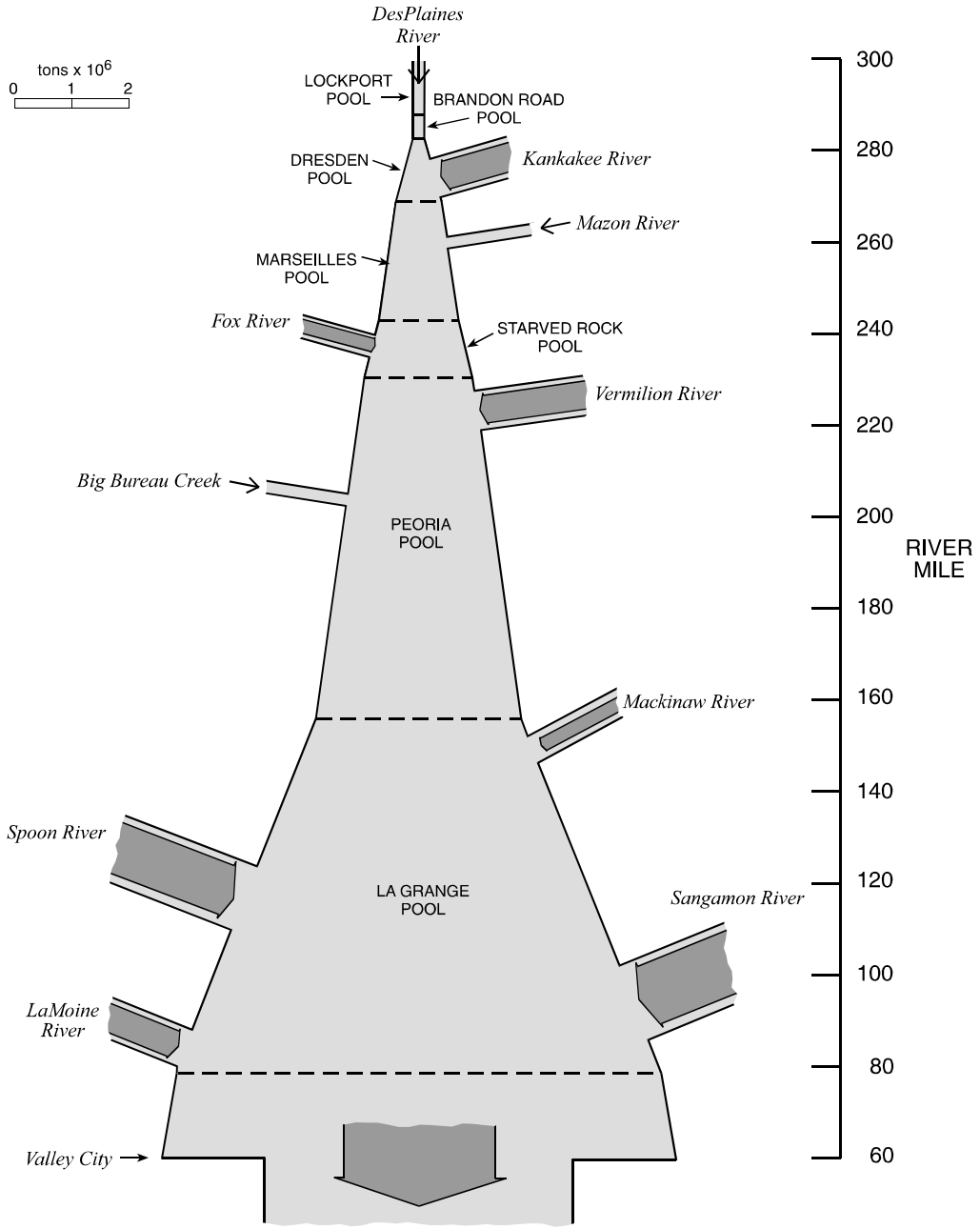

Fig. 4 Sediment budget estimate for the Illinois River, 1981–2000, from Demissie *et al.*, 2004. (Note: to convert River Miles to River Kilometres multiply by 1.61, and to convert tons to metric tons divide by 1.10.)

different periods. For example, if collection of sediment data in the river basin continues until 2010, a different estimated sediment budget would result for the period 2000–2010. Assuming relatively comparable climate conditions, those data could be used to assess if conservation practices, including CREP, reduced sediment delivery in the Illinois River. At the same time we can also evaluate the trend in sediment delivery from individual watersheds and identify locations showing progress or problems. The reliability of this method in comparing sediment budgets for different periods will depend on the availability of quality data for periods being compared.

Another method for evaluating the cumulative impact of land-use changes (on sediment and nutrient delivery) is through application of watershed models capable of simulating sediment and nutrient transport. That capability is already being developed for the Illinois River basin and its tributaries. Hydrological, sediment, and nutrient data being collected under the Illinois River CREP program will be used to calibrate and validate the models so that they can provide reliable results for use in assessing the effectiveness of CREP and other conservation programs within the Illinois River basin. Land-use records are being collected and compiled and thus can be used as input for watershed models. Significant changes in land use would be expected to result in changes in hydrology and in sediment and nutrient delivery.

By using both methods outlined here, it will be possible to assess and evaluate the changes in land use and sediment and nutrient deliveries and the relationships between the two.

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