Interactive Drivers of Land-Cover/Land-Use Change in the Upper Mississippi River Basin (Part II)

An Integrated Modeling System of Climate, Conservation Policy, and Land Manager Choices

Catherine L. Kling, Eugene S. Takle *(Dept. of Agronomy)*,
Hongli Feng, Manoj Jha, Sergey Rabotyagov,
Eric Lu *(Dept. of Agronomy)*, Philip W. Gassman,
Josh Parcel, Todd Campbell

CARD
Center for Agricultural and Rural Development
IOWA STATE UNIVERSITY

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Introduction

Intensive agriculture has resulted in soil and water ecological degradation across much of the Midwest. Historically, conservation policies have played an important role in mitigating such adverse effects. There is now a new impetus to significantly expand the role of conservation. The impacts of this expansion on land cover/land use change (LCLUC) and the environment are not fully understood. Further, there is a lack of information on the further consequences of climate change and the regional feedbacks to the climate system. Preliminary environmental impacts are presented here for the Upper Mississippi River Basin (UMRB) using a framework that incorporates the combined drivers of climate change and conservation policies.

Past Project Results

At the last NASA Science team meeting we presented results on the impacts of the conservation policy driver and the climate change driver. For the sound conservation policy (SCP) scenario considered, we found the impacts on streamflow were minimal but significant on sediment and phosphorous, greater than 30% (Kling et al.) To evaluate the impacts on climate change, we used 21st century results from the GGDL-CM 2.0 GCM model. We found a 6% increase in mean precipitation and substantial decrease of sediment and nutrient runoff in streams (Takle et al.)

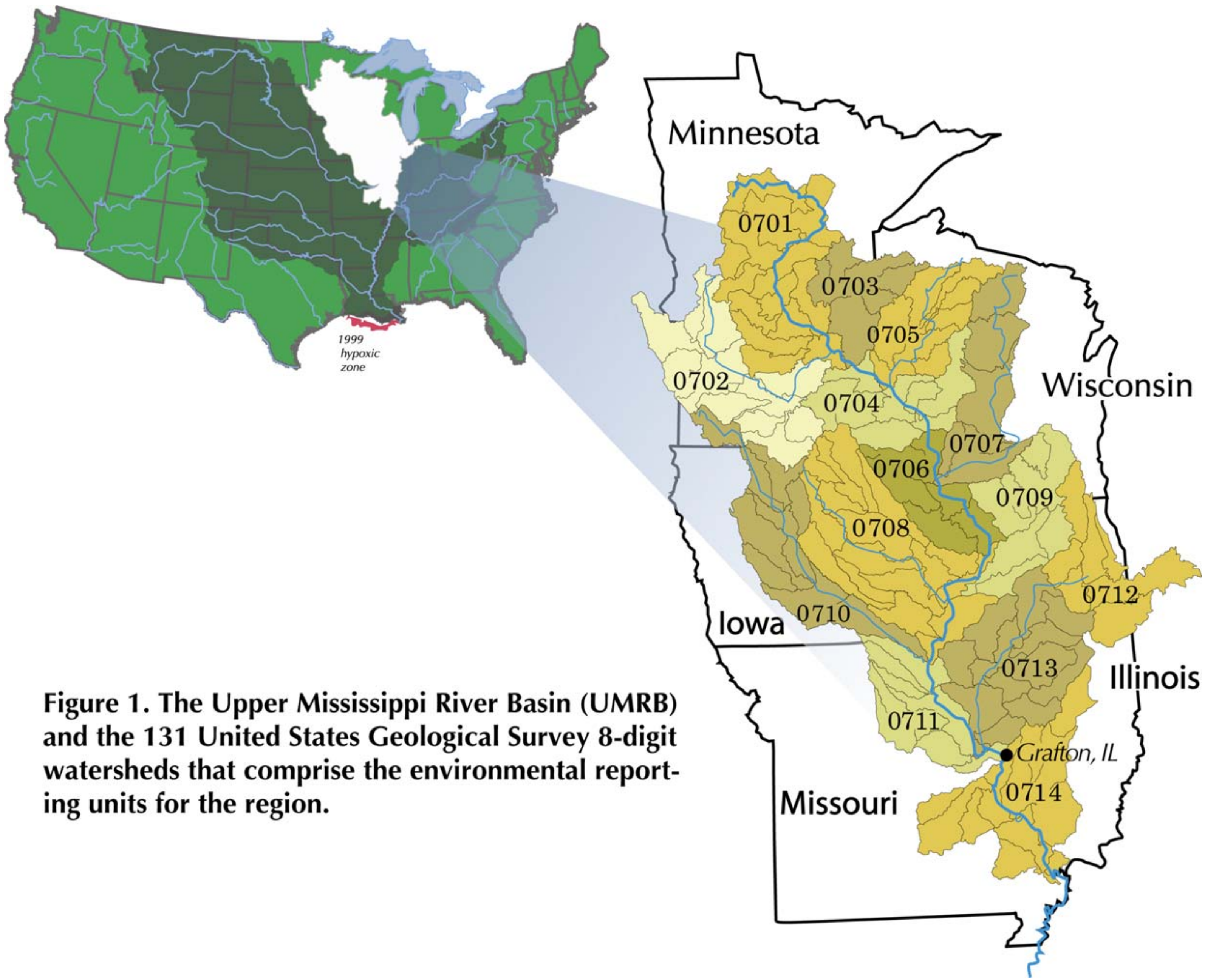

Figure 1. The Upper Mississippi River Basin (UMRB) and the 131 United States Geological Survey 8-digit watersheds that comprise the environmental reporting units for the region.

Current Project Progress

In the past project results, the impacts of the drivers are assessed separately. In this study, we assess how the impacts of the two drivers are affected by the presence of the other driver. Specifically, we examine the scenarios as described in Table 1.

Table 1. Scenario definition

Scenario Code	Climate		Conservation Policy		Crop Choices		
	Historical	Future	Yes	No	Observed Historical	Model Historical	Model Future
S1	X			X	X		
S2	X		X		X		
S3	X			X		X	
S4		X		X			X
S5		X	X				X
S6		X	X			X	

ESTIMATES OF THE EFFECTS of conservation policy can be obtained by comparing S1 and S2 for current climate, and by comparing S4 and S5 for future climate. Similarly, the impacts of climate change can be represented by comparing S3 with S4 (or S5, or S6) depending on whether conservation policy or adjustment in crop choices is considered. The contrast of the last two scenarios gives an example of the policy implications of land managers' adaptation behaviors.

Climate predictions. The current results are based only on the "miub_echo_g" GCM (additional GCM and RCM projections will be used in the future analyses).

The temperature changes predicted by the model fall between 3° and 4°C in the UMRB region for 2046-2065. The changes are quite uniform across the 12 months. There is more variation in precipitation shown in Table 2.

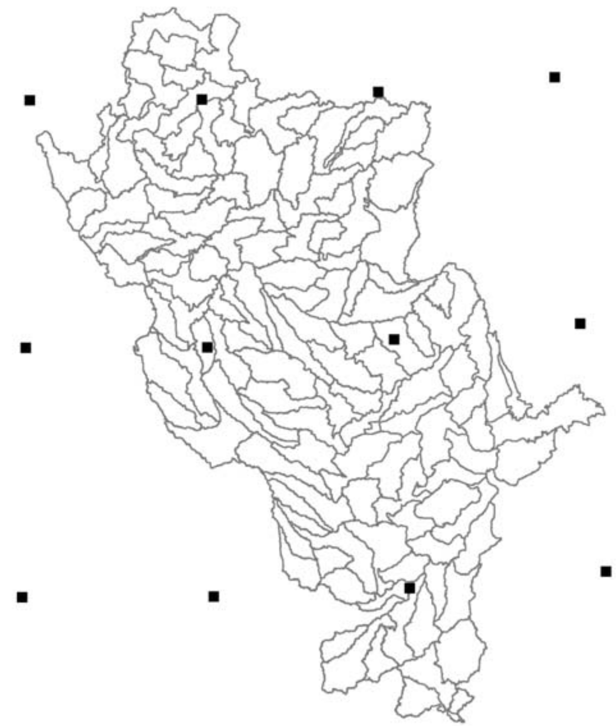

Figure 2. The location of model gridpoints for the "miub_echo_g" model.

Table 2. Percentage changes in monthly precipitation by 4-digit HUCs.

HUC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
7010	-9.6	-14.5	19.1	-23.2	-13.0	7.9	5.6	29.8	3.2	-28.8	18.4	8.1
7020	-9.2	-19.0	11.1	-22.6	-5.9	4.0	14.9	22.0	0.8	-34.4	16.6	1.0
7030	-7.5	-11.3	20.0	-20.2	-15.0	3.3	4.8	22.6	9.0	-27.5	15.5	8.4
7040	-9.1	-12.0	20.0	-23.4	-13.2	-2.7	0.4	6.6	15.9	-29.1	17.5	11.7
7050	2.8	5.9	24.4	-6.0	-22.3	-13.4	1.1	-4.6	31.2	-22.6	5.3	9.9
7060	-9.1	-9.2	22.9	-20.3	-14.1	-7.4	-5.6	-2.6	25.5	-24.3	10.2	7.8
7070	-3.6	-1.9	24.3	-13.8	-17.5	-10.5	-4.4	-4.9	29.7	-22.3	6.3	7.6
7080	-10.8	-13.5	20.1	-25.0	-12.0	-3.5	-1.8	3.1	17.5	-29.1	18.0	11.9
7090	-8.2	-7.0	24.2	-18.1	-14.9	-8.9	-7.2	-5.0	28.9	-22.1	6.9	5.9
7100	-12.4	-17.0	17.6	-29.5	-9.5	1.1	2.6	9.6	8.2	-33.9	26.5	15.6
7110	-16.6	-22.0	15.7	-28.4	-4.8	2.3	-2.0	1.7	19.1	-27.7	10.9	9.9
7120	6.5	-1.1	15.6	-6.3	-14.8	0.4	6.3	1.6	33.4	-11.1	7.3	8.4
7130	-11.5	-16.3	19.6	-24.7	-8.4	-1.2	-5.4	-5.7	27.3	-25.0	6.4	4.1
7140	-12.9	-19.9	17.9	-26.9	-6.2	1.3	-4.8	-5.9	26.8	-26.0	6.2	3.3

Decisions on crop choices. A cropping practice model was developed to estimate how land managers respond to climate change and other incentives. The crop decisions are assumed to be affected by climate and other factors including the expected economic returns and rotations. The predicted acreage for corn and soybeans under the current and future climate are shown in Figures 3 and 4.

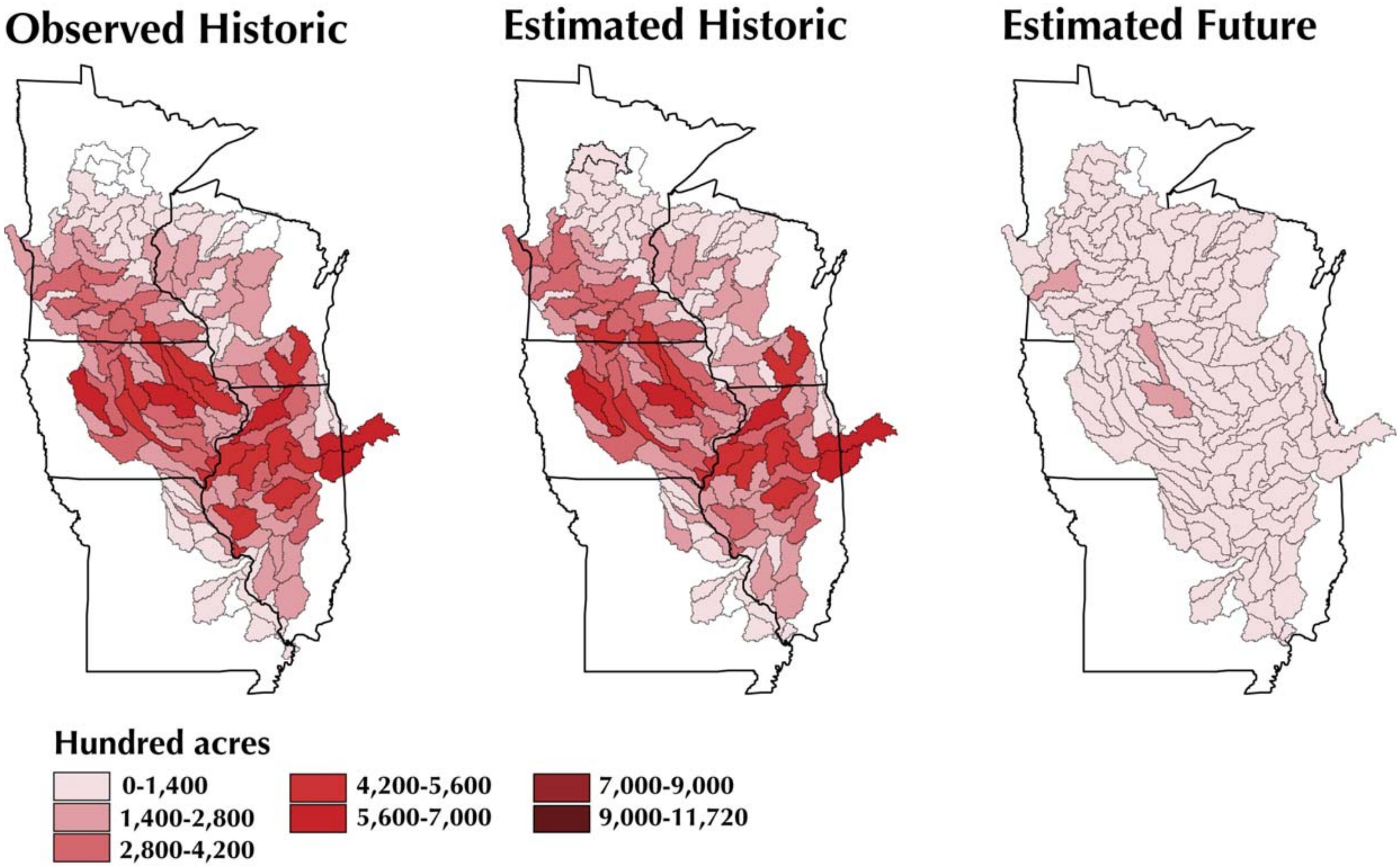

Figure 3. Land allocation to corn

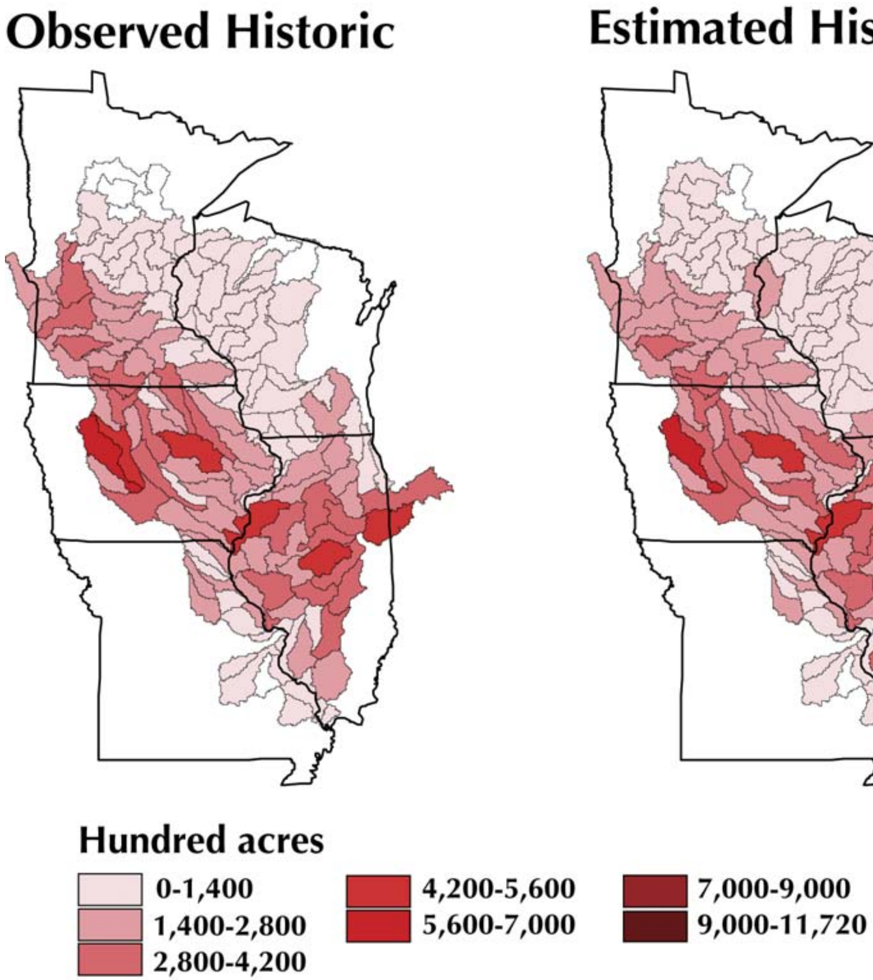

Figure 4. Land allocation to soybeans

Environmental Impacts (SWAT Results)

The Soil and Water Assessment Tool (SWAT) is a simulation model, widely used in water quality modeling (Arnold et al.). We have not completed SWAT modeling for all scenarios listed in Table 1. The results for finished scenarios are shown in Table 3.

Table 3. Average Annual Loadings at Grafton, Illinois

	Scenarios	Flow (m^3/s)	Sediment Yield (Metric Tons)	Nitrate (Metric Tons N)
Current climate	without SCP	3,800	26,220,000	328,000
	with SCP	3,700	20,178,000	270,000
Future climate	without SCP	3,000	18,063,000	251,000
	with SCP	3,500	17,077,000	256,000
			% Change	
Current climate	without SCP	--	--	--
	with SCP	-3	-23	-18
Future climate	without SCP	-21	-31	-23
	with SCP	-8	-35	-22

Ongoing Work

The project team is currently working on several tasks to improve our modeling framework. The crop choice model needs to be refined. The SWAT model is being further calibrated and validated. An optimization algorithm is being tested to replace the rule-of-thumb sound conservation practice scenarios. The feedback effects of LCLUC change to the climate system is also being investigated.

Acknowledgements

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