Project Outcomes

The overarching goal of our Water Sustainability and Climate project (called REACH: REsilience under Accelerated CHange) was to develop a framework within which the vulnerabilities of a natural-human system can be assessed to guide decision-making towards eco-hydrologic sustainability and resilience. Over the lifetime of our project, REACH collaborators have created an interdisciplinary body of work that has highlighted the importance of specific places, times and processes in determining how human and climate induced changes to intensively managed agricultural landscapes propagate through river networks to result in impacts to downstream water quality.

Our efforts have leveraged large, existing publicly available datasets, underscoring the immense value of publicly funded long-term data collection. We have also generated unique, unprecedented original field datasets that have enabled us to examine spatial and temporal linkages between land use, hydrology and water quality impacts; these datasets are now published for public use. Many of our research contributions have focused on developing reduced complexity models to understand how land and water are connected and modified via biophysical processes to affect pollutant loads and aquatic life. At the same time, we have worked to integrate new knowledge into existing mechanistic models widely used by state and federal agencies for conservation planning. In addition to providing new insights into the biophysical underpinnings of agricultural landscapes, our research has highlighted tradeoffs in ecosystem services derived from competing conservation management scenarios. This work involved forging new paths with stakeholders to incorporate science into decision making, establishing a tight network of collaboration with Federal and State agencies, agricultural producers, and conservation groups.

Considerable time and effort was invested into reconciling conflicting disciplinary perspectives and working collectively towards a truly interdisciplinary collaboration in which researchers from different fields understood the objectives and critiques of those from other disciplines. This work was not always easy, but was ultimately fruitful. According to a state agency staff partner, the scientific advancements made by the REACH group have done more to 'change the game' around water quality management in Minnesota than any other scientific collaboration. Many of our findings point to the role of altered hydrological regimes in driving pollutant outcomes, the importance of hydrology-driven transport of near channel sediment sources and nutrients, the role of wetlands in mitigating watershed-scale pollutant loads, and the ways in which biogeochemical processes can alter pollutant export behavior.

One of the culminating elements of this work is a set of biophysical models, coupled to a holistic water quality valuation framework, that can identify the costs and benefits of conservation scenarios designed to address multiple water quality endpoints (nitrogen, phosphorus, and suspended sediment) at large watershed scales. This effort includes key biophysical processes that have previously been overlooked, such as connections between hydrology and in-channel sediment transport, and the removal of nitrogen via wetlands. Importantly, our approach has allowed for the accounting of wetland restoration effects on downstream water quality impacts, something which to date has been omitted from many conservation planning tools. Placement of conservation scenarios on the landscape are optimized for both local water quality targets (i.e., in-state water quality standards for streams, rivers, and lakes) and downstream water quality targets (i.e., nutrient and sediment reduction goals for Lake Pepin and the Gulf of Mexico). We have linked conservation landscapes to the provision of a broad array of ecosystem services, including the costs and benefits to public goods such as air and drinking water quality, recreation, and biodiversity conservation. Our research has also provided an evaluation of multiple potential policy mechanisms that could be used to cost effectively implement conservation actions across the landscape to meet water quality targets and maximize ecosystem benefits.

Figures

Fig. 1. Corn and soybean cultivation in the Minnesota River Basin (MRB). The rate of corn and soybean cultivation has been rapidly increasing and currently covering nearly 86% of the crops in the MRB.

Fig. 2. Tilage tracks. Agriculture is the main land use in the Minnesota River basin where approximately 82% of the total available area in the farm lands consists of row crops.

Fig. 3. Subsurface drain tiles. The replacement of hay and small grains with row crops of corn and soybean since the 1970s has been accompanied by expansion of artificial surface and subsurface drainage.

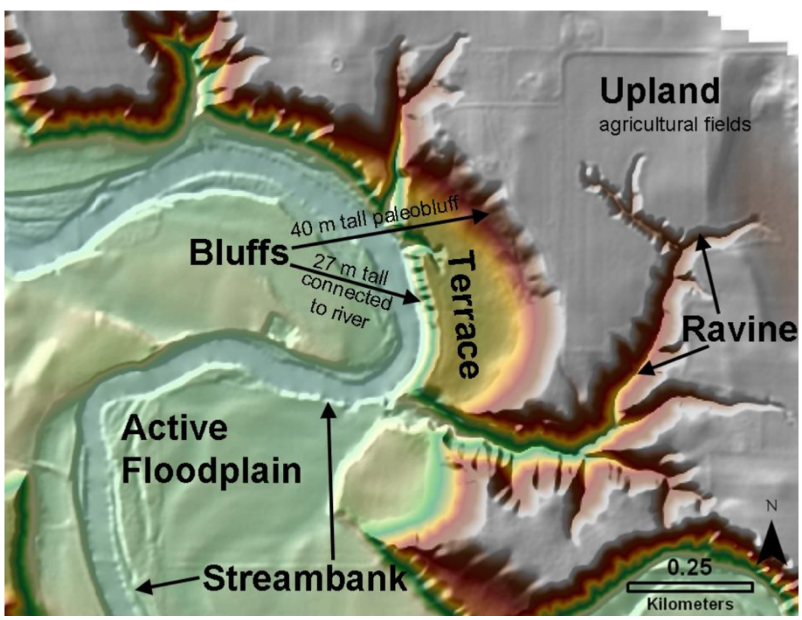

Fig. 4. Digital elevation model of a portion of the Le Sueur River watershed. The DEM illustrates the primary sediment sources and sinks including uplands (primarily corn and soybean fields), ravines (large permanent gullies), bluffs (composed of glacial sediments), banks (composed of alluvial sediments), and floodplains.

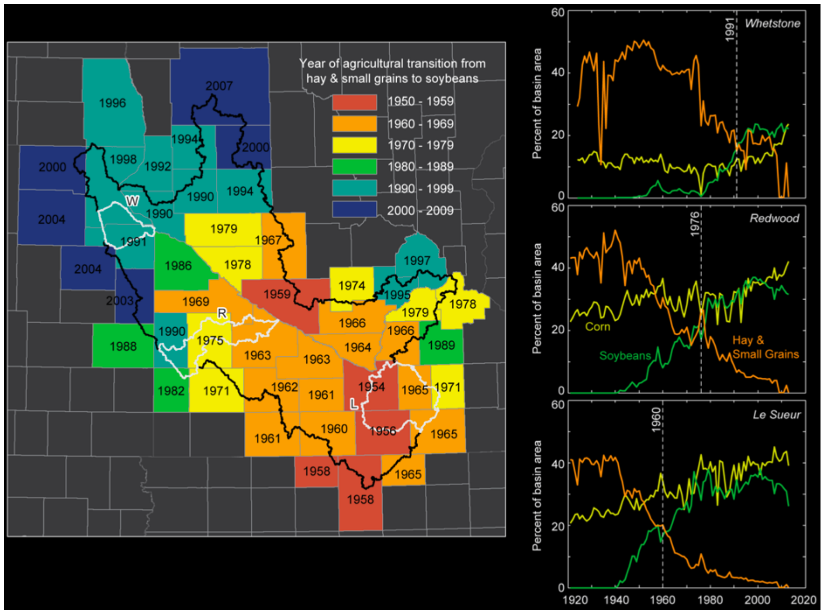

Fig. 5. Spatial progression of agricultural changes in the Minnesota River Basin. Using land-cover data at the county level, we define the Land-Cover Transition as the year when the percentage of area for growing soybeans exceeded that for hay and small grains. The map demonstrates the southeast to northwest progression of this agricultural transition.

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Fig. 6. Annual project meeting at the St. Anthony Falls laboratory, University of Minnesota. Every year, the project PIs and members meet to update everyone about their progress and conduct planning for future work.

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