Forecasting and Assessing Environmental Performance in a Non-Market Economy

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Overview

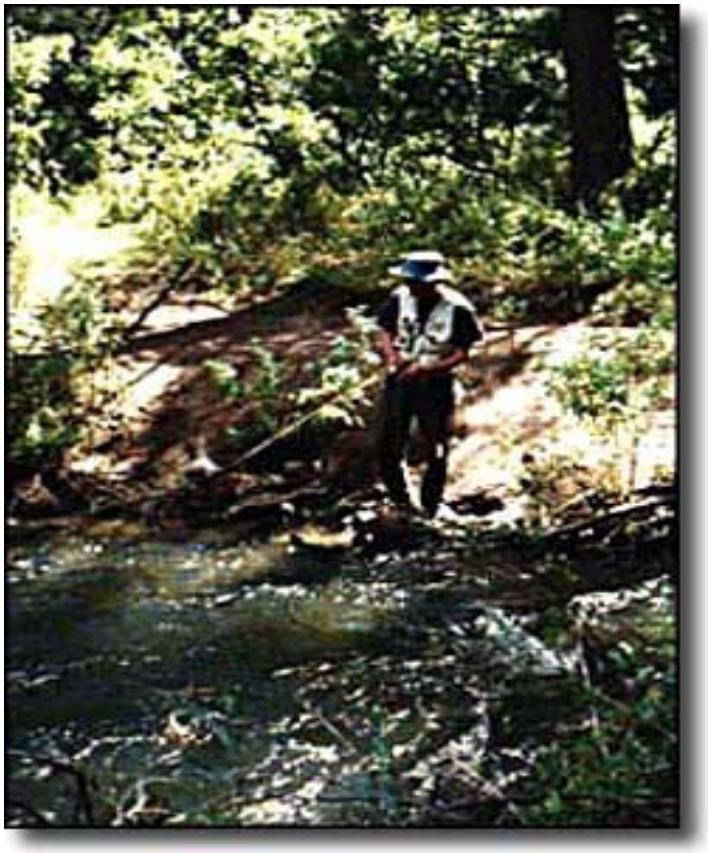
- Improving water quality through reducing nutrients in the Mississippi River, Chesapeake Bay, and other venues is a key focus:
  - Forecasting challenges for scientists :
    - Establishing the correct indicators to measure progress;
    - Ensuring that models are correctly specified;
  - Forecasting challenges for economists:
    - Working to achieve goals in the least-cost manner;
    - Measuring the performance of conservation programs;
    - Translating indicators to a $-value associated with benefits;
    - Demonstrating progress to policymakers.

Types of Water Quality Targets

- EPA implements the Clean Water Act, setting:
  - Water quality targets for the Chesapeake Bay (in terms of total daily maximum loads of specific pollutants).
  - Targets for the size of the Gulf of Mexico hypoxic zone.
- States, working with EPA, set water quality targets:
  - Florida—quantitative nutrient limits;
  - California—sediment standards on the northern coast.
- USDA, in conjunction with EPA and states, can:
  - Identify priority areas and conservation practices to target improved water quality and other benefits.

Benefits of Improved Water Quality

- Reduced nitrogen and phosphorus loadings:
  - Lower size of hypoxic zones;
  - Improve aquatic habitat;
  - Create recreational opportunities;
  - Reduce costs of providing clean water for drinking and industry.



Conservation Practices

(actions to mitigate the effects of agricultural production on the environment)

- Examples:
  - Buffer strips and grass waterways;
  - Restore and create wetlands;
  - No-till cultivation;
  - Crop rotations;
  - Nutrient management plans.
  - Land retirement from crop production.

Grassed waterway in Wisconsin

Challenges to Modeling Water Quality…

(…all of which lead to model specification issues)

- Evolution is occurring with regard to the impact of nutrient form on water quality—
  - Rather than total nitrogen and phosphorus, some scientists now argue that soluble nitrogen and phosphorus are key variables.
- And the link between practices and water quality—
  - One study found that incorporating a variable for tile drainage can improve the predictive power of nitrogen loadings in the Gulf.

Drainage from a field in Michigan

Lagged Effects

- Some conservation practices do not immediately affect nutrient loadings—
  - Vegetation can take years to reach maturity.
- Stream sediment also has a role—
  - Eroded soil from cropland can have long-term effects when deposited into streams.

Confounding Effects

- Further, "acts of God" can dwarf the effects of practices on water quality.
- Multiple sources affect water quality, not just conservation:
  - Waste treatment plants;
  - Hard surfaces that affect water flow, such as roads, houses, parking lots.
  - Livestock and human proximity.
- Bottom line: A long time series is needed to ascertain the effects of conservation practices.

Saginaw River sediment plume in Lake Huron

Stream Flow and Nitrogen Flux

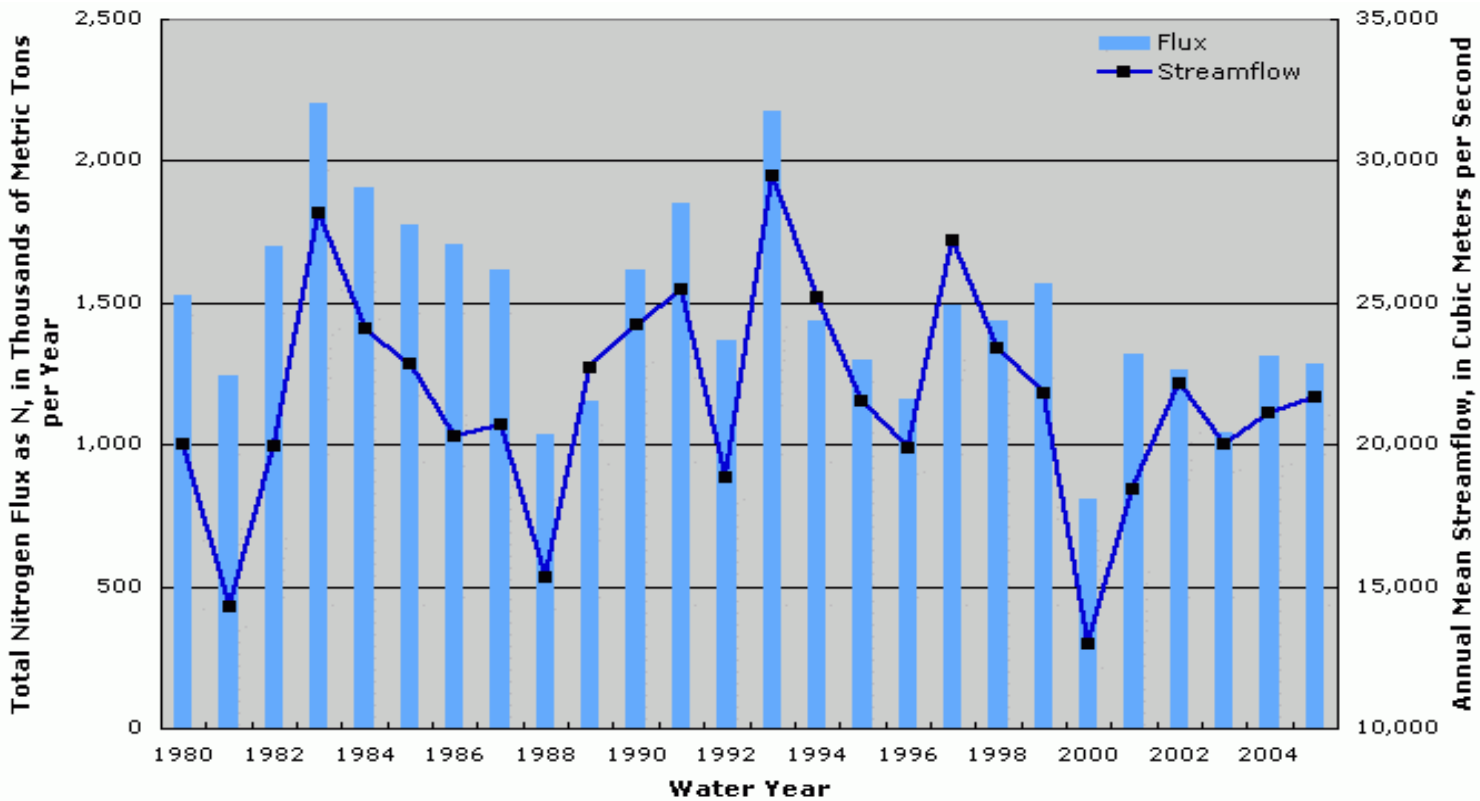


Figure 2. Annual total nitrogen flux and streamflow for total Mississippi-Atchafalaya River Basin.

USGS

USGS Open-File Report 2007-1080

Stream Flow and Phosphorus Flux

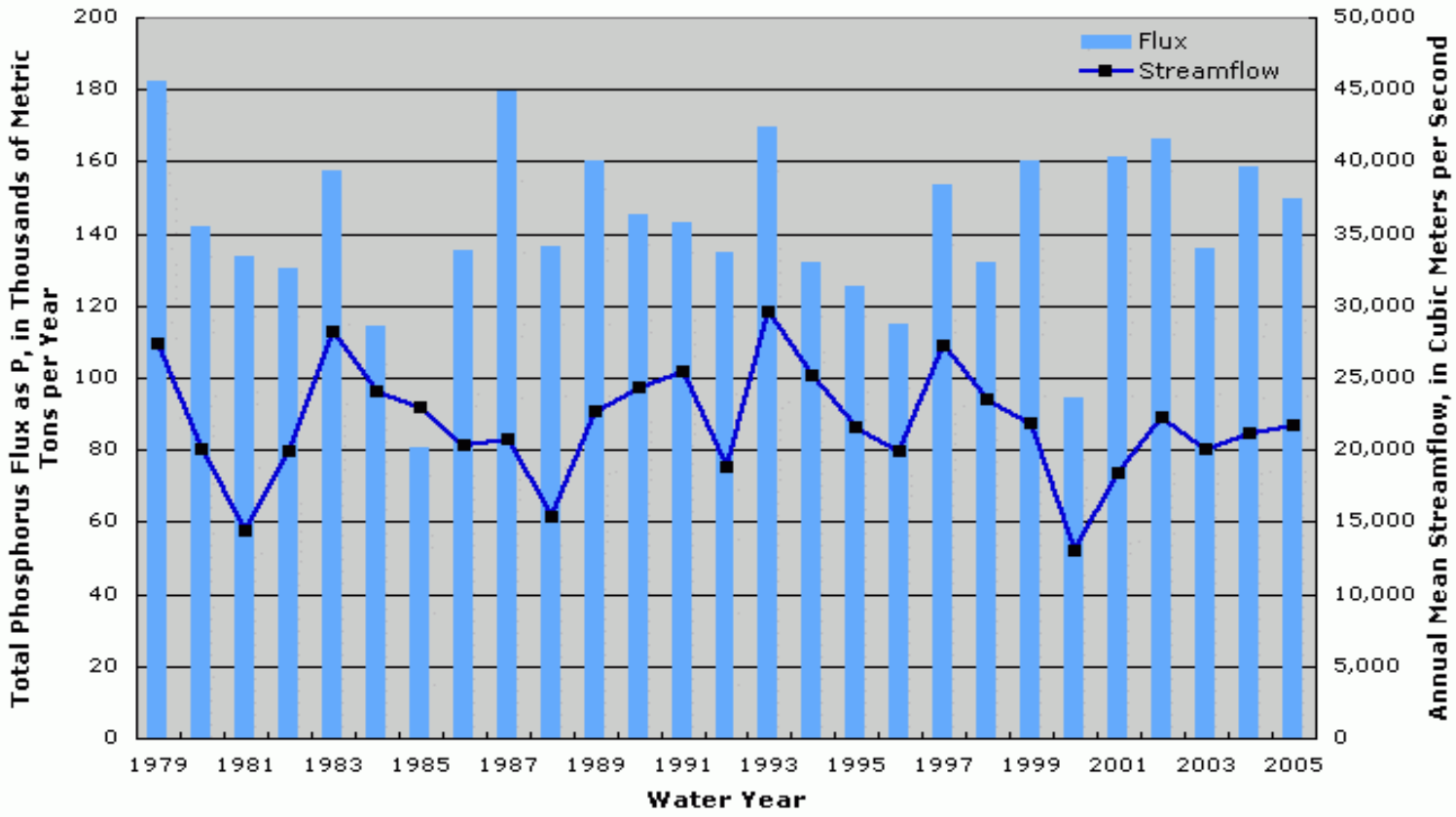


Figure 3. Annual total phosphorus flux and streamflow for total Mississippi-Atchafalaya River Basin.

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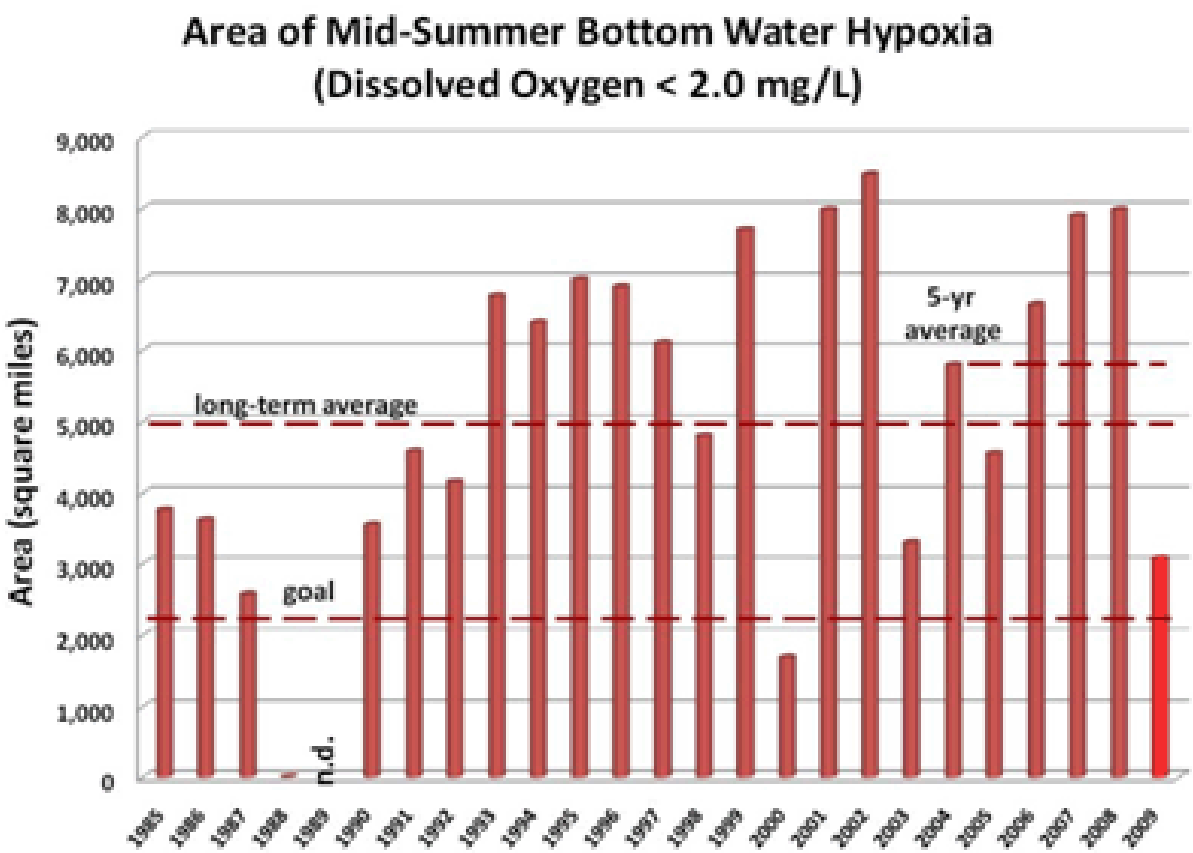
Variation in the Hypoxic Zone in the Gulf of Mexico



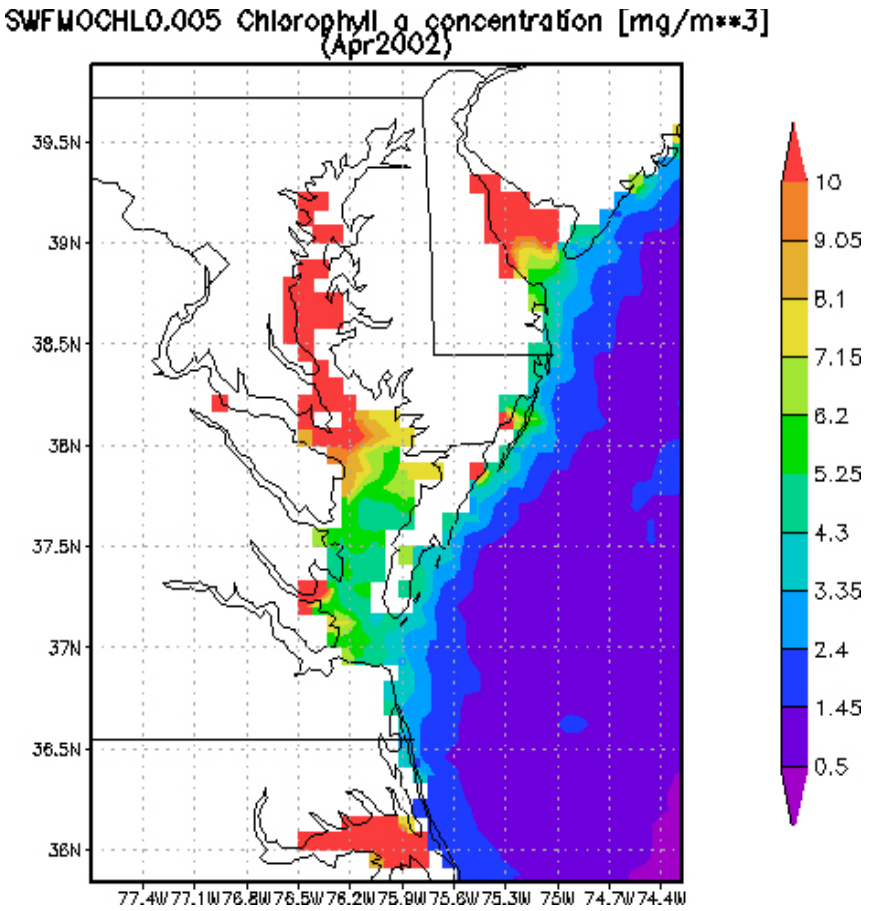
Source: Rabalais, et al.

Alternative Model Specifications

- USDA and EPA have different approaches to modeling water quality—
  - USDA—Focus is on agricultural land use and the impacts of specific conservation practices (nutrient mgt., buffers, etc.) on nutrient and sediment loss and other variables.
  - EPA—Focus is on setting total daily maximum load levels for specific nutrients; takes into account different patterns in land use (agricultural practices are more generally captured relative to the USDA model).

Complications and Opportunities

- None of these models account for voluntary actions by producers outside of existing conservation programs;
- Model predictions should be validated against actual monitoring of nutrient levels.



Economic Issues

- A recent study of Iowa's Raccoon River examined factors affecting nitrate patterns. Findings:
  - Exclusive use of corn/soybean rotations increases nitrate loss in the spring relative to rotations including small grains;
  - There's no silver bullet: The complete production system must be examined, not just fertilization rates and timing.

Crop	Returns over variable costs	Returns over total costs
Corn after Soybeans	$463 per acre	$158 per acre
Oats	-$24 per acre	-$193 per acre

Source: Iowa State University, 2011.

Examples of State Activities

- *Maryland*—Nutrient management planning program, together with regulation, help delay nitrogen applications…
  - …soil tests, yield goals, estimation of residual nitrogen.
- *Florida*—Move from "narrative" to quantitative measures of water quality…
  - …near-term costs to producers are low, but may increase over the longer-term if goals change.

Conservation Reserve Program

- Recipients receive cost-share assistance, annual rental payments, and various incentives to establish 10-15 year conserving covers on eligible farmland;
- Approximately 31 million acres enrolled currently;
- Annual rental payments total $1.7 billion.

CRP land adjacent to a stream and corn field

CRP Monitoring and Evaluation

- This collaborative work between USDA, other government agencies, and academia estimates the benefits of CRP. It has found that CRP:
  - Has prevented more than 8 billion tons of soil from eroding since 1985;
  - Reduces nitrogen losses by an estimated 600 million pounds per year;
  - Reduces phosphorus losses by an estimated 100 million pounds per year.
- CRP also reduces the impacts of downstream flooding and recharges aquifers.

CRP Monitoring and Evaluation

(Example: CRP initiative to construct wetlands in Iowa)

- Constructed wetlands are particularly useful in areas dominated by tile drainage.
- They remove 40-90 percent of the nitrogen that would otherwise flow downstream.
- Simulations indicate that about 500,000-1 million acres of constructed wetlands would reduce nitrogen discharge into the Gulf of Mexico by 30 percent on average annually.

Constructed wetland near Dubuque, IA

Concluding Thoughts

- Social scientists must be aware of the intertwined nature of science, economics, and other fields when developing forecasts.
- Validating models on a regular basis must be done to provide a true gauge of progress.
- Capturing the full set of environmental benefits is important.
- Communicating progress and "confounding effects" to policy-makers is critical.