What have we learned from watershed-scale programs to protect water quality in agricultural watersheds?

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The Fundamental Issue

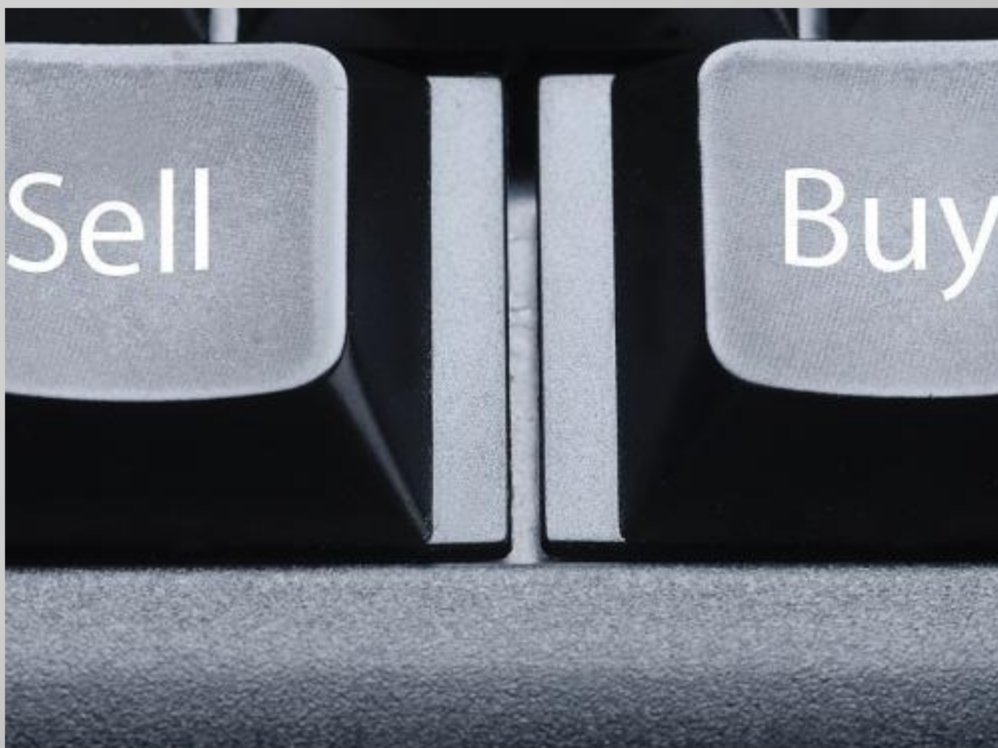
- We know that conservation practices work at the field/farm scale

- It has been challenging to show that a program of conservation practices can improve water quality at the watershed scale

We Need to Know How Conservation Programs Work to Improve Water Quality at the Watershed Scale

- Document the effectiveness of efforts to improve and protect water quality;
- Advance the state of the science;
- Satisfy program requirements to generate results (e.g., TMDL);
- Show farmers that what they are doing is worthwhile off the farm;
- Improve accountability of government programs;
- Improve the chances of securing and maintaining funding for programs

We Need to Know How Conservation Programs Work to Improve Water Quality at the Watershed Scale



Relating Water Quality Change to Conservation Practice Adoption at the Watershed Scale:
A Brief History

USEPA Black Creek Project
1978-1984

USEPA Model Implementation Program
1978-1982

USEPA/USDA
Rural Clean Water Program
1980-1995

USDA Hydrologic Unit Area Projects & Demonstration Projects
1991-1994

USDA Conservation Effects Assessment Program
2004-2011

USEPA Section 319
National NPS Monitoring Program
1991 - present

RCWP	USEPA/USDA Rural Clean Water Program 1980-1995
NNPSMP	USEPA Section 319 National NPS Monitoring Program 1991 - present
CEAP	USDA Conservation Effects Assessment Program 2004-2011

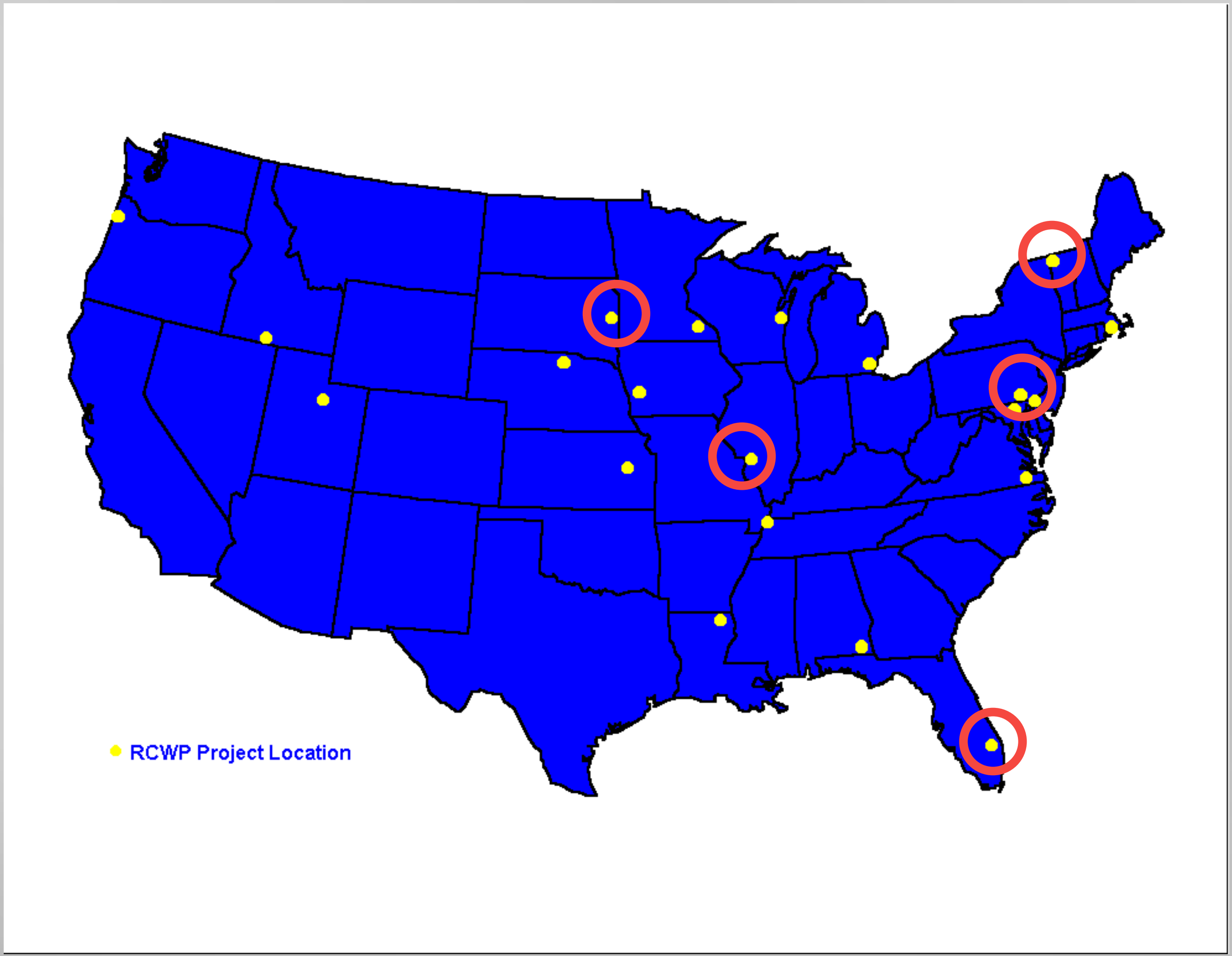
RCWP – Rural Clean Water Program

- First national program to integrate land treatment and water quality monitoring
- Objectives
  - Assist agricultural landowners to reduce NPS water pollutants
  - Achieve improved water quality in cost-effective manner
  - Develop and test programs & policies for the control of ag NPS pollution
- Multi-agency - USEPA, USDA (NRCS, ERS, Extension, Forest Service), states, local

RCWP

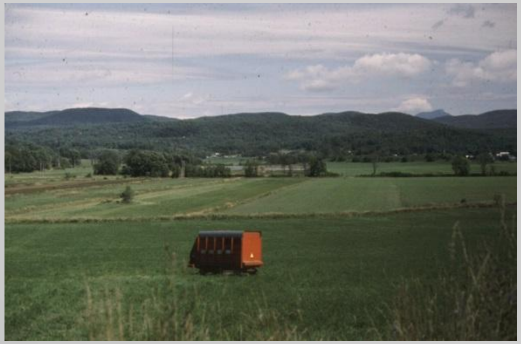
- $64 million → 21 projects across the U.S. representing range of pollution problems, impaired waters, and agricultural settings
- Voluntary landowner participation; cost sharing and technical assistance incentives for implementing BMPs
- All projects had some water quality monitoring ; 5 projects selected for intensive monitoring and evaluation → **show that program of land treatment could improve water quality at the watershed level**

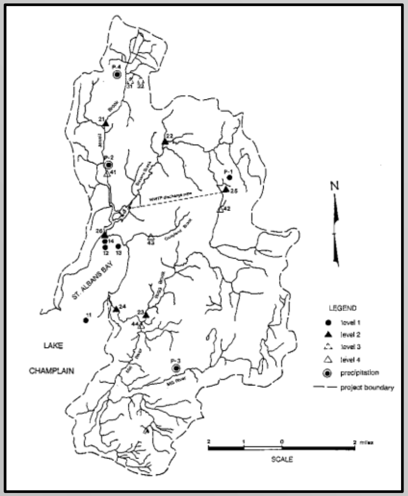
RCWP

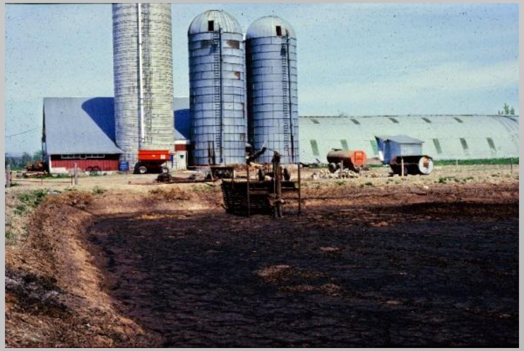


RCWP - Results

- Significant adoption of BMPs
- Improved cooperation and coordination among agencies and between local/state/federal interests
- Advanced understanding of how to plan, implement, manage, and monitor voluntary agricultural NPS pollution control efforts







RCWP - Results

- Individual projects documented some effects on water quality, e.g.,
  - Florida – reduced P concentrations entering Lake Okeechobee
  - Oregon – reduced bacteria levels in shellfish beds
  - South Dakota - innovative techniques for vadose zone and lake monitoring
  - Vermont – documented impacts of winter manure application to cropland

RCWP - Results

RCWP projects largely failed to provide clear evidence of water quality response to land treatment at the watershed level

- Legacy pollutants/lag time?
- Insufficient treatment?
- Incorrect BMPs?
- BMP placement?
- Operation and maintenance?
- Poor monitoring?

RCWP – Lessons Learned

- **Prioritize for higher probability of success:**
  - Clearly documented impairment
  - Measureable water quality objectives
  - Local project support
  - Adequate technical assistance, I&E.
- **Provide sufficient financial and technical resources** to support adequate water quality monitoring and evaluation programs
- **Set realistic, specific, and measurable project goals.** Monitoring programs should be designed to determine progress toward established goal(s).

RCWP – Lessons Learned

- ≥2 years of water quality monitoring is needed prior to land treatment: identify critical pollutant sources, establish baseline.
- A long-term commitment to water quality monitoring is required
- Good monitoring design is critical to control for effects of natural variability (e.g., weather)
- Significant land use activities should be identified and monitored to relate to water quality monitoring data.

RCWP – Lessons Learned

- Target land treatment to critical pollutant source areas
- Emphasize management and maintenance of BMPs
- One-to-one contact is the most effective approach to gaining producer participation
- Cost share assistance is the most important factor in obtaining producer participation in voluntary NPS control programs.
- Feedback between land treatment and water quality monitoring activities is critical

NNPSMP – National NPS Monitoring Program

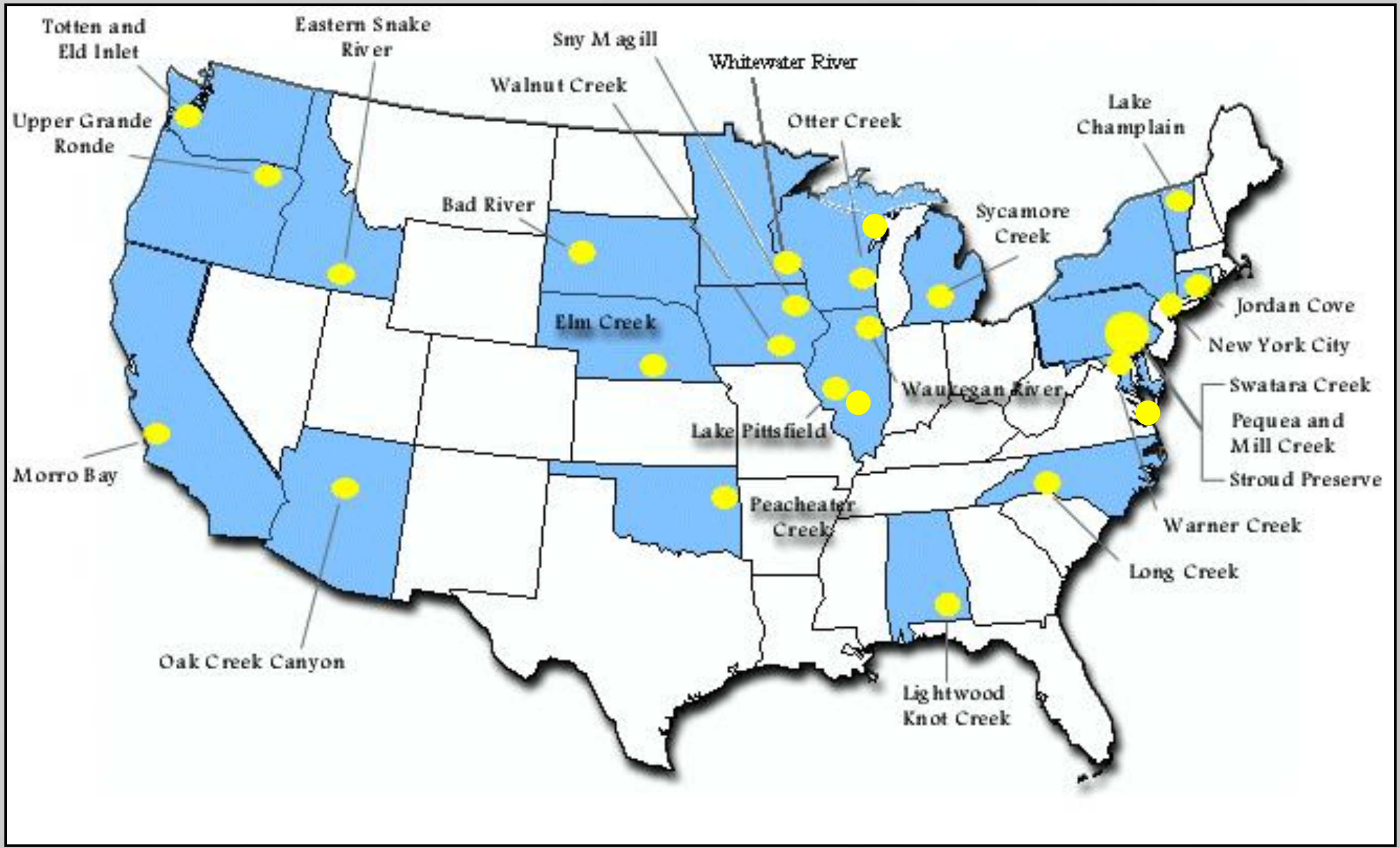
PROGRAM OBJECTIVES

- Scientifically evaluate the effectiveness of watershed technologies designed to control nonpoint source pollution;
- Improve our understanding of nonpoint source pollution.

NNPSMP

- Long-Term Monitoring Projects to Document Water Quality Improvements from BMPs
- Apply lessons learned from earlier programs
  - Experimental design
  - Water quality & land use monitoring
  - Project management
  - Analysis and reporting
  - Project funding
- Funded through USEPA under CWA §319

NNPSMP



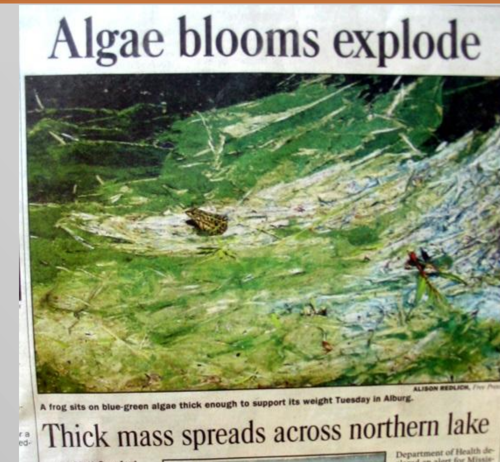
- 28 projects (24 completed)
- 7 – 10+ years
- BMPs, land use tracking, and water quality monitoring
- Mainly ag, but also urban



NNPSMP

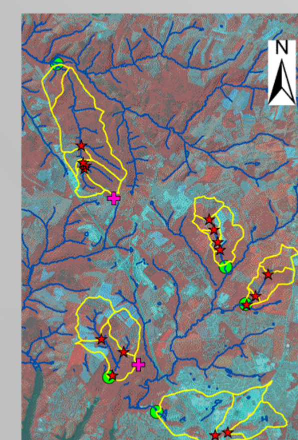
Project Selection Criteria:

- Documented water quality problem, pollutants, sources;
- Well-defined critical areas;
- Land treatment implementation plan;
- Quantitative realistic land treatment and water quality goals;
- Monitoring designs that have a high probability of documenting changes in water quality;
- Well-established institutional arrangements;
- Effective information & education


Algae blooms explode

A frog sits on blue-green algae thick enough to support its weight Tuesday in Alburg.

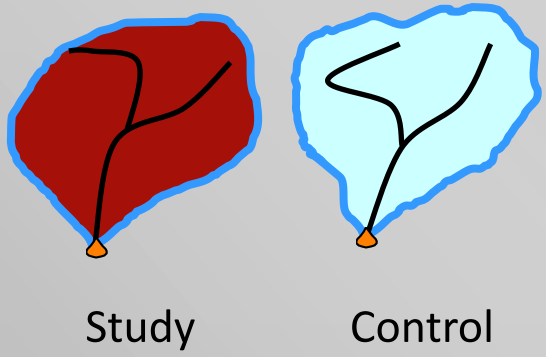
Thick mass spreads across northern lake

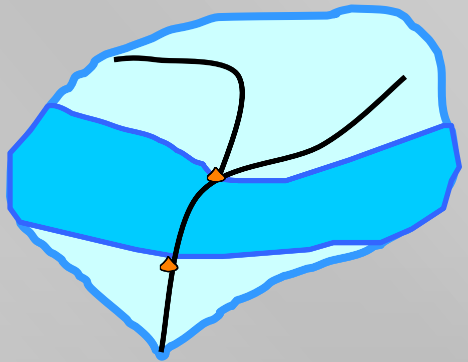


NNPSMP

Monitoring Plan → increase probability of attributing changes in water quality to BMPs:

- Choice of monitoring focus (chemical/physical or biological/habitat).
- Monitoring design: paired watersheds, upstream-downstream, reference site for biological/habitat monitoring;
- Monitor land use/land treatment and important covariates;
- Specify monitoring frequency;
- Data uploaded to USEPA database.





Lake Champlain Basin, VT

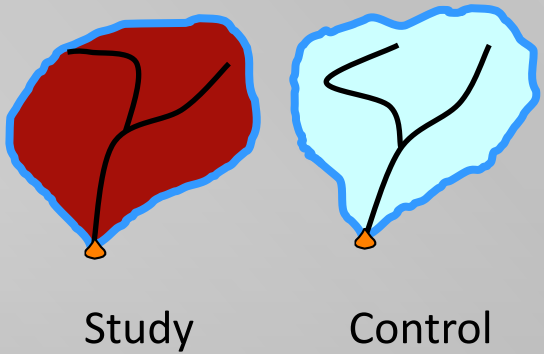
Pollutants

- Phosphorus
- Bacteria

Treatment:

- Livestock exclusion
- Riparian restoration

Paired watershed design



Results:

- **50% decrease in bacteria & TP**
- **Fencing and riparian restoration cost-effective**

Upper Grande Ronde River, OR

Water Quality Impairment

Rainbow trout: temperature

Treatment

Channel restoration,

Cattle exclusion/fencing

Paired watershed, upstream-downstream, reference site

Results

- Improved slope, W/D ratios, sinuosity, pools, cool water habitat
- Improved number of trout
- Pool habitat provided critical temperature refuge

Walnut Creek, IA

Water Quality Impairment

Nitrate-N in streams from row cropland

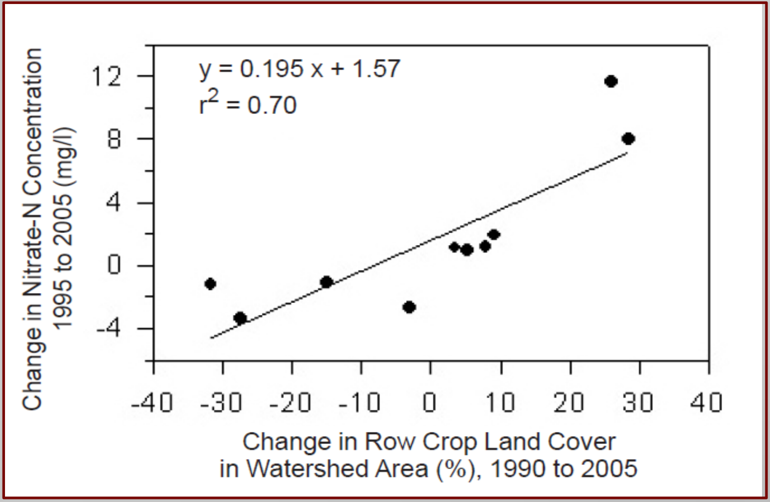
Treatment

Retirement of cropland, prairie restoration

Paired watershed

Results

- NO_3-N decrease 1.2 - 3.4 mg/L (12-40% reduction) in small watersheds
- Stream NO_3-N increased rapidly after CRP lands converted back to cropland
- Documentation of lag time in ground water transport to stream



NNPSMP – Lessons Learned

Significant water quality improvements in different ecoregions from:

- Livestock exclusion & riparian restoration
- Erosion control
- Animal waste/nutrient management
- Stream restoration




NNPSMP – Lessons Learned

Grazing management/ Riparian restoration

- Improvements in water quality
    - TSS, P, and N concentration and load;
    - indicator bacteria counts;
    - macroinvertebrates
- Improvements in water quality mainly due to excluding animal waste from the stream and reduction of streambank erosion
- Removal of sediment and nutrients from cropland through a restored forested riparian buffer.

NNPSMP – Lessons Learned

Erosion Control

- Improvements in water quality: reductions in SS and turbidity, P load
- Water quality improvements in one project were statistically linked to % of land in no-till.
- Because of the dynamics of sediment delivery to water bodies, there may be considerable lag time between erosion control at the source and improved water quality.

NNPSMP – Lessons Learned

Animal Waste/Nutrient Management

- Improvements in water quality
    - indicator bacteria counts,
    - BOD, and P and TSS concentration and load;
    - macroinvertebrates
    - mixed results for N

- Animal waste management without nutrient management, riparian buffers, and management of both surface and subsurface flows (e.g., drain tiles) will not solve nutrient problems.

NNPSMP – Lessons Learned

Restoration

•Significant improvements in aquatic habitat, water temperature, stream biota.
•Efforts to restore aquatic biota should address **water quality** as well as habitat and temperature issues
•Reductions in agrichemical inputs resulting from cropland conversion and implementation of nutrient and pesticide management → significant reductions of nitrates and pesticides at the watershed outlet.

NNPSMP – Programmatic Lessons Learned

Keys to project success

- Accurate identification of pollutants and sources
- Control of practice selection and implementation scheduling
- Tight focus on one or two BMPs is superior to broad program of many different practices
- Small watersheds are easier to work in than large, diverse basins

NNPSMP – Programmatic Lessons Learned

Identify critical source areas

- Visual observation alone may be insufficient to identify critical areas when pollutant delivery pathways are not fully understood.
- For streams and riparian areas, streamwalks and local knowledge may be more useful than modeling

NNPSMP – Programmatic Lessons Learned

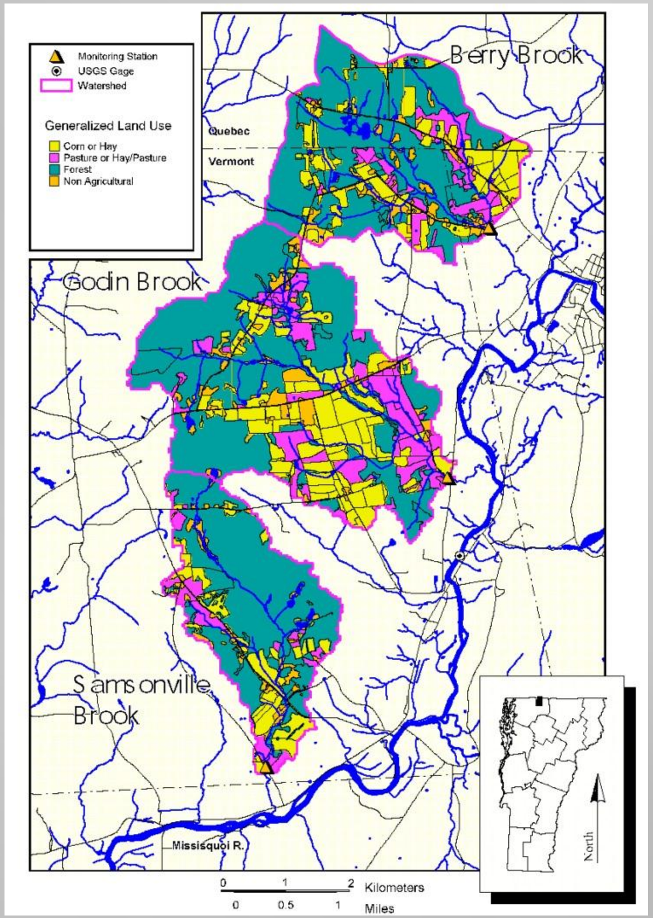
Water quality monitoring

- Develop a specific water quality monitoring design
- Ability to account for weather and other sources of variation
- Select variables to monitor and frequency of sampling based on expected change
- General sampling after BMP installation is not effectiveness monitoring.

NNPSMP – Programmatic Lessons Learned

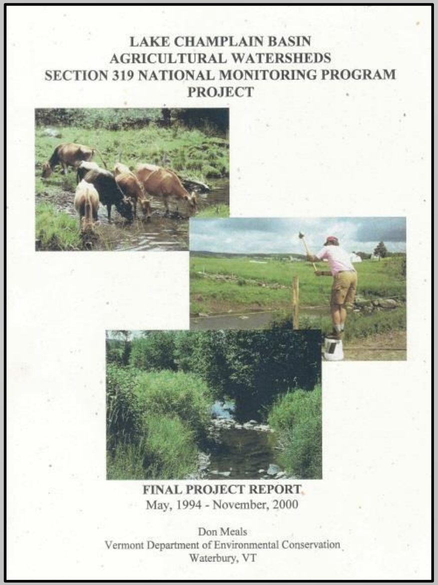
Track land use/management/treatment

- Track operation and maintenance of land treatments after implementation
- Tracking is more effective when conducted by the water quality monitoring project in a small watershed, rather than relying on an external agency in a larger basin.
- There is no substitute for ground-based tracking of practice implementation, O & M
- Flexibility in land treatment implementation is important - the ability to make changes/adjustments to make practice(s) work benefits the project.



NNPSMP – Programmatic Lessons Learned

- Report and communication plan for project evaluation and lessons-learned to policy-makers
- Reporting often ends up taking a back seat to more pressing issues, especially in state agencies with high workloads. Priority and time needs to be given to effective evaluation, reporting and communication of project results.


LAKE CHAMPLAIN BASIN
AGRICULTURAL WATERSHEDS
SECTION 319 NATIONAL MONITORING PROGRAM PROJECT

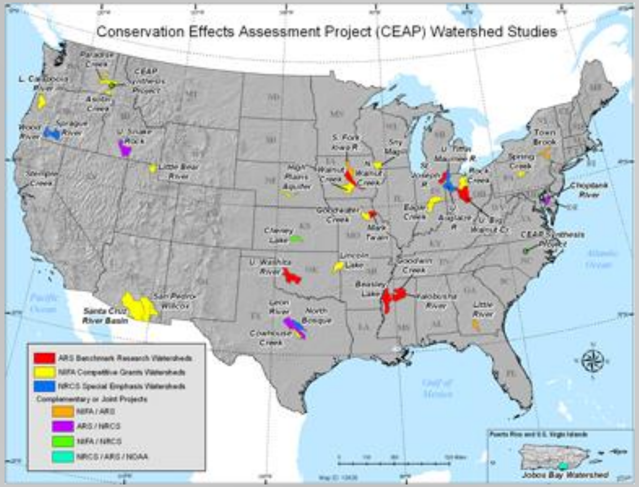
FINAL PROJECT REPORT
May, 1994 - November, 2000

Don Meals
Vermont Department of Environmental Conservation
Waterbury, VT

CEAP – Conservation Effects Assessment Prg.

USDA multi-agency effort:

- Quantify the environmental effects of conservation practices and programs
- Develop the science base for managing the agricultural landscape for environmental quality.



National & regional assessments – e.g., Upper Mississippi River Basin, Chesapeake Bay

Watershed assessments

- NRCS – Natural Resources Conservation Service
- ARS – Agricultural Research Service
- NIFA – National Institute for Food and Agriculture

USDA United States Department of Agriculture National Institute of Food and Agriculture

CEAP

Questions for all NIFA CEAP projects

1. How do the **timing, location, and implemented practices** affect water quality at the watershed scale?

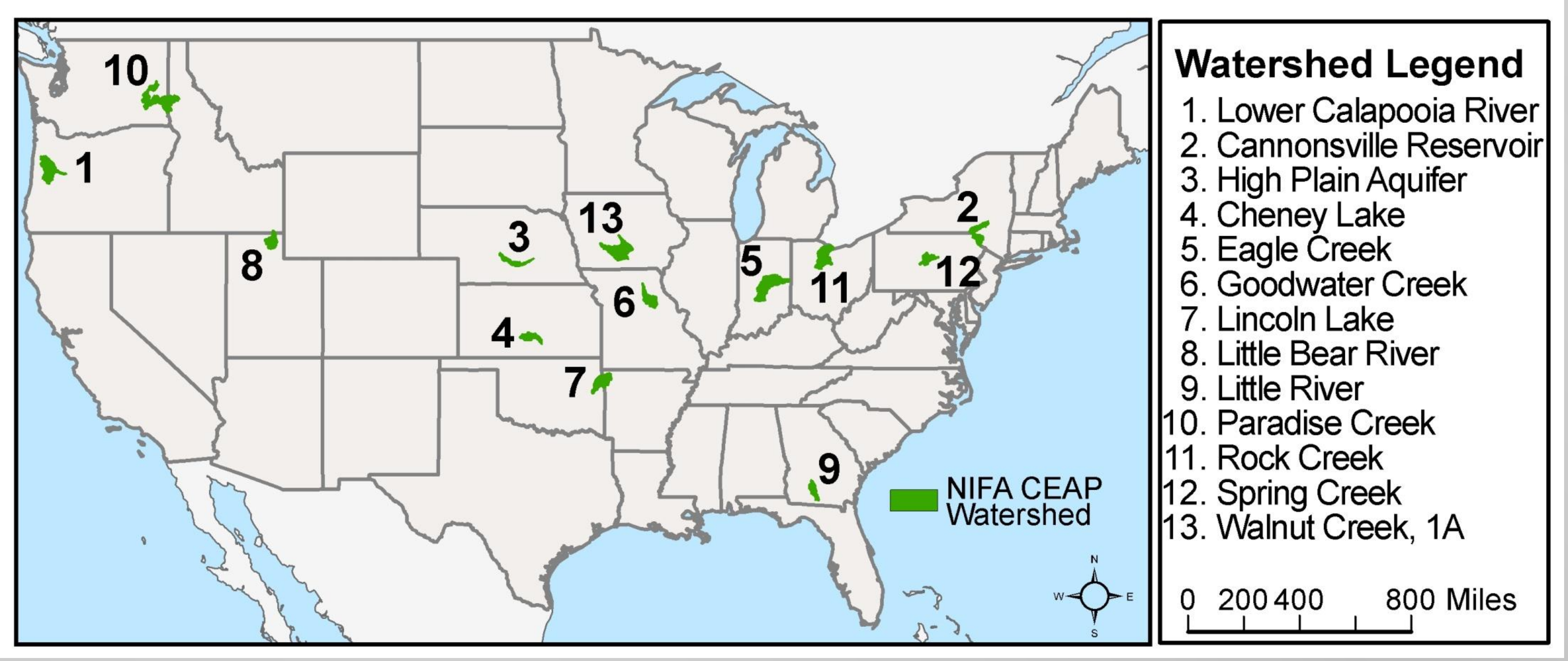
2. What are the **relationships among conservation practices** implemented with respect to their impact on water quality?

3. What **social and economic factors** facilitate or impede implementation of conservation practices?

4. What is the **optimum set of conservation practices and optimal placement** within the watershed in order to achieve water quality goals?

Joint efforts between USDA agencies (NRCS, Extension) and University researchers

CEAP


Watershed Legend
1. Lower Calapooia River
2. Cannonsville Reservoir
3. High Plain Aquifer
4. Cheney Lake
5. Eagle Creek
6. Goodwater Creek
7. Lincoln Lake
8. Little Bear River
9. Little River
10. Paradise Creek
11. Rock Creek
12. Spring Creek
13. Walnut Creek, 1A
NIFA CEAP Watershed
0 200 400 800 Miles

State	Water Resource	Pollutant of Concern	Pollutant Source
Arkansas	Lincoln Lake & streams	P	Pastures, Animals, Development
Georgia	Little River	N, P	Crop Land
Idaho	Paradise Creek	Sediment	Crop Land
Indiana	Eagle Creek & Reservoir	Sediment, P, N, Atrazine, *E. coli*	Crop Land, Development
Iowa	Walnut Creek	N	Crop Land
Kansas	Cheney Lake	P, Sediment	Crop Land, Animals
Missouri	Goodwater Creek	Atrazine, P, N, Sediment	Crop Land
Nebraska	High Plains Aquifer	N	Irrigated Crop Land
New York	Cannonsville Reservoir	P	Crop Land, Animals
Ohio	Rock Creek to Lake Erie	Sediment, P	Crop Land
Oregon	Calapooia River	Temperature, *E. coli*	Crop Land, Animals
Pennsylvania	Spring Creek	Sediment, N, P, Macroinvertebrates	Pastures, Animals, Development
Utah	Little Bear River	P	Crop Land, Animals

CEAP

What are the Key Findings from Projects Relative to the Original Four CEAP Questions?

CEAP

1. Timing, location, and implemented practices

- Five projects were able to demonstrate water quality changes
  - Two employed long-term monitoring (ID & OH)
  - Two were paired watershed projects that were part of the USEPA 319 National NPS Monitoring Program (IA & NY)
  - One used a paired watershed design (PA)


New York CEAP, 2010


Ohio CEAP, 2009


Iowa CEAP, 2008

CEAP

1. Timing, location, and implemented practices

Conservation practice issues that prevented projects from demonstrating water quality effects:

- Practices did not address pollutant(s) of concern
- Practices did not match pollutant sources
- Practices were not implemented in critical areas
- Practices were not used by landowners
- Practices were not maintained

CEAP

1. Timing, location, and implemented practices

<u>Water quality monitoring</u> issues that prevented projects from demonstrating water quality effects:

- Retrospective data difficult to apply
- Monitoring program was designed for a for a different purpose, not suited to detect change
- Monitoring variables did not match the major pollutant(s) of concern
- Comparable data on land use and management not available

Utah CEAP, 2008

CEAP

1. Timing, location, and implemented practices

Water quality monitoring issues that prevented projects from demonstrating water quality effects:

- Inappropriate monitoring scale
- Long lag time in response to treatment
- Climate variability

Kansas CEAP, 2010

CEAP

1. Timing, location, and implemented practices

- Influence of location and timing on water quality change was not directly demonstrated by any projects
- Ex post facto analysis of critical areas vs. BMPs
- Modeling was used to explore the issues:
  - Variable source areas, controlled by the extent of soil saturation, were key in generation of runoff and transport of soluble nutrients
  - Suites of practices can substantially enhance the conservation benefits of individual practices (172 conservation scenarios)

CEAP

2. Relationships among conservation practices

- Contradictory relationships were demonstrated for
  - Terraces, grassed waterways, and drains
  - Conservation tillage used on claypan soils that increased atrazine runoff
  - Conservation tillage, terrace deconstruction, and ephemeral erosion


Ohio CEAP, 2009

- No additive or independent relationships were noted

CEAP

2. Relationships among conservation practices

- Water Quality Monitoring
  - Monitoring must be carefully designed and this question may be better suited for plot or field scale work
- Watershed Modeling
  - New algorithms and methods must be developed for credible representation of watershed processes.
  - Significant expertise is required to properly calibrate, test and apply existing watershed models.

CEAP

3. Social and economic factors

Some promote adoption:

- Economic incentives, including but not limited to cost-share
- Conservation practices that have multiple benefits
- Additional partners providing resources
- Ability to see the pollutant
- Threat of regulation
- Ease of use or management
- Type of practice - structural
- Changes in technology
- Belief system of farmer
- Land ownership: type of rental agreements and communication

New York CEAP, 2009

CEAP

3. Social and economic factors

Some impede adoption:

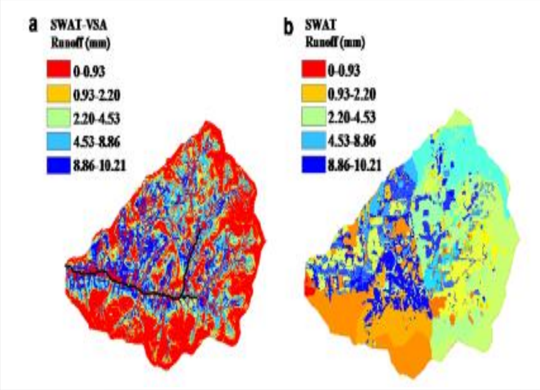
- Expensive and inflexible agency design standards
- Lack of reliable follow-up
- Excessive legal requirements
- Attitudes toward government
- Type of practice - management
- Belief system of farmer
- Land ownership: type of rental agreements and communication

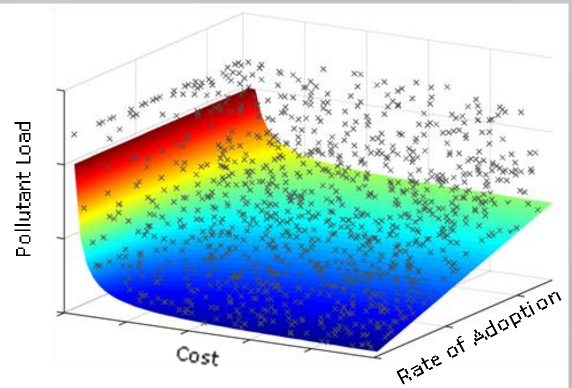

Pennsylvania CEAP, 2010

CEAP

4. Optimum set of conservation practices and optimum placement

- Question only addressed by modeling
- Methods:
  - Scenario analysis
  - Optimization methods
- Optimization was used by two projects
  - Minimize cost
  - Minimize pollutant loads

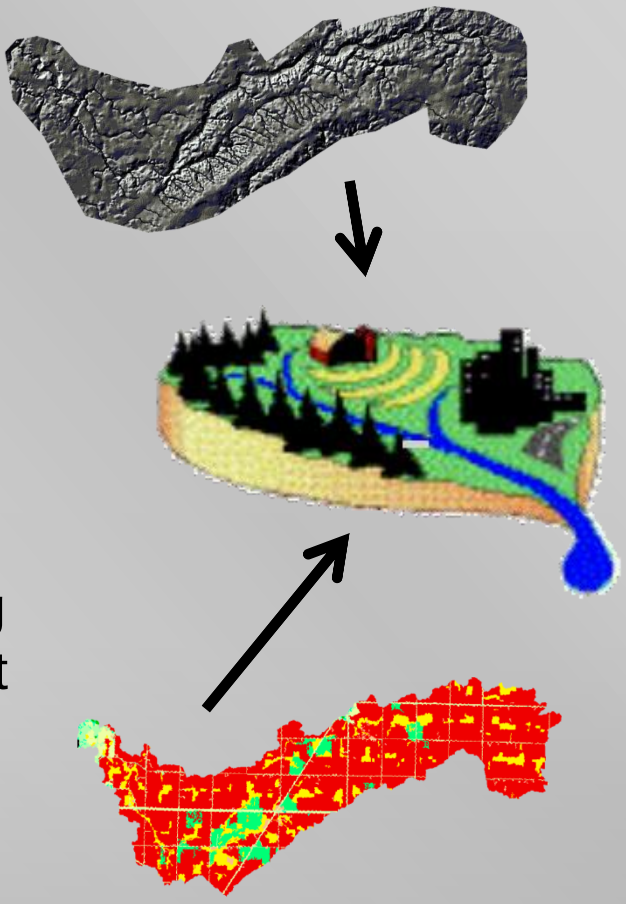




CEAP

4. Optimum set of conservation practices and optimum placement

- New algorithms and methods must be developed for credible representation of watershed processes:
  - Channel processes, gully erosion
  - Representation of conservation practices
- Socioeconomic factors must be incorporated in the analysis
- Role of natural variability of climate, changing land use, and other uncertain conditions must be considered.



CEAP

What Outreach Techniques Were Most Effective?

Most projects did not measure directly

- What worked:
  - Trusted local advisor
  - Farmer-to-farmer programs
  - Other farmers (formal, informal or agency led)

Indiana CEAP, 2011

CEAP

What Outreach Techniques Were Most Effective?

- What did not work as well:
  - Agency-led education
  - Education does not necessarily lead to behavior change – many resources are needed
  - Watershed NGOs will never replace agency personnel

New York CEAP, 2008

Lessons Learned from NIFA-CEAP: Top 15 Countdown

Lessons Learned from NIFA-CEAP: Top 15 Countdown

1. Conservation planning must be done at the watershed scale with sufficient water quality and potentially modeling information.
2. Before implementing conservation practices, identify the pollutants of concern and the sources of the pollutants.
3. Identify critical source areas to prioritize conservation practices.
4. Identify watershed farmers' attitudes toward agriculture and conservation practices to promote adoption.
5. Even after conservation practices have been adopted, continue to work with farmers on maintenance and sustained use.

Lessons Learned from NIFA-CEAP: Top 15 Countdown

6. Technical assistance to farmers is most effective when delivered by a trusted local contact and is very people intensive. Reduced funding is eroding the ability of NRCS, extension, and soil & water conservation districts to deliver effective programming.

7. Economic incentives were often required for adoption of conservation practices not obviously profitable or fitting with current farming systems.

8. Conservation practice adoption is a multivariate choice and although economics are exceptionally important, there are many other factors that are part of the decision-making process.

Lessons Learned from NIFA-CEAP: Top 15 Countdown

9. Most conservation implementation projects should NOT conduct water quality monitoring.
10. For projects that do conduct water quality monitoring, establish monitoring systems that are designed to specifically evaluate response to treatment and ensure that projects include the necessary resources and expertise.

Lessons Learned from NIFA-CEAP: Top 15 Countdown

11. To link water quality response to land treatment changes, conservation practices activities must be monitored as intensively as water quality monitoring, and at the same temporal and spatial scales.

12. Knowledge of land use, management, and conservation practices is absolutely essential to understand effectiveness of conservation programs. Such data are often unavailable due to confidentiality or incomplete.

Lessons Learned from NIFA-CEAP: Top 15 Countdown

13. Watershed models are very complex. Select the correct model(s) and modify if necessary. Ensure sufficiently trained personnel, well calibrated and validated models, and adequate water quality and land treatment data, including spatial and temporal changes of these data.

14. The scientific basis of modeling is still evolving. There are still many deficiencies in our knowledge and in existing modeling tools for representation of critical natural processes and key management actions at the watershed scale. In general, the complexity and non-linear nature of watershed processes overwhelm the capacity of existing modeling tools to reveal the water quality impacts of conservation practices.

Lessons Learned from NIFA-CEAP: Top 15 Countdown

15. Programs have been funded since 1978 with the goal of understanding conservation practice effects at the watershed scale. Some of the lessons learned in the NIFA-CEAP were observed in these earlier programs and projects; some are new. **The lessons were RARELY integrated into most state and federal programming that funds conservation practices.** With dwindling resources and mounting environmental degradation, it is essential that many of the lessons from NIFA-CEAP be integrated into policy and agency protocol if water resources are to be protected or improved.

Without effective programs, we are unlikely to be effective in linking conservation practices to water quality response.

MAJOR CHALLENGES

Balance

Map 30 Excess manure phosphorus assuming no export of manure from farm, 1997

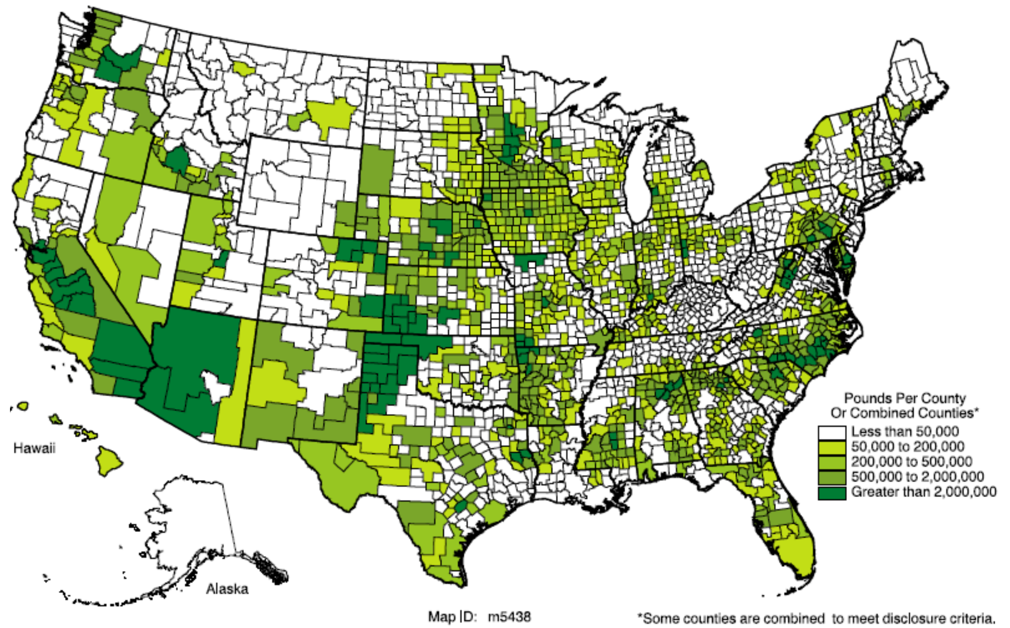
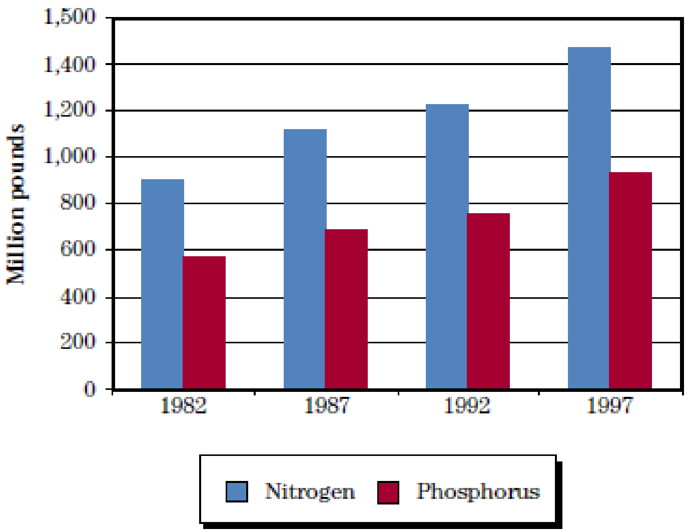
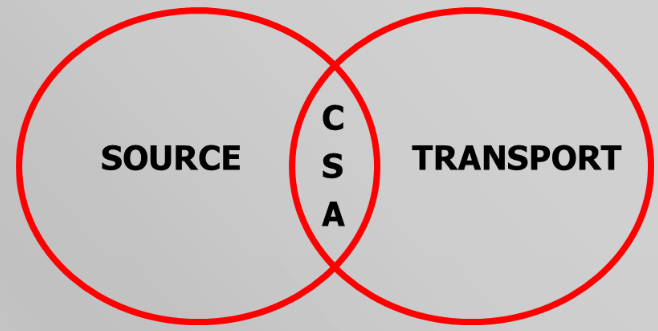


Figure 27 Million pounds of farm-level excess nutrients

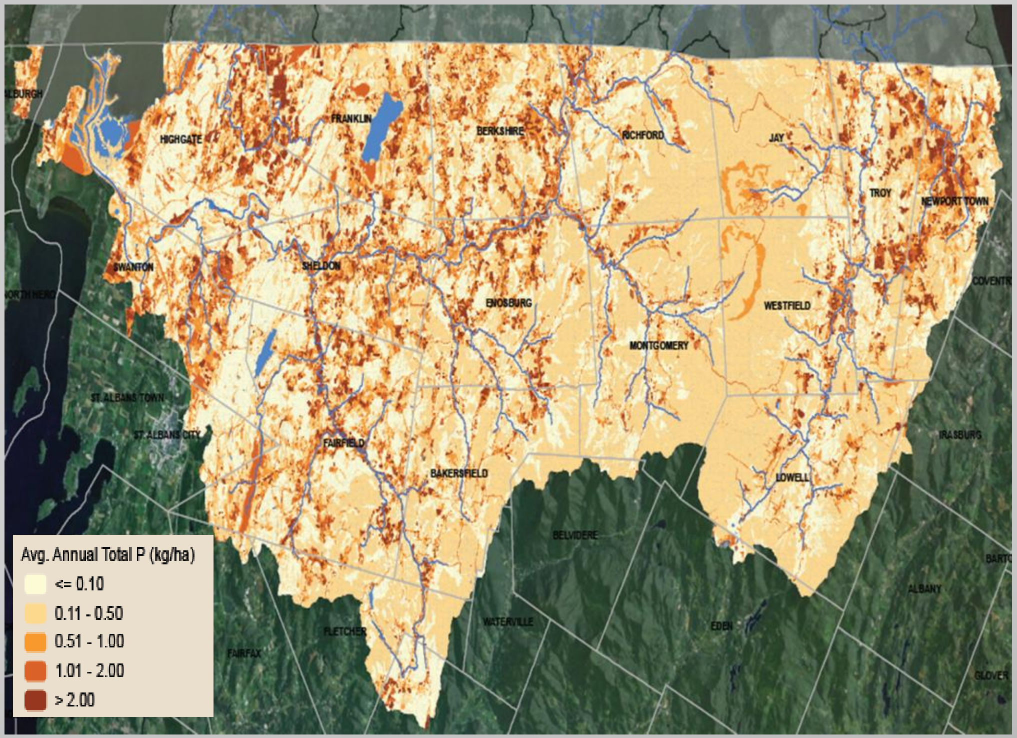


MAJOR CHALLENGES



Critical Source Areas/Prioritization

- How do we identify CSAs?
- How do we effectively target BMPs?

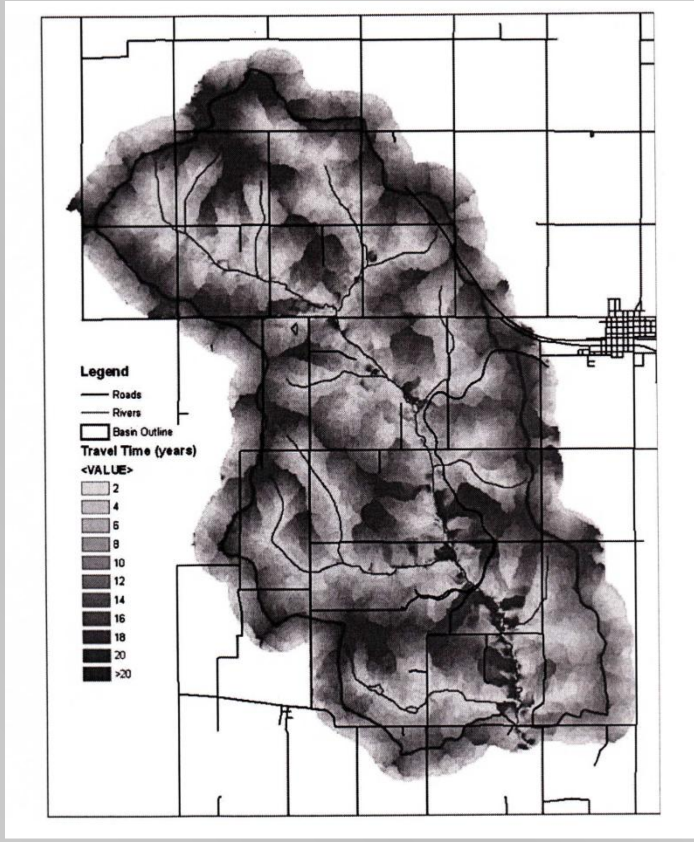


MAJOR CHALLENGES

BMP verification

- Do BMPs exist?
- Are they functional?
- Are they maintained?

MAJOR CHALLENGES



Lag Time

- How long do we have to wait for results?
- How do we adapt programs?

Time required for practice(s) to produce desired effect + **Time required for effect to be delivered to water resource** + **Time required for water body to respond to effect**

Acknowledgments

- Jean Spooner, NC State University
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- Dana Hoag, Colorado State University
- Al Luloff, Pennsylvania State University
- Greg Jennings, NC State University
- Dan Line, NC State University
- Mark McFarland, Texas A&M University
- Andrew Sharpley, University of Arkansas

Resources

- **Rural Clean Water Program**

http://www.water.ncsu.edu/watershedss/info/rcwp/

EVALUATION of the EXPERIMENTAL RURAL CLEAN WATER PROGRAM 1993

Resources

- **National NPS Monitoring Program** http://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/index.htm
  - 2011 Summary Report
  - Lessons Learned
  - NWQEP Notes newsletter
  - Presentations from annual NPS monitoring workshops

Resources

- **National NPS Monitoring Program** ***Tech Notes*** http://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/tech_notes.htm

1 *Exploring Your Data*

2 *Designing Water Quality Monitoring Programs*

3 *Surface Water Flow*

4 *Lag Time in Water Quality Response to Land Treatment*

5 *Using Biological and Habitat Monitoring Data to Plan Watershed Projects*

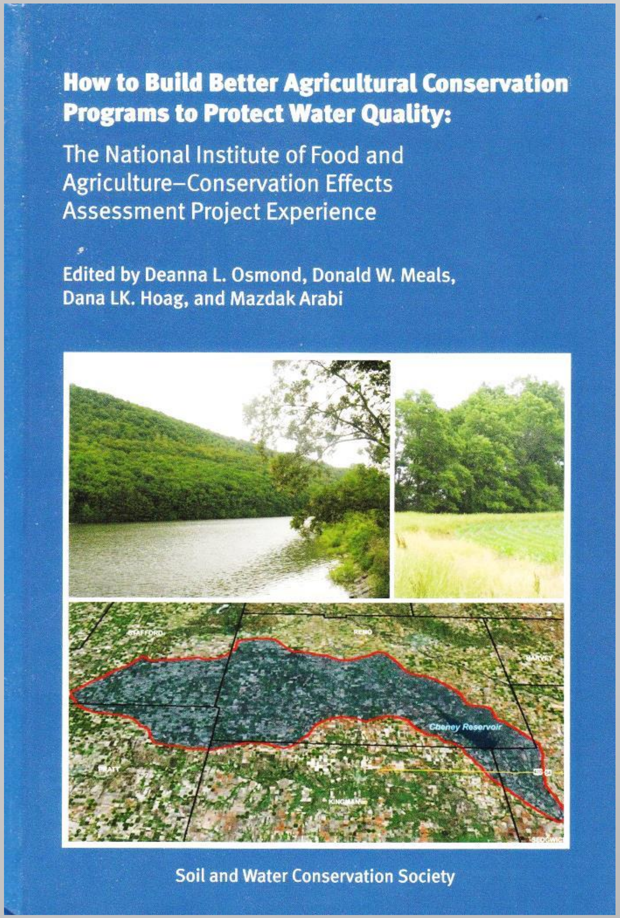
6 *Statistical Analysis for Monotonic Trends*

7 *Minimum Detectable Change (MDC) Analysis*

CEAP

How to Build Better Agricultural Conservation Programs to Protect Water Quality

Soil & Water Conservation Society, 2012



Rural Clean Water Program

http://www.water.ncsu.edu/watershedss/info/rcwp/

National NPS Monitoring Program

http://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/index.htm

National NPS Monitoring Program *Tech Notes*

http://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/tech_notes.htm

Synthesis Report: CEAP-NIFA Competitive Grant Watershed Studies

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/ceap/?cid=stelprdb1047821