Effects of Conservation Practices on Environmental Quality in Small Watersheds

ARS’ Benchmark Watershed Research Network

Dr. Mark R. Walbridge
Division Chief
Renewable Energy, Natural Resources and Environment
Research, Education and Extension Office (REEO)
USDA/Research, Education & Economics (REE)
Washington, DC
Objectives

- Quantify the environmental benefits of conservation practices on croplands
- Determine how best to implement conservation practices in different regions of the US
- Produce a core body of scientific assessments that would help Farm Bill policy-makers and program managers optimize conservation investments to meet our nation’s environmental, food, and fiber needs
ARS’ Benchmark Watershed Research Network

- ARS established a network of 14 long term ‘Benchmark’ Watersheds that included:
  - 12 existing ARS watersheds
  - 2 new watersheds [Choptank River, MD; Upper Snake Rock Creek, ID]
  - The size of existing watersheds was increased to conform to an 8-digit HUC scale
  - MO example: Goodwater Creek—originally 28 mi²; Mark Twain > 2500 mi²

- Land use is primarily rain-fed agriculture except for Upper Snake Rock Creek, which is primarily irrigated agriculture.

- Most watersheds were selected in 2003/2004, became fully operational in 2004/2005, and now have 4-5 years of extant data.
Specific Accomplishments

- **The Watershed Studies**
  - Theoretical and Empirical Assessment Of the Effects of Conservation Practices At the Watershed Scale

- **The STEWARDS Database**
  - ARS’ New Data Management & Storage System

- **The Future**
CEAP Special Issue
Nov-Dec 2008

Doug Karlen and Warren Busscher, Guest Editors

23 research and synthesis papers
South Fork of the Iowa River

Setting: recent glaciation; poorly drained soils; artificial drainage
An inventory of conservation practices in the South Fork Watershed revealed a nearly 80% rate of conservation-practice adoption, yet significant WQ problems.

Legacy of pre-conservation agriculture. (Solution: Riparian assessment and management)

Gaps in conservation: Practices needed to address management of soybean residue, and improve nutrient retention. (Solutions: diversified cropping, e.g., cover crops; technologies to allow true valuing of manure nutrients)

Most practices aimed to control runoff, but tile drainage is the dominant hydrologic pathway. (Solutions: nutrient removal wetlands, modified or controlled drainage systems)
Requires knowledge of:
1) pollutants being transported
2) transportation pathways
3) timing of transport

Using this knowledge:
1) helps identify ways to trap or treat pollutants
2) ensures that conservation practices are as effective as possible

Where?

What pathway?

When?

Dosskey et al. (2002)

Helmers et al., 2005
Precision Conservation Techniques

Placement of buffers

Conservation tools that target specific practices

Placement of wetlands
BMP placement in Town Brook lowers costs

- Basic:
  - Nutrient management plans
  - Crop rotations & contour strip crop
  - Riparian forest buffers

- Optimal:
  - Crop rotations & nutrient management plans
  - Contour strip crop & nutrient management plans
  - None
Remote Sensing of Cover Crop Nutrient Uptake in the Choptank Watershed

**Context:** Collaboration between USDA Agricultural Research Service (ARS) and Maryland Department of Agriculture (MDA)

**Objective:** Evaluate the effects of cover crop implementation on nitrogen uptake and sequestration

**MDA Cover Crop Programs**

- 128,638 acres in 2005-6 ($4.7 million)
- 251,564 acres in 2006-7 ($8.5 million)
- ~250,000 acres in 2007-8 (~ $8 million)

_Hulless barley cover crops can provide ethanol bioenergy and nutrient uptake – a double win for the environment and a new crop for the farmer_

_Nitrogen capture by winter cover crops reduces nutrient loss to the Chesapeake Bay ~ But, how much is actually captured?_
Cover crop program implementation in the Choptank River Watershed

2005-2006

2006-2007

Remote Sensing of Cover Crop Nutrient Uptake

Method: Combine farm cost-share program information, satellite remote sensing, and on-farm sampling

Cover crop program implementation in the Choptank River Watershed 2005-2006 2006-2007
Identifying Sediment and Contaminant Sources and Transport Pathways Informs the Choice of Appropriate Conservation Practices

**Concentrated Flow Sources--Major Contributor of Eroded Sediment**

**Sediment Sources**
Beyond RUSLE (Sheet & Rill Erosion) need to be Addressed

Ephemeral Gullies
Channels
Edge-of-Field Gullies

Watershed Physical Processes Research Unit – Oxford, MS
Sediment Load
by Unit Area Ranking Ratio

10% of the drainage area produces 76% of the sediment load.

36% of the sediment load originated as ephemeral gully erosion.

Kansas Cheney Lake CEAP Special Emphasis
AGNPS Watershed Modeling
Conservation Tillage

Potential annual water savings—state of Georgia

Current adoption rate (30%) saves equivalent of 3-12 months of water used by city of Atlanta

Potential Water Savings at Different Adoption Rates of Conservation Tillage

- 30% adoption (current rate)
- 40% adoption (10% increase)
- 100% adoption (total conversion)

Gallons of water saved (billion)

- corn
- peanuts
- cotton

Potential water savings for corn, peanuts, and cotton at different adoption rates.
Satellite-Derived Maps of Conservation Tillage could reduce efforts by >60% to verify producer compliance with cost-sharing programs.
Importance Of Long-term Studies

Phenomena that are influenced by annual and/or inter-annual variability in hydrology or other factors require 8-10 years+ of data for accurate estimation/quantification.

No matter what else is needed in a watershed study, hydrology and weather will need long-term data for context.
Dry and Wet Periods for Precipitation and Runoff Depth
Fort Cobb Reservoir Watershed; 1940-2005

Precipitation
- Dry period 1964-1972
- Dry period 1977-1980
- Wet period 1986-1997

Runoff Depth

Preliminary data, subject to revision
<table>
<thead>
<tr>
<th>Year</th>
<th>14-d, 38 ppb</th>
<th>30-d, 27 ppb</th>
<th>60-d, 18 ppb</th>
<th>90-d, 12 ppb</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>35</td>
<td>44</td>
<td>68</td>
<td>105</td>
</tr>
<tr>
<td>1993</td>
<td>6</td>
<td>34</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995</td>
<td>8</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1996</td>
<td>14</td>
<td>25</td>
<td>44</td>
<td>93</td>
</tr>
<tr>
<td>1997</td>
<td>18</td>
<td>30</td>
<td>56</td>
<td>89</td>
</tr>
<tr>
<td>1998</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>5</td>
<td>2</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>2002</td>
<td></td>
<td></td>
<td></td>
<td>16</td>
</tr>
<tr>
<td>2003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td></td>
<td>9</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td></td>
<td></td>
<td>59</td>
</tr>
<tr>
<td>2006</td>
<td>2</td>
<td>15</td>
<td>35</td>
<td>69</td>
</tr>
</tbody>
</table>
Quantify the impact of late spring nitrate test on NO$_3$ losses at watershed scale

- After 4 years managing N-fertilizer on 16 fields with LSNT, annual mean flow-weighted NO$_3$ concentrations in surface water reduced by $\geq 30\%$ within a 366 ha watershed.
STEWARDS Benefits

• The STEWARDS collection of ARS data is much bigger, higher quality, more visible, and higher impact than any individual unit’s presence could be
  – i.e., *The whole is more than the sum of the parts (let alone any part)*
  – Metadata search engines add visibility to a wider audience
  – Metadata delivery and organization raise the confidence in the data and raise the chances it will be used properly
  – CUAHSI and NASA’s database-to-database links are possible
  – STEWARDS has brand name recognition at agency and department level

• **STEWARDS has an extremely powerful interface**
  – The interface allows familiar and modern access
  – Search capabilities dwarf those of ASCII structures
  – Uniform visualization and queries speed multiple-location retrievals
  – Ease of use and retrieval should make STEWARDS the preferred method

• **Data delivery is a high ARS/USDA priority, and STEWARDS is a model**
  – CSREES and possibly NRCS watersheds are planning to go to STEWARDS
  – Similar databases for REAP, Gracenet, and air quality data

• **Local watersheds benefit from modern data management methods**
  – Example data structure simplifies decisions for new watersheds
  – Accrue efficiencies in future watershed data management operations
  – Data management training for staff is useful in other research projects
## ARS’ Benchmark Watershed Research Network

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watersheds</td>
<td>@30</td>
</tr>
<tr>
<td>States*</td>
<td>17</td>
</tr>
<tr>
<td>Established</td>
<td>1912 - 2007</td>
</tr>
<tr>
<td>Record (yrs)</td>
<td>1 - 93</td>
</tr>
<tr>
<td>Area (km²)</td>
<td>0.2 - 5208</td>
</tr>
<tr>
<td>CEAP Croplands</td>
<td>15</td>
</tr>
<tr>
<td>CEAP Grazing Lands</td>
<td>2 (8)</td>
</tr>
<tr>
<td>CEAP Wetlands</td>
<td>2</td>
</tr>
<tr>
<td>2007 NEON RFP</td>
<td>3 (19)</td>
</tr>
<tr>
<td>LTER</td>
<td>2</td>
</tr>
<tr>
<td>WATERS</td>
<td>1</td>
</tr>
<tr>
<td>NEON Domains</td>
<td>12</td>
</tr>
<tr>
<td>ARS Management Areas</td>
<td>8</td>
</tr>
<tr>
<td>HUC Regions</td>
<td>12 (of 21)</td>
</tr>
</tbody>
</table>
Solving Future Problems For Agriculture

‘Problem Solving’ Strategies That Draw Upon ARS’ Benchmark Watershed Research Network

- Strengthening Rural Communities Through Market-Based Environmental Stewardship
- Watershed-scale Restoration Efforts
- Water Implications of Biofuel Production
- Short- and Long-Term Effects of Climate Change on Water Availability
- Increasing Water Use Efficiency/Water Reuse/Water Management
- Large-scale Water Quality Problems (Gulf Hypoxia; Chesapeake Bay)
- Agricultural Component of a National Water Census
Summary

- 30 Watersheds With Significant Geographic Extent Across the US and Important Linkages to Other Networks and Programs
- This Network Can Serve As a Research Platform To Help Solve Future Problems For US Agriculture
Acknowledgments

- All of the ARS Scientists and Locations That Contributed To This Presentation