Modeling the Effects of Agricultural Conservation Practices on Water Quality in the Pacific Northwest Basin

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Presentation Overview

- CEAP National Assessment
  - CEAP/SWAT/APEX Modeling Approach

- Pacific Northwest Basin – Calibration and Validation

- Determine the Major Sources of Sediment and Nutrients delivered to local streams in the PNWB

- Determine the Off-site Benefits of Agricultural Conservation Practice Scenarios on Water Quality in the Pacific Northwest Basin
CEAP/SWAT/APEX National Modeling System

**Watershed Configuration Details**
- Subbasins/Rivers/Routing/Reservoirs

**Weather**
- Precipitation
- Temperature

**Dry and Wet Atmospheric Nitrogen Deposition**

**APEX Farm Scale Model**
(Calibrated)

**SWAT Watershed Model**
(Calibrated)

**Instream Processes**
- Routing through reach, ponds, reservoirs to 8-digit watershed outlet
- Through main river reaches to basin outlet

**Point Sources**
- Flow, TSS and nutrient loadings from Municipal and Industrial Plants

**Uncultivated Land**
- Flow, sediment, nutrient and pesticide loadings from HRUs

**Cultivated Cropland & CRP**
- Edge of field flow, sediment, nutrient & pesticide loadings from subareas with practices

**Effects on Edge of Field Water Quality**

**Conservation Scenarios**
1. Current Conservation Baseline: APEX inputs with current conservation practices from CEAP survey
2. No Practice: APEX inputs without conservation practices
3. Additional Treatment Need: APEX inputs with different combinations of practices & practice acres (ENMC and ENMA)
4. Background: APEX inputs with grass-tree mix condition on cropland

**Results**
- Effects on Local/Instream Waters
  1. Reductions in sediment, nutrients and pesticide yields and loads at 8-digit watersheds due to current conservation practices and additional treatment practices on cropland
  2. Reductions in instream loads at river points due to current conservation and additional treatment scenarios

**NRI/Survey/Conservation Practice Details**
- Structural Practices
- Cultural Management Practices
- Practice Acres
- Farming Activities/Survey Database
- NRI

INTEGRATE APEX OUTPUT
<table>
<thead>
<tr>
<th>River Name</th>
<th>Gage Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Okanogan River at Malottt, WA</td>
<td>S1</td>
</tr>
<tr>
<td>Snake River near Heise, ID</td>
<td>S2</td>
</tr>
<tr>
<td>Snake River at King Hill, ID</td>
<td>S3</td>
</tr>
<tr>
<td>Snake River at Weiser, ID</td>
<td>S4</td>
</tr>
<tr>
<td>Willamette River @ Portland, OR</td>
<td>S5</td>
</tr>
<tr>
<td>Columbia River at Beaver Army</td>
<td>S6</td>
</tr>
</tbody>
</table>
Pacific Northwest Basin

Drainage Area: 7,18,450 km²

9% - Cropland Area

Metropolitan Cities: Seattle, Portland, Spokane, Boise, etc

Nutrient enrichment in many freshwater streams: Many streams exceed EPA’s nutrient criteria standards

USDA has implemented several conservation practices
Specific Objectives

1) Calibrate the Pacific Northwest Basin (PNWB) model for sediment and nutrient loads multiple gauges,

2) Determine the major sources of sediment and nutrients delivered to local waters in the Pacific Northwest Basin, and

3) Evaluate the effects of the current agricultural conservation and future conservation needs on water quality in the Pacific Northwest Basin.
Calibration Results at the Gages

**a) Streamflow Calibration**

SIMULATED FLOW (CMS) VS. OBSERVED FLOW (CMS)

- Equation: $y = 0.9636x$
- $R^2 = 0.9999$

**b) Sediment Calibration**

SIMULATED LOAD (MILLION TONES) VS. OBSERVED LOAD (MILLION TONES)

- Equation: $y = 1.0226x$
- $R^2 = 0.9996$

**c) Total Nitrogen Calibration**

SIMULATED LOAD (TONNES) VS. OBSERVED LOAD (TONNES)

- Equation: $y = 0.8139x$
- $R^2 = 0.9596$

**d) Total Phosphorus Calibration**

SIMULATED LOAD (TONNES) VS. OBSERVED LOAD (TONNES)

- Equation: $y = 0.9119x$
- $R^2 = 0.9942$
Sources of Sediment and Nutrients

a) Sediment

b) Nitrogen

c) Phosphorus

- Cultivated cropland
- Grassland
- Urban
- Point Sources
- Forest and Other Sources
Practices Simulated Within APEX

a) Structural Practices
In-field Practices for erosion control
- Contour Farming
- Strip Cropping
- Contour Buffer Strips
- Terraces
- Grass Terraces
- Tile Drain
- Grade Stabilization Structures
- Grassed Waterways
- Diversion

Edge of Field Practices for buffering
- Filter Strips
- Riparian Forest Buffers
- Riparian Herb. Cover
- Field Borders
- Vegetative Barrier

Wind Erosion Control Practices
- Windbreak / Shelterbelt
- Herbaceous Wind Barrier
- Hedgerow planting
- Cross Wind Practices

b) Cultural/ Agronomical Management Practices
Residue, tillage, nutrient, pesticide and irrigation management practices and cover crops

c) Long-term conservation cover
## Conservation Practice Scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Practice Details simulated in APEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Practice</td>
<td>No conservation practices on cropland</td>
</tr>
<tr>
<td>Current Conservation Condition (Baseline 2003-06)</td>
<td>Current conservation practices on cropland</td>
</tr>
<tr>
<td>Enhanced Nutrient Management on all under-treated</td>
<td>Nutrient management and structural practices on all under-treated cropland area that have either a high or moderate conservation treatment need</td>
</tr>
<tr>
<td>cropland (ENMA)</td>
<td></td>
</tr>
<tr>
<td>Background</td>
<td>Grass-tree mix grown on cropland. No cultivated land contribution. Includes non-cultivated, and point source contributions and natural background loads from the cropland replaced by grassland</td>
</tr>
</tbody>
</table>

- SWAT simulations made using flow, sediment and nutrient loads generated for each of the above scenario
a) Edge of field sediment losses and reductions in the Pacific Northwest Basin

- Loads (Mill. Tonnes)
  - 0
  - 10
  - 20
  - 30
  - 40
  - 50
  - 60

- Reductions (%)
  - 0
  - 25
  - 50
  - 75
  - 100
  - 125

b) Instream sediment loads delivered to Pacific Ocean and reductions

- Loads (Mill. Tonnes)
  - 0
  - 2
  - 4
  - 6
  - 8
  - 10
  - 12
  - 14
  - 16
  - 18

- Reductions (%)
  - 0
  - 25
  - 50
  - 75
  - 100
  - 125

Legend:
- Red: No-practice scenario
- Blue: ENMA
- Green: Current conservation condition
- Brown: Background
- Light Green: Current Conservation Reduction
- Light Brown: ENMA Reduction
b) Edge of field nitrogen losses and reductions in the Pacific Northwest Basin

- Load (Tonnes)
  - 0
  - 50,000
  - 100,000
  - 150,000
  - 200,000
  - 250,000
  - 300,000
  - 350,000
- Reductions (%)
  - 0
  - 25
  - 50
  - 75
  - 100
  - 125

- No-practice scenario
- ENMA
- Current conservation condition
- Background
- Current conservation Reduction
- ENMA Reduction

d) Instream nitrogen loads delivered to Pacific Ocean and reductions

- Load (Tonnes)
  - 0
  - 50,000
  - 100,000
  - 150,000
  - 200,000
  - 250,000
  - 300,000
  - 350,000
- Reductions (%)
  - 0
  - 25
  - 50
  - 75
  - 100
  - 125

- No-practice scenario
- ENMA
- Current conservation condition
- Background
- Current conservation Reduction
- ENMA Reduction
Water Quality Benefits: Conservation Scenarios

e) Edge of field phosphorus losses and reductions in the Pacific Northwest Basin

f) Instream phosphorus loads delivered to Pacific Ocean and reductions

- No-practice scenario
- ENMA
- Current conservation condition
- Background
- Current conservation Reduction
- ENMA Reduction
a) Instream Sediment Load Delivered in the Pacific Northwest Basin
Instream Water Quality Benefits (Spatial): Conservation Scenarios

b) Instream Nitrogen Load Delivered in the Pacific Northwest Basin

- Kootenai: No Practice 17, Current Conservation Condition 3, ENMA 39, Current Conservation Reduction 45
- Yakima: No Practice 2, Current Conservation Condition 1, ENMA 4, Current Conservation Reduction 31
- Willamette: No Practice 21, Current Conservation Condition 1, ENMA 24, Current Conservation Reduction 27
- Puget Sound: No Practice 3, Current Conservation Condition 40, ENMA 38, Current Conservation Reduction 31
- Oregon closed: No Practice 4, Current Conservation Condition 3, ENMA 31, Current Conservation Reduction 33
- U. Snake: No Practice 3, Current Conservation Condition 3, ENMA 4, Current Conservation Reduction 40
- M. Snake: No Practice 3, Current Conservation Condition 3, ENMA 4, Current Conservation Reduction 40
- L. Snake: No Practice 3, Current Conservation Condition 3, ENMA 4, Current Conservation Reduction 40
- U. Columbia: No Practice 3, Current Conservation Condition 3, ENMA 4, Current Conservation Reduction 40
- M. Columbia: No Practice 3, Current Conservation Condition 3, ENMA 4, Current Conservation Reduction 40
- L. Columbia: No Practice 3, Current Conservation Condition 3, ENMA 4, Current Conservation Reduction 40
Instream Water Quality Benefits (Spatial): Conservation Scenarios

c) Instream Phosphorus Load Delivered in the Pacific Northwest Basin

Load (Tonnes)

0 5,000 10,000 15,000 20,000 25,000 30,000 35,000 40,000


Legend:
- No Practice
- ENMA
- Current Conservation Reduction

Current Conservation Condition
Background
ENMA Reduction
Major Findings from Assessment on PNWB

- Conservation practices reduces field level losses of sediment, nutrients and pesticides. Benefits of the practices are better reflected and greater at field level.

- Conservation practices improves water quality of streams and rivers, lakes and other water bodies in the river basin.

- Targeting critical acres improves effectiveness of conservation practices significantly.

- Modeling can aid in all of the above processes.

- Modeling tools available to study other emerging issues on eutrophication, algae blooms, climate change, future conservation programs, and restoration efforts at regional level.
Thank you !!!