Methods for Simulating Conservation Practices and Estimating Effects for the CEAP National Assessment

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Abstract

This work prototypes the National Assessment field-scale modeling effort by developing and implementing an analysis on a small, yet diverse, subset of the CEAP national sample. The scope of the microanalysis is to investigate and describe model inputs, simulation techniques, conservation practice design considerations, scenario construction and implementation, and the attendant simulation model effects. A related, though separate, effort uses the framework as the basis for 1) validating the APEX model against field research data and 2) estimating sources and quantities of error introduced by the simplifications and generalities employed in the National Assessment simulations. Objectives for presenting this work include:

- encourage discussion and obtain useful feedback about the simulation techniques, especially concerning methods to simulate conservation practice effects, prior to full-scale production of the National Assessment, and
- advance efforts to validate model effects and quantify estimation error associated with the National Assessment simulations by engaging with field researchers as potential collaborators.

Background: The CEAP National Assessment

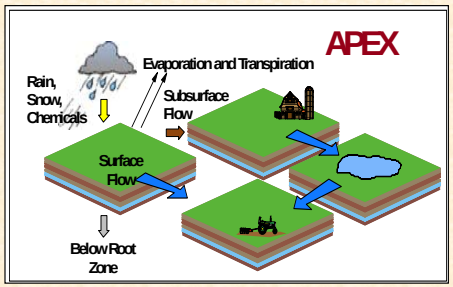
The purpose of the cropland component of the CEAP National Assessment is to estimate the environmental effects of conservation practices applied to cropland. Estimates are made via a sampling and modeling approach. Using a national sampling framework, current information on land management, including farming practices and conservation practices, are obtained from farm surveys. These data are combined with soil, climate, topography, and stream reach databases using a system of simulation models to estimate the physical effects of conservation practices. The National Assessment has four major objectives:

1) estimate the benefits of current conservation practices on the landscape,
2) estimate the need for conservation practices and the benefits that could be realized if appropriate conservation practices were implemented on all cropland,
3) simulate alternative options for implementing conservation programs on cropland in the future, and
4) incorporate science-based estimates of practice benefits into NRCS's Performance Reporting System (PRS) to provide annual estimates of benefits for each program.

Together, the objectives provide an integrated framework to understand current conditions, design and evaluate alternative approaches to meet conservation goals, and continually assess and reassess the performance in relation to the goal(s).

For the National Assessment, both field-level and in-stream benefits will be estimated. Field-scale effects are estimated with the APEX model and include reductions in nitrogen, phosphorus, pesticide, and soil loss from farm fields as well as soil quality improvements. CEAP is integrating the model output from APEX with the SWAT/HUMUS model to simulate the transport of water and potential pollutants from the land to receiving streams and routes the flow downstream, allowing estimation of the reduction in in-stream concentrations of sediment, nutrients, and pesticides attributable to implementation of conservation practices.

The Agricultural Policy Environmental eXtender Model



- Weather (simulated or actual)
- Heat transfer to the soil
- Runoff, percolation, evapotranspiration, snowmelt
- Erosion & Sedimentation (wind and water)
- Crop growth (N & P uptake, stresses, yields, N-fixation)
- Carbon Cycling (Century)
- Crop rotations, inter-cropping, weed competition
- Nutrients (application, runoff, leaching, mineralization, denitrification, volatilization, nitrification)
- Pesticide (application, movement, degradation)
- Tillage, Irrigation, and Drainage
- Grazing
- Manure application
- Ponds and reservoirs
- Buffer strips and grassed waterways
- Subsurface flow between subbasins

Data Inputs to the National Assessment

National Resource Inventory (NRI)

CEAP sample points are a selected subset of the National Resource Inventory. The NRI is a statistical sample of approximately 800,000 points designed to obtain the status and trends of land use and natural resource conditions on U.S. nonfederal lands. Data are collected using remote sensing (photo interpretation) supported by onsite field investigation; points are linked to national soil and climate databases.

Model inputs describing land characteristics for sample points include:

- slope, slope length, soil descriptions and soil layer attributes; and
- climate data such as daily temperatures and precipitation, as well as long-term monthly averages of solar radiation, wind speed, and relative humidity.

CEAP Survey

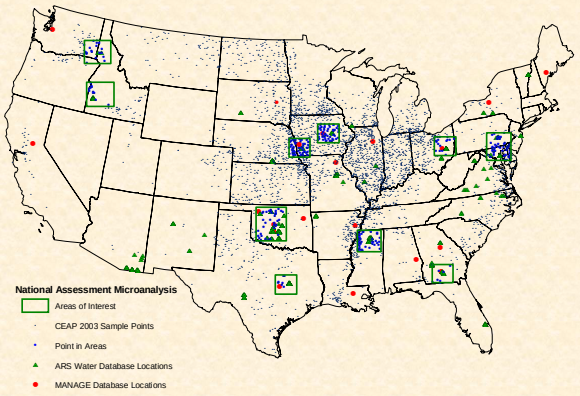
For the CEAP sample points, on-site personal interviews with farm operators are conducted to administer a questionnaire designed to obtain field-specific land management information. Farmer interviews are followed by a review of conservation plan records at the county NRCS office.

Model inputs describing site-specific land management include: crop rotation, tillage and other field operations, irrigation and drainage, nutrient and pest management, and applied conservation practices.

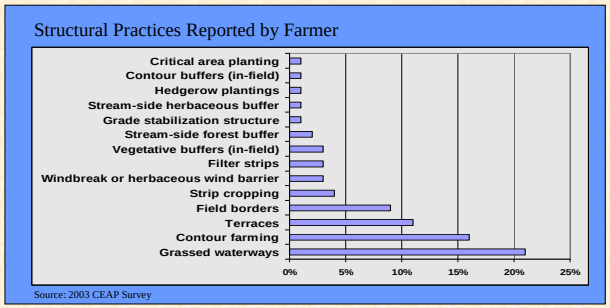
National Assessment Microanalysis

Domain Criteria

Criteria to select a subset of CEAP points were 1) the spatial distribution of major crops and cropping systems, 2) areas with known conservation problems and practice applications, 3) points having land management and physical characteristics similar to nearby field research, and 4) points designated as "accepted" from the 2003 CEAP survey.



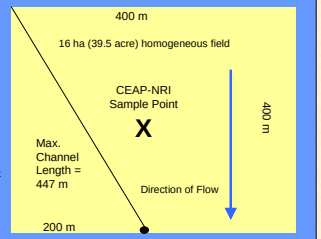
Green boxes represent areas included in the microanalysis, blue points designate 2003 CEAP sample points, green triangles indicate research sites having precipitation and runoff data in the ARS Water Database, and red dots are research sites with nutrient loading data in the MANAGE database (Harmel et al. 2005). Within boxes, points are compared to field research sites. Sample points similar to the research sites are selected for the domain. To date, only survey points in Georgia and Texas have been matched to field research data.



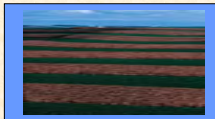
Representing Practices: A Few Examples

No Conservation Practices

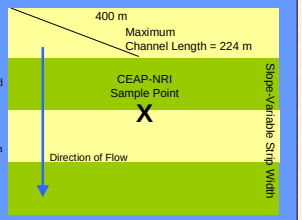
Upland slopes are assumed to be uniform and are set to NRI slope. Maximum channel length represents the most distant point from the outlet and is calculated from the field width and field length. Channel slope is estimated as a fraction of the upland slope based on field area (about 0.427x for 16 ha). Initial Curve Number is set as a function of soil hydrologic group, cropping system, and slope. The Support Practice Factor is 1. Management is from CEAP Survey.



Contour Strip Cropping

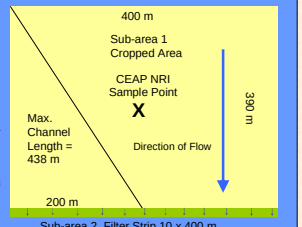


Upland slope set to NRI slope. Where slope < 3% field has 2 strips each with a slope length of 200m;3-9% 4 strips of 100m; 9-13% 6 strips of 66.67m; 13-17% 8 strips of 50m; 17-21% 8 strips of 50m; 21-25% 16 strips of 25m. Channel lengths are calculated using strip width and field length. Channel slope is a fraction of upland based on strip area (about 0.617x for 4 ha). Curve Number is set 2 CN lower than no practice setting. Practice Factor =1 where alternating strip are row or small grain crops; 0.75 where some strips are grass/hay; and 0.5 where half of strips are grass/hay. Management is from CEAP Survey.



Grass Filter Strip

The cropland area (sub-area 1) is simulated as in the no practice simulation with minor changes reflecting the different area and dimensions. The down-slope border of the cropland area is fitted with a second sub-area representing a 10 x 400 m grass filter strip. The Fraction of Floodplain Flow parameter (FFPQ) is set so 95 percent of surface flow from the cropland area moves through the filter strip. Channel parameters and roughness coefficients are set to spread the flow and slow the velocity. Suitable species are selected base on location and appropriate management operations including planting, fertilizing, and harvesting are performed on the filter strip sub-area.



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