

Chapter 12

Paradise Creek Watershed, Idaho: National Institute of Food and Agriculture–Conservation Effects Assessment Project

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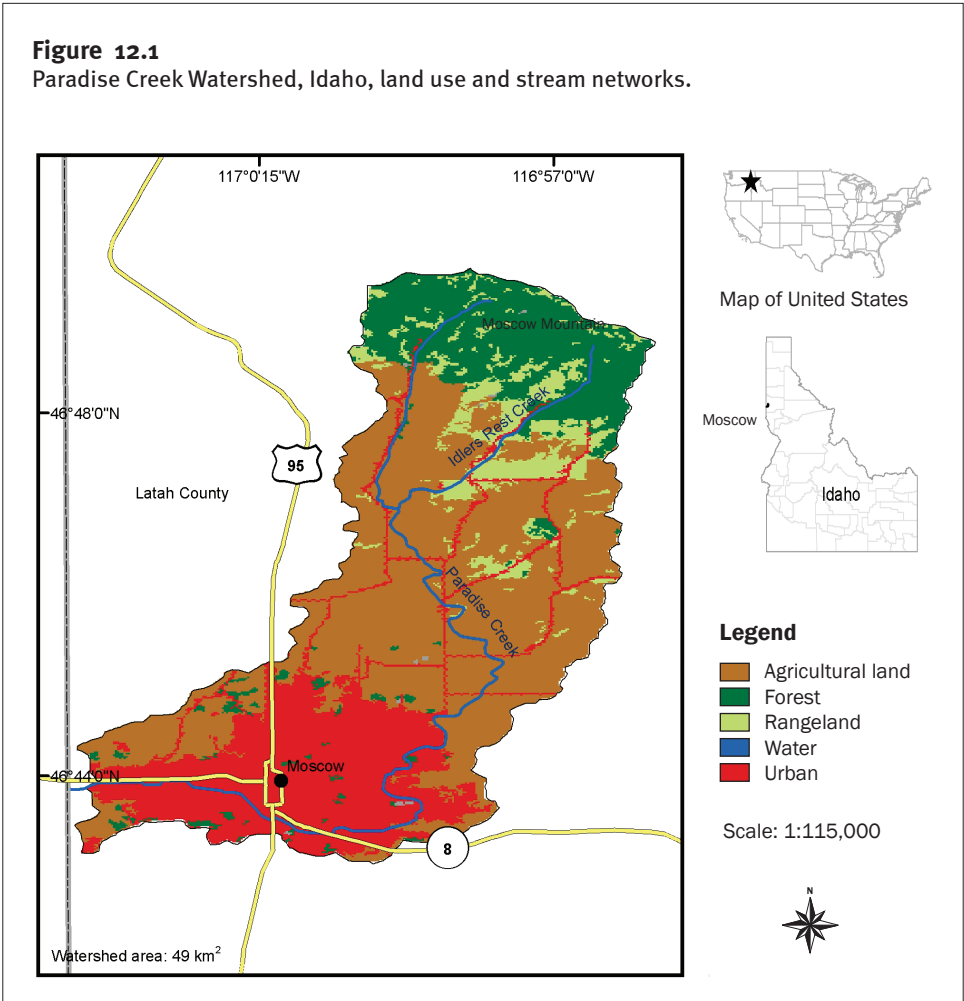
Specific objectives of the Idaho National Institute of Food and Agriculture–Conservation Effects Assessment Project (NIFA–CEAP), Evaluation of Conservation Practices in a Mixed Land-Use Watershed using Cumulative Effects Modeling and Interdisciplinary Analyses, included the following:

1. Analyze water quality monitoring data to determine effectiveness of conservation practices and evaluate the value of spatial and temporal monitoring
2. Apply cumulative effects modeling to explain geospatial and temporal factors determining effectiveness of conservation practices in the Paradise Creek Watershed
3. Identify primary social, cultural, and economic motivations and barriers related to conservation practices affecting decision making by agricultural growers, landowners, and local residents within the affected Paradise Creek Watershed
4. Develop a tool to determine the optimal suite of conservation practices within Paradise Creek Watershed by integrating cumulative effects, socioeconomic factors, and temporal variation in water quality
5. Develop an outreach plan for disseminating results and technology transfer to appropriate audiences and provide evaluation techniques for outreach efforts
6. Develop and implement a plan for data storage and retrieval

Watershed Information

The Paradise Creek Watershed is located in the Palouse region of the United States. The Palouse region is characterized by rolling topography and loess soils, a combination that historically has led to high erosion rates. Paradise Creek starts in the higher altitudes of Moscow Mountain and flows for 31 km (50 mi) through the City of Moscow and into Washington State, where it enters the South Fork of the Palouse River near Pullman, Washington (figure 12.1). The NIFA–CEAP was applied to the Paradise Creek Watershed upstream of the Moscow, Idaho, Moscow Waste Water Treatment Plant (WWTP) discharge (Brooks et al. 2010). The upper por-

Figure 12.1
Paradise Creek Watershed, Idaho, land use and stream networks.



tion of the watershed consists of steep slopes, while moderately steep rolling hills comprise the majority of the watershed. Some subbasins are drained by intermittent streams.

The watershed is 4,980 ha (12,306 ac) in area and is located in the Palouse River Hydrologic Basin (17060108). Land use in the watershed consists of forest land (16%, northern area), agriculture (70%, central area), and urban areas (14%). Agricultural land use consists almost exclusively of nonirrigated cropland that produces wheat, barley, peas, and lentils.

Soils are moderately well-drained loess (silt loam texture Argixerolls). Some soils have fragipans with argillic layers at a depth of 0.5 to 1 m (1.6 to 3.3 ft), which cause perched water tables during the rainy season (winter and spring), enhancing runoff from these soils.

Annual precipitation is approximately 620 mm (24.4 in), while average snowfall depth is 2,119 mm (83.4 in). Of the rainfall, nearly 40% is low intensity rain or snow occurring from November through January. Most erosion is from combined rain and snowmelt events. In the western Palouse, 95% of the precipitation is used by crops, while only 60% is used by crops in the eastern Palouse.

Temperature means range from a high of 28.5°C (83.8°F) in the summer to a low of 1.4°C (34.5°F) in January. Freeze and thaw cycles in February and March can cause massive runoff and erosion. When soils are thawing and a frozen layer remains just under the soil surface, large runoff and erosion events occur. Due to greater average temperatures, frozen soil conditions have been less conducive to soil erosion processes during February and March than in the past.

Paradise Creek is a fourth order stream comprised of 55 stream segments, of which 49 flow through agricultural land. Peak flows occur when rain falls on snow and during snowmelt as runoff is dominated by saturation excess overland flow. Infiltration excess overland flow occurs only when soils are frozen or when soils are freshly tilled in late spring due to soil crusting. In addition, when stream banks next to agricultural fields are not vegetated, they are susceptible to channel erosion.

Water Quality Information

Paradise Creek is designated for the following intended uses by the State of Washington (default status): salmonid spawning, primary contact, recreation, and domestic water supply. Intended uses designated by the State of Idaho include cold water, secondary contact, and agricultural water supply.

Sediment is the primary pollutant of concern in Paradise Creek. Paradise Creek was the first water resource added to the Section 303(d) of the Clean Water Act list (list of impaired and threatened waters) in Idaho (USEPA 2011), and a sediment total maximum daily load (TMDL) was approved in 1998. The primary water quality objective to obtain this TMDL is to reduce sediment delivery to Paradise Creek so that it is no more than 136 Mg y⁻¹ (150 tn yr⁻¹), representing an 85% reduction from the estimated average load.

Other pollutants of importance in the Paradise Creek Watershed include ammonia, nutrients, habitat modification, pathogens, flow alteration, and temperature. Nonpoint pollution sources include nonirrigated cropland, grazing lands, land development, urban runoff, roads, and forest land. The Moscow WWTP and the University of Idaho aquaculture facility are the point sources, especially for nutrients.

Water quality monitoring consisted of the following:

- Total suspended sediment grab samples at the Moscow WWTP location
- Continuous turbidity measurements at three locations along Paradise Creek (2001 to 2008)
- Event-based total suspended sediment concentration samples at three locations along Paradise Creek (2001 to 2008)
- Temperature and electrical conductivity measurements at three locations (2001 to 2008)
- Continuous streamflow measurements at four locations (2001 to 2008)

The water quality monitoring design consisted of watershed and subwatershed monitoring:

- An upstream/downstream design that consisted of eight preconservation (1999 to 2002) and postconservation practice sites was monitored biweekly (2004 to 2008) for flow, turbidity, and total suspended solids.
- The US Geological Survey daily discharge station (1978 to 2008) recorded daily averages.
- An upstream/downstream single-watershed design or a single station, single-watershed design was used to collect data at four stations on the channel network and immediately upstream and downstream of conservation practices to reveal their impact(s) on hillslope processes. Turbidity, and total suspended solids were measured prior to conser-

vation practice installation, between 1999 and 2002, and after practice implementation, between 2004 and 2008. Flow was monitored during the entire 1978 to 2008 period.

- A single station, single-watershed design was used to monitor water quality above the Moscow WWTP (1979 to 1980 and 1988 to 2008); daily totals were recorded for outflow below the plant, and total suspended solids were sampled (three samples per week) above and below the WWTP.
- Five automated weather stations were used to collect data regarding precipitation, temperature, solar radiation, humidity, and wind. One station has collected data since the 1960s.

The Palouse Clearwater Environmental Institute was the data coordinator during the NIFA–CEAP, and all data types (excel spreadsheets, geographical information system spatial data, digital elevation model, etc.) were stored on a server.

Land Treatment

In 1975, a federal government project, Solutions to Environmental and Economic Problems (STEEP), was funded to research soil erosion in the Palouse Region of the United States. Land-grant universities in Washington, Oregon, and Idaho were very involved in the STEEP Project. After five years of research, an aggressive extension component was added. During the 30 years that the project has worked in the area, most growers have had a three-year or longer conservation cropping rotation. The Revised Universal Soil Loss Equation 2 (RUSLE2) predictions have shown a 75% reduction in soil loss during this time. Practice implementation accounted for 70% of the reduction (Kok 2007).

Conservation practices were installed in Paradise Creek Watershed as part of the US Environmental Protection Agency (USEPA) Section 319 Project that was funded to meet the sediment TMDL. The USEPA 319 Project lasted for three years (2001 to 2004), and the practices selected for the USEPA Section 319 Project were based on USDA Natural Resources Conservation Service (NRCS) standards (contour cropping and seeding, tillage, gully plug, direct seed, conservation tillage).

There was no identification of critical areas within the watershed for either the STEEP or the USEPA Section 319 Project. The Soil and Water Conservation District and USDA NRCS led the USEPA Section 319 Project, which initially planned to install buffer strips across the watershed. However, the NIFA–CEAP team, through the Watershed Advisory Group, convinced the district to put emphasis on gullies. As a consequence, the district did a field-by-field inspection to determine the fields that needed gully plugs, conservation tillage, buffer installation, and other conservation practices. The USEPA Section 319 Project set a limit of 121 ha (300 ac) per grower, and most growers participated, although some growers were not interested in implementing conservation practices. During the NIFA–CEAP, the Soil and Water Conservation District continued to work with growers to increase adoption of conservation practices using standard cost shares for conservation practice implementation.

At the start of the USEPA Section 319 Project, a meeting was held to explain the project to the growers, and the Soil and Water Conservation District was extremely active in recruiting growers. The growers selected those practices they wanted. Both type and timing of implementation of practices on a grower's farm were based on the individual grower's interest in the practice(s). Many conservation practices were installed as a suite of practices (e.g., reduced tillage and gully plugs) rather than a single practice, and about 50% of the watershed was

treated with conservation practices. The number and type of practices are listed below, and these selected practices were consistent with the ideal choice of practices needed to reduce erosion:

- Riparian buffers—8.5 ha (21 ac)
- Gully plugs—18
- Structural improvements (e.g., rock chutes)—11
- Stream restoration—7 km (4.6 mi)
- Wetland restoration—1.4 ha (3.5 ac)
- Riparian restoration—1.4 ha (3.5 ac)
- Permanent grass plantings (Conservation Reserve Program [CRP])—325 ha (800 ac)
- Nonirrigated cropland converted to direct seeding rotation—552 ha (1,365 ac)
- Increased use of conservation tillage

Conservation practices for the urban areas included 7 km (4.4 mi) of stream restoration, 6.5 ha (16 ac) riparian restoration, and 656 m² (7,056 ft²) of wetland construction.

Due to the efforts of the past 30 years to implement conservation practices and some grower-to-grower transfer of information, conservation practice implementation was reasonably high in the region. Continued discussions with growers by Soil and Water Conservation District or USDA NRCS personnel helped increase implementation. The district conservationist of USDA NRCS had been in the area for a long time and was respected by the growers. This helped increase adoption rates of conservation practices.

While a continuum of conservation practice adoption existed in the Palouse, a suite of social, economic, and agronomic factors continued to influence many growers with the effect of lower than average adoption rates compared to other regions like the Midwest. As was the case of conservation practice adoption, there were many subtle factors that can affect adoption. One grower in the watershed, who believed in conservation tillage, stated that he did not implement it because the practice would reduce his labor force and he would have to fire his hired help, which consisted of his brother and a friend.

Land treatment was monitored by the NIFA–CEAP researchers, who developed field-by-field maps of crop rotations and documented the type of tillage practices being used. These data were incorporated into annual digital land-use maps going back to 1995. The locations of practices implemented through the Section 319 Project were also documented. Additional monitoring occurred throughout the USEPA Section 319 Project, and some monitoring occurred before and after the NIFA–CEAP.

Water Quality Response

Despite conservation practice adoption, the TMDL still existed because the TMDL target sediment load was only met once; in 2001, sediment load reductions were near the TMDL standard. Although the TMDL was not met, the sediment loading data showed statistical decreases of sediment from the rural areas (Brooks et al. 2010).

Climate variability made it difficult to determine long-term trends in sediment loading. In 1994, 45 Mg (50 tn) of sediment were delivered to the outlet at the Moscow WWTP, while in 1996, 10,614 Mg (11,700 tn) were measured. In order to remove the effect of climate variability, the total annual sediment load was normalized by total annual stream volume for the year to calculate an annual flow-weighted mean sediment concentration. Since 1979, there was a long-term statistically significant decline in the average sediment load using both event-based

sampling data (2002 to 2008) and weekly grab samples taken over the past 28 years (Brooks et al. 2010). This decreasing sediment load was attributed primarily to the implementation of minimum tillage and perennial grasses (CRP); implementation of these practices was initiated in the late 1970s and early 1980s through the STEEP program, with continued adoption after that time.

In addition to determining changes in sediment load due to conservation practice implementation, researchers worked to better characterize the sediment sources. This included investigating runoff and erosion processes in urban areas during the project, including measurement of cross-sections throughout the channel network. Estimates of the sediment source loading for the TMDL assessment attributed the agricultural area as the major sediment source (88%) and the urban area as a minor source (5%). Results from event-based data (2002 to 2008) indicated that in one year, 82% of the sediment load was derived from the urban areas; overall, 43% of the annual sediment load in this time period was derived from urban areas. A trend analysis indicated that sediment from rural areas declined, while no noticeable change was observed in the annual sediment concentrations in the urban region of the watershed. Despite the lack of trend in sediment concentrations from urban land, it was documented that runoff rates were consistently greatest from urban areas, and event-based sampling data showed that urban areas contributed an average of more than 40% of the annual sediment loads (Brooks et al. 2010). Delayed reduction in sediment load at the watershed outlet was attributed, at least in part, to the influence of legacy sediments stored in stream channels.

Model Application

Modeling was used to explain geospatial and temporal factors to determine conservation practice effectiveness. In addition, the models were used to address what-if questions for various types of practices.

The Water Erosion Prediction Project (WEPP) model was appropriate to the hydrology of the Palouse as the model already had an erosion component built in, in addition to its climate, land treatment, soil, and topographic data. In addition, NIFA–CEAP researchers were already familiar with WEPP. In order to conduct the modeling, it was necessary to improve WEPP to better represent shallow groundwater return flow and saturation excess runoff. The WEPP model was selected because it has the ability to simulate effects of specific tillage practices through measurable and definable parameters rather than empirical coefficients that require many years of long-term data for calibration. In addition, the project researchers believed that it was a high priority to select physically based models that represent the dominant hydrologic processes within the region. These dominant hydrologic processes were identified through an eight-year study at a small catchment located just outside the watershed (see Brooks et al. 2007; Brooks et al. 2004; O’Geen et al. 2003; McDaniel et al. 2001, 2008). During this project, Brooks et al. (2007) tested and developed algorithms for accurately simulating the hydrology of landscapes that have shallow restrictive soil layers. These algorithms were incorporated into WEPP, which has the ability to simulate effects of specific management practices on sediment detachment, transport, and delivery from hillslopes. Simulated daily sediment loads from hillslopes were input to a physically based hydrodynamic stream channel model called CONCEPTS (Conservation Channel Evolution and Pollutant Transport System) that predicts the detachment, transport, and delivery of sediment from stream beds and banks composed of both cohesive and noncohesive soils. By sending the output from WEPP into the CONCEPTS model, the group

was able to conduct long-term scenario testing. Long-term simulations indicated that there is significant sediment storage in the stream channels and that flushing this stored sediment from the channels could take as long as 19 years (Newson 2007).

Hydrologic data from the hillslope and catchment study by Brooks et al. (2004) were used to estimate model parameters in the hydrology algorithms of the revised WEPP. Hillslopes were delineated using GeoWEPP (the Geo-spatial interface for the Water Erosion Prediction Project). The watershed scale was accomplished by combining WEPP outputs with outputs from CONCEPTS. The hillslope version of the WEPP model did not simulate gully erosion. Thus, the watershed was subdivided into finer hillslopes that captured the impact of gully erosion with the CONCEPTS model.

Although certain algorithms in the revised WEPP model were run on an hourly time step (i.e., snowmelt, subsurface water movement), the output from the model was on a daily time step. Therefore, all validation efforts were done on a daily time step. No formal sensitivity analysis was conducted during the validation as efforts were focused on model verification.

Data necessary to run the models consisted of a digital elevation models, soil maps, channel networks, and land use and weather data. Climate data for all years were available for one weather station at the watershed outlet. Daily data were also available from the headwaters at the Moscow Mountain from the USDA NRCS National Water and Climate Center (SNOTEL data) and from 15-minute precipitation data at the Moscow 5 NE cooperative station.

Land treatment data (cropping patterns, conservation practices) were available since 1995. Most conservation practices were implemented during 2001, although some conservation practice installation began in the mid-1970s, including stream restoration practices that were not available in the land treatment data.

Watershed erosion rates for the entire basin over a 30-year average period were modeled using tillage type as the principal driver. Project researchers were not sure that they were measuring sediment reductions due to conservation practices implemented since 1997 (i.e., gully plugs, stream bank restoration); however, they were confident that effects of conservation tillage reduced sediment loads because of gradual adoption of these practices that started in the mid-1970s.

Socioeconomic Analysis

The social survey in the Paradise Creek NIFA–CEAP used a mixed-methods design executed in two phases: an in-depth survey for landowners within the study watershed and a social survey of growers across the dryland production region. The in-depth local survey was a comprehensive in-person study of the remaining four growers in the Paradise Creek Watershed that focused on the economics of the farm and used a semistructured interview approach combined with economic data instruments.

The regional survey covered a geographic area larger than Paradise Creek Watershed. This regional social survey was a stratified telephone sample of agricultural growers using the Dillman method to develop attitudinal responses to conservation practices. A sampling frame was compiled from grower lists in Idaho and Washington as well as county extension lists in the Palouse region. Quantitative and qualitative questions, which were developed through collaborative discussions with the Paradise Creek Watershed growers, were asked. Fifty-five percent of the eligible growers returned the survey.

Results of the regional social survey showed that growers in the region are well educated, with over 80% having undergraduate or graduate degrees. Of these growers surveyed, 80 were employed on farm with 75% as full-time growers; 48% made US\$30,000 or above as net annual income. Crops were rotated, and a three-year rotation might consist of winter wheat, spring wheat or barley, and peas or lentils. Two-year rotations included winter wheat and a cereal crop, possibly with a third year of canola.

The following points summarize results from the regional survey (Tosakana et al. 2010):

- Growers believed that erosion has been reduced (since 1970, there has been a 75% increase in conservation tillage and no-tillage).
- Water quality stewardship was high.
- Most erosion was not occurring on the respondents' lands.
- Many growers promoted conservation.
- Profit was a primary concern among a majority of respondents (63%).
- Some growers did not want to wait on government incentives to implement conservation practices.
- On average, on-farm decisions were influenced more by growers than others.
- Cost of implementing and maintaining conservation practices remained important in on-farm decision making.
- Acceptance toward targeting of conservation practices was split depending on question wording; sometimes targeting was accepted, and sometimes it was not. Eighty percent believed program funding should go to problem areas, but 69% thought program funding should be equally divided between watersheds.
- Growers liked cost share through the CRP and Environmental Quality Incentives Program (EQIP), but were neutral on the Conservation Security Program (CSP).
- Growers liked practices they voluntarily put in place.
- Growers liked incentives for conservation practices.
- Gully plugs were only used about 30% of the time, regardless of slope and were seen as slightly more effective as slope increased.
- Strip cropping use increased with slope; effectiveness was seen as increasing with slope.
- Buffer strips were used about 50% of the time, regardless of slope; effectiveness was seen about the same, regardless of slope.
- No-tillage was used (60%), regardless of slope; a slight increase in effectiveness with slope was reported.
- Conservation tillage was used (85%), regardless of slope; a slight increase in effectiveness with slope was reported.
- Contour tillage or direct seeding was seen to be equally effective, regardless of slope.
- Most conservation practices were seen as inconvenient.
- For some respondents, conservation practices were seen as an economic cost.
- Ninety-five percent of respondents thought soil erosion has decreased, 92% believed that soil erosion has decreased in their watershed, 90% believed that reduced soil erosion has improved water quality, 60% believed that conservation takes effort, and 86% agreed that growers are burdened with on-site costs. Sixty-five percent of respondents initiated practices on their own; 96% think reducing soil loss is important for conservation.
- Land ownership did not seem to determine use of conservation practices.

Growers trusted the Soil and Water Conservation Districts and the USDA NRCS to implement conservation practices, although they were divided about the value of the USDA CSP. Cost share was seen to be essential in practice implementation for those participating in the government programs. Growers noted substantial problems with USDA NRCS standards and specifications for implementing the programs. Because EQIP standardizes the conservation practices, many growers believe they can do a better job of designing and installing conservation practices. Growers want to see more flexibility in conservation practice design and installation.

Thirty-year WEPP model simulations provided the basis for the cost-effectiveness analysis. The costs and/or benefits of the practices were optimized using the General Algebraic Modeling System (GAMS). The optimization engine was not dynamically linked with the WEPP model, (i.e., the hydrologic model was not called for individual optimization evaluations), but the WEPP model runs included the necessary scenarios. The WEPP model outputs were used to evaluate field-by-field effects of conservation practices. The CONCEPTS model was not used in the optimization study. Thus, channel sedimentation processes and their impacts on the overall pollution transport in the watershed were not incorporated in the analysis.

The conservation practices considered in the optimization study included two- and three-year crop rotations, gully plugs, buffer strips, permanent grass or tree plantings (CRP), and tillage practices. Field-by-field operation (104 fields) and ownership costs for each field were collected from the in-depth survey for landowners within the study watershed. The Cropping Systems Simulation (CropSyst) (Stöckle et al. 2011) and WEPP models were then used in an optimization model. CropSyst is a multiyear multicrop daily time-step simulation model. Crop yields were estimated by the CropSyst model based on soils, geographic location, weather patterns, management practices, and rotations and the 10-year average crop prices for northern Idaho. Researchers also developed farm-specific cost-benefit budgets based on data collection in the watershed.

Sediment load reductions were set at 0%, 30%, 50%, and 70% to obtain the cost per ton of soil saved relative to percent-affected area. The percent-affected area was less than the percent reduction in sediment load until the percent-affected area reached 50%. Two optimizations were conducted: one was based on a field-by-field adoption, where grower's preferences constrained choices, and the other was based on subfields, where the grower could choose any practice.

Conservation tillage was found to be by far the most cost-effective practice, whereas gully plugs were found to be effective at smaller spatial scales. It was estimated that reduction of sediment loads from upland areas up to 50% could be achieved at much lower costs than the remaining 50% of the reduction. To increase sediment reduction over 50%, more gully plugs and buffers must be installed in the Paradise Creek Watershed. Results also showed that for every incremental reduction in sediment load, cost would increase exponentially.

Outreach

Outreach objectives for the Paradise Creek NIFA–CEAP were to provide information about the effectiveness of specific conservation practices to (1) growers and residents of the watershed, (2) local and state officials, (3) federal stakeholders, and (4) active watershed groups. Stakeholders were considered to be outside groups.

Four newsletters about the Paradise Creek Project were developed and sent to 350 stakeholders in Washington, Idaho, Oregon, and California. Talks on the Idaho NIFA–CEAP were presented to the regional USEPA executive committee and to the regional USEPA staff in Seattle,

to state USDA NRCS offices in Idaho and Washington, to the soil conservation commission staffs in Idaho and Washington, and at local Soil and Water Conservation District association meetings. Finally, newsletter-ready articles were made available to faculty in county extension offices in Idaho and Washington. After the NIFA–CEAP is over, soil and water personnel and the tillage extension specialist, who works at Washington State University and the University of Idaho, expect to use the results in other watersheds. The four newsletters are referenced below:

- Mahler, R.L., J. Boll, J.D. Wulforst, and L. Van Tassell. 2007. CEAP survey results: Incentives to conserve soil and water resources. PNWWATER 113. http://www.pnwwaterweb.com/WQFlyers_PNW113.pdf.
- Mahler, R.L., J. Boll, J.D. Wulforst, and L. Van Tassell. 2007. Dryland farms: Factors affecting conservation decisions. PNWWATER 111. http://www.pnwwaterweb.com/WQFlyers_PNW111.pdf.
- Mahler, R.L., J. Boll, J.D. Wulforst, and L. Van Tassell. 2007. The Inland Empire: Growers make water quality a high priority. PNWWATER 109. http://www.pnwwaterweb.com/WQFlyers_PNW109.pdf.
- Mahler, R.L., J. Boll, J.D. Wulforst, and L. Van Tassell. 2004. UI Paradise Creek Project to assess conservation measures. PNWWATER 047. http://www.pnwwaterweb.com/WQFlyers_PNW047.pdf.

In addition to newsletters and presentations, legislatures were sent a water quality survey. Returned surveys (50% return rate) indicated that they were unaware of water quality progress being made through this project and others. As a result of the survey, the legislators started using the regional NIFA–CEAP water quality Web site, and the University Of Idaho received three inquiries from US Congress.

Paradise Creek Watershed National Institute of Food and Agriculture–Conservation Effects Assessment Project Publications

This project’s results have been published in numerous journal articles, book chapters, and other publications. The list of these publications is provided below.

Publications

- Brooks, E.S., J. Boll, A.J. Snyder, K.M. Ostrowski, S.L. Kane, J.D. Wulforst, L.W. Van Tassel, and R. Mahler. 2010. Long-term sediment loading trends in the Paradise Creek Watershed. *Journal of Soil Water Conservation* 65(6):331-341, doi:10.2489/jswc.65.6.331.
- Brooks, E.S., J.F. Kaufman, K.M. Ostrowski, P.A. McDaniel, and J. Boll. 2006. Soil heterogeneity and the hydrology of the high precipitation zone of the Palouse region. Paper number 062288 presented at the 2006 American Society of Agricultural and Biological Engineers Annual International Meeting in Portland, Oregon, American Society of Agricultural and Biological Engineers, St. Joseph, MI. July 9-12, 2006.
- Crabtree, B., J. Boll, E.S. Brooks, K.M. Ostrowski, S. Dun, and J. Wu. 2006. Spatially distributed soil erosion prediction in a watershed in northern Idaho. Paper 062292, Presented at the 2006 American Society of Agricultural and Biological Engineers Annual International Meeting, Portland, OR. July 9 -12, 2006.
- Ostrowski, K.M., J. Boll, and E.S. Brooks. 2004. A hillslope-scale experiment to determine the presence of a plow-pan under conservation tillage. Paper presented at the 2004 Pacific Northwest

American Society of Agricultural Engineers Regional Meeting, Paper PNW04-1003, American Society of Agricultural Engineers, St. Joseph, MI, September 23-25, 2004.

- Ostrowski, K.M., J. Boll, W.J. Price, E.S. Brooks, and J. Newson. 2006. Use of monitoring data to evaluate watershed management practices in a mixed-land use watershed in northern Idaho. Proceedings of the Joint Federal Interagency Conference, Silver Legacy Hotel, Reno, Nevada. April 2-6, 2006.
- Tosakana, N.S.P., L.W. Van Tassell, J.D. Wulffhorst, J. Boll, R. Mahler, E.S. Brooks, and S. Kane. 2010. Determinants of the adoption of conservation practices by farmers in the Northwest Wheat and Range Region. *Journal of Soil and Water Conservation* 65(6):404-412, doi:10.2489/jswc.65.6.404.

Presentations

- Boll, J., E. Brooks, K. Ostrowski, B. Crabtree, J. Newson, J.D. Wulffhorst, L. Van Tassell, N.S. Tosakana, R. Mahler, T. Lamar, G. Fizell, and D. Vollmer. 2007. Evaluation of conservation practices: Interdisciplinary analysis and modeling. USDA Cooperative State Research, Education, and Extension Service National Water Conference, Savannah, GA. January 28-February 1, 2007.
- Boll, J., E.S. Brooks, B. Crabtree, N.S. Tosakana, J.D. Wulffhorst, L. Van Tassel, and R.L. Mahler. 2006. Evaluation of conservation practices at the watershed scale using interdisciplinary analyses. Presented at the Managing Agricultural Landscapes Workshop, Soil Water Conservation Society, Westin Crown Hotel, Kansas City, MO. October 11-13, 2006.
- Boll, J., E.S. Brooks, S. Dun, B. Crabtree, J. Wu, and W.J. Elliot. 2006. Incorporation of saturation excess processes into the Water Erosion Prediction Project (WEPP) model. Abstract H34C-04. *Eos, Transactions, American Geophysical Union* 87(52), Fall Meeting Supplement.
- Boll, J., E.S. Brooks, and K.M. Ostrowski. 2005. Evaluation of conservation practices in a mixed land use watershed using cumulative effects modeling. Paper no. 052047. Presented at the 2005 American Society of Agricultural Engineers International Meeting, Tampa Convention Center, July 17-20, 2005.
- Boll, J., E.S. Brooks, K.M. Ostrowski, B. Crabtree, J. Newson, J.D. Wulffhorst, L. Van Tassell, N. Tosakana, and R.L. Mahler. 2008. CEAP: Cumulative effects modeling and interdisciplinary analyses. USDA Cooperative State Research, Education, and Extension Service National Water Conference. February 4-7, 2008.
- Boll, J., E.S. Brooks, J.D. Wulffhorst, M. Isik, and B. Mahler. 2005. Evaluation of conservation practices in a mixed-land use watershed using cumulative effects modeling and interdisciplinary analyses. Presented at the USDA Cooperative State Research, Education, and Extension Service National Water Quality Conference, San Diego. February 6-10, 2005.
- Boll, J., J.D. Wulffhorst, E.S. Brooks, L. Van Tassell, R. Mahler, and N. Tosakana. 2006. Interdisciplinary approaches to conservation practices in a mixed-land use watershed. Proceedings of the 48th Annual Idaho Academy of Science Meeting & Symposium, Moscow, ID. March 23-25, 2006.
- Brooks, E.S., and J. Boll. 2005. A simple GIS-based snow accumulation and melt model. Western Snow Conference, Great Falls, Montana. Proceedings. April 11-14, 2005.
- Brooks, E.S., and J. Boll. 2009. Uses and limitations of the soil survey in hydrological modeling. Abstract H21F-0914. *Eos, Transactions, American Geophysical Union* 90(52), Fall Meeting Supplement.
- Brooks, E.S., K. Ostrowski, J. Boll, and A. Snyder. 2008. Particle size influence on the relationship between turbidity and total suspended solids. Poster. Presented at the Consortium of Universities for the Advancement of Hydrologic Science Workshop, Boulder, CO. July 16-18, 2008.
- Crabtree, B., E.S. Brooks, K. Ostrowski, W.J. Elliot, and J. Boll. 2006. The Water Erosion Prediction Project (WEPP) model for saturation excess conditions: Application to an agricultural and a forested watershed.) Abstract H31C-1444. *Eos, Transactions, American Geophysical Union* 87(52) Fall Meeting Supplement.
- Newson, J., E.S. Brooks, K.M. Ostrowski, and J. Boll. 2006. Measurement and modeling of sediment transport in a cohesive stream in northern Idaho. Paper 062068. Poster presented at the 2006

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Project Personnel

All project personnel work at the University of Idaho. Jan Boll (agricultural and biological engineer) was the project investigator, and J.D. Wulffhorst (rural sociologist), Robert Mahler (water quality extension specialist), and Larry W. Van Tassel (agricultural economist, currently at University of Nebraska-Lincoln) were coproject investigators. Erin Brooks worked as a senior scientist on this project.

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