Chapter 13

Eagle Creek Watershed, Indiana: National Institute of Food and Agriculture–Conservation Effects Assessment Project

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The purpose of the Indiana National Institute of Food and Agriculture–Conservation Effects Assessment Project (NIFA–CEAP), Watershed-Scale Evaluation of BMP Effectiveness and Acceptability: Eagle Creek Watershed, Indiana, was twofold. First, the purpose was to analyze an extensive water quality database for the watershed so that trends in water quality could be analyzed with current conservation practices and then modeling could be used to compare observed trends in water quality to what could be achieved under different conservation management approaches. The second purpose was to develop an understanding of the social and economic limitations to the adoption of conservation practices and, by analyzing the current social limitations to acceptance of water quality management alternatives, devise strategies to accelerate positive change.

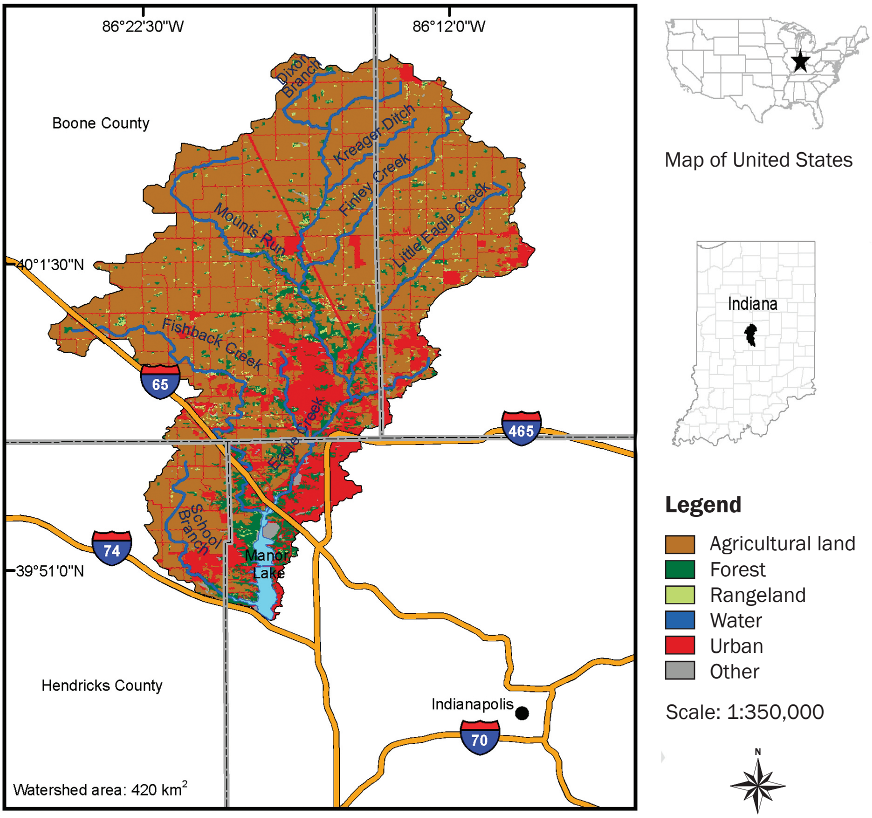
Specifically, the Eagle Creek NIFA–CEAP Watershed study had four objectives:

1. Determine the effectiveness of existing and potential conservation practices in the Eagle Creek Watershed at reducing atrazine, phosphorus (P), nitrogen (N), *E. coli*, and sediment entering the reservoir
2. Determine the social acceptability of potential conservation practices
3. Determine the economic profile of potential conservation practices
4. Use project results to provide conservation agencies with information they can use to better target cost share dollars and outreach strategies

Watershed Information

The Eagle Creek Watershed (hydrologic unit code #05120201120) is located in central Indiana (figure 13.1) and is part of the Upper White River Watershed, which lies in the Mississippi River Basin. The watershed is 31,161 ha (77,000 ac) in area, and Eagle Creek Reservoir serves as a drinking water supply for Indianapolis, the 12th largest city in the United States and one of the fastest growing urban areas in the United States. Eagle Creek is part of the White River system (Upper Mississippi River Basin), which has been ranked by the US

Figure 13.1
Eagle Creek Watershed, Indiana, land use and stream networks.



Geological Survey (USGS) as the 30th most impaired for nitrate-nitrogen (NO_3-N) and 100th most impaired for P out of 808 hydrologic unit code eight watersheds in the basin.

There are 10 subbasins within the Eagle Creek Watershed: eight empty into Eagle Creek and two discharge directly into the reservoir. The watershed spans four counties, and land use is 63% agricultural, 19% urban, 13% forested, and 2% open water. The upper portion of the watershed is 75% agricultural. Urbanization is concentrated near the reservoir and includes suburbs of Indianapolis. The Eagle Creek-Irishman Run subwatershed has the least amount of agriculture (25%) and the largest urban areas (25%), while land use in Fishback Creek, also near the reservoir, is 59% agriculture and 9% urban. These watersheds are becoming increasingly developed.

Riparian buffers exist on few first-order streams, which represent 80% of stream miles, whereas forested buffers are much more common on the higher-order streams. The shoreline for the reservoir is 22% grass, 52% trees, 23% trees and grass, 2% riprap and grass, and 2% concrete.

This Midwestern watershed is relatively flat, with slopes less than 3% in the agricultural areas. Steeper slopes occur adjacent to the reservoir. Soils consist of thin loess over loamy glacial till; in the upper reaches of the watershed, soils are deep and poorly drained. In the northwest portion of the watershed, most of the soils are classified as hydric. Closer to the reservoir, soils are somewhat poorly drained to well drained. Many of the soils in the watershed are highly productive if they are drained; otherwise due to the flat topography and poor drainage, the soils are less productive.

Like most of the Midwest, the climate of the Eagle Creek Watershed is humid and temperate. Average annual precipitation is 1,050 mm (41 in), with higher rainfall occurring from March through August. Some of the precipitation is snow, with an average annual snowfall of 690 mm (27 in). Temperature lows occur in January (–3°C [26°F]) with highs in July (24°C [75°F]). Within the last 10 years, the rainfall pattern has changed with a greater amount of rainfall occurring in the fall, winter, and spring. Storms have also increased in intensity.

The predominant cropping system is corn (usually conventionally tilled) and soybeans (usually no-tilled), with some hay and pasture. The majority of the farmed land is drained either by subsurface tile lines or by surface ditches, and many wetlands have been removed (Vidon et al. 2008b; Wagner et al. 2008). Much of the flow from agricultural areas is from tile drains into streams and ditches. Flow in these drains stops mid-June and usually resumes in late October.

There are four confined animal feeding operations in the watershed, and a fifth lies just outside the boundary and may cross watershed boundaries through tile drainage systems. There are numerous animal operations that are smaller than the Indiana regulatory threshold for confined animal feeding operations in the watershed. The exact number is difficult to ascertain, but they contribute to water quality degradation in the watershed. The majority of nutrients in the Eagle Creek system are from commercial fertilizers; however, wastewater treatment plants that discharge into Eagle Creek just north of the reservoir dominate the contribution of total P loads, especially during lower-flow conditions.

Water Quality Information

Water quality monitoring was not conducted by the Indiana NIFA–CEAP. Most water quality data have been collected since 2003 through monitoring related to the Central Indiana Water Resources Partnership (Johnstone et al. 2010; Vidon et al. 2008a) and the US Environmental Protection Agency (USEPA) Section 319 grants. The Indianapolis Water company and their operators, Veolia Water Indianapolis, have also collected water quality information in the reservoir and at spot locations in the watershed.

The streams have been classified by the state of Indiana for aquatic life and full-body recreation uses. The intended uses of the reservoir are drinking water, full-body contact, and aquatic life. When water quality data are compared to these intended uses, all streams in the Eagle Creek Watershed are considered impaired and are on the Indiana Section 303(d) list of the Clean Water Act (USEPA 2011) for *E. coli*, which exceed standards for full body contact. In addition, the lake is considered to be eutrophic as the reservoir is affected by excessive algae due to high N and P loads. Biotic indices for macroinvetebrates and fish have ranged from very poor to good, depending on the stream, but in general, habitat is impaired. Sediment, primarily from stream banks, contributes to the habitat impairment. Fish consumption advisories exist due to high levels of polychlorinated biphenyls in fish tissue. Finally, elevated atrazine concentrations are a significant problem in the drinking water reservoir because of the high added costs in water treatment. Atrazine sometimes exceeds USEPA drinking water standards during spring runoff and into the summer (April through September).

Recent studies supported by other funding have detected emerging contaminants (pharmaceuticals, estrogenics, and personal care products) in surface waters in the Eagle Creek Watershed. These contaminants are attributed to waste water treatment and septic effluent in tile systems. Data have been collected during both high and low flow conditions. However, results are only available for low flow conditions so the relative impact of overland flow sourced inputs is unknown at this time.

Water quality monitoring was conducted at the basin and subbasin scales, and principal monitoring activities included the following:

- Eleven stations were monitored using monthly grab samples and events aimed at observing seasonality and hot spots.
- Three long-term stations were monitored for long-term trends. Daily pollutant loads for each watershed were calculated by multiplying daily discharge (extrapolated from nearby USGS gages by assuming similar run-off coefficients for each subwatershed) by daily pollutant concentrations estimated using an unbiased stratified ratio estimator method.
- Storm events were sampled hourly and combined with USGS flow data, and high frequency sampling was used to address scale and flow path issues.
- The main watershed outlet was monitored for mass balance and nutrient loads to reservoir.
- The reservoir was monitored.

The constituents monitored depended on type of monitoring and included atrazine, NO_3-N, dissolved organic carbon, total suspended solids, total P, ortho-P, and *E.coli* bacteria.

Land Treatment

Standard USDA conservation programs and Section 319 funding were employed to install conservation practices. Due to the voluntary nature of the conservation programs, which are based on the willingness of the producers to implement practices, no critical areas were defined for targeting practices. In addition, no specific implementation objectives were specified for the project as conservation practices fell under regular program implementation.

Under USEPA Section 319 funding, 16 producers installed 3,640 ha (9,000 ac) of no-tillage, nutrient management, cover crops, and filter strips in headwater areas of the watershed in Boone County and in the Fishback Subbasin. Unfortunately, most of the practices do not affect NO_3-N and atrazine movement to subsurface drainage.

Researchers struggled to acquire information on past conservation practices to support the assessment portion of this project. A graduate student project combined USDA records (made available late in the project under a memo of understanding between the project and USDA), landowner interviews, and remote sensing to identify, inventory, and locate the installation and operation of conservation practices in the watershed.

The USDA Natural Resources Conservation Service (NRCS) data required considerable processing to eliminate double-counting because the data came as points on the field—each point potentially representing multiple practices, practices that were applied annually, or the same practice that addressed a different USDA NRCS resource concern. USDA records identified 299 operational and 107 structural conservation practices, which were reduced to 84 distinct operational and 48 unique structural practices after initial processing.

Remote sensing picked up only 27 structural practices and no operational practices, while producer interviews detected 47 structural practices and 185 operational practices and thus remote sensing detected fewer structural practices, while producer interviews identified significantly more operational practices. Using all three sources of information, 94 structural practices and 215 operational practices were identified. The most common structural practices were grassed waterways, filter strips, and riparian buffers; the most common operational practices were no-tillage and conservation tillage.

When data sources were compared to actual interviews, 53% of the structural practices were identified by government records, while 67% were identified through producer interviews. Operational practices were identified in government records 76% of the time relative to 87% from producer surveys. Researchers found the following trends:

- Government records were accurate, but USDA Farm Service Agency attributes were missing. All were difficult to obtain.
- Interviews were information rich but were time consuming to conduct.
- Photos were effective to confirm and supplement records and interviews.
- Combined data collection techniques provided a clearer picture of conservation practices in the watershed compared to any single approach.

Thus, while USDA records identified the majority of practices (emphasizing the importance of agency data for this purpose), the combined techniques provided a clearer picture of best management practices in the watershed compared to any single approach.

A windshield survey conducted to evaluate stream bank erosion and riparian buffers indicated that subwatersheds closer to the Eagle Creek Reservoir had the greatest stream erosion, while headwater streams had the least amount of adequate buffers. Animal access to streams was greatest in Eagle Creek-Kreager Ditch and Mounts Run-Neese Ditch subwatersheds. In addition, the watershed was mapped for land use—buffers, pasture, cropland, and urbanization—using high resolution aerial photography.

Water Quality Response

The drinking water reservoir continues to suffer from eutrophication and requires treatment for atrazine levels that still exceed USEPA drinking water standards. Because of the low-flow bias and transient peaks of pollutant concentration, it is doubtful that water quality monitoring will be able to detect changes in pollutants. In addition, most of the agricultural conservation practices that have been implemented in the Eagle Creek Watershed do not address the delivery of N and atrazine—two of the major pollutants—because these constituents are transported through the tile drainage and most of the conservation practices were targeted at erosion and sediment.

Summarized water quality data showed the following nutrient and atrazine patterns:

- NO_3-N concentrations in agricultural watersheds were typically 6 mg L^{-1} but were 1 mg L^{-1} in mixed land-use areas. (The USEPA recommended criteria for the concentration of NO_3-N in streams for this ecoregion is 1.6 mg L^{-1} or less.)
- Total P levels in agricultural areas were 0.07 mg L^{-1}, whereas in the streams with wastewater treatment plants, the total P levels were much greater. (The USEPA recommended criteria for total P in streams for this ecoregion is 0.0625 mg L^{-1} or less.)
- Most of the P was coming from urban stormwater and treatment plants (urban sector), while the N was mainly derived from agriculture.
- Atrazine levels as high as 30 μg L^{-1} had been recorded. It was costly for the reservoir managers to monitor (US$1 million per year) and treat (US$0.5 million per year char-

coal treatment) for atrazine. Atrazine moved readily through macropores into tile lines under agricultural fields.

Model Application

The primary goal of the modeling effort was to evaluate the water quality impacts of conservation practices that have been implemented in the Eagle Creek Watershed over the past decade. The Soil and Water Assessment Tool (SWAT) was used to simulate hydrologic and water quality processes in the watershed. The SWAT model was calibrated and tested for simulating daily streamflow at a USGS gaging station and monthly nitrate and atrazine loads at ten stream locations over the 1997 to 2004 period. The calibrated model was used for the following:

- To estimate the impacts of existing conservation practices on nitrate and atrazine loads at the watershed outlet
- To estimate the impacts of potential conservation scenarios on nitrate and atrazine loads at the watershed outlet
- To evaluate the uncertainty in the estimated effects of conservation practices

The SWAT model was selected for several reasons: (1) suitability of the model for representation of hydrologic and water quality processes in watersheds with similar physical, climatic, hydrologic, and management characteristics (Gassman et al. 2007); (2) the capacity of the model to represent land-use change over time; (3) existing expertise within the project team for using the model; and (4) availability of comprehensive theoretical and user's guide documentation and strong technical support from the SWAT development team. The SWAT model had been shown to appropriately represent important processes in corn-soybean dominated agroecosystems with continental temperatures and humid climatic conditions. Prevalence of subsurface drainage systems and rapidly growing urban areas in the watershed also motivated the adoption of the SWAT model for hydrologic and water quality modeling.

The SWAT model for the Eagle Creek Watershed captured the spatial variability of pollutant sources, climatic conditions, soils, and land-use characteristics by subdividing the watershed into 53 subwatersheds and 2,117 hydrologic response units. The portion of the watershed located upstream of Zionsville USGS flow-gaging station encompasses 35 subwatersheds and 446 hydrologic response units. A spatially explicit, process-based approach was developed to represent conservation practices and their impacts of hydrologic and water quality processes (Arabi et al. 2008). For example, pollutant loadings from a field with a grassed waterway were routed through the grassed waterway using SWAT channel routing algorithms. Subsurface drainage systems were considered in all agricultural fields with low drainage capacity. Crop rotation, tillage practices, and fertilizer and pesticide type, timing, and amount were obtained from pertinent literature (Larose et al. 2007) and personal communications with watershed stakeholders.

Climate data for the watershed were obtained from two National Climatic Data Center stations, namely, the Eagle Creek Station (elevation 255 m [738 ft]) and Whitestown Station (elevation 287 m [942 ft]). Soil characteristics were obtained from the Soil Survey Geographic (SSURGO) database and were augmented by the US General Soil Map (State Soil Geographic database [STATSGO]) dataset in areas with missing SSURGO soil information. Topographic characteristics were represented using a 1 arc-second (~30 m [~98 ft]) resolution National Elevation Dataset digital elevation model. Hydrographic features, such as streams, lakes, and subwatersheds, were obtained from the National Hydrography Dataset.

Rapid urbanization in the northeastern portion of the Eagle Creek Watershed is an important consideration in development of the SWAT model. Land-use land-cover data from the National Land Cover Dataset corresponding to years 1992 and 2001 combined with information from the National Agricultural Statistic Service in 2000, 2001, 2003, and 2004 were used to reflect the temporal changes in land-use land-cover characteristics.

Prior to calibration of the SWAT model, a detailed sensitivity analysis using the Morris's Randomized Oat Design screening method was performed to identify model parameters that are important for calibration of the SWAT model. The analysis focused on the influence of model parameters on streamflow, baseflow, nitrate, and atrazine responses.

A split-sample strategy, both in time and space, was used to calibrate and test the model. The calibration and testing period was from January 1, 1996, to December 31, 2004. The calibration and testing sites included a USGS flow station site at Zionsville with more than 50 years of daily streamflow data and 10 Marion County Health Department and Eagle Creek Task Force sampling stations, all located upstream of the Zionsville USGS station, with more than 100 data points for both nitrate and atrazine. Data from five water quality sampling locations with varying drainage areas, along with the USGS gaging station, were used for calibration. Data from the other five stations were used for testing the model performance. A hybrid manual and automatic calibration strategy was adopted to estimate model parameters for the Eagle Creek Watershed. Several parameter estimation techniques were used to enhance the model performance based on noncommensurate measures of model performance, including percent bias, coefficient of determination, and the Nash-Sutcliffe efficiency coefficient. The parameter estimation techniques used in the study included Shuffled Complex Evolution-UA, Random Walk Metropolis Hasting algorithm, Gibbs Sampler, DiffeRential Evolution Adaptive Metropolis (DREAM), and Dynamically Dimensioned Search. In all cases, the Dynamically Dimensioned Search algorithm outperformed the other parameter estimation techniques.

Model simulations using the calibrated parameter set resulted in very good model performance based on thresholds suggested in pertinent literature (Moriasi et al. 2007). An important observation during the calibration procedure was that incorporation of rule of thumb measures describing within watershed processes, such as denitrification rate or the ratio of nitrate transported to streams through subsurface drainage to total nitrate, was critical in accurate representation of hydrologic and water quality processes in the watershed system.

Specifically, SWAT was used to evaluate the water quality impacts of existing and potential conservation practices in the Eagle Creek Watershed, to look at pollutants of concern (nitrate and atrazine), and to assess the specific effects of structural practices (grassed waterways, riparian buffers, filter strips) and operational practices (tillage and residue management [no-tillage, conservation tillage], and conservation cover). In addition, modeling uncertainties were propagated forward into the evaluation of conservation practices in order to test the hypothesis that the effectiveness of conservation practices can be ascertained using the SWAT model with high confidence. Finally, the role of landscape position of practices on their effectiveness was tested relative to the hypothesis that implementation of conservation practices in areas in close proximity of higher order streams would yield higher water quality benefits.

The Indiana Project team used the calibrated model for evaluation of the existing and potential conservation practices for nitrate and atrazine reduction in the Eagle Creek Watershed. Unfortunately, the data about the type, location, and timing of existing conservation practices in the watershed became available to the modeling team at the end of the project period, which hampered delivery of project outputs within the initial project timeline. The project team will continue the modeling effort to evaluate the water quality benefits of currently installed practices in addition to several other potential conservation scenarios, including installation of grassed waterways and filter strips with varying widths at different locations within the watershed.

The modeling team will also use the probabilistic approach developed by Arabi et al. (2007) to evaluate the uncertainty in the estimated reductions in nitrate and atrazine loads (i.e., water quality benefits of practices in the Eagle Creek Watershed). Within this probabilistic framework, conservation practices are evaluated at several thousand points in the parameter space instead of one point estimate based on the calibrated parameter set. In addition to an overall estimate of the effectiveness of practices, this probabilistic method will give a 95% confidence interval for the estimates.

Socioeconomic Analysis

Social Component

The project examined factors affecting conservation practice acceptability and producer characteristics relative to practice adoption. All information for the socioeconomic section is derived from Reimer et al. (2011, 2012).

Farmer attitudes were surveyed to determine the reason for the use of conservation practices and the relative environmental awareness and farmer use and knowledge of conservation practices. Farmers and some nonoperators, both inside and outside the Eagle Creek Watershed, were surveyed. Within the Eagle Creek Watershed, the original list of producers consisted of 54 names and, of those 54, 13 people refused and 9 were never reached, yielding a 32-person survey response.

Project researchers conducted in-depth interviews with each farmer using a pretested survey instrument in 2007 to 2008. All interviews were transcribed for later analysis. Interviews were categorized to focus on reasons for adoption using three themes: (1) farm as a business, (2) off-farm environmental benefits, and (3) stewardship.

Views of conservation practices varied among farmers. However, most producers viewed on-farm environmental benefits from conservation practices in terms of production benefits. For example, conservation tillage reduces soil loss, labor costs, and production costs, while cover crops increase soil N. On-farm production benefits were often the only reason producers were using conservation tillage or nutrient management.

Producers who focused on farming as a business were less likely to use conservation practices, unless the practice saved time and/or money. For these farmers, conservation tillage was often adopted due to reduced fuel and labor costs. Reasons for reluctance to adopt practices ranged from the cost associated to taking land out of production to the time the practice took (e.g., cover crops) and the associated relationship between time and money. In addition, some producers' reluctance to adopt conservation practices was due to their age and impending retirement.

Some producers recognized off-site environmental impacts and were implementing practices to protect off-farm resources. Cover crop and filter strip use were associated with off-farm protection. Finally, some producers implemented conservation practices due to stewardship beliefs. Stewardship manifested itself in different ways: maintaining the land for future generations, for religious reasons, or because the individual had been blessed with resources and a good life. Overall, it was determined that farmers' acceptance of conservation practices and adoption rates was related to the farmer's conservation or environmental stewardship attitudes.

Farmers were categorized by use of conservation practices (conservation tillage, cover crops, filter strips, and grassed waterways) and by conservation practice perception (table 13.1). Conservation practice adoption was similar for producers who valued stewardship or who were concerned about off-site environmental impacts. Although adoption was similar between these two groups, farmers focusing on environmental concerns also focused on other reasons for conservation practice adoption; farmers adopting practices for stewardship reasons stated no other reasons for adoption.

Of the conservation practices reviewed, the adoption rate was greatest for grassed waterways and was lowest for cover crops. Overall conservation practice use was greatest for grassed waterways (56%) and conservation tillage in corn (56%). All producers use no-tillage for soybeans in this watershed. Filter strip usage was 41%, and cover crops had the lowest use at 22%. Although nutrient management and pesticide management had high levels of use (59% and 69%, respectively), only one component of these management conservation practices had to be used in order to qualify. For instance, nutrient management considers rate, source, timing, and placement. Only one of these four aspects of nutrient management had to be used in order for the practice to qualify as nutrient management.

Horse producers were surveyed in a separate survey after noting that horse pastures and farms were often lacking conservation practices. Nine stables and one owner agreed to participate in the equine survey. Horse farm size ranged from 3 to 36 horses (mean = 12.3) and 2 to 17 ha (5 to 43 ac) (mean = 7.9 ha [19.6 ac]), with an average stocking rate of 0.32 horses ha^{-1} (0.8 horses ac^{-1}), which is considered excessive. The horse owners were unaware of conservation practices, both because equine magazines do not deal with conservation and because these landowners fall outside typical USDA conservation programs. This group is interested but needs further education to acquaint them with environmental problems associated with their operations and to teach conservation practices.

Economic Component

Modeling was conducted to examine the cost effectiveness of agricultural conservation practices. The modeling focused on N, P, *E. coli*, sediment, and atrazine. Factors influencing pollutant contributions were location, amount of pollution load emitted, and conservation practice effectiveness.

The modeling identified the marginal cost of water quality improvements for the simulated landscape mosaics, ranked the simulated mosaics in terms of marginal cost, and traced the

Table 13.1
Farmers' perceptions of their farms as related to conservation production adoption.

Farm perception	Low adoption	Medium adoption	High adoption	Total farmers
Focus on production (instead of business)	9	4	4	17
Focus on off-site impacts of agriculture (off site)	0	6	9	15
Focus on stewardship	1	3	6	10

cumulative potential impact of a subset of mosaics that are both cost effective and acceptable to land-use managers, using cost-curve construction for conservation practices.

Modeling was conducted using 20 representative farms and 4 confined animal feeding operations, using distance transfer factors to route pollutants. Conservation effectiveness values were obtained from multiple published sources and cost data from the literature and state agency reports. The economic model did not use hydrologic modeling outputs but rather used transfer coefficients based on distance.

The optimization routine was run for six scenarios; five of the scenarios constrained all pollutants except one, and one scenario allowed all pollutants to change simultaneously. The results suggested the following:

- Optimal conservation practice mix switches at different levels of pollutant reduction, so implementation strategies need to change as target pollutant levels are reduced.
- Constraining a specific target pollutant (e.g., sediment) will often also achieve reduction of other pollutants.
- Lowering the pollutant reduction target increases total program cost, but the specific magnitude of increase depends on pollutant type.

Water quality modeling was delayed due to the difficulties of obtaining land-use data from the USDA NRCS, and as a consequence, the watershed modeling data could not be integrated into the economic modeling.

Outreach

There were no specific objectives for outreach, but the intent of the outreach was to help the Eagle Creek Watershed Alliance and other organizations better target conservation practices. Because land-use data collection through the USDA NRCS was delayed, project completion was also delayed; the project has been unable to conduct outreach from the Indiana NIFA–CEAP results.

During the Indiana NIFA–CEAP, the Eagle Creek Watershed Alliance provided funding through a USEPA Section 319 grant for conservation practice implementation and environmental outreach to area farmers. The Alliance hired a farm promoter, a retired USDA NRCS conservationist, to persuade farmers to adopt conservation practices. Cooperative extension does not do conservation planning or education with farmers; soil and water districts are too busy to work with producers on conservation education and adoption.

Additional funding has allowed the development of an experimental bioswale (constructed wetland) that captures 3 ha (7 ac) of tile drainage. It is similar to bioswales constructed in Germany and France and will allow researchers to compare effectiveness data. The bioswale is already being used for field-day demonstrations.

The Indiana State Department of Agriculture is working with about 16 farmers in the watershed using the Iowa Soybean Association On-Farm Network program to coordinate interaction and learning among farmers to improve N management. The program uses stalk nitrate tests along with guided aerial imagery to show the producers the relationship between N fertilizer application (via stalk nitrate) and yield. Producers are provided the results of the testing and the implications are discussed.

Eagle 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.

Arabi, M., J.R. Frankenberger, B. Engel, and J.G. Arnold. 2008. Representation of agricultural management practices with SWAT. Hydrological Processes 22:3042-3055.

Prokopy, L.S., R. Perry-Hill, and A.P. Reimer. 2011. Equine farm operators: An underserved target audience for conservation practice outreach? Journal Equine Veterinary Science 31:447-455, doi:10.1016/j.jevs.2011.01.008.

Reimer, A.P., A.W. Thompson, and L.S. Prokopy. 2011. The multi-dimensional nature of environmental attitudes among farmers in Indiana: Implications for conservation adoption. Agriculture and Human Values, doi:10.1007/s10460-011-9308-z.

Reimer, A.P., D.K. Weinkauf, and L.S. Prokopy. 2012. The influence of perceptions of practice characteristics: An examination of agricultural best management practice adoption in two Indiana watersheds. Journal Rural Studies 28:118–128.

Project Web Site

The Center for Earth and Environmental Science. An Urban Environmental Center. http://www.CEES.iupui.edu.

Funding

Beyond the NIFA-CEAP funding (Award No. 2006-51130-03706), this watershed has received grants from the USEPA 319 Grant Program and Indiana Department of Environmental Management for the project, Eagle Creek Watershed Implementation Project, October of 2009 to September of 2010 (US$655,375). These same two agencies funded the Eagle Creek Watershed Alliance: Phase I Watershed BMP Implementation, Education, and Public Outreach, for a total of US$522,911 between March of 2006 and March of 2009. The Veolia Water Indianapolis, LLC spent US$2,125,000 between May of 2003 and August of 2011 funding the Central Indiana Water Resources Partnership.

Project Personnel

Ronald Turco (environmental microbiologist) and Lenore Tedesco (hydrogeologist, currently executive director of the Wetlands Institute, Delaware) were the coproject investigators for this joint Purdue University–Indiana University Purdue University, Indianapolis effort. Coproject investigators included Jane Frankenberger (agricultural engineer), Linda Prokopy (social scientist), Gerald Shively (economist), and Mazdak Arabi (civil engineer, currently Colorado State University, Colorado). Denise Weinkauf, Adam Reimer, Brian Walker, Caitlin Grady, Anthony Oliver, and Tony Spencer were graduate students on this project.

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Reimer, A.P., A.W. Thompson, and L.S. Prokopy. 2011. The multi-dimensional nature of environmental attitudes among farmers in Indiana: Implications for conservation adoption. Agriculture and Human Values, 1-12, doi:10.1007/s10460-011-9308-z.

Reimer, A.P., D.K. Weinkauf, and L.S. Prokopy. 2012. The influence of perceptions of practice characteristics: An examination of agricultural best management practice adoption in two Indiana watersheds. Journal Rural Studies 28:118–128.

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