Chapter 11

Walnut Creek and Squaw Creek Watersheds, Iowa: National Institute of Food and Agriculture–Conservation Effects Assessment Project

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The goal of the Iowa National Institute of Food and Agriculture–Conservation Effects Assessment Project (NIFA–CEAP), Economic and Water Quality Effects of Multiple Conservation Practices in Three Midwest Watersheds, was to provide science-based information to policymakers concerning the water quality benefits and economic costs of implementing multiple agricultural conservation practices in these watersheds. The three primary watersheds were (1) Walnut Creek Watershed in south central Iowa and the Squaw Creek Watershed (which was the "control watershed" within the paired-watershed study), (2) Sny Magill Creek Watershed and Bloody Run Creek Watershed (which was also a "control watershed" within that paired-watershed study), and (3) the South Fork of the Iowa River Watershed in north central Iowa.

Specific objectives included the following:

1. Assemble water quality, land management, conservation practices, and economic data to adapt and calibrate model(s) that represent the water quality and economic responses to conservation practices commonly used in each watershed.
2. Calibrate the Soil and Water Assessment Tool (SWAT) using baseline conditions that include measures of water quality and estimated economic effects of conservation practices in hydrologic and agronomic settings typical of Midwest agriculture.
3. Compare the SWAT results to those from a groundwater-surface water model (GFLOW) and a sediment delivery model based on the Modified Universal Soil Loss Equation (MUSLE) within ArcView GIS (geographical information system).
4. Determine the combinations of conservation practices and their optimal positions within a watershed to achieve local water quality goals and estimate the required conservation budget to meet those goals.
5. Extend findings of the three watershed studies to watershed and commodity groups, environmental nongovernmental organizations, state government, and other interested parties through a variety of activities.

The total project consisted of three watersheds; however, this report focuses only on the Walnut Creek and Squaw Creek watersheds.

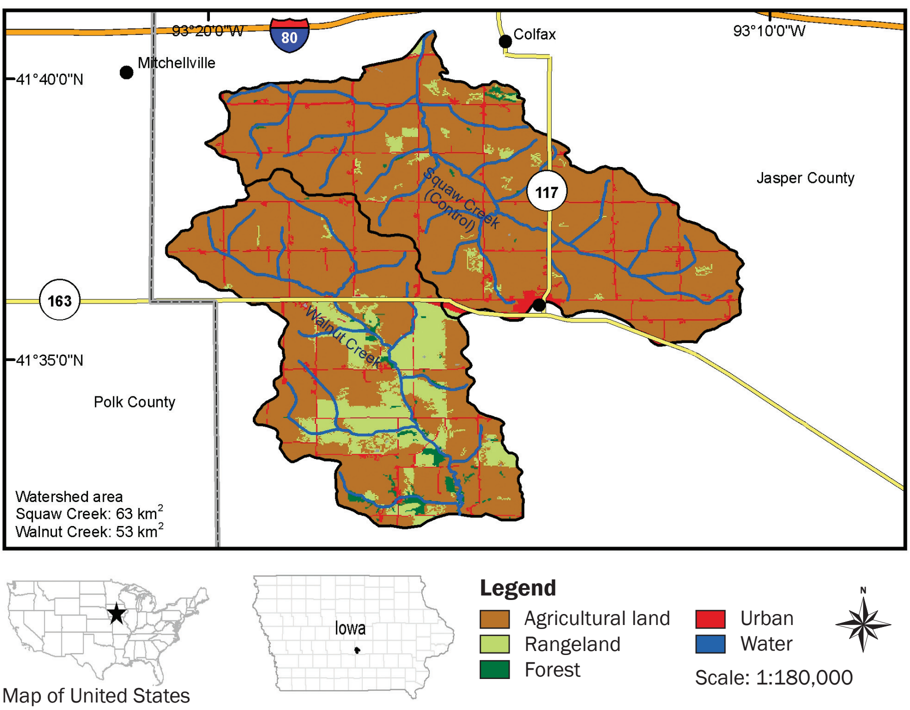
Watershed Information

The Walnut Creek Watershed (5,822 ha [14,387 ac]) is located in the Southern Iowa Drift Plain region of the United States (figure 11.1). The Southern Iowa Drift Plain region is characterized by steeply rolling hills, well-developed drainage, and loess and till soils, a combination that contributes to high erosion rates. The Walnut Creek Watershed was part of a paired-watershed study conducted during 1995 to 2005 (Schilling et al. 2006), in which Walnut Creek was the treatment watershed and the Squaw Creek Watershed (4,744 ha [11,723 ac]) was the control watershed.

In 1990, land use in both Walnut and Squaw Creek watersheds was dominated by row crops of corn and soybeans, with 69% row crop in Walnut Creek and 71% in Squaw Creek. From 1990 to 2005, major changes in land cover occurred in both watersheds. Squaw Creek showed an increasing trend of row crop land use, whereas row crop in Walnut Creek significantly decreased as part of a program to restore native prairie in the Neal Smith National Wildlife Refuge.

In Squaw Creek, a 9% increase in row crop area from 1990 to 2005 was likely due to the passage of the Freedom to Farm Act in 1996 that appeared to have substantially increased row crop production across major US crop production areas. Land previously categorized as

Figure 11.1
Walnut and Squaw Creek Watersheds, Iowa, land use and stream networks.



grasslands enrolled in the Conservation Reserve Program (CRP) was converted to row crop production. This trend was particularly evident in two monitored subbasins, where the row crop percentage increased by 26% and 29%.

In the Walnut Creek Watershed, row crop land use decreased from 69% to 54% between 1992 and 2005 as a result of prairie restoration by the US Fish and Wildlife Service (USFWS) at the Neal Smith National Wildlife Refuge. The total refuge size in 2008 was 3,480 ha (8,421 ac). The preserve has three missions: environmental education, ecological restoration, and research. Cropped land in the preserve must abide by specific management practices: only 112 kg N ha^{-1} (99 lb N ac^{-1}) can be spring applied to corn, phosphorus (P) and potassium applications must be based on soil tests, no pesticides can be applied, and soybean/corn rotations must be used. From 1992 to 2005, an average of approximately 90 ha (222 ac) of prairie was planted each year. As of 2005, 1,223 ha (3,022 ac) of land in the Walnut Creek Watershed was planted in native prairie, representing 23.5% of the watershed. In the subbasins, restored prairie accounted for 14% to 46% of the land area.

Dominant soils are silty clay loams, silt loams, or clay loams formed in loess and till. Major soil associations are Tama-Killduff-Muscatine (Argiudolls, Eutrudepts, and Hapludolls). Annual precipitation is approximately 750 mm (30 in). Discharge during the project varied from 109 to 422 mm (4 to 17 in) at the Walnut Creek Watershed outlet and 85 to 430 mm (3.5 to 16.9 in) at the Squaw Creek Watershed outlet. Average total discharge was slightly higher in Walnut Creek than Squaw Creek, but baseflow discharge was less in Walnut Creek. The percentage of streamflow as baseflow was higher in Squaw Creek (62%) than in Walnut Creek (57%).

Both creeks have been extensively channelized and are incised into their valleys. About 0.6 to 1.8 m (2 to 6 ft) of postsettlement alluvium is present in both valleys. Stream gradients in the main stem vary from 0.01 to 0.002. Other basin characteristics are very similar between the two watersheds.

There are 48 bison and 17 elk in a 304 ha (751 ac) enclosure within the Walnut Creek Watershed. Additional livestock can be added to the reserve because stocking rates are significantly below the carrying capacity. The animals graze on the pasture and are not fed by farmers. There are additional small holdings of livestock scattered throughout the watershed, but they are all pastured, and there is no manure storage or application to the land. Livestock thus make relatively insignificant contributions to the total nutrient load of the basin.

Water Quality Information

Walnut Creek drains into a segment of the Des Moines River that is classified by the Iowa Department of Natural Resources in recent water quality assessments as "not supporting its designated uses." Squaw Creek drains into a segment of the Skunk River that is classified as "partially supporting its designated uses" by the Iowa Department of Natural Resources. Assessments in this area cite agricultural nonpoint sources as the principal water quality concern. Water quality problems were related to agricultural production on highly erodible land. It is important to note that the project goal was not to restore specific impaired stream segments but was to evaluate prairie restoration and reconstruction as a conservation practice (and it is also important to note that neither Walnut Creek nor Squaw Creek are defined as impaired waterways by the Iowa Department of Natural Resources).

Walnut and Squaw creeks are affected by many agricultural nonpoint source water pollutants, including sediment, nutrients, pesticides, and animal waste. Water quality in these streams is typical for many of Iowa's small warm water streams: it varies significantly with changes in discharge and runoff. Streambank erosion has contributed to significant sedimentation in the creeks.

Initial water quality monitoring started when the USFWS collected data during the first year of the prairie preimplementation period in 1991. The Tri-State Monitoring Project then collected data in the Walnut Creek Basin during the 1992 to 1994 preimplementation period. In 1991, nitrate-nitrogen (NO_3-N) concentrations ranged from 14 to 19 mg L^{-1}, with a mean of 16 mg L^{-1}. Atrazine concentrations ranged from 0.24 to1.2 μg L^{-1}. The event sampling in 1994 had fewer samples. The NO_3-N ranged from 2.1 to 11.0 mg L^{-1}, with an average of 6.1 mg L^{-1} in Walnut Creek, and it ranged from 0.1 to 20 mg L^{-1}, with an average 10.0 mg L^{-1}, in the tributaries. Atrazine in the main stem of Walnut Creek ranged from <0.1 to 0.3 μg L^{-1} and was higher in the tributaries (up to 3.1 μg L^{-1}). In Walnut Creek, primary biological productivity was low, and the condition of the fish community was poor. Two sets of storm event samples were collected in 1995.

More recent water quality monitoring consisted of the collection of discharge, suspended sediment, and water quality data in both creeks since 1995 (except for 2006). The water quality monitoring approach consisted of a paired-watershed design. The outlets of Walnut Creek (treatment) and Squaw Creek (control) watersheds were monitored concurrently. Each watershed had stations upstream and downstream in order to differentiate natural processes from land-use changes. Gradual changes in water quality were compared to evaluate land treatment effectiveness. This data collection included the following:

- Standard US Geological Survey gaging stations (automatic samplers) were located at the mouth of each watershed and at an upstream site in Walnut Creek.
- Suspended sediment concentrations were measured daily at the three gages by the US Geological Survey.
- Recent deployment of continuous turbidity sensors at the two downstream sites was also being field tested for correlation with standard suspended sediment measurements.
- Surface water chemistry was monitored weekly to monthly at 10 sites across the Walnut Creek and Squaw Creek watersheds. Four stations were sampled once in August, October, December, and February; these samples were analyzed for NO_3-N, ammonium-nitrogen, P, pesticides (in season), other anions, fecal coliforms, pH, dissolved oxygen, redox potential, turbidity, conductivity, and temperature.

This project differed from typical paired-watershed studies because pretreatment data collection was not sufficient to derive relationships between the treatment and control watersheds during the calibration period. Moreover, land treatment implemented by the refuge in the Walnut Creek Watershed occurred gradually throughout the entire monitoring period. For these reasons, a gradual change model that incorporated covariates from the control watershed was used, instead of comparing distinct pre and postconservation practice periods as in a more typical paired-watershed study.

The nitrate and pesticide parameters were sampled at 10 sites in Walnut and Squaw Creek watersheds combined during March through September. The sampling was biweekly or monthly. In August, October, December, and February, only four sites were sampled. Turbidity and suspended sediment were monitored daily with automatic samplers, and data were compiled for storm event statistical evaluation.

An important result of subwatershed monitoring showed that row crop conversion to prairie resulted in a 30% decrease in stream NO_3-N concentration, while CRP conversion to row crop resulted in a 1,200% increase in NO_3-N concentration.

Flow and suspended sediment measurements are available for download from the US Geological Survey (USGS Iowa 2012).

Land Treatment

A Cropland Management Plan was prepared by the USFWS in 1993 to guide the rapid conversion of traditional row crop areas to native, local ecotype habitat. The goal was to restore the land as rapidly as possible, although the rate of refuge development varied with political, ecological, and operational needs of the refuge. As refuge development took place, various tracts of land in crops were removed from row crop production and were converted to native habitat. The intent was to eliminate crop production in the refuge within approximately 10 years.

Therefore, the primary objectives of the Walnut Creek Monitoring project were to (1) quantitatively document, over time, reduction in nonpoint source pollution and the associated environmental improvements resulting from watershed habitat restoration and land management changes, (2) use the monitoring data to increase understanding of which implementation measures are successful, and (3) expand public awareness of the need for nonpoint source pollution prevention measures in the State of Iowa.

No specific water quality objectives were set for this project because the intent was to restore the area to presettlement conditions. An assumption was made that a decrease in row crop agriculture would lead to reductions in nutrients and pesticide concentrations in Walnut Creek. Prairie restoration was expected to restore the native ecosystem and reduce pollutants by completely eliminating crop production, and strict procedures imposed for pesticide and nutrient management on refuge-owned land were expected to significantly reduce pesticide and nutrient inputs.

Land acquisition by the USFWS determined the areas for prairie implementation. This was a gradual process and was determined by availability of funds for acquisition, as well as willingness of landowners to sell. Those continuing to farm lands in the project area were subject to restrictions on agriculture chemical applications and management reporting. Refuge cropland is managed by conventional crop rotation of corn and beans. No-tillage production methods were mandatory, whereas other management methods were more prescriptive, including soil conservation practices, nutrient management through soil testing, yield goals, and nutrient credit records. All chemicals and application rates were approved prior to application to minimize adverse impacts on nontarget plants and animals. Use of chemicals that were not on the preapproved list was granted only after demonstrating that the intended use was consistent with an Integrated Pest Management Plan and that crop scouting indicated a favorable cost/benefit ratio. All cooperative farmers were required to enter into a contract for crop scouting services for pest management. The USFWS personnel worked with landowners to adopt the Cropland Management Plan for the refuge and also coordinated soil testing, crop scouting, and nutrient and herbicide applications.

Land-use practices for Walnut and Squaw Creek watersheds were recorded on an annual basis during the life of the project, and land-cover data were compiled using plat maps, USDA Natural Resources Conservation Service (NRCS) crop data, aerial photographs, and field surveys. The USFWS personnel recorded prairie planting areas and locations of rental ground in the Walnut Creek Watershed. Historical land use in the watersheds (prerestoration) was compiled from 1:24,000 scale color-infrared aerial photographs taken in 1992. Land-use data were entered into an ArcView GIS, along with the water quality, discharge, and sediment data.

Land use and agriculture management tracking allowed estimation of reductions in nutrient and pesticide applications in the Walnut and Squaw Creek watersheds as result of implementation. However, the requirements for producers still cropping on refuge land to report nutrient applications was not enforced very well; however, these applications represented only ~5% of refuge land.

Progress of conservation practice implementation objectives since 1993 has been as follows:

- 1,224 ha (3,025 ac) of prairie were planted (23%)
- Walnut Creek row crop area decreased by 54%
- Squaw Creek row crop area increased between 71% and 80%
- Walnut Creek nitrogen (N) applications were reduced by 21% and pesticide use was reduced by 28%
- Squaw Creek N applications increased by 13% over 1990 N applications

Water Quality Response

Despite the prairie restoration and conservation practice adoption, Walnut Creek still has not been restored to presettlement water quality. Suspended sediment concentrations and loads varied widely during the 10-year monitoring period. Sediment transport through Walnut and Squaw Creek watersheds was very flashy, evidenced by most of the annual suspended sediment load occurring during intermittent high-flow events. Single-day suspended sediment loads accounted for 25% to 37% of the annual sediment total. Suspended sediment concentrations were similar in Walnut Creek and Squaw Creek, with average and median values of 104.1 and 46.0 mg L^{-1} at the Walnut Creek Watershed outlet and 90.1 and 42.7 mg L^{-1} at the Squaw Creek Watershed outlet, respectively. Project researchers believe that the lack of change in sediment load following treatment could be due to the highly seasonal pattern of sediment export, the fact that stream power was not reduced by the treatments, failure to address streambank erosion, and long-term sediment storage in floodplains and stream channels.

During 1995 to 2005, the Walnut Creek mean annual nitrate concentrations averaged 9.5 mg L^{-1}, with a range of 8.2 to 11.5 mg L^{-1}. Project results indicated that the prairie restoration in the Walnut Creek Watershed improved water quality with regard to nitrate concentrations and loads. Planting ~25% of the Walnut Creek Watershed in native prairie resulted in a reduction of nitrate of ~1.2 mg L^{-1} over 10 years and of 8 to 12 mg L^{-1} in the subbasins. Conversely, nitrate concentrations increased 1.9 mg L^{-1} in the Squaw Creek Watershed, where row crop production increased by approximately 253 ha (625 ac) (Schilling et al. 2006). A smaller Squaw Creek subbasin was monitored for land-use change (~25% increase in row crop production as CRP grassland was converted), and the corresponding increase in nitrate loading was 10 mg L^{-1} or greater over the baseline concentrations.

Atrazine was the most commonly detected herbicide in Walnut and Squaw Creek watersheds with detection frequencies greater than 70%. Acetochlor was occasionally detected (up to a 27%), whereas alachlor and metolachlor were rarely detectable (less than 5%). Cyanazine detections were also rare during the last five years of the project. Statistical changes in herbicide concentrations over time were mixed because both decreasing and increasing trends were observed. Researchers suggested that the lack of change in herbicides detected at the watershed outlet, despite a documented ~28% reduction in applications, may have been due to the tendency of a fixed-interval sampling schedule to miss highly episodic runoff events.

Fecal coliform bacteria were detected frequently above the US Environmental Protection Agency water quality standard of 200 organisms per 100 mL (3.38 fl oz) in both watersheds. No changes in fecal coliform concentrations were observed during the 10-year monitoring project at the downstream Walnut Creek Watershed outlet. Increases in fecal coliform concentrations were noted in two Walnut Creek subbasins.

Phosphorus monitoring began in water year 2001, and thus, five years of monitoring data were available for project reporting. Phosphorus did not change in any of the main stem streams in either Walnut Creek or Squaw Creek. Lack of P concentration trends in five years of monitoring in the watersheds was expected given the episodic transport and variability in P concentrations detected in water.

Quantitative collections from Squaw Creek and Walnut Creek had poor macroinvertebrate colonization during the project. Taxa richness metrics for Walnut Creek initially showed consistent improvement until 2001, after which metrics steadily declined to levels below initial measurements from the project's inception. Thirty-one species of fish from eight families were collected from Walnut Creek, and twenty-two species of fish from six families were collected from Squaw Creek since 1995. The fish communities in both streams were dominated by minnows, and most of the minnow species collected were considered abundant to common in Iowa streams.

Model Application

Calibration and validation exercises were performed with the Soil and Water Assessment Tool (SWAT) model for both watersheds. Field-level survey data, Iowa Department of Natural Resources land-use data, aerial photos, USDA NRCS Soil Survey Geographic (SSURGO) database soil maps, topographic data, and climate data from multiple weather stations were used to represent watershed characteristics in the SWAT model. The calibration and validation periods for both watersheds were 2000 to 2004 and 1996 to 1999, respectively. Following calibration and validation, the goal was to estimate the long-term benefit(s) of agricultural conservation practices and/or land-use changes in both watersheds. Results were published in peer-reviewed journals for the Squaw Creek applications (Jha et al. 2010; Rabotyagov et al. 2010a, 2010b). The Walnut Creek results, which were presented in a conference venue (Rabotyagov et al. 2008), were considered preliminary due to problems encountered while trying to calibrate SWAT for Walnut Creek. The calibration problems were likely due to inaccuracies in precipitation data and possible difficulties in replicating the prairie hydrologic cycle accurately; efforts continue to correct these problems.

Detailed conservation practice data were collected at the field level for both the Walnut and Squaw Creek watersheds by a consultant (a retired USDA NRCS field specialist) using a tablet PC. The data included information about conservation practice type, time of installation, and location of conservation practices. Conservation practice data collection was carried out during 2005. Practices listed in the tool included terraces, contour farming, contour buffers, field borders, strip-cropping, water/sediment control basins, ponds, and tillage (no tillage, mulch tillage, and conventional tillage). However, nutrient management information could not be determined via this data collection method for specific fields; instead, typical fertilizer application rates were used. The water quality impacts of conservation practices were captured by representing their impacts on hydrologic and water quality processes in SWAT. For example, the impact of grassed waterways was captured by adjusting the Universal Soil Loss Equation (USLE) P-factor (erosion control practice) in the SWAT model.

In the Squaw Creek Watershed, the conservation practices team used SWAT to assess the effects of placement of warm-season grasses in the agricultural landscape to optimize nutrient load reduction to the stream (Jha et al. 2010). In 2009, most of the perennial grass was located in the center of the watershed. The four modeled land-use changes included (1) CRP grasslands converted to row crops, (2) highly erodible lands converted to grasslands, (3) upper portions of the watershed converted from row crop to grasslands, and (4) row crops in the floodplain converted to grasslands. Modeled results indicated that CRP conversion to row crops increased nitrate loading by 29 kg ha^{-1} (25.5 lb ac^{-1}). The other practices reduced nitrate loading. The highly erodible land to grassland conversion reduced nitrate 28.7 kg ha^{-1} (25.3 lb ac^{-1}), which translates into a 47% reduction in nitrate due a 41% change in watershed land use. The upper basin cropland to grassland conversion reduced nitrate by 20.7 kg ha^{-1} (18.2 lb ac^{-1}), or 16.1%, by converting 19% of the land use. The least reduction in nitrate (14 kg ha^{-1} [12.3 lb ac^{-1}]) occurred when grasslands were planted in the floodplain; nitrate loading was reduced by 8% by converting 15% of the row crops to grassland. These modeled results were compared to another Iowa watershed, and it was concluded that nitrate load reductions were probably unique to each watershed, and therefore, management decisions should be unique.

A GIS–based Revised Universal Soil Loss Equation (RUSLE) model suggested that prairie reconstruction in the Walnut Creek Watershed reduced sheet and rill erosion by more than 50% compared to the Squaw Creek control. However, in-stream monitoring data showed that there was essentially no reduction in sediment during the 1995 to 2005 time period at the Walnut Creek Watershed outlet. Field mapping conducted in 1998, 2005, and 2010 indicated that streambank erosion contributed greatly to sediment export in Walnut Creek (up to 50% of total) compared to Squaw Creek (14% of total).

Socioeconomic Analysis

The calibrated SWAT model was used for the Squaw Creek Watershed to conduct optimization analyses as a function of conservation practice water quality effectiveness and costs (Rabotyagov et al. 2010a, 2010b). The SWAT model was dynamically linked with an evolutionary algorithm–based optimization approach in both studies to search for the most cost-efficient combination of conservation practices in the watershed. Rabotyagov et al. (2010a) focused on the impacts of optimal conservation practice placement, in terms of both N and P reduction, within the context of shifting land-use patterns, where the land-use shifts reflect recent crop price trends resulting in expanded corn production across the watershed. Rabotyagov et al. (2010b) reported the effects of optimal conservation practice placement across the watershed as a function of two N-reduction strategies: (1) control of mean annual N loadings and (2) meeting the goal of weather-resilient solutions, in which N targets had to be met for different generated weather sequences.

The same set of baseline and conservation practices was analyzed for both of the SWAT and single-objective optimization method studies, which are referred to as the “allele set.” This allele set consisted of 33 different management practice combinations, which included the following practices: conventional tillage, reduced tillage, mulch-tillage, and no-tillage; each tillage practice in combination with contouring, grassed waterways, terraces, or reduced fertilizer input (20% reduction in N application); each tillage practice in combination with reduced fertilizer and contouring, grassed waterways, and terraces; and finally land retirement (or CRP). Conservation practice cost data and commodity data were obtained from a variety of sources.

Graphs for each practice and combination of practices represented the percentage of N load reduction and its associated cost. For example, land retirement reduced N the most (70%), but it had the greatest cost. Mulch tillage and reduced tillage had the lowest impact on N reduction and also the lowest cost.

An approximate optimal trade-off frontier was constructed (annual cost versus NO_3-N loading in t y^{-1}). Reducing the total annual mean watershed NO_3-N to export to 40 t y^{-1} (44 tn yr^{-1}) was relatively expensive, resulting in a total annual cost of close to US$1,000,000. However, allowing the mean target nitrate loading to increase to 60 t y^{-1} (66 tn yr^{-1}) resulted in annual costs of approximately US$200,000, a substantial cost reduction compared to the lower nitrate reduction target. Weather-resiliency was also modeled, and findings were that controlling mean nitrogen loadings was much cheaper than ensuring that the probability of exceeding the water quality standard was reduced. In other words, more conservation practices will need to be implemented to ensure that in years with high rainfall, NO_3-N loadings will not exceed water quality standards. Obviously, staying within water quality standards will be considerably more expensive than trying to control an average pollutant export level.

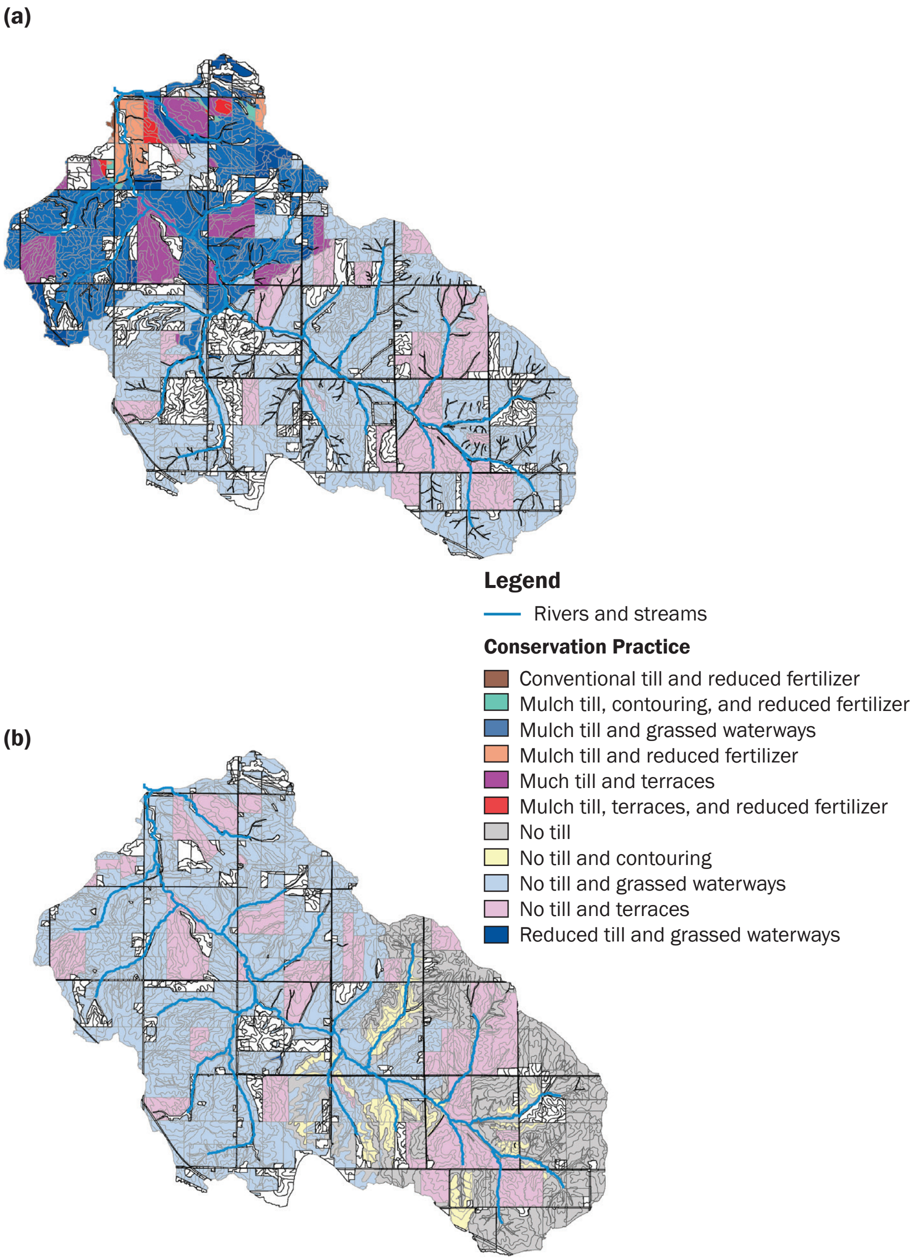
The modeling application used by Rabotyagov et al. (2010a) allowed conservation practices to be mapped back to the watershed in order to position conservation practices for the greatest effectiveness based on the criteria selected. For example, to reduce pollutant loading annually by an average of 20%, mulch-tillage in the upper watershed, with mulch-tillage and grassed waterways in the lower portion, were the conservation practices of choice. If a 20% reduction was needed under extreme weather conditions (weather resilient), no-tillage with grassed waterways and no-tillage with grassed waterways and N fertilizer reduction would be required.

Rabotyagov et al. (2010b) examined the effects of changed cropping systems on N and P loading runoff rates. Detailed crop budgets were used to explore changes in crop rotation or land use (greater or less use of marginal lands). The baseline cropping system was set for 2005 and included areas planted with each crop, as well as tillage and conservation practice areas. Not surprisingly, as cropland increased or as more corn was produced, both N and P loading increased. Using trade-off frontiers, it was shown that costs for reductions in N and P rose at an increasing rate: a 10% reduction costs US$10,597 per year, while a 50% reduction costs over US$275,000 per year. This trade-off frontiers method provided the ability to determine the mix and spatial distribution needed to meet pollution reduction targets relative to resource availability and to build the type of maps shown in figure 11.2. These maps show spatial implementation of conservation practices to reduce nutrient loadings.

Outreach

The outreach objectives for the Walnut Creek CEAP were to extend findings of the three watershed studies included within the overall Iowa CEAP to watershed and commodity groups, environmental nongovernmental organizations, the state government, and other interested

Figure 11.2
Solutions achieving at least a 30% reduction in both nutrients from historical land-use baselines (from Rabotyagov et al. 2010b): (a) "Historical_N30_P30" (solution #1541), and (b) "Alternative_N30_P30" (solution #2026).



parties through a variety of activities. This goal was carried out for research conducted for the Walnut Creek Watershed (and Squaw Creek Watershed, which was the control watershed within the paired-watershed study), the Sny Magill Creek Watershed (and Bloody Run Creek Watershed, which was also a control watershed within that paired-watershed study), and the South Fork of the Iowa River Watershed.

Information regarding research conducted at the Walnut Creek and Squaw Creek watersheds was disseminated at the refuge to visitors and invited groups, to the public (through published reports), at numerous conference, workshop, and special interest group presentations, and through the news media. Of broader interest, the Walnut Creek and Squaw Creek Project was also serving as a demonstration site for riparian restoration and small wetland restoration. Having a linked water quality evaluation program made these demonstrations more effective for general use and translation to a broader audience. Similar outreach activities were conducted for research performed for the Sny Magill Creek and Bloody Run Creek watersheds and the South Fork of the Iowa River Watershed.

Iowa 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.

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

Publications

Asbjornsen, H., M.D. Tomer, M. Gomez-Cardenas, L.A. Brudvig, C.M. Greenan, and K.E. Schilling. 2007. Tree and stand transpiration in a Midwestern bur oak savanna after elm encroachment and restoration thinning. Forest Ecology and Management doi:10.1016/j.foreco.2007.04.043.

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The United States Geological Survey National Water Information System. http://waterdata.usgs.gov/ia/nwis/sw.

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Project Personnel

Catherine L. Kling (economist, Iowa State University [ISU]) was the project investigator, and Philip W. Gassman (environmental scientist, ISU), Matthew J. Helmers (agricultural engineer, ISU), Thomas M. Isenhart (ecologist, ISU), William W. Simpkins (hydrogeologist, ISU) and Keith E. Schilling (research hydrogeologist, Iowa Geological and Water Survey) were coproject investigators. Other participants included Thomas B. Moorman (microbiologist, USDA Agricultural Research Service), Mark D. Tomer (soil scientist, USDA Agricultural

Research Service), Calvin Wolter (geographic information system analyst, Iowa Geological and Water Survey), Manoj K. Jha (now a civil engineer, North Carolina A&T University), and Sergey Rabotyagov (now an economist, University of Washington).

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