# Chapter 14

## Cheney Lake Watershed, Kansas: National Institute of Food and Agriculture–Conservation Effects Assessment Project

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The project goal of the Kansas National Institute of Food and Agriculture–Conservation Effects Assessment Project (NIFA–CEAP), Assessing the Impact of a Strategic Approach to Implementation of Conservation Practices, was to assess the water quality benefits resulting from a strategic approach to conservation practice implementation. Specific objectives included the following:

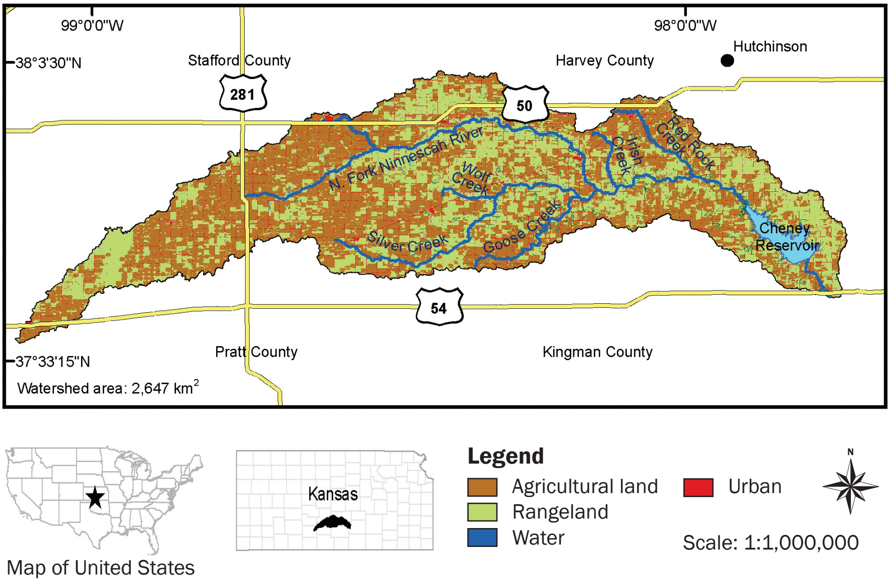
1. Determine the measurable effects of conservation practices on water quality trends in the Cheney Lake Watershed in South-Central Kansas
2. Quantify the additional water quality benefits resulting from strategic placement of an optimal suite of conservation practices
3. Evaluate social factors that influence the adoption and maintenance of conservation practices
4. Evaluate the economic impact of strategic conservation practice placement
5. Educate and motivate agricultural producers to implement the optimal conservation practices in the optimal locations

## Watershed Information

The Cheney Lake Watershed is located on the North Fork Ninnescah River (hydrologic unit code #11030014) and associated tributaries in five South-Central Kansas counties (figure 14.1). The lake was constructed between 1962 to 1964 to provide a drinking water source, downstream flood control, recreational use, and wildlife benefits. The City of Wichita, Kansas, acquires 60% to 70% of its daily water supply for about 400,000 people from Cheney Lake, as well as 10 other smaller communities. It is expected that even more communities will need this water supply. The remainder of the drinking water is from groundwater.

The watershed is 2,416 km$^2$ (933 mi$^2$) and encompasses five mainly agricultural counties. The population of the Cheney Lake Watershed is less than 4,000 people, and populations of the six largest towns in the watershed range from 200 to 1,200 people. Because of the small population in the watershed, the potential for point source pollution is considered to be small, as verified by a low-flow investigation. Five National Pollutant Discharge Elimination System–

**Figure 14.1**
Cheney Lake Watershed, Kansas, land use and stream networks.




permitted facilities are located within the watershed and contribute an estimated 2% of total annual phosphorus (P) loads.

Cheney Lake has been impaired by frequent algal blooms during the summer months since the early 1990s. These blooms have caused taste and odor problems in drinking water withdrawn from the lake by the City of Wichita. Excessive P concentrations in the water are a contributing cause of the blooms. Impairments have been documented by data from US Geological Survey (USGS), the Kansas Department of Health and Environment (KDHE), and Cheney Lake Watershed Inc. In addition, historical water quality data also indicate that sedimentation and pesticides are problems in the lake. Total maximum daily loads have been set by the KDHE for eutrophication and silt for Cheney Lake.

Land use in Cheney Lake Watershed is 99% agricultural, with 58% of watershed land in crop production, 25% pasture, and 17% to 20% set aside as tallgrass prairie through the Conservation Reserve Program (CRP). The pastureland is generally located around the stream areas because it cannot be farmed. There are approximately 1,000 farms in the watershed. Crops include corn, grain sorghum, soybeans, and wheat. In 1995, there were 10,927 ha (27,000 ac) of corn, 20,639 ha (51,000 ac) of grain sorghum, 2,023 ha (5,000 ac) of soybeans, and 80,937 ha (200,000 ac) of wheat in the watershed. There has been a significant increase in corn and soybeans and a reduction of continuous wheat over the past 10 years. Most producers have diversified farms that involve both crops and cattle. Livestock in the watershed include 76,000 cattle (as of January 1, 1996) and 14,000 hogs (as of December 1, 1995). There are about 20 small dairies in the watershed, which are owned by Amish and Mennonite farmers.

The topography is mostly flat as most fields have no more than 2% slope, although slopes can range from a minimum of 0% to a maximum of 6%. Groundwater is easily recharged in this basin and is found as little as 3 m (10 ft) below the surface. During the fall and winter, baseflow provides the water in the streams. The area closer to the lake has a much denser stream network; the western portion of the watershed has few streams. All soils are classified as mollisols in this watershed, and texture ranges from sand to clay; the clay-textured soils are found closer to Lake Cheney. Rainfall exhibits a typical summer pattern with the majority of the rainfall in the spring and summer in intense rainfall events. Rainfall at the eastern edge of the watershed is approximately 813 mm $y^{-1}$ (32 in $yr^{-1}$), but it dwindles to 610 mm $y^{-1}$ (24 in $yr^{-1}$) at the western edge.

## Water Quality Information

The KDHE determined the primary source of pollution to Cheney Lake is from agricultural nonpoint sources. A USGS study reported that agricultural activities accounted for 65% of the P transported to Cheney Lake. It was estimated that from 1965 to 1998, 3,810 t (8.4 million lb) of P were transported to Cheney Lake. From a 1996 to 2001 study, the USGS documented elevated P concentrations in watershed streams and concluded that agricultural sources were the primary cause of water quality impairment.

In addition to the USGS, the KDHE has monitored streamflow and water quality (P) in the main tributary to Cheney Reservoir since 2000. Throughout the years of KDHE monitoring, chlorophyll *a* concentrations in Cheney Lake have averaged 3.42 µg $L^{-1}$. The chlorophyll *a* concentration has increased over time from 1.98 µg $L^{-1}$ in 1987 to 6.10 µg $L^{-1}$ by 1999. Furthermore, sampling by the KDHE showed elevated total P (TP) concentrations in the lake (averaging 0.12 mg $L^{-1}$). The KDHE estimates an annual P load to the lake of 97 t $y^{-1}$ (107 tn $yr^{-1}$).

In the past, the Citizen's Management Committee, which was formed to oversee the Cheney Lake Water Quality Project, established a water quality goal of reducing streamwater P concentrations to less than 0.10 mg $L^{-1}$, which would require a 50% reduction of incoming P. The USGS data demonstrate that average P concentrations ranged from 0.23 to 0.50 mg $L^{-1}$, indicating enrichment by agricultural activities or large natural concentrations in soils. However, historical (1965 to 1998) average TP concentrations in the surface inflow to the lake were 0.76 mg $L^{-1}$, as calculated on the basis of P deposited in the lake sediment. Additionally, a recent analysis demonstrated that reducing P may be even more difficult than previously thought because during extreme flow events (100-year storm), TP losses exceeded 15 times the TP goal established by the Citizen's Management Committee.

The principal water quality objective of the NIFA–CEAP Cheney Lake Watershed Project was to determine the effect of current agricultural conservation practices on water quality trends given the timing, location, and suite of practices implemented. There was extensive surface water monitoring within the Cheney Lake Watershed. Surface water monitoring began in 1962. Since that time, the KDHE continued monitoring a number of locations in the watershed. Between 1975 and 1999, the KDHE participated in eight Cheney Lake water quality surveys. The KDHE reported that the watershed is ranked seventh throughout the state of Kansas in priority for watershed restoration and established total maximum daily loads for eutrophication and silt.

The water quality monitoring design used in Cheney Lake Watershed was primarily a before and after trend analysis using historical data associated with conservation practice implementation. The USGS conducted extensive water quality studies of Cheney Lake Watershed from

1996 through 2000, including detailed streamflow and water quality monitoring at five locations in the watershed. Since 2000, monitoring has only occurred at the watershed outlet station #1 (main tributary to Cheney Lake). Monitored constituents included TP, dissolved P, sediment, total nitrogen, atrazine, and chlorophyll *a*.

The Kansas NIFA–CEAP established a surface water monitoring system in the watershed to compare current water quality conditions with water quality conditions in the 1990s. Because land treatment and water quality monitoring were continuous from 1994 through 2009 (with some interruptions in water quality monitoring), water quality monitoring points were selected to capture watersheds that had high rates of conservation practice adoption. Two water quality monitoring sites were reestablished from a USGS study (1997 to 2000). Automatic samplers at Red Rock Creek and Goose Creek collected continuous flow data and collected time-composited water samples during storm events from April of 2007 through September of 2010. Grab samples were taken during base flow on a weekly basis from April through September and monthly during the winter. Water quality samples were collected from a third site (on the North Fork of the Ninnescah) where USGS had maintained continuous flow monitoring since 1965. Grab samples were taken at this site on a weekly basis from April through September, and monthly samples were taken during the winter from April of 2007 through December of 2010. These results were used to augment water quality data taken by the USGS on a sporadic basis from 1994 to 1997 and from 2001 to 2009, with intensive water quality sampling from 1997 to 2000. The combined dataset for the North Fork of the Ninnescah was analyzed for water quality trends over a 15-year period (1995 through 2009). Similar constituents to the USGS survey were monitored.

Water quality monitoring data was stored in spreadsheet format (Microsoft Excel). Model inputs and outputs were stored in relational databases (Microsoft Access) and ArcGIS Personal GeoDatabases.

## Land Treatment

Like most of the NIFA–CEAP watershed studies, conservation practice implementation was not an objective of the project. The objective was to evaluate the previously implemented practices. The schedule of implementation was based on available funds and willingness of producers as discussed in the rest of this section.

The Cheney Lake Water Quality Project was established in 1992 to reduce agricultural pollutants to Cheney Lake. The Citizen's Management Committee was formed to oversee the Cheney Lake Water Quality Project. The committee consists of seven farmers and landowners, and they hold three-year terms. The Citizen's Management Committee set goals of voluntary participation and minimal financial burden for participating farmers. Specifically, the Citizen's Management Committee set land treatment objectives of 100% voluntary participation and emphasized changing on-farm management. The City of Wichita provides farmers partial reimbursement for implementing structural practices and incentives for improved management.

Most conservation practices implemented in the Cheney Lake Watershed are eligible for state and federal cost share at a rate of 50% to 70%. The City of Wichita pays all or most of the remainder of farmers' costs (typically 30% to 40%). In addition, certain conservation practices that are not funded by the USDA Natural Resources Conservation Service (NRCS), such as fencing grassland once it is no longer in the CRP, are eligible to receive partial reimbursement through the City of Wichita. A new practice funded by the City of Wichita involves paying producers US\$40.50 $ha^{-1}$ (US\$100 $ac^{-1}$) to change cropland to grassland, but the grassland must be managed and maintained for 10 years. The funds for these conservation practices are paid directly from the City of Wichita to the farmers.

The farmers were responsible through the Citizen's Management Committee for selecting conservation practices that were funded by the City of Wichita. Members on the Citizen's Management Committee educated other producers in the watershed through discussions, small farmer meetings, and other means. They were focused on helping producers install practices that were correct for the farmer and his/her operation. Until recently, the Citizen's Management Committee funded most proposed projects, but due to current budget constraints and a better understanding of the impact of focused implementation, they have begun targeting conservation practices in areas of the watershed closer to Cheney Lake. Practices in the upper portion of the watershed have been deemphasized.

The greatest density of conservation practices is located in areas of the watershed farthest downstream, nearest to Cheney Lake. Terrace installation was the top-ranked conservation practice implemented in terms of area impacted and was the second-ranked practice in terms of the number of contracts. New CRP grasslands increased by 11,412 ha (28,200 ac) between 1997 and 2007, surpassing all other conservation practices. However, the majority of CRP grasslands was established by 1994. Household waste improvements (i.e., septic system repair) were the third most common conservation practice implemented in the watershed.

Trends in conservation practice implementation were different depending on the practices installed. The watershed area protected by conservation tillage contracts increased steadily, peaking at slightly more than 2,833 ha (7,000 ac) under contract in 2006. Numbers of nutrient management planning and conservation tillage contracts were highly variable during the period examined. This could be a result of the changes in cost-share programs, influences of weather, crop prices, or other variables affecting the willingness of producers to enroll in incentive programs for these conservation practices. Data collection for these practices was also difficult due to changes in tracking procedures by the USDA NRCS; therefore, the data may not be complete. Producers may also have adopted these practices without incentives or cost share and thus, they were not tracked. Trends in terrace and waste management conservation practices were similar in that the majority of the contracts issued after the year 2000 were issued for locations that had previously implemented the conservation practice. This indicated that the same producers were returning to add additional practices. Finally, nutrient management planning contracts declined during the past five years; farmers disliked the program governing nutrient management contracts, and it is no longer promoted.

Land use and/or the implementation of conservation practices were monitored. Data on conservation practices, their locations, and times of implementation were primarily obtained from a database maintained by the Cheney Lake Water Quality Project. Any conservation practices funded through the City of Wichita must be included in the georeferenced database. The spatial distribution of conservation practices was evaluated by determining practice implementation in each of the 14-digit hydrologic unit code subwatersheds within the Cheney Lake Watershed. Land-treatment data are available for the entire watershed from 1994 to 2006.

Before the Kansas NIFA–CEAP, there was no identification or selection of critical areas for implementation of conservation practices, except for CRP grasslands that had an explicit environmental benefit index use designation as part of the funding criteria. As part of the Kansas

NIFA–CEAP, a Revised Universal Soil Loss Equation (RUSLE)–based geographical information system was developed to better identify critical areas based on soil loss in the Cheney Lake Watershed. Parameters needed for the Revised Universal Soil Loss Equation Version 2 (RUSLE2) were determined and then used to estimate soil loss. Fields with the greater erosion rates (top 20% of the watershed) were identified as critical areas. It is estimated that these areas deliver 56% of the total sediment. Fields with CRP grasslands were often found in these priority areas because this practice was targeted to highly eroding land in the watershed, but the converse was true of conservation tillage; most conservation tillage was not used in the critical areas.

There was little difference in rates of conservation practice implementation for priority and nonpriority fields. Overall, 11% of the watershed area received conservation practices, with 13% of the prioritized area receiving practices and 11% of the nonprioritized area receiving conservation practices. Only 22% of implemented conservation practices were located in the prioritized areas (as designated through the RUSLE map). It was determined that 51% of the priority area was in wheat and 70% was in conventional tillage.

Unfortunately, the USDA NRCS cannot prioritize smaller than a 12-digit hydrologic unit code (small watersheds) and thus targeting practices to particular fields using federal cost share is not possible. A concurrence of potentially reduced funding from the City of Wichita and information developed from the Cheney Lake NIFA–CEAP has helped the farmers in the Citizen's Management Committee determine that conservation practices need to be focused near the lake to reduce sediment and P losses. In addition, the Citizen's Management Committee incentive program for grass plantings is only available in priority areas of the watershed.

Typically, producers choose practices that match fairly well with ideal conservation practices unless they are unwilling to adopt any new stewardship practices. Due to the nature of rangeland bordering streams, landowners prefer off-stream watering over fencing as a means to limit stream access. Participation in formal nutrient management programs is low, although producers may practice nutrient management on their own. Landowners were not interested in fencing cows to keep them out of the creek or in using nutrient management.

Local control and cooperation, plus relationships between landowners and City of Wichita, seem to have contributed to successful implementation and wide participation in conservation practices, although lack of specific goals makes it difficult to gage success. Producer comfort with conservation practice implementation seemed much greater than in many other watersheds.

The Citizen's Management Committee made important observations about conservation practice adoption:

- There is a group of farmers who are not interested in changing their practices, particularly older farmers who do not want to invest in new equipment.
- It is important for conservation districts and the USDA NRCS to learn about the farm and then suggest conservation practices, which is the reverse of what is usually done.
- Individual USDA NRCS personnel make a difference. The USDA NRCS employees who are more flexible help producers get practices on the field.
- Farmers often go to their neighbors for help with conservation practices.
- Farmers should have the power to determine the best solutions for their farms.

Conservation tillage practices are more likely to continue than nutrient management because implementation of conservation tillage requires the purchase of equipment and major changes in management. Based on economic surveys, many producers moved to conservation tillage in response to adding crop rotations, increases in fuel prices, and labor constraints. Conservation tillage adds functionality for the producers; nutrient management does not. Yields of corn and soybeans have increased much more rapidly than wheat and sorghum, which makes them more attractive as part of the cropping system and allows the addition of conservation tillage because continuous wheat requires tillage in order to control disease. In addition, Roundup Ready technologies have made conservation tillage easier to implement. High corn and soybean prices encourage these crops to be planted, which has influenced the adoption of a crop rotation with these crops and the use of conservation tillage.

## Water Quality Response

The water quality response was measured at the main USGS gaging station on the North Fork of the Ninnescah (capturing 80% of the watershed area) and thus was interpreted as representing the response for the majority of implemented conservation practices. Fifteen years of monthly water quality data were used to explore water quality response through simple regressions, multiple linear time-series regressions, multiple regression with nonparametric smoothing functions, and Kendall trend analysis, with adjustments for flow and season. There is a downward trend in sediment, but it is not significant for any of the statistical analysis, and no trends in P were detected. Water quality has not deteriorated, but there is no clear trend that indicates improvement in water quality parameters. Modeling, however, suggested that conservation practices resulted in slight declines in sediment load (8%) with even smaller declines in P load (3%) over the 15-year period; there was no explicit link between practices and water quality response.

This lack of measured water quality response could be due to temporal and spatial factors. It is possible that the monitoring regime was not intensive enough to detect small trends with statistical confidence in the context of natural variability in water quality. Sediment reduction trends may not be discernible in measured data due to temporal patterns of conservation tillage implementation, where the majority of no-tillage conversion occurred at the end of the monitoring period. Furthermore, the majority of the CRP grassland installations occurred before the water quality monitoring time frame. The lack of focus for practices implemented within priority areas may also be a factor.

The Cheney Lake NIFA–CEAP did some unique research on the processes of ephemeral erosion, which may be the greatest source of sediment in the watershed. It was estimated that 0.61 t $ha^{-1}$ (1.3 tn $ac^{-1}$) of soil was lost yearly. More than 55% of the ephemeral gulleys were found in low-residue wheat cropland without terraces. Initial research indicates that field watershed size may be the most important factor in reducing sediment losses as terraces provided more protection than conservation tillage.

## Model Application

Three different models—the Soil and Water Assessment Tool (SWAT), a RUSLE2–based model, and an empirical regression–based model—were used to identify areas with high soil erosion potential, watershed properties that control the formation of gullies in agricultural fields, and erosion and P reduction benefits of conservation practiced in the watershed.

The SWAT was used to evaluate the impacts of conservation practices for abating sediment and P loads. This modeling exercise was performed in two stages:

1. Red Rock Creek Modeling was done to determine watershed-level effects of conversion to no-tillage.
2. North Fork Ninnescah Modeling was done to determine individual and collective (watershed-scale) effects of tillage, CRP, and terracing practices.

The SWAT model was used to test the hypothesis that conversion to no-tillage has changed sediment loss compared to conventional tillage by simulating sediment loss under actual management and then reverting all tillage to pre-1994 conventional tillage. By computing the differences between modeled scenarios, the no-tillage effect can be determined. Specifically, the objectives of the SWAT model application included the following:

- Accurately represent temporal implementation of conservation practices
- Accurately represent spatial implementation of conservation practices
- Evaluate the watershed-scale effects of implemented no-tillage practices on sediment and P loads in the Red Rock Watershed
- Evaluate the watershed-scale effects of implemented tillage, CRP, and terracing practices on sediment and P loads in the North Fork Ninnescah Watershed
- Evaluate the potential benefits of no-tillage implementation in the Red Rock Creek Watershed at various levels of implementation in terms of the percentage of the watershed covered

Comparison of SWAT and the Annualized Agricultural Nonpoint Source Pollution (AnnAGNPS) model indicated that SWAT was the more appropriate model for the Cheney Lake Watershed for modeling hydrology and P (Parajuli et al. 2009). Therefore, SWAT was used for simulating hydrologic and water quality processes in the study area. The SWAT model can represent many important hydrological and water quality processes. In addition, SWAT includes specific algorithms for representation of different tillage practices, including no-tillage. Terraces can be represented by changing the Universal Soil Loss Equation (USLE) P factor (conservation practice factor) and the slope length for a given field. The CRP can be represented by changing the land cover for a given field. However, SWAT does not include algorithms for representation of ephemeral gully erosion processes. Also, the existing algorithms for representation of channel sedimentation processes in SWAT have not been widely corroborated. For example, the model cannot take account of legacy sediments and channel evolution over a long-term period.

The SWAT model is a distributed watershed model that allows the watersheds to be divided into subwatersheds and then hydrologic response units (HRUs) to represent the spatial variability of watershed properties (e.g., soil, land cover, terrain), in order to capture the spatiotemporal variability of climatic conditions, soils, and land uses. The Red Rock Creek Watershed model included 12 subbasins and 1,069 HRUs, while the North Fork Ninnescah Watershed model included 21 subbasins and 4,501 HRUs. For both watersheds, a series of 55 15-year crop rotations were used to simulate temporal implementation of cropping systems in the watershed. Temporal distribution of the terraces was implemented with the "ops" table in ArcSWAT version 2009.93.5, and SWAT model computations were performed on a daily time-step. No in-stream nutrient processes were represented.

The modeling team worked with the USDA NRCS to acquire land-use history and terrace information, which were used as direct model inputs. The USDA NRCS also provided qualitative information on irrigation systems (well depths, effects on streamflow, irrigation amounts, etc.), groundwater hydrology, and tillage practices in the watershed, all of which were beneficial to the modeling efforts. The 2006 to 2009 USDA NRCS cropland data layers were processed to determine land use and crop rotations in the study area. Tillage practices were determined through producer surveys and visual observation, while year of conversion to no-tillage was determined from producer surveys. Other data used for creating the SWAT models included the following:

- Elevation data were obtained from the National Elevation Dataset.
- Soil data were obtained from the Soil Survey Geographic (SSURGO) database.
- Climate data were obtained from the National Climatic Data Center climate station data.
- Land-use data were obtained from a corroborated land-use geographical information system coverage with an overall accuracy of 85% that differentiates among summer crop; winter wheat with low, medium, and high residue levels; and rangeland with low, medium, and high vegetative-cover classes, which were developed by CoPI Mankin.
- Additional land-use data were developed to identify the major crop rotations employed in the watershed. Data from the USDA NRCS Cropland Data Layer for 2006 through 2009 were simplified based on the major crops and land uses then overlain to determine the rotations present in each field. Data from Cheney Lake Watershed Inc. that identified area enlisted in the CRP was also combined with USDA NRCS CDL data. The resulting data set identified 10 crop rotations and 3 nonagricultural land uses in the watershed. This data was used for modeling the cumulative and individual effects of conservation practices in the watershed.

It should be noted that further efficiencies in modeling efforts were achieved by utilization of datasets (soils, land uses, topography) and additional coverages (conservation practices) that had already been generated by the Kansas Biological Survey modeling team and were available for use in this project. All the geographical information system datasets needed to initiate SWAT modeling of the Cheney Lake Watershed were quality-assured and accessible.

Rainfall and temperature data were sparse within the watershed (only one long-term gage), which complicated the modeling efforts. Other data sources had rain gages within the watershed for brief periods. Therefore, long-term rainfall data were compiled for nearby rain gages and were used to approximate the rainfall within the watershed. Also, over 25 volunteer rain gages were distributed within the watershed as part of the Community Collaborative Rain, Hail & Snow Network to start building a better database for future modeling efforts.

Important model parameters included in the calibration and testing of the SWAT model were identified based on the prior experience of the modeling team and also the review of relevant literature. Methods to determine model input values were divided into the following three categories: determined by calibration, determined based on measured data, and determined based on field observations, literature values, and professional judgment.

Sensitivity analyses were performed for 22 input variables in the SWAT model and were used to determine effects of tillage on sediment and P loss in the Red Rock Creek Watershed. Values that had the highest sensitivity were adjusted uniformly for the whole model, regardless of the conservation practices in place (i.e., sensitive input parameters were not used as key variables in modeling differences between conservation practices). The one exception was the USLE P factor, which by definition, is used to define if there are specific management practices that affect erosion. In this study, the USLE P factor was used to model the effects of terracing.

Model calibration and validation of SWAT were performed for The Red Rock Creek Watershed and the North Fork Ninnescah Watershed. For the Rock Creek Watershed, a manual calibration procedure was used to adjust flow, sediment and P parameters using data at the watershed outlet. The calibration period was for 1997 to 2000, and the number of calibration data points was 1,369 daily data points for flow and 45 monthly data points for monthly flow, sediment load, and TP load. The Load Estimator LOADEST program was used to compute monthly sediment and TP loads based on measured sediment and P concentration data. The Nash–Sutcliffe model efficiency coefficient ($E_{NS}$) was used as the primary error-statistic for evaluation of model performance. Other parameters used to evaluate model fit were bias and root mean square error. The results at the watershed outlet indicated very good daily flow calibration ($E_{NS}$ = 0.73), very good monthly sediment load calibration ($E_{NS}$= 0.77), and very good monthly TP load calibration ($E_{NS}$ = 0.89).

The calibration period for the North Fork Ninnenscah Watershed was from 1997 to 2000, using 180 monthly data points (45 data points at four locations). The 21 subbasins developed in the SWAT model setup were grouped into four drainage areas corresponding to the drainage areas of four water quality sampling locations. Calibration was performed for the period after the implementation of conservation practices was started. Management practices were simulated to represent, as close as possible, to the actual practices during the calibration. The same level of no-tillage was represented. The model was calibrated for monthly flow, sediment, and TP at three nested locations within the watershed as well as at the watershed outlet. The LOADEST program was used to compute monthly sediment and TP loads based on measured data. Based on $E_{NS}$, flow calibration was unacceptable ($E_{NS}$ for all stations < 0.5), although bias indicated satisfactory to good calibration for three of the four outlets. The sediment calibration was considered good for the two outlets with larger drainage area ($E_{NS}$ > 0.50 at the North Fork Ninnescah and West North Fork Ninnescah outlets); however, the sediment calibration for two outlets with smaller drainage areas was considered unacceptable ($E_{NS}$ < 0.3 at the Goose Creek and Silver Creek outlets). The TP calibration results at the North Fork Ninnescah and Silver Creek outlets were good ($E_{NS}$ > 0.5), but the results were unacceptable at the Goose Creek and West North Fork Ninnescah outlets ($E_{NS}$ < 0.5).

Once calibrated, the following three tillage scenarios were used in the model: 50% no-tillage (status quo), 94% no-tillage, and 100% no-tillage. Modeled reductions showed a decrease of 34% to 61% in erosion, a 19% to 43% reduction in sediment yield, a 14% to 27% reduction in TP, and a 13% to 30% increase in dissolved P when compared to the conventional tillage scenario (status quo).

The overall conclusions of modeling in the Red Rock Creek Watershed based on the comparison of the 1994 condition with the 1994 to 2008 conditions indicated that no-tillage was effective at reducing field-scale and watershed-scale sediment loads. The estimated reduction of watershed-scale sediment loads (~13% to 20%) was less than field-scale reductions (~33%), perhaps due to sediment retention in ephemeral streams. The model predictions pointed to a 15% reduction in TP in runoff by 2009.

In the North Fork Ninnescah Watershed, modeled scenarios were based on the comparison of the 1994 condition with the 1994 to 2008 conditions. No-tillage was effective at reducing field and watershed-scale sediment loads, but effects of no-tillage were less pronounced in the Cheney Lake Watershed because of spatial distribution of the fields that were converted to no-tillage relative to fields that were contributing to erosion. Just as in Red Rock Creek Watershed, estimated reduction of watershed-scale sediment loads was less than field-scale reductions due to sediment retention in ephemeral streams. Modeling did not show any discernible TP trends. The model estimates of total suspended sediment and TP reductions for the North Fork Ninnescah Watershed are small enough that detection of these changes with monitoring data is highly unlikely. Although modeled estimates of sediment reductions were greater for Red Rock Creek Watershed, they are still likely to be less than what could be identified in short-term monitoring data that are available.

A RUSLE2–based model was developed within the Environmental Systems Research Institute ArcGIS platform to identify priority locations within the Cheney Lake Watershed for implementation of sediment and P conservation practices. The model was applied to estimate average annual sheet erosion for each field in the watershed for two conditions: 1994 management conditions and 2006 management conditions. This model was also used to calculate the percentage of implemented practices that were located in priority areas identified from the RUSLE2 model.

The RUSLE2–based model implemented in ArcGIS revealed the priority areas within the Cheney Lake Watershed based on estimated average annual sheet erosion for fields. A summary of the results follow:

- It was estimated that the top 20% priority fields in the watershed account for nearly 56% of the total watershed erosion.
- From the analysis based on the 1994 management, it was found that priority fields were more likely to be converted to CRP grasslands than nonpriority fields.
- Conversely, there was no significant difference between rate of implementation of no-tillage and terracing in priority and nonpriority fields.
- Watershed analysis based on current management showed that priority areas have relatively more cropland in conventional tillage systems compared to the nonpriority areas, while nonpriority areas have relatively more cropland in no-tillage.

Finally, an empirical regression–based model was developed to link the formation of ephemeral gullies in agricultural fields to the terrain, soil, and other characteristics of the land. This model can be used to estimate average annual sediment loading from ephemeral gullies in fields with different conservation practices. Modeling ephemeral gullies in the watershed was impeded by lack of high resolution (1 m [3.3 ft]) elevation data in the watershed. Modeling work was conducted on fields outside the watershed that had the required data. Additional LiDAR (light detection and ranging) elevation data were collected for the watershed in conjunction with USDA NRCS, but these data were not available for use during the project's time frame.

## Socioeconomic Analysis

There are approximately 1,000 farms in the watershed. Crops are produced on 52% of the land area and include corn, grain sorghum, soybeans, and wheat, and continuous winter wheat is the dominant crop within priority areas.

Examples of current conservation practices include cover crops, filter strips, crop rotations, management-intensive grazing systems, strip cropping, no-tillage production, grassed waterways, terraces, and permanent grass plantings. Seventeen percent of the land in the watershed has been enrolled in the CRP. From 1994 to 2006, there have been more than 1,369 conservation practices implemented, protecting more than 31,485 ha (77,800 ac) of land. Funds from the City of Wichita have been used to implement conservation practices on about 13% of the agricultural land in the watershed. All of these practices were approved through the Citizen's Management Committee. Conservation practices were implemented on 15% and 25% of the cropland and pastureland, respectively. The greatest density of projects is located in areas of the watershed farthest downstream, nearest to Cheney Lake (Devlin et al. 2008).

Economic and social incentives have been important in the adoption of practices. Financial resources from the USDA NRCS, state cost share, and from the City of Wichita, which is an urban-rural partnership, have provided funds for practice installation and/or implementation. A social incentive through the Citizen's Management Committee, which intentionally is comprised of diverse members, has been successful in increasing participation. For instance, there has often been someone familiar with the Amish or Amish-Mennonite community who works with this community to encourage conservation practice adoption.

The social survey for the Kansas Project had four objectives:

1. Identify farmers' attitudes regarding conservation practices and the environment
2. Identify socioeconomic factors that influence adoption and maintenance of practices
3. Gage farmers' level of understanding of science supporting conservation practices relative to water quality
4. Identify farmers' attitudes regarding priority areas

Interviews with producers and other watershed stakeholders in year one included 28 producers and in year two included 21 producers, seven members of the Citizen's Management Committee, three from the City of Wichita, and seven from the USDA NRCS or conservation districts (Selfa and Becerra 2011b). Multiple lessons were learned from the interviews. Reasons for success were local knowledge, local leadership, cooperation, and the partnership between the city of Wichita and watershed farmers.

The survey indicated that priority area designation would not encourage or discourage participation in conservation programs. It is conservation program interest rather than "place in the watershed" that drives implementation of conservation practices. For instance, producer knowledge/attitudes affected practice adoption. These factors included knowledge about watershed, knowledge about water quality issues, acknowledgement that producers were responsible for water quality, and finally positive attitudes that the environmental benefits from conservation practices translated into economic benefits.

Producers had certain commonly held views of conservation practices; farmers thought there was a positive impact on water quality from CRP, reduced tillage, terraces, waterways, grazing management, alternative watering, and riparian buffers. Most surveyed farmers (95%) thought conservation practices were effective. Farmers and ranchers believed that the best conservation practice was pasture, while they perceived nutrient management most negatively.

Motivations for adoption of conservation practices included a large range of goals:

- To save money by reducing costs or using time efficiently
- To reduce production costs
- To increase soil conservation
- To help the environment
- To save Cheney Lake
- To take care of the land (stewardship)
- To avoid being told how to do things (preemptive)

The greatest motivations were found to be saving money and the reducing production costs, with adoption factors lower on the list (e.g., stewardship and not being told how to do things) as being less motivational for conservation practice adoption.

Other factors were considered barriers to conservation practice adoption. There were more barriers than motivators, and these factors ranged from production costs to farmer age:

- High costs of practice and low commodity prices
- Economics of converting equipment and/or reduced production
- Spreading of tree seedlings
- Program restrictions and/or landlord restrictions
- Fear of reversal and having to repay cost share
- Time requirements and limitations (fit, paper work)
- Lack of program flexibility to adapt to changing conditions (weather)
- Concern about harming the community
- Stage of life (age)
- Lack of knowledge
- Not wanting people to tell farmers how to do things
- Government involvement

Taken as a whole, the conclusions from farmer and stakeholder interviews found that the primary barriers to the adoption and maintenance of conservation practices were economics, land restrictions, concern about having to repay cost share, time for paperwork, lack of program flexibility, government involvement, and not wanting to be told how to farm. Alternatively, positive producer attitudes towards conservation and protection of the environment were a motivator for adoption, and producers who had adopted practices were usually willing to adopt again.

A preliminary economic study of crop rotations, comparing risk and return to water quality protection was led by M. Langemeier. Six rotations were examined: continuous wheat conventional tilled and no tilled; wheat–grain sorghum–soybean rotation conventional tilled, no tilled, and reduce tilled; and alfalfa–wheat tilled. Risk and return data was from the Kansas Farm Management Association; water quality data was from SWAT modeling. Two scenarios were examined: how to maximize returns (max profit scenario) and how to maximize returns subject to keeping risks below a specified threshold (low-risk scenario).

Reducing risk only reduced profits by 2% while reducing risk by 59%. However, reducing risk also increased the water quality variable outputs for water yield, sediment yield, and TP. The implication was that it would be difficult to achieve high profit, low risk, and to reduce impacts on water quality given the soils and crops examined. However, these were preliminary results. Other soils and rotations will be examined.

## Outreach

Most of the outreach to implement conservation practices was provided by the Reno County Conservation District and the Citizen's Management Committee, which worked with their neighbors to implement practices. The Cheney Lake NIFA–CEAP team served in a more technical role and provided information to these two groups. They met at the beginning of the project and then annually with the Cheney Lake Watershed, Inc. committee to review objectives and progress and to seek guidance in the direction of the project. Typically these meetings were attended by 35 to 40 people. Based on comments from members of the Citizen's Management Committee and the Cheney Lake Watershed, the feedback and exchange with personnel from the Cheney Lake NIFA–CEAP helped them understand their watershed better. The final project findings were communicated in a watershed meeting.

Three times a year, project meetings were held on the campus of Kansas State University to coordinate project activities between the NIFA–CEAP team and watershed citizens. The Cheney Lake Water Quality Project and the USDA NRCS were invited to these meetings and often attended. Project investigators visited the Citizen's Management Committee meetings as needed (once or twice a year) based on the questions raised during the project meetings.

In addition to working with stakeholders, the geographical information system layers developed for the watershed from the Cheney Lake NIFA–CEAP are being made available to local decision makers. These layers geographically indicate where appropriate best management practices will have the greatest impacts within the watershed. Finally, the results of the Cheney Lake NIFA–CEAP are available in the following two-page fact sheets:

- Assessing the Effect of Conservation Practices (Devlin et al. 2011a)
- Conservation Decision-Making Factors (Devlin and French 2011)
- Erosion from Ephemeral Gullies (Douglas-Mankin et al. 2011)
- Local Leadership: Goals and Actions (Selfa and Becerra 2011a)
- Modeling the Effect of No-Till (Nelson et al. 2011b)
- Prioritization of Conservation Practice Implementation (Nelson et al. 2011a)
- Trends in Conservation Practices (Devlin et al. 2011b)
- Water Quality Monitoring (Barnes and Nelson 2011)

## Cheney Lake 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

Agudelo, S.C., N.O. Nelson, T.D. Keane, P.L. Barnes, and G.M. Pierzynski. 2011. Phosphorus adsorption and desorption potential of stream sediments and field soils in agricultural watersheds. Journal of Environmental Quality 40:144-152.

Maski, D., K.R. Mankin, K.A. Janssen, P. Tuppad, and G.M. Pierzynski. 2008. Modeling runoff and sediment yields from combined in-field crop practices using SWAT. Journal of Soil and Water Conservation 63(4):193-203, doi:10.2489/jswc.63.4.193.

Parajuli, P., N.O. Nelson, L. Frees, and K.R. Mankin. 2009. Calibration and validation of AnnAGNPS and SWAT models in USDA-CEAP agricultural watersheds in South-Central Kansas. Hydrological Processes 23:748-763.

Parajuli, P.B., K.R. Douglas-Mankin, P.L. Barnes, and C.H. Green. 2009. Fecal bacteria source characterization and sensitivity analysis of SWAT 2005. Transactions of the American Society of Agricultural and Biological Engineers 52:1847-1858.

Parajuli, P.B., K.R. Mankin, and P.L. Barnes. 2008. Applicability of targeting vegetative filter strips to abate fecal bacteria and sediment yield using SWAT. Agricultural Water Management 95:1189-1200.

Parajuli, P.B., K.R. Mankin, and P.L. Barnes. 2009. Source specific fecal bacteria modeling using Soil and Water Assessment Tool Model. Bioresource Technology 100(2):953-963.

Starzec, K., L. French, N. Nelson, and D. Devlin. 2008. Conservation in the Cheney Lake Watershed. Journal of Soil and Water Conservation 63(6):204A-207A, doi:10.2489/jswc.63.6.204A.

## Conference Proceedings

Barnes, P.L., T.D. Keane, D.L. Devlin, and K.R. Douglas-Mankin. 2009. Watershed assessment to target practice placement. American Society of Agricultural and Biological Engineers Paper No. MC09-302. American Society of Agricultural and Biological Engineers, St. Joseph, MI.

Daggupati, P., and K.R. Douglas-Mankin. 2009. Identifying potential ephemeral gully locations at a watershed scale. American Society of Agricultural and Biological Engineers Paper No. 09-7439. American Society of Agricultural and Biological Engineers, St. Joseph, MI.

Parajuli, P.B., N.O. Nelson, L.D. Frees, and K.R. Mankin. 2008 Conservation Effects Assessment Using SWAT in Cheney Lake Watershed CEAP South-Central Kansas. Proceedings of the American Society of Agricultural and Biological Engineers Annual Conference, American Society of Agricultural and Biological Engineers Paper No. 084769. Providence, RI, June 29 – July 2, 2008. PowerPoint presentation. St. Joseph, MI.

## Extension Publications, Technical Bulletins, and Other Publications

Barnes, P., and N. Nelson. 2011. Cheney Lake Watershed: Water Quality Monitoring. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3037. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/mf3037.pdf.

Devlin, D., and L. French. 2011. Cheney Lake Watershed: Local Leadership: Goals and Actions. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3032. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/MF3032.pdf.

Devlin, D., N. Nelson, L. French, K. Douglas-Mankin, P. Barnes, L. Frees, T. Selfa, H. Miller, and M. Langemeire. 2011. Cheney Lake Watershed: Assessing the Effect of Conservation Practices. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3033. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/mf3033.pdf.

Devlin, D., N. Nelson, L. French, H. Miller, P. Barnes, and L. Frees. 2011. Cheney Lake Watershed: Trends in Conservation Practices. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3034. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/MF3034.pdf.

Douglas-Mankin, K., P. Daggupati, A.Y. Sheshukov, P. Barnes, D. Devlin, and N. Nelson. 2011. Cheney Lake Watershed: Erosion from Ephemeral Gullies. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3030. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/MF3030.pdf.

Nelson, N., A. Bontrager, K. Douglas-Mankin, D. Devlin, P. Barnes, and L. Frees. 2011. Cheney Lake Watershed: Prioritization of Conservation Practice Implementation. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3031. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/mf3031.pdf.

Nelson, N., D. Devlin, K. Douglas-Mankin, and P. Barnes. 2011. Cheney Lake Watershed: Modeling the Effect of No-till. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3036. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/MF3036.pdf.

Selfa, T., and T. Becerra. 2011. Cheney Lake Watershed: Conservation Decision-Making Factors. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3035. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/mf3035.pdf.

## Book Chapters

Selfa, T., and T. Becerra. 2011. Upstream-downstream: Forging rural-urban partnerships for shared water governance in central Kansas *In* Pathways for Getting to Better Water Quality: The Citizen Effect, ed. L.W. Morton and S. Brown, 121-131. Springer Press.

Wright-Morton, L., T. Selfa, and T. Becerra. 2011. Shared leadership for watershed management *In* Pathways for Getting to Better Water Quality: The Citizen Effect, ed. L.W. Morton and S. Brown, 29-40. Springer Press.

## Presentations

Agudelo, S., N.O. Nelson, T.D. Keane, P.L. Barnes, and G.M. Pierzynski. 2009. Phosphorus adsorption and desorption potential of stream sediments and field soils. Poster. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America International Annual Meeting. *In* American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Canadian Society of Soil Science. Abstracts 2009 [CD-ROM]. Pittsburg, PA. November 1-5, 2009. Madison, WI: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

Agudelo, S., N.O. Nelson, T.D. Keane, P.L. Barnes, and G.M. Pierzynski. 2009. Stream geomorphology effects on phosphorus availability in stream sediments. PowerPoint presentation. Proceedings of the American Society of Agricultural and Biological Engineers Annual Conference, Reno, NV, June 2 –24, 2009.

Agudelo, S.C., N.O. Nelson, T.D. Keane, P.L. Barnes, and G.M. Pierzynski. 2009. Geomorphologic influences on bank sediment phosphorus chemistry. Poster. USDA Cooperative State Research, Education, and Extension Service National Water Conference. St. Louis, MO, February 8-12, 2009.

Barnes, P.L., T.D. Keane, D.L. Devlin, and K.R. Douglas-Mankin. 2009. Watershed water-quality assessment tools. USDA Cooperative State Research, Education, and Extension Service National Water Conference, St. Louis, MO, February 8-12, Washington, DC: USDA.

Becerra, T., and T. Selfa. Participatory governance: Recognizing human action in watershed management. Rural Sociology Society Meetings. PowerPoint presentation. Madison, WI, July 30-August 2, 2009.

Bontrager A., N.O. Nelson, L. Frees, and L. French. 2010. Implementation of the Revised Universal Soil Loss Equation within a GIS framework. Poster. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America International Annual Meeting. Long Beach, CA, October 31-November 4, 2010. *In* American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Canadian Society of Soil Science, Abstracts 2010 [CD-ROM]. Madison, WI: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

Bontrager, A.J., N.O. Nelson, and M.J. Davis. 2009. Implementation of the Revised Universal Soil Loss Equation within a GIS framework. Poster. USDA Cooperative State Research, Education, and Extension Service National Water Conference. St. Louis, MO, February 8-12, 2009.

Daggupati, P., K.R. Douglas-Mankin, and P.L. Barnes. 2009. Identifying potential ephemeral gully locations at watershed scale using GIS techniques. USDA Cooperative State Research, Education, and Extension Service National Water Conference, St. Louis, MO, February 8-12, 2009. Washington, DC: USDA.

Daggupati, P., K.R. Douglas-Mankin, A.Y. Sheshukov, and P.L. Barnes. 2010. Monitoring and estimating ephemeral gully erosion using field measurements and GIS. USDA Cooperative State Research, Education, and Extension Service National Water Conference, Hilton Head, SC, February 21-25, 2010. Washington, DC: USDA.

Daggupati, P., A. Sheshukov, K.R. Douglas-Mankin, P.L. Barnes, and D.L. Devlin. 2009. Field-scale targeting of cropland sediment yields using ArcSWAT. 5th International SWAT Conference, Boulder, CO, August 3-4, 2009. Washington, DC: USDA Agricultural Research Service.

Davis, M., N. Nelson, L.D. Frees, and L. French. 2008. Effects of conservation practices on erosion in Cheney Lake Watershed. Poster. Water and the Future of Kansas Conference, Topeka, KS. March 25, 2008.

Davis, M., N. Nelson, and L. French. 2007. Spatial relationships between conservation practices and sediment or nutrient loss potential in an agricultural watershed. Poster. *In* American Society of

Agronomy, Crop Science Society of America, Soil Science Society of America, Canadian Society of Soil Science. Abstracts 2007 [CD-ROM]. Madison, WI: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

Davis, M.J., N.O. Nelson, L. Frees, and L. French. 2009. Effects of conservation practices on erosion in Cheney Lake Watershed. Poster. USDA March 25, 2008. National Water Conference. St. Louis, MO, February 8-12, 2009.

Langemeier, M., N. Nelson, P. Parajuli, and S. Perkins. 2010. An examination of the tradeoff between net return, risk, and water quality for crop rotations in South Central Kansas. PowerPoint presentation. Paper presented at the 2010 Southern Agricultural Economics Association Meeting, Orlando, FL, February 2010.

Langemeier, M., and N.O. Nelson. 2010. The feasibility of improving water quality in the Cheney Lake Watershed. The water cycle, managing the challenges in water resources. PowerPoint presentation. 30th International Symposium of the North American Lake Management Society. Oklahoma City, OK, November 3-5, 2010.

Langemeier, M., and D. Rempe. 2007. The relative cost efficiency of no-till farms. PowerPoint presentation. Paper presented at the 2007 Risk and Profit Conference, Department of Agricultural Economics, Kansas State University, August 16-17, 2007.

Nelson, N.O. 2010. Evaluating P sources that contribute to P loss from rural landscapes. Nutrient Management for Water Protection in Highly Productive Systems of the Heartland. PowerPoint presentation. Heartland Regional Water Quality Workshop. Nebraska City, NE, June 8-10, 2010.

Nelson, N.O. 2010. No-till: Does it improve water quality? PowerPoint presentation. Water and the Future of Kansas Conference, Topeka, KS, October 26, 2010.

Nelson, N.O., K.R. Douglas-Mankin, P.L. Barnes, and D.L. Devlin. 2010. No-till effects on sediment loss in Cheney Lake Watershed: Field to watershed scale perspective. PowerPoint presentation. Proceedings of the 2010 USDA-NIFA National Water Conference, Hilton Head, SC, February 21-25, 2010.

Nelson, N.O., K.R. Douglas-Mankin, P.L. Barnes, and D.L. Devlin. 2010. Temporal and spatial effects of no-till cropping practices on water quality improvement in the Cheney Lake Watershed. The Water Cycle, Managing the Challenges in Water Resources. PowerPoint presentation. 30th International Symposium of the North American Lake Management Society, Oklahoma City, OK, November 3-5, 2010.

Nelson, N.O., K.R. Douglas-Mankin, D. Devlin, and P.L. Barnes. 2011. Cheney Lake Watershed Conservation Effects Assessment Project. Water and the Future of Kansas Conference, Topeka, KS, September 30, 2011.

Nelson, N.O., K.R. Douglas-Mankin, D. Devlin, and P.L. Barnes. 2011. Conservation practice effects on water quality in the Cheney Lake Watershed. Poster. American Society of Agronomy, Crop Science Society of America, Soil Science Society of America International Annual Meeting. International Annual Meeting. Oct. 16-19, 2011. San Antonio, TX. *In* American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Canadian Society of Soil Science, Abstracts 2011 [CD-ROM]. Madison, WI: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America International Annual Meeting.

Nelson, N.O., K.R. Douglas-Mankin, M.R. Langemeier, D.L. Devlin, P.L. Barnes, T.L. Selfa, B.L. Hargrove, and L. French. 2011. Assessing the impact of a strategic approach to implementation of conservation practices: Cheney Lake Watershed CEAP. Proceedings of the 2011 USDA-NIFA National Water Conference. Washington, DC, January 31–February 1, 2011.

Nelson, N.O., L. French, L.D. Frees, and D.L. Devlin. 2007. Conservation practice implementation history and trends in Cheney Lake Watershed. Poster. Soil and Water Conservation Society 2007 Annual Conference. Tampa, FL, July 21–July 25, 2007.

Nelson, N.O., P.B. Parajuli, M.J. Davis, P.L. Barnes, K.R. Mankin, M.R. Langemeier, D.L. Devlin, T.L. Selfa, B.L. Hargrove, L. French, L. Frees, and A.J. Bontrager. 2009. Conservation practice evaluation with SWAT and GIS databases in the Cheney Lake Watershed Conservation Effects

Assessment Project (CEAP). PowerPoint presentation. USDA Cooperative State Research, Education, and Extension Service National Water Conference. St. Louis, MO, February 8-12, 2009.
Parajuli, P., N.O. Nelson, L. Frees, and K.R. Mankin. 2008. Evaluation of SWAT and AnnAGNPS in the Cheney Lake Watershed CEAP. USDA Cooperative State Research, Education, and Extension Service, National Water Conference, John Ascuaga's Nugget Hotel Resort, NV, February 3-7, 2008.
Parajuli, P.B., and N.O. Nelson. 2008 Assessing crop yield and water quality impact using models. *In* American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Canadian Society of Soil Science, Abstracts 2008 [CD-ROM]. Madison, WI: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.
Selfa, T., and T. Becerra. 2009. Cheney Lake Watershed: Partnerships and governance. PowerPoint presentation. Heartland Regional Water Conference. Overland Park, KS, October 27-29, 2009.
Selfa, T., and T. Clark. 2008. Diffused water governance and forums for local participation: Examples from Kansas. PowerPoint presentation. Rural Sociology Society meetings, Manchester, NH, July 28-31, 2008.
Selfa, T., and T. Becerra. 2009. Examining the social dynamics of watershed governance: Lessons from Kansas. PowerPoint presentation. USDA Cooperative State Research, Education, and Extension Service National Water Conference, St. Louis, MO, February 8-12, 2009.
Sheshukov, A., P. Daggupati, M.C. Lee, and K.R. Douglas-Mankin. 2009. ArcMap Tool for preprocessing SSURGO soil database for ArcSWAT. 5th International SWAT Conference, Boulder, CO, August 3-4, 2009. Washington, DC: USDA Agricultural Research Service.

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## Project Personnel

Nathan Nelson (soil scientist) was the project investigator. Kyle Douglas-Mankin (biological and agricultural engineer), Michael Langemeier (economist), Daniel Devlin (agronomist), Philip Barnes (biological and agricultural engineer), and Theresa Selfa (sociologist, currently State University of New York, Syracuse) were all coproject investigators. Students trained and mentored on the project include Prem Parajuli (postdoctoral associate), Terri Becerra (PhD), Prasad Daggupati (PhD), and Austin Bontrager (MS). All students and faculty were associated with Kansas State University. Other participants included Lisa French and Howard Miller (Cheney Lake Watershed Inc.) and Lyle Frees (Natural Resource Conservation Service).

The participating institutions in this effort included Kansas State University, the USDA NRCS, the Cheney Lake Watershed Project, and Citizen's Management Committee. Kansas State University was the lead institution. The participating units at Kansas State University included the Department of Agronomy, Department of Biological and Agricultural Engineering, Department of Agricultural Economics, and Department of Sociology, as well as the Kansas Center for Agricultural Resources and the Environment. The Department of Agronomy was the lead unit. The participating Kansas State University units provided skills and expertise in watershed modeling, soil and water conservation, implementation of conservation practices on the ground, and agronomic practices, including soil and crop management, interagency collaboration on water issues, and participatory approaches to watershed management.

## References

Barnes, P., and N. Nelson. 2011. Cheney Lake Watershed: Water Quality Monitoring. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3037. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/mf3037.pdf.

Devlin, D., and L. French. 2011. Cheney Lake Watershed: Conservation Decision-Making Factors. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3035. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/mf3035.pdf.

Devlin, D., N. Nelson, L. French, K. Douglas-Mankin, P. Barnes, L. Frees, T. Selfa, H. Miller, and M. Langemeire. 2011a. Cheney Lake Watershed: Assessing the Effect of Conservation Practices. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3033. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/mf3033.pdf.

Devlin, D., N. Nelson, L. French, H. Miller, P. Barnes, and L. Frees. 2011b. Cheney Lake Watershed: Trends in Conservation Practices. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3034. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/MF3034.pdf.

Douglas-Mankin, K., P. Daggupati, A.Y. Sheshukov, P. Barnes, D. Devlin, and N. Nelson. 2011. Cheney Lake Watershed: Erosion from Ephemeral Gullies. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3030. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/MF3030.pdf.

Nelson, N., A. Bontrager, K. Douglas-Mankin, D. Devlin, P. Barnes, and L. Frees. 2011a. Cheney Lake Watershed: Prioritization of Conservation Practice Implementation. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3031. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/mf3031.pdf.

Nelson, N., D. Devlin, K. Douglas-Mankin, and P. Barnes. 2011b. Cheney Lake Watershed: Modeling the Effect of No-till. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3036. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/MF3036.pdf.

Parajuli, P., N.O. Nelson, L. Frees, and K.R. Mankin. 2009. Calibration and validation of AnnAGNPS and SWAT models in USDA-CEAP agricultural watersheds in South-Central Kansas. Hydrological Processes 23:748-763.

Selfa, T., and T. Becerra. 2011a. Cheney Lake Watershed: Local Leadership: Goals and Actions. Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Publication MF3032. Manhattan, KS. http://www.ksre.ksu.edu/library/h20ql2/MF3032.pdf.

Selfa, T., and T. Becerra. 2011b. Upstream-downstream: Forging rural-urban partnerships for shared water governance in Central Kansas, *In* Pathways for Getting to Better Water Quality: The Citizen Effect, ed. L.W. Morton and S. Brown, 121-131. Springer Press.