M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 03l Project Abstract
For the Period Ending June 30, 2014

PROJECT TITLE: Measuring Conservation Practice Outcomes
PROJECT MANAGER: Megan Lennon
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 03l

APPROPRIATION AMOUNT: $ 340,000

<u>Overall Project Outcome and Results</u>

Accounting for on the ground outcomes and measureable environmental benefits to the quality of soil, water, and habitat is an essential component of implementing conservation projects. Local Government Units (LGUs), including Counties, Soil and Water Conservation Districts, and Watershed Districts, utilize pollution reduction estimators to quantify the outcomes of conservation projects. Board of Water and Soil Resources (BWSR) currently utilizes models or 'estimators' to measure the pollution reduction benefits of installed Best Management Practices (BMPs). Estimators quantify the outcomes of conservation practices in terms of reduced soil erosion, sediment and phosphorus reduction, carbon sequestered, etc. In order to improve the accounting of conservation practices and measurement of environmental benefits, existing estimators must be revised and new estimators developed.

Through a partnership with the University of Minnesota Department of Soil, Water and Climate, four new estimators were developed: Permanent Cover Erosion Reduction model, the Septic System Improvement Estimator, the Milkhouse Waste Practices Estimator, and the Hydrologic Soil Group – Knowledge Matrix tool. These estimators fill gaps where estimators did not exist previously. The existence of these estimators allows Local Government Units and other conservation partners to better quantify the environmental outcomes of conservation implementation. Training for LGUs and other conservation partners was conducted and made available in multiple formats (in-person, webinar, instructional videos). Many LGUs have already used the new estimators and we anticipate widespread adoption in the future.

Additional results include development of a framework to model and track movement of endocrine disrupting compounds and a data quality analysis of pollution reduction reporting. Three reports resulted from the work in the project. The reports are listed and briefly summarized below.

- *Modeling Soil Erosion with ^{137}Cs*: This report explains the process of modeling landscape-scale soil erosion and provides instructions on using the model to estimate long-term average erosion rates.
- *eLINK Data Quality Control Analysis:* This report provides an overview of the pollution reduction estimates in eLINK and recommends actions to improve data quality and completeness.
- *Endocrine Disrupting Chemical Retention Framework*: This report explains the behavior of endocrine disrupting compounds in the environment and provides a framework for measuring the movement and transport of such chemicals.

Project Results Use and Dissemination
The estimators are used by LGUs and conservation partners to quantify outcomes of installed Best Management Practices. The measured outcomes are collected in BWSR's eLINK database. The associated *eLINK Data Quality Control Analysis* report helps BWSR improve reporting of conservation project outcomes by recommending actions for improving education and outreach and developing internal mechanisms for quality control. Work completed by the University of Minnesota has gained interest amongst the broader scientific community and has been presented at international conferences. All reports, estimators and training materials developed during this project are available on the BWSR website: www.bwsr.state.mn.us

Conference citations:

Dalzell, B. J., C. Fissore, E. Nater, K. Yoo, and A. Wu. 2011. Redistribution of Soil Organic Carbon in Agricultural Soils. Oral presentation given at the annual meeting of the Geological Society of America. October 2011. Minneapolis, MN

Dalzell, B. J., C. Fissore, E.A. Nater, and K. Yoo. 2010. Terrain Control on Soil Organic Carbon Distribution in Loess Soils with Varying Land Cover. Poster presentation given at the annual fall meeting of the American Geophysical Union. December 2010. San Francisco, CA

Dalzell, B.J., E.A. Nater, K. Yoo, and C. Fissore. 2013. Legacy of Topography and Land Use on Erosion and Soil Organic Carbon Burial over Decadal Timescales. Presented at the annual fall meeting of the Geological Society of America. October 2013. Denver, CO.

Nater, E. A., B. J. Dalzell, C. Fissore, A. Wu, K. Yoo, and P. Ginakes. 2012. Legacy of Topography and Land Use on Erosion and Soil Organic Carbon Burial. Oral presentation given at the annual fall meeting of the American Geophysical Union. December 2012. San Francisco, CA

Nater, E. A., B. J. Dalzell, C. Fissore, A. Wu, and K. Yoo. Distribution and Movement of Soil Organic Carbon in Grassland and Agricultural Landscapes. Poster presentation given at the annual fall meeting of the American Geophysical Union. December 2011. San Francisco, CA

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2011 Work Plan Final Report

Date of Status Update: 09/15/2014
Date of Next Status Update: Final Report
Date of Work Plan Approval: 6/23/2011
Project Completion Date: 6/30/2014 **Is this an amendment request? no**

Project Title: Measuring Conservation Practice Outcomes

Project Manager: Megan Lennon
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Location:

Counties Impacted: Statewide

Ecological Section Impacted: Lake Agassiz Aspen Parklands (223N), Minnesota and Northeast Iowa Morainal (222M), North Central Glaciated Plains (251B), Northern Minnesota and Ontario Peatlands (212M), Northern Minnesota Drift and lake Plains (212N), Northern Superior Uplands (212L), Paleozoic Plateau (222L), Red River Valley (251A), Southern Superior Uplands (212J), Western Superior Uplands (212K)

Total ENRTF Project Budget:

ENRTF Appropriation $:	340,000
Amount Spent $:	340,000
Balance $:	0

Legal Citation: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 03l

Appropriation Language:
$170,000 the first year and $170,000 the second year are from the trust fund to the Board of Water and Soil Resources to improve measurement of impacts of conservation practices through refinement of existing and development of new pollution estimators and by providing local government training.

I. PROJECT TITLE: Measuring Conservation Practice Outcomes

II. Final PROJECT SUMMARY:

Overall Project Outcome and Results

Accounting for on the ground outcomes and measureable environmental benefits to the quality of soil, water, and habitat is an essential component of implementing conservation projects. Local Government Units (LGUs), including Counties, Soil and Water Conservation Districts, and Watershed Districts, utilize pollution reduction estimators to quantify the outcomes of conservation projects. Board of Water and Soil Resources (BWSR) currently utilizes models or 'estimators' to measure the pollution reduction benefits of installed Best Management Practices (BMPs). Estimators quantify the outcomes of conservation practices in terms of reduced soil erosion, sediment and phosphorus reduction, carbon sequestered, etc. In order to improve the accounting of conservation practices and measurement of environmental benefits, existing estimators must be revised and new estimators developed.

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Additional results include development of a framework to model and track movement of endocrine disrupting compounds and a data quality analysis of pollution reduction reporting. Three reports resulted from the work in the project. The reports are listed and briefly summarized below.

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III. PROJECT STATUS UPDATES:

Project Status as of January 2012: Outcome 1 of Activity 1 is complete. Several meetings were held with the UM research team to refine the list of estimators proposed for development. Discussions also included BWSR staff involved in selecting projects for Legacy funding. The many projects funded with the Clean Water part of Legacy funding has helped identify the need for new or revised estimators. Concerning Activity 2, the UM research team has made good progress determining sediment movement on the landscape. These findings, which are preliminary, show promise in developing estimators for Best Management Practices (BMP) associated with erosion and sediment. Moreover, since much non-point phosphorus loading is associated with sediment, the research may have help improve phosphorus estimators.

Project Status as of September 2012: University of Minnesota researchers made significant progress towards completing Outcome 2 of Activity 1. The University of Minnesota developed an estimator for septic system improvement projects. This estimator is currently in 'draft' format and is being reviewed by BWSR staff. The University of Minnesota continues to develop additional estimators for priority BMPs. In Activity 2, over 60 additional grassland and cropland sites were sampled for carbon and ^{137}Cs analysis. Laboratory work is ongoing to prepare soil samples and run elemental analysis for organic carbon content and gamma spectroscopy for ^{137}Cs. Outcome 3 of Activity 3 is underway. BWSR staff is conducting data analysis on reported pollution reductions thus establishing a baseline range of values for a subset of BMPs in eLINK. The data analysis serves as a foundation for development of quality control recommendations.

Amendment Request (02/14/2013): The University of Minnesota will develop and conduct a portion of the training sessions in Activity 3. A total of $19,500 will be shifted to the University of Minnesota contract from the following budget categories: TBD (competitive bid) - $8,000; Training Materials - $4,000; Printing - $2,000; Travel Expenses - $5,500.

Outcome end dates in all Activities are extended to reflect 1) the one year project extension due to the Minnesota Government shutdown in 2011 as well as 2) additional time needed to process samples in Activity 2. Approved by the LCCMR 2-28-2013

Project Status as of March 2013: University of Minnesota researchers continue making progress towards completing Activity 1 Outcome 2. New estimators will be deployed after the new eLINK system is launched in April 2013. Work on Activity 2 proceeds around the clock with ^{137}Cs and organic carbon measurements. Fieldwork and sample processing is complete and analytical work remains. Activity 3 continues with curriculum development and quality assurance/quality control analysis.

Project Status as of August 2013: University of Minnesota researchers continue work on Activity 1 Outcome 2. The Septic System Improvement Estimator is complete and posted on the BWSR eLINK homepage. The Milk House Waste Water Improvement estimator is in development and the Knowledge Matrix – Hydrologic Soils Group estimator is in a final testing stage. Soil and Cesium – 137 analyses continue for Activity 2, Outcome 2 and a soil erosion/deposition model is in early stages of development. Model development will accelerate as additional Cesium data becomes available. As a component of Activity 3, training and education events are planned for October 2013 for the Septic System Improvement Estimator. Additional training and education events will be scheduled as the Milk House Waste Water Improvement and Knowledge Matrix – Soil Hydrologic Group estimators are finalized.

Project Status as of February 2014:
Activity 1 outcomes 2 and 3 are near completion. The Milk House Waste Water Improvement estimator is in a testing phase and will be finalized in the spring. Soil and Water Conservation Districts in Southeast Minnesota are testing the estimator and providing feedback. The Hydrologic Soils Group – Knowledge Matrix estimator is undergoing final changes to incorporate feedback from the testing process. Soil testing for Activity 2 is ongoing and soil movement models are being developed. Digital terrain attributes are being used to develop multiple regression approaches for predicting landscape-level distribution of ^{137}Cs (which is used as a proxy for soil erosion and deposition.) Work continues on Activity 3 with training events, guidance development and eLINK data analysis. A University of Minnesota partner presented the Septic System Improvement Estimator at the 2013 BWSR Academy. The Hydrologic Soils Group – Knowledge Matrix instructional user guide is undergoing finalization following changes made after the beta testing process. The final user guide will be posted to the BWSR eLINK website in Spring 2014. eLINK data Quality Control and Quality Assurance review continues. In March 2014, work begins on Activity 4.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Develop new and improve existing pollution estimators

Description: Create a work team composed of BWSR staff and University of Minnesota researchers. The work team will identify BMPs requiring new estimator development and those requiring revision of current estimators. The team will work collaboratively to generate new estimators, improve existing estimators, and launch the new estimators for use by LGUs and other conservation professionals.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 86,000
Amount Spent: $ 86,000
Balance: $ 0

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
1. Work team develops recommendations for priority estimator development	December 2011	$ 13,000
2. Work team collaborates with the University of Minnesota and other soil and water conservation organizations to develop/revise priority estimators	December 2013	$ 68,000

3. Deploy new estimators for outcome tracking in eLINK	December 2013	$ 5,000

Activity Status as of January 2012: Outcome 1 of Activity 1 is complete. Several meetings were held with the UM research team to refine the list of estimators proposed for development. Discussions also included BWSR staff involved in Legacy funding. The many projects funded with the Clean Water part of Legacy funding has helped identify the need for new or revised estimators.

Activity Status as of September 2012: Staffs of the Department of Soil, Water and Climate and Bioproducts and Biosystems Engineering are leading the development of estimators. University of Minnesota researches made significant progress in developing an estimator for septic system improvement projects. This estimator is currently in 'draft' format and is being reviewed by BWSR staff. The University of Minnesota continues to develop additional estimators for priority BMPs.

Activity Status as of March 2013: The septic system improvement estimator is complete and training will begin in Spring 2013. Another calculator in development is the Milk House Waste Water Improvement pollution reduction estimator. A third estimator in development is a Soils add-on to the MPCA developed Minimum Impact Design Standards calculator.

Activity Status as of August 2013: The Septic System Improvement Estimator is posted on the BWSR eLINK homepage and is in use by Local Government Units. The Milk House Waste Water Improvement estimator remains in development at the University of Minnesota Water Resources Center. The Soils add-on to the Minimum Impact Design Standards calculator, titled *Hydrologic Soils Group – Knowledge Matrix,* is in a peer review process and beta tested by a subset of Local Government Units.

Activity Status as of February 2014: The Milk House Waste Water Improvement Practices estimator is in a testing phase and will be finalized in the spring. Soil and Water Conservation Districts in Southeast Minnesota are testing the estimator and providing feedback. The Hydrologic Soils Group – Knowledge Matrix estimator is undergoing final changes to incorporate feedback from the testing process.

Final Report Summary: Three new estimators were developed. Local Government Units (LGUs) and other partners use these estimators to quantify the benefits of conservation practices and provide measurable outcomes for grant reporting. The Septic System Improvement Estimator was launched in October 2013 and LGUs used it in the January 2014 reporting period. Reporting data shows that the quality of pollution reduction estimates improved after the estimator was made available. We believe this is directly attributable to the new estimator and estimator training at the BWSR Academy. The Milk House Waste Water Improvement estimator and the Hydrologic Soils Group – Knowledge Matrix were both launched in in June 2014. There has not been a reporting period since the launch and therefore cannot quantify their impact on pollution reduction estimates. However, we believe the estimators and associated training will improve pollution reduction estimates and provide measurable outcomes for conservation practices. See the eLINK Data Quality Control Analysis report (a component of Activity 3) for further discussion.

Milkhouse Waste Practices Estimator: Is a spreadsheet-based model that calculates annual pollutant loads from problematic milk house wastewater systems and accounts for the benefits of a range of milk house wastewater improvements. This tool estimates reductions in Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Phosphorus, and Nitrogen. This tool is intended for use on projects where the producers cannot add the milk house wastewater to liquid manure storage. The user guide provides an introduction to the MWIE, as well as tips and instructions for using it. The user guide and model is available at www.bwsr.state.mn.us/outreach/elink. The Milk House Waste Water Improvement estimator was launched in June 2014.

Septic System Improvement Estimator: The Septic System Improvement Estimator (SSIE) is a spreadsheet-based model that calculates annual pollutant loads from problematic septic systems and accounts for the benefits of a range of septic system improvement, educational efforts and programs to identify the problematic systems. This tool estimates reductions in Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), Fecal Coliform bacteria, Phosphorus, and Nitrogen. The user guide provides an introduction to the SSIE, as well as tips and instructions for using it. The user guide and model is available at www.bwsr.state.mn.us/outreach/elink. The Septic System Improvement Estimator was officially launched in October 2013.

Hydrologic Soils Group – Knowledge Matrix: Provides a standardized decision support system to determine the appropriate Hydrologic Soils Group from a combination of off-site and field-determined soils information. A hydrologic soil group is used in a number of applications including the MPCA Minimal Impact Design Standards (MIDS) Calculator or sizing a stormwater features using the MPCA's Stormwater Manual (MPCA, 2013). This decision support tool improves the accuracy of MIDS calculations by updating Hydrologic Soil Group ratings to reflect current environmental conditions. The Hydrologic Soils Group – Knowledge Matrix tool was launched in June 2014.

ACTIVITY 2: Field Verification
Description:
Summary
A team of researchers (Nater, Fissore, Dalzell) at the University of Minnesota will directly measure and model sediment erosion and deposition on lands under annual row crop and perennial grassland management in order to determine the effectiveness of perennial grassland conservation management practices in limiting sediment production to streams. The activity includes development of estimators to quantify pollution reduction benefits of sediment-trapping BMPs. The new estimators will be used to initiate a framework for modeling the movement of a variety of land-applied chemicals to surface waters.

Background
Erosion of soils by water redistributes soil sediments within fields and can lead to increased sediment in adjoining streams and other surface water bodies. Because many chemicals adhere strongly to soil sediments, eroded sediments can carry these chemicals with them.

Conservation practices have been implemented over the years to reduce accelerated erosion and to protect sediments from entering surface waters. These include changes in tillage and residue management and the use of perennial grasses in grassed waterways, riparian buffers, and on steep slopes. While there is general agreement that these practices reduce erosion and sediment production, the actual quantities of sediment movement reduced by these practices is uncertain.

Erosion/Deposition Estimator Development

The erosion/deposition estimators will be based on the relationship between LIDAR-based Digital Terrain Attributes and a 50-year average of soil movement measured by the of Cesium-137 isotope method. Cesium-137 is a radioactive isotope that is produced only by nuclear fission; there are no natural sources. Large quantities of Cesium-137 were released into the atmosphere during above ground nuclear weapons testing and were carried into the stratosphere and distributed worldwide. Subsequent deposition (fallout) contaminated soils regionally with a small but relatively uniform dose of Cesium-137 which adheres tightly to surface soil particles, providing a measurable label for surface soils. Any redistribution of Cesium-137 since the cessation of above ground testing in 1963 is due to the physical movement of surface soil sediments by erosion, animal activity, or human activity. (Although Cesium-137 was released to the atmosphere during the Chernobyl explosion and is currently being released by the damaged reactors at Fukushima, Japan, the quantities deposited on Minnesota soils are negligible and will not interfere with these analyses). The total quantity of surface soil eroded from or deposited on any point in the landscape since the mid 1960s can be determined by measuring the activity of Cesium-137 in soils with a gamma ray spectrometer. Annual average rates of sediment movement can then be calculated and will be related to Digital Terrain Attributes to develop estimators of erosion/deposition and potential sediment production to surface waters.

LIDAR-based digital elevation models will soon be available for the entire state, providing the opportunity to enhance the estimation of erosion/deposition. Current estimates are developed using the RUSLE2 model, which is based on slope steepness and length, soil characteristics, and land use characteristics. Digital Terrain Attributes such as Compound Terrain Index and Stream Power Index also use slope steepness and length, but in addition include the curvature of the slope (which determines if runoff is focused or dispersed) and the area upslope of any point on the landscape that contributes runoff to that point. These attributes (and others) can be readily calculated from a LIDAR-based DEM and provide a better estimate of the potential for erosion or deposition at any point in the landscape, improving the accuracy of estimators based on them. (This approach was developed in collaboration with Dr. Kyungsoo Yoo and Joel Nelson).

Summary Budget Information for Activity 2: **ENRTF Budget: $ 196,000**
Amount Spent: $ 196,000
Balance: $ 0

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
1. Identify sites on public lands or cooperating landowners that have either been continuously under tillage or have been continuously under perennial grassland for the last 50 years. Use LIDAR-based Digital Terrain Attributes (Compound Terrain Index [CTI], Stream Power Index [SPI]) of these sites to select sampling locations that encompass a broad array of Digital Terrain Attribute values.	November 2012	$ 26,000
2. Collect soil samples by depth increment for each site identified and analyze soil samples for total carbon, ^{137}Cs (cesium-137) and ^{210}Pb (lead-210).	December 2013	$ 100,000
3. Determine sediment movement as a function of Digital Terrain Attributes for both grassland and tilled sites. Report results and implement estimators.	January 2014	$ 70,000

Activity Status as of January 2012: The UM research team has made good progress determining sediment movement on the landscape. These findings, which are preliminary, show promise in developing estimators for Best Management Practices (BMP) associated with erosion and sediment. Moreover, since much non-point phosphorus loading is associated with sediment, the research may have help improve phosphorus estimators.

Activity Status as of September 2012: Over 60 additional grassland and cropland sites were sampled for carbon and ^{137}Cs analysis. Laboratory work is ongoing to prepare soil samples and run elemental analysis for organic carbon content and gamma spectroscopy for ^{137}Cs.

Activity Status as of March 2013: Field work and sample processing has been completed for all grassland and cropland sites. In total, 220 sites were sampled during the field campaign for this project from 2010 through 2012 representing well over 2000 discrete soil samples for analysis. Crop and Grass sites were equally represented, with 111 and 109 sites sampled, respectively.
All samples have been dried, sieved and archived. Current efforts are focused on completing elemental analysis (C and N) of grassland samples that were collected in 2012 as well as ^{137}Cs analysis of all soil samples. Thus far, measurements have been completed on approximately 750 and 1500 samples for ^{137}Cs and organic carbon, respectively. Because ^{137}Cs measurements are time-intensive (approximately 12-24 hours per sample), ongoing measurement of remaining samples is a round-the-clock operation that will likely extend well into 2013. Remaining soil samples for organic carbon determination are being prepared for analysis by Dr. Cinzia Fissore at Whittier College. While ^{137}Cs analyses are ongoing, enough preliminary data points have been collected to proceed with our investigation of state-wide trends in the influence of land cover and soil movement on soil organic matter across landscapes representative of the southern 1/3 of Minnesota.
Ongoing and remaining tasks: Remaining analytical work is focused on completing instrumental analysis of soil samples (organic C and ^{137}Cs). Existing data are currently undergoing quality control and being prepared for development of empirical models intended to quantify erosion effects on soil carbon across Minnesota's agricultural landscapes.

Activity Status as of August 2013
Recent efforts for Activity #2 have been focused on processing of ^{137}Cs data including correcting collected energy spectra for instrument efficiency and determining appropriate minimum detectable activity (MDA) levels for each sample. (Instrument efficiency correction is based on a prepared mixture of known radioactivity; MDA levels vary with each sample based on acquisition time and background spectra characteristics.) Additional work has been performed to develop protocols and generate maps of digital terrain attributes for areas containing clusters of sample locations around the state. Current GIS-based work is focused on quality checking of digital terrain attribute products and filling missing gaps where LiDAR data were not initially available. Digital terrain attributes, ^{137}Cs data, and soil organic carbon (SOC) data are being assembled into a master data file for final quality check and eventual input into development of empirical models of soil erosion for different regions of the state. Samples from grassland sites from scientific and natural areas (SNAs) are being prepared for both ^{137}Cs and SOC analysis (smaller sample amounts from these sites requires different sample preparation protocols).
Ongoing and remaining tasks include finalizing analytical SOC and ^{137}Cs work, data quality checks, and empirical model development. Due to the slow nature of ^{137}Cs analysis, it is likely that outcome 2 will be ongoing until the completion of the project. Resulting from delayed ^{137}Cs analysis, outcome 3 will be completed in Spring 2014.

Activity Status as of February 2014:
Digital terrain attributes are being used to develop multiple regression approaches for predicting landscape-level distribution of ^{137}Cs. Preliminary results from these approaches show that ^{137}Cs distribution is dependant upon both land use, slope steepness, and hillslope profile curvature. Regression model development is ongoing and current efforts are twofold:

1) Evaluating the differences in decadal-scale soil re-distribution across Southern Minnesota. Different study regions are being evaluated individually for model development based on digital terrain attributes. Following development of the best model for each region, resulting models will be compared to determine whether or not soil movement could be predicted with a more simple set of models that could be applied uniformly. This line of inquiry may also include adding climate factors as potential model variables.
2) Determining the difference in soil redistribution patterns between cropland and grassland landscapes. Different regression models are being developed based on land use. The resulting soil movement maps will be used to identify landscape segments that show the greatest difference between the two land uses. This will allow us to directly quantify how much soil

erosion may be prevented by implementing perennial vegetation on specific landscape segments.

In addition to model development of soil movement, ^{137}Cs data are being used in conjunction with soil organic carbon (SOC) data to investigate the impacts of landscape-scale soil redistribution on decadal scale soil carbon cycling. Preliminary results suggest that soil erosion, followed by deposition in select landscapes can represent an important local sink of SOC via burial mechanisms. These conclusions are supported both by empirical (digital terrain attribute) based approaches as well as direct measurements of soil movement via ^{137}Cs profiles.

Final Report Summary:

The University of Minnesota developed a new tool for measuring environmental outcomes for permanent vegetative cover practices like grassland restoration. The estimator is based on regression models and erosion maps and it will be useful for measuring outcomes and pollution reduction for conservation programs like RIM and the Conservation Reserve Program. Prior to the development of this estimator, there was not an easy to use, reliable model to estimate erosion reduction for conversion to perennial grasslands. The development of this estimator is timely and aligns with the increase in RIM project implementation.

The estimator has two components: GIS-based soil erosion maps and instructions for calculating the parcel-average erosion rate for a parcel of interest. The University of Minnesota and BWSR are in the process of selecting the best data delivery mechanism for users. The estimator and background data is scheduled for posting on the BWSR website by October 2014.. The exact blueprint of the estimator evolved throughout the project period. If given additional funding and time, it would have been beneficial to develop a user interface for the estimator to make it simpler to use. BWSR is dedicated to making the estimator as user-friendly as possible and will continue making improvements as staff time allows. The University of Minnesota developed a report for Activity 1 titled *Modeling Soil Erosion with* ^{137}Cs

Modeling Soil Erosion with ^{137}Cs Summary: In order to develop landscape-scale estimates of soil erosion in Minnesota's agricultural landscapes, we conducted a broad survey study of ^{137}Cs in cultivated fields and uncultivated reverence sites located across the southern third of Minnesota. Produced during atmospheric testing of nuclear weapons in the 1950s and 1960s, ^{137}Cs binds tightly to soils and serves as an effective tracer for soil movement on decadal timescales. A ^{137}Cs conversion model was used to determine soil erosion rates for 107 locations in cultivated sites. Measured soil erosion rates ranged from 49 t ha^{-1} yr^{-1} (erosion) to -74 t ha^{-1} yr^{-1} (deposition). Based on these measured rates, regression models were developed with the goal of broadly predicting soil erosion rates based on topographic characteristics. Digital terrain attributes were calculated from LiDAR-derived (Light Detection And Ranging) digital elevation models and then used as predictor terms in regression model development. Resulting models showed that: (1) profile curvature, (2) planform curvature, and (3) slope steepness were significant model terms in predicting erosion rates for different Minnesota Major Land Resource Areas (MLRAs). The resulting regression models were able to explain 38% of the variability observed in measure soil erosion rates. When applied to cultivated landscapes, the regression models create maps of predicted long-term rates of soil erosion or deposition. These maps will be helpful to BWSR personnel, soil conservationists, and other local government unit personnel to help identify which portions of the landscape would benefit the greatest from perennial vegetation conservation practices. In a complementary manner, these maps may also be used to quantify the soil and water quality benefits of farm land enrollment into a conservation program (or, conversely, the environmental impact of converting perennially vegetated land for cultivation) like Re-Invest in Minnesota (RIM).

ACTIVITY 3: LGU Training and education

Description:
Develop and host training sessions for LGUs and other eLINK users on the newly revised and developed pollution reduction estimators. Training content will be developed in multiple platforms and available in alternative formats (i.e. video) that is widely accessible. A quality assurance and quality control assessment of LGU-reported pollution reduction values will verify the training was successful and LGUs are using the estimators correctly. Adjustments to estimation and reporting procedures following quality assurance and quality control review.

Summary Budget Information for Activity 3: **ENRTF Budget: $ 50,000**
Amount Spent: $ 50,000
Balance: $ 0

Activity Completion Date:

Outcome	**Completion Date**	**Budget**
1. Curriculum development for estimator training sessions	January 2014	$ 15,000
2. Host training sessions for new and revised estimators (in-person, webinars, instructional videos)	March 2014	$ 25,000
3. Quality control and quality assurance review of pollution reduction estimates	June 2014	$ 10,000

Activity Status as of January 2012: N/A at this time.

Activity Status as of September 2012: Outcome 3 of Activity 3 is underway. Data analysis on reported pollution reductions was conducted to establish a baseline range of values for a subset of BMPs in eLINK. The data analysis serves as a foundation for development of quality control recommendations.

Activity Status as of March 2013: Curriculum development is underway for the Septic System improvement estimator. Quality control and quality assurance analysis on eLINK data continues. Sara Heger from the University of Minnesota presented the Septic System Improvement Estimator at the MN Onsite Wastewater Conference in Alexandria, MN 1/29/13 -1/31/13.

Activity Status as of August 2013: Training sessions for the Septic System Improvement Estimator are scheduled for October at the BWSR Academy – the annual training conference for local government staff. An instructional user guide for the Hydrologic Soils Group – Knowledge Matrix is in draft form and will be finalized this fall. Quality control and quality assurance analysis on eLINK data continues and will ramp up following the January 2014 eLINK reporting deadline when additional data is captured.

Activity Status as of February 2014: A University of Minnesota partner presented the Septic System Improvement Estimator at the 2013 BWSR Academy. The Hydrologic Soils Group – Knowledge Matrix instructional user guide is undergoing finalization following changes made after the beta testing process. The final user guide will be posted to the BWSR eLINK website in Spring 2014. eLINK data Quality Control and Quality Assurance review continues.

Final Report Summary: Training sessions were completed for three estimators: the Septic System Improvement Estimator, the Milk House Waste Water Improvements etimator and the Hydorlogic Soils Group – Knowledge Matrix tool. The training was delivered in multiple formats including in-person, webinar,and instructional videos or modules. The in-person training for the Septic System Improvement Estimator took place at the 2013 BWSR Academy (26 participants). Training evaluations showed that participants found the training and the estimator useful, particularly for studying proposed developments. The Milk House Waste Water Improvement webinar took place June 12, 2004 (28 participants). The training module (video tutorial) was also posted to the BWSR website in June. To date, there have been 7 page views. Participants reported the estimator was easy to use and would be helpful in LGUs outcome reporting. An additional piece of particularly useful feedback was a request to upgrade the tool to include pollution reduction estimates to water bodies. The current estimator is only an 'edge of field' model and does not address effluent after it leaves the field as defined in the estimator. The Hydrologic Soils Group – Knowledge Matrix training module (video tutorial) was posted in June 2014. To date, there are 15 page views. The number of website visits for both the Hydrologic Soils Group – Knowledge Matrix and the Milk House Waste Water Improvement estimator is low. The low traffic is likely due to the timing offset of estimator deployment and the timing of grant reporting. The Milk House Waste Water Improvement estimator and the Hydrologic Soils Group – Knowledge Matrix were first made available to LGUs in June 2014. The website visits reported reflect one month of activity. Also, LGUs most frequently use estimators in December and January of each year, the months immediately prior to grant reporting deadlines. As the next reporting period nears, we anticipate a spike in website visits for the online training tutorials.

The report *eLINK Data Quality Control Analysis* provides an overview of the pollution reduction estimates in eLINK and recommends actions meant to improve data quality and completeness.

eLINK Data Quality Control Analysis summary:

eLINK is a central database housing pollution reduction outcomes for BWSR's grants to local government units (LGUs). Since 2003 eLINK has tracked BWSR grants and project outcomes including pollution reduction estimates. The database contains gaps in pollution reduction reporting. These gaps exist for various reasons including:

- Insufficient models to estimate pollution reductions for all practices
- Inadequate enforcement of reporting requirements
- Inability to demonstrate benefits of preventative practices, e.g., Well Sealing, Nutrient Management Planning and Use Exclusion.

In an era of accountability and reporting of environmental outcomes, it is essential that BWSR demonstrates environmental benefit from BWSR-funded projects. The key to accountability and demonstrating outcomes is ensuring pollution reductions are 1) entered in the grant reporting process and 2) represent the best estimate for on the ground pollution reductions.

The Environment and Natural Resources Trust Fund provided funding as recommended by the Legislative Commission on Natural Resources to address BWSR's need for improved measurement of conservation practice outcomes. As a part of the *Measuring Conservation Practice Outcomes* project, BWSR and the University of Minnesota developed new pollution reduction estimators addressing eLINK's data gaps. Additionally, a quality control analysis was completed as a part of the *Measuring Conservation Practice Outcomes* project. The quality control analysis includes the following elements: 1) statistical analysis and interpretation of pollution reduction estimates derived from a newly developed estimator, 2) statistical analysis of reported pollution reduction from the most commonly-funded BMPs, 3) quality control recommendations, and 4) resources for internal quality control.

ACTIVITY 4: Develop framework for movement of chemicals and land-applied EDCs in soils
Description:
Summary
This activity combines the erosion/deposition estimator developed in activity 2 with partition coefficients for land-applied chemicals reported in published literature to create a pollution reduction estimator for

Atrazine (the most common land-applied EDC). Ideally this activity would include developing estimators for 9 of the most common land-applied EDCs (atrazine, daidzein, equol, genistein, 17-alpha-trenbolone, 17-beta-trenbolone, monensin, tylosin and virginiamycin) however existing research on these emerging chemicals is insufficient and partition coefficients are not currently available with the exception of atrazine. For the remaining land-applied chemicals without published partition coefficient values, a framework will be developed for modeling chemical movement when data become available. (This approach was developed in collaboration with Drs. Bill Koskinen and Pam Rice).

Background

Many chemicals adhere to surface soils, binding tightly to mineral and/or organic matter particles. Examples include phosphorus, numerous organic compounds (pesticides and herbicides, animal antibiotics, endocrine disrupting chemicals, natural chemicals), and many others. Transport of these chemicals occurs when soil particles are transported by erosion or other processes. Other chemicals such as nitrate, chloride, and sulfate, are soluble in water and do not adhere tightly to soil particles. Transport of these chemicals occurs with the movement of water, either as surface runoff or as subsurface flow to groundwater or in tile drainage.

A partition coefficient is a chemical term used to describe the relative affinity of a chemical for one phase (water) as opposed to another (soil). The relative affinity of a chemical for the soil phase is dependent on the nature of the soil (particularly the clay content and the organic matter content) and the structure of the chemical and how it interacts with the soil components. Partition coefficients for a chemical can be measured in the laboratory and are valid for a specific soil type.

If we know the concentration of a chemical in the field, the partition coefficient for a specific chemical/soil type combination, and we can estimate of the erosion/deposition rate, then we can estimate the movement of that chemical on the landscape and determine how effective conservation practices are at retaining it on the landscape. Consequently, a good erosion/deposition estimator provides a framework for estimating the movement of chemicals across the landscape if partition coefficients are available or can be determined. For a specific region where the clay and organic matter content and type are relatively uniform, partition coefficients can be applied across the region. For some well-studied chemicals, sufficient information may exist in the literature to allow a good prediction of the water-soil partition coefficient for a specific region. For most chemicals, and particularly for emerging chemicals such as many of the endocrine disrupting chemicals, existing data are insufficient. Our awareness of many of the endocrine disrupting chemicals is relatively recent and our understanding of their behaviors in natural systems is in its infancy.

The advantage of this method of estimating the movement of chemicals is that it is far more universal than field monitoring and measurement of the movement of chemicals where direct measurements are made for one chemical for only one or two years on a small number of fields or sites. Our approach can be applied to a much broader region and additional chemicals can be added as need or when data become available. An example of a similar type of estimator is the Minnesota Phosphorus Index, which is based in part on the movement of sediments as predicted by RUSLE2 and the strong affinity of phosphorus for soil particles.

Summary Budget Information for Activity 4:

ENRTF Budget: $ 8,000
Amount Spent: $ 8,000
Balance: $ 0

Activity Completion Date:

Outcome	Completion Date	Budget

1. Develop pollution reduction estimators for chemicals with known partition coefficients	June 2014	$ 2,000
2. Develop framework for measuring chemical movement in soils; including sample collection protocol and laboratory protocols.	June 2014	$ 6,000

Activity Status as of January 2012: N/A at this time.

Activity Status as of September 2012: N/A at this time.

Activity Status as of March 2013: N/A at this time.

Activity Status as of August 2013: N/A at this time.

Activity Status as of February 2014: In March 2014, work begins on developing pollution reduction estimates and developing a framework for measuring and documenting chemical movement in soils.

Final Report Summary:
A framework was developed for modeling movement of endocrine disrupting chemicals. The document *Endocrine Disrupting Chemical Retention Framework* describes the technical background and framework development. This framework can be used as a springboard for additional research to track the movement and fate of endocrine disrupting compounds in the environment.

Endocrine Disrupting Chemical Retention Framework Summary:
A number of chemicals of emerging concern, including pesticides and herbicides, antibiotics used in animal agriculture, and growth-promoting hormones, are associated with agricultural activities. Many of these chemicals have, or are suspected of having, properties that affect or disrupt endocrine systems. These endocrine-disrupting chemicals (EDCs) may be applied directly to crops or the soil, or are present in manures that are applied to soils. Consequently they have the potential to be transported into surface waters by surface runoff or through tile drains.

Because many of these chemicals are strongly associated with soil solids, they are transported mainly as chemicals sorbed to suspended sediment, not as chemicals dissolved in water.

Many of these chemicals are hydrophobic and thus have a strong affinity for organic matter. This is expressed by the K_{OC} value (the distribution coefficient between the aqueous phase and organic carbon (OC)). This is a commonly measured parameter for organic chemicals in soil environments because it normalizes sorption in soils having varying properties to a single value.. If you know the K_{OC} value for a chemical and the OC of organic matter (OM) content of the soil, you can determine the distribution of the chemical between the aqueous phase and the soil-sorbed phase.

V. DISSEMINATION:

Description:
Pollution reduction estimators developed, revised and verified in activities 1 and 2 will be made web available on the BWSR eLINK homepage (http://www.bwsr.state.mn.us/outreach/eLINK/index.html). Guidance documents and instructional materials developed in activity 4 will also be available on the eLINK homepage. In-person training sessions on pollution reduction estimators are planned throughout the State and specific dates and locations will be highlighted on the BWSR Training website (http://www.bwsr.state.mn.us/training/index.html) as well as in the *Train Tracks* training newsletter. The framework for estimating land-applied EDCs and protocols for sampling and analysis of EDCs will be available on the BWSR soils website (http://www.bwsr.state.mn.us/soils/index.html).

Status as of January 2012: Professor Ed Nater and his research team presented a poster entitled: "Distribution and Movement of Soil Organic Carbon in Grassland and Agricultural Landscapes" at the American Geophysical Union Annual Meeting in San Francisco, December 2011.

Status as of September 2012: No additional dissemination.

Status as of March 2013: An oral presentation, entitled *Legacy of Topography and Land Use on Erosion and Soil Organic Carbon Burial,* was given at the 2012 annual American Geophysical Union conference. Below is a summary of presentations associated with this project.

Nater, E. A., B. J. Dalzell, C. Fissore, A. Wu, K. Yoo, and P. Ginakes. 2012. Legacy of Topography and Land Use on Erosion and Soil Organic Carbon Burial. Oral presentation given at the annual fall meeting of the American Geophysical Union. December 2012. San Francisco, CA

Nater, E. A., B. J. Dalzell, C. Fissore, A. Wu, and K. Yoo. Distribution and Movement of Soil Organic Carbon in Grassland and Agricultural Landscapes. Poster presentation given at the annual fall meeting of the American Geophysical Union. December 2011. San Francisco, CA

Dalzell, B. J., C. Fissore, E. Nater, K. Yoo, and A. Wu. 2011. Redistribution of Soil Organic Carbon in Agricultural Soils. Oral presentation given at the annual meeting of the Geological Society of America. October 2011. Minneapolis, MN

Dalzell, B. J., C. Fissore, E.A. Nater, and K. Yoo. 2010. Terrain Control on Soil Organic Carbon Distribution in Loess Soils with Varying Land Cover. Poster presentation given at the annual fall meeting of the American Geophysical Union. December 2010. San Francisco, CA

Status as of August 2013: The Septic System Improvement Estimator is posted on BWSR's eLINK grant reporting homepage (http://www.bwsr.state.mn.us/outreach/eLINK/SSIE_April_2013.xlsx). The Septic System Improvement Estimator was also posted on the scrolling Highlights section on BWSR's homepage.

Status as of February 2014:
These results have gained interest amongst the broader scientific community and have been presented at two international conferences in 2013:

Dalzell, B.J., E.A. Nater, K. Yoo, and C. Fissore. 2013. Legacy of Topography and Land Use on Erosion and Soil Organic Carbon Burial over Decadal Timescales. Presented at the annual fall meeting of the Geological Society of America. October 2013. Denver, CO.

Dalzell, B.J., E.A. Nater, K. Yoo, C. Fissore, A. Wu. 2013. Terrain Influences on Soil Organic Carbon Translocation and Burial: Applications of High-Resolution Digital Elevation Models. Poster presentation given at the annual fall meeting of the American Geophysical Union. December 2013. San Francisco, CA

Final Report Summary:

Presentations at International conferences:

Dalzell, B. J., C. Fissore, E. Nater, K. Yoo, and A. Wu. 2011. Redistribution of Soil Organic Carbon in Agricultural Soils. Oral presentation given at the annual meeting of the Geological Society of America. October 2011. Minneapolis, MN

Dalzell, B. J., C. Fissore, E.A. Nater, and K. Yoo. 2010. Terrain Control on Soil Organic Carbon Distribution in Loess Soils with Varying Land Cover. Poster presentation given at the annual fall meeting of the American Geophysical Union. December 2010. San Francisco, CA

Dalzell, B.J., E.A. Nater, K. Yoo, and C. Fissore. 2013. Legacy of Topography and Land Use on Erosion and Soil Organic Carbon Burial over Decadal Timescales. Presented at the annual fall meeting of the Geological Society of America. October 2013. Denver, CO.

Dalzell, B.J., E.A. Nater, K. Yoo, C. Fissore, A. Wu. 2013. Terrain Influences on Soil Organic Carbon Translocation and Burial: Applications of High-Resolution Digital Elevation Models. Poster presentation given at the annual fall meeting of the American Geophysical Union. December 2013. San Francisco, CA

Nater, E. A., B. J. Dalzell, C. Fissore, A. Wu, K. Yoo, and P. Ginakes. 2012. Legacy of Topography and Land Use on Erosion and Soil Organic Carbon Burial. Oral presentation given at the annual fall meeting of the American Geophysical Union. December 2012. San Francisco, CA

Nater, E. A., B. J. Dalzell, C. Fissore, A. Wu, and K. Yoo. Distribution and Movement of Soil Organic Carbon in Grassland and Agricultural Landscapes. Poster presentation given at the annual fall meeting of the American Geophysical Union. December 2011. San Francisco, CA

Training events and modules:

BWSR Academy October 2013 – Septic System Improvement Estimator
Milk House Waste Water Improvement Estimator Webinar June 2014
Milk House Waste Water Improvement Estimator module – ongoing
Hydrologic Soils Group – Knowledge Matrix module - ongoing

Pollution reduction estimators and user guides are available on the BWSR eLINK homepage (http://www.bwsr.state.mn.us/outreach/eLINK/index.html). The Endocrine Disrupting Compounds framework developed in Activity 4 is available on the BWSR Soils webpage http://www.bwsr.state.mn.us/soils/index.html. Training modules and webinar recordings are available on the BWSR Training webpage http://www.bwsr.state.mn.us/training/index.html.

VI. PROJECT BUDGET SUMMARY:

1 **ENRTF Budget:**

Budget Category	$ Amount	Explanation
Personnel:	$ 55,000	1 BWSR classified staff (.25 FTE) to manage project address activities 1 and 3; 1 BWSR unclassified staff (.2 FTE) to address activities 1 and 3.
Professional/Technical Contracts:	$282,000	Contract with University of Minnesota to develop and revise pollution reduction estimators, conduct field verification and to review land-applied EDCs.
Equipment/Tools/Supplies:	$3,000	Software/licenses for training programs, supplies for workbooks, guidance documents and training packets, soil sampling and field verification supplies.
TOTAL ENRTF BUDGET:	**$ 340,000**	

Explanation of Use of Classified Staff: LCCMR project funds do not supplant Agency general funds used for salary. Classified staff, Megan Lennon, is currently funded with special project funds devoted to conservation outcomes. These funds end 6/30/2011.

Explanation of Capital Expenditures Greater Than $3,500: N/A

Number of Full-time Equivalent (FTE) funded with this ENRTF appropriation: The ENTRF appropriation for the Measuring Conservation Practice Outcomes supports a total 6.44 FTEs over two years:

Dr. Ed Nater	.05 FTE for 2 years
Cinzia Fissore	.1 FTE for 2 years
Brent Dalzell	.5 FTE for 2 years
Graduate Research Assistant 1	.1 FTE for 1 year
Graduate Research Assistant2	.5 FTE for 2 years
Graduate research assistant, undergraduate research assistants or research fellows (4 total)	.38 FTE for 2 years
Greg Larson	.2 FTE for 2 years
Megan Lennon	.25 FTE for 2 years

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
State			
BWSR In-kind services	$ 35,000	$ 23,000	BWSR IT staff support for Activity 3, specifically QA/QC and website development necessary for hosting web training.
TOTAL OTHER FUNDS:	**$ 35,000**	**$ 23,000**	

VII. PROJECT STRATEGY:

A. Project Partners:

Paid in ENTRF funds: The project team includes Ed Nater (paid), Cinzia Fissore (paid), Brent Dalzell (paid) and two graduate students (paid), from the University of Minnesota's Department of Soil, Water and Climate, and Greg Larson (paid) and Megan Lennon (paid) from BWSR. Project partners from the University of Minnesota will conduct field research and collect and analyze data necessary for revision and development of new models to estimate environmental benefits of conservation practices. The University of Minnesota will receive a total of $262,500. Megan Lennon is the project manager, and Greg Larson will consult with University partners regarding research, and conduct training for local governments units on new and revised pollution reduction estimators.
Paid in-kind or unpaid: Additional project partners include Julie Blackburn (unpaid) and Conor Donnelly (paid in-kind) from BWSR. Julie Blackburn will consult on development of outcome measures and Conor Donnelly will provide IT support, outcome measure implementation, quality control/quality assurance, and training.

B. Project Impact and Long-term Strategy:

The activities included in this proposal are critical to measuring the environmental outcomes and determining the effectiveness of conservation practices in Minnesota. BWSR's ongoing work with conservation programs necessitates assessments of practice effectiveness. With additional funding, this project could expand to include more comprehensive EDC research that is complimentary to both the 2010-2012 LCCMR project by Swackhammer, Koskinen and Rice and the 2011-2013 LCCMR proposal by Sadowsky. A mid-level analysis of land applied EDCs requires additional funding of $30,000 and would provide analysis of 5 EDCs (3 phytoestrogens, atrazine, and 1 growth hormone) on 3 soil types. A full scale analysis of land-applied EDCs requires additional funding of $88,000 and would provide analysis of 8 ECDs (atrazine, 3 phytoestrogens, 1 growth hormone, and 3 livestock antibiotics) on 8 soil types. The suite of EDCs chosen for both the mid-level and full scale analysis is identical to those in the Sadowsky and Swackhammer, Koskinen and Rice proposals. Analysis of the same suite of EDCs allows for inter-study comparability and lower analytical costs.

C. Spending History:

Funding Source	**M.L. 2009 or FY 2010**
Board of Water and Soil Resources - Clean Water Fund	$ 102,200

VIII. ACQUISITION/RESTORATION LIST: N/A

IX. MAP(S): N/A

X. RESEARCH ADDENDUM: N/A

XI. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted not later than January 2012, September 2012, and March 2013. A final report and associated products will be submitted between June 30 and August 1, 2013 as requested by the LCCMR.

Final Attachment A: Budget Detail for M.L. 2011 (FY 2012-13) Environment and Natural Resources Trust Fund Projects

Project Title: Measuring Conservation Practice Outcomes
Legal Citation:
Project Manager: Megan Lennon
M.L. 2011 (FY 2012-13) ENRTF Appropriation: $ 340,000
Project Length and Completion Date: 3 years; June 30, 2014
Date of Update: August 14, 2013

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent 02/28/2014	Balance 02/28/2014	Activity 2 Budget	Amount Spent 02/28/2014	Balance 02/28/2014	Revised Activity 3 Budget 02/28/2014	Amount Spent 02/28/2014	Balance 02/28/2014	Activity 4 Budget	Amount Spent 04/28/2014	Balance 04/28/2014	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	**Develop new and improve pollution reduction estimators**			**Field Verification**						***Land-applied Endocrine Disrupting Compounds review***				
Personnel (Wages and Benefits)														
Megan Lennon, classified staff, BWSR Soil Scientist: $35,000 (100% salary and fringe); .25 FTE for 2 years	17,500	17,500	0				17,500	17,500	0				35,000	0
Greg Larson, unclassified staff, BWSR soil scientist: $20,000 (100% salary and fringe); .2 FTE for 2 years.	10,000	10,000	0				10,000	10,000	0				20,000	0
Professional/Technical Contracts														
University of Minnesota: for pollution reduction estimator development (activity 1) and field verification (activity 2). Contract includes: • Brent Dalzell, Research Associate: $59,000 (75% salary, 25% fringe); .5 FTE for 2 years. • Rebecca Beduhn, Research Scientist: $6,667 (80.5% salary, 19.5% fringe); 1 FTE for 3.3 months • Cinzia Fissore, Research Associate (July - August 2011; Assistant professor starting September 2011): $26,881 (75% salary, 25% fringe); .5 FTE for 3 months • 1 Graduate Research Assistant: $ 42,200 (80.5% salary, 19.5% fringe); .5 FTE for 2 years • 2 Undergraduate Researchers: $10/hr (91% salary, 9% fringe). 1 FTE each for 5 months • Ed Nater, Professor: $4,000 (75% salary, 25% fringe); .05 FTE for 1 year • Graduate research assistants, undergraduates or research fellows: $62,500 (average 75% salary, 25% fringe). • Soil sampling and field work equipment/supplies, $8000 • GIS laboratory fees, $1,500 • Travel expenses, $7,000	58,500	58,500	0	196,000	196,000	0	19,500	19,500	0	8,000	8,000	0	282,000	0
Equipment/Tools/Supplies														
Software programs and licenses for training and quality assurance/quality control review • Camtasia 7.0 - Create Tutorials, Demos, Courses and Online Videos • Statistica (or similar statistical analysis software) - QA/QC analysis of outcomes measured with pollution reduction estimators • Raptivity - create learning interactions for online training sessions and webinars							2,200	2,200	0				2,200	0
Training materials: Supplies for handouts/workbooks, binders, dividers, usb drives for storing data, postage for mailing training material.							800	800	0				800	0
COLUMN TOTAL	**$86,000**	**$86,000**	**$0**	**$196,000**	**$196,000**	**$0**	**$50,000**	**$50,000**	**$0**	**$8,000**	**$0**	**$0**	340,000	0

B31F-0374

Distribution and Movement of Soil Organic Carbon in Grassland and Agricultural Landscapes

AGU Fall Meeting
December 2011

E. Nater[1], B. Dalzell[1,*], C. Fissore[1,2], A. Wu[1], and K. Yoo[1]
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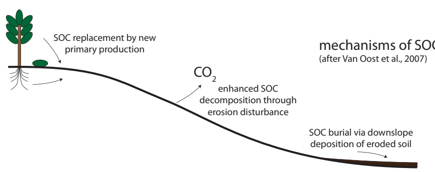
abstract

In order to quantify land use impacts on the magnitude and landscape distribution of soil organic carbon (SOC) we are applying terrain attributes calculated from LiDAR-derived digital elevation models to predict SOC in the upper 1.5 m of soil at grassland and agricultural sites situated on loess soils in southeastern Minnesota. We developed separate regression models for surface (upper 25 cm) and deep (down to 1.5 m) soils and for grassland vs. agricultural sites. Key attributes were: profile curvature, slope, and compound topographic index. In addition to soil depth, these attributes were used to generate regression equations that were able to predict 82% and 77% of the observed variability in grassland and agricultural soils, respectively. While efforts to expand these relationships to perform landscape-scale SOC mass balance are ongoing, preliminary results suggest that agricultural landscapes don't necessarily have less SOC than grasslands. Observed SOC in the upper 10 cm of grassland soils is generally greater than in agricultural soils, this is in agreement with conventional thinking that conversion of grasslands to agriculture results in depletion of SOC. However, when SOC is quantified over the top 1.5 m of soil, agricultural sites show substantial SOC accumulation to deeper soil depths in downslope areas which can represent large pools of SOC in these landscapes. Ongoing efforts include dating of soil horizons via ^{137}Cs analysis in order to assess rates of soil and SOC movement and potential loss in these landscapes.



mechanisms of SOC loss or accumulation
(after Van Oost et al., 2007)

introduction and background

In agricultural landscapes, erosion of SOC represents either a potential carbon source or sink depending on: (1) replacement of eroded soil organic matter via primary production, (2) enhanced degradation of SOC during erosion, and (3) deposition and burial of SOC at downslope locations (Van Oost et al., 2007). Different studies have identified agricultural erosion as either a global net source (Lal et al., 2004) or a net sink of carbon (Smith et al., 2005) with more recent studies indicating that agricultural soil erosion represents a small C sink (Van Oost et al., 2007). While valuable, these global estimates do not consider site-specific factors such as soil texture, climate, land management, and topography that are likely to influence the magnitude of soil erosion as a SOC source or sink. Improved local estimates are necessary to assess how landscape conversion and current land management practices may influence local and regional C budgets.

It is the overall goal of this study to evaluate how terrain attributes derived from digital elevation models can be used to predict SOC in agricultural and grassland soils across southern Minnesota and explore how these relationships may be used to evaluate potential conservation practices for reducing edge-of-field soil losses and enhancing SOC storage.

study area

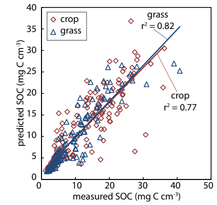
Samples presented here were collected from cropland and grassland sites located in southeastern Minnesota (Fillmore county). Soils in this region are typically Mollisols and Alfisols that are well-drained with moderate to good development. Topography in the eastern portion of the county is bedrock controlled with deeply incised streams and karst features overlain by deep (2 to 7 m) loess. Further west, soils are sandy loess with less relief over dense pre-Illinoian till. Sites were selected to represent soils that have been influenced by row crop agriculture as well as soils that are under perennial grasses (verified with historic aerial photographs).

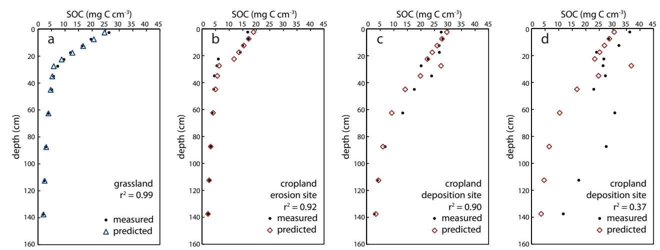
sampling

Sample points were selected to represent the range of terrain attributes (slope, contributing area, curvature) at a site. Soil pits were used to sample the upper 50 cm of the soil profile at 5-10 cm intervals. Deeper soils were sampled with a multi-stage core sampler in 25 cm intervals down to 150 cm. Organic carbon content was measured via high-temperature combustion. SOC content was corrected for bulk density.

results

SOC data were separated into grassland vs. cropland sites and further divided into samples representing the upper 25 cm of soil and samples from 25 to 150 cm. Separate regression equations were developed to predict SOC at each depth interval based on commonly available terrain attributes. Key attributes were slope (%), profile curvature, and compound topographic index. When tested against observed data, these regression equations were able to predict 82% and 77% of the observed variability in grassland and cropland soils, respectively.

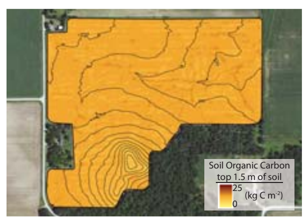




The regression equations developed from terrain attributes did a good job of representing SOC profiles for most grassland and cropland sites (a, b, c) and also captured the variability found in cropland sites (b, c). However, our regression approach did strongly under predict deep SOC accumulation at one of our cropland depositional sites (d). This site has experienced substantial soil accumulation over the past ~50 years (approx. 25 cm of soil accumulation indicated by the ^{137}Cs profile - see ongoing work section).

field application

The empirical relationships developed from field samples and terrain attributes were applied to selected farm fields to compare SOC distribution under cropped and grassland conditions.

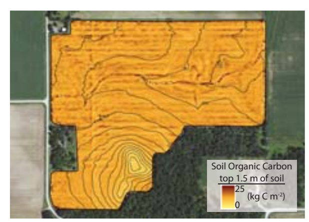


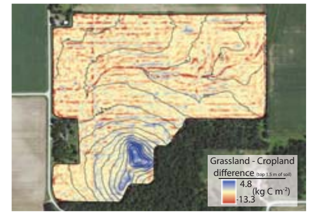
grasslands SOC

Under grasslands, SOC was generally uniform throughout field sites with slight depletion in typical erosion sites and slight accumulation in downslope depressional areas.

cropland SOC

Predicted SOC trends in the cropland landscape were more variable than those from the grassland landscape with greater SOC depletion and accumulation at erosional and depositional sites, respectively.

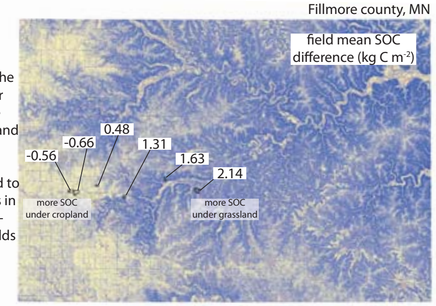




comparing landscapes (cropland - grassland)

SOC pools in landscape elements with steep slopes and negative (convex) profile curvature was greater under grasslands (blue areas) while depressional areas with low slopes and positive (concave) profile curvature accumulated greater SOC under cropland (yellow to red areas).

grassland - cropland difference for selected fields
Fillmore county, MN



landscape trends

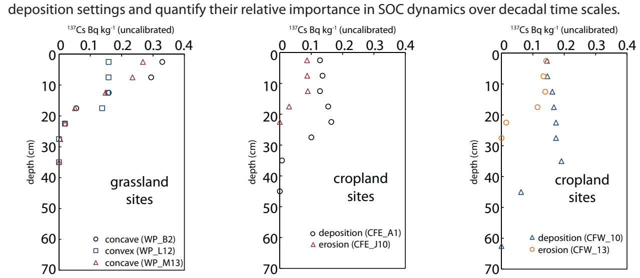
In the lower relief fields located in the western part of Fillmore county, our empirical models predict that more SOC would be present under cropland management.

In contrast, SOC pools are predicted to be larger under grassland scenarios in farm fields located in the central-to-eastern part of the county. Farm fields in this area tend to have steeper slopes.

These results (especially in lower relief landscapes) are consistent with the findings of Van Oost et al. (2007) which showed that agricultural erosion can be a net sink of SOC (especially in more flat landscapes). However, topographic variability within a region (or even within a single field) can ultimately determine the direction and magnitude of SOC source/sink relationships.

ongoing work

We are currently performing similar analyses on samples collected across a wide range of parent materials and climatic conditions across the southern half of Minnesota. Further, we are complementing SOC data with measurements of ^{137}Cs activity in order to quantify soil erosion and deposition in these landscapes. Combining ^{137}Cs and SOC data will also allow us to assess the stability of SOC pools in erosion and deposition settings and quantify their relative importance in SOC dynamics over decadal time scales.



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