

2015 Project Abstract

For the Period Ending June 30, 2018

PROJECT TITLE: Conservation Easement Assessment and Valuation System Development

PROJECT MANAGER: Bonnie Keeler

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FUNDING SOURCE: Environment and Natural Resources Trust Fund

LEGAL CITATION: M.L. 2015, Chp. 76, Sec. 2, Subd. 09k

APPROPRIATION AMOUNT: \$250,000

AMOUNT SPENT: \$247,000

AMOUNT REMAINING: \$3,000

Overall Project Outcome and Results

Our research sought to address a problem that conservation practitioners and the LCCMR face; how do we know that a proposed easement acquisition is a good use of resources? What benefits does it provide, and is it the best parcel to provide those benefits? We set out to understand existing approaches, and create a tool to complement their strengths and improve conservation targeting.

After researching the methods state agencies and NGOs use to prioritize acquisitions in the state, we designed a tool to complement existing approaches in two ways. First, we observed that existing systems all use a rubric to score proposed acquisitions on a parcel-by-parcel basis. Detailed local knowledge gathered in site visits is important for decision-making, however, it is impossible to gather site-level data for the entire state. Valuable parcels will be missed without a statewide, landscape-level perspective. To complement existing rubrics, our approach scored over 300,000 privately held, undeveloped parcels to provide the context of how a proposed acquisition compares to all other parcels in the state.

Second, our approach created 11 environmental benefit metrics, designed to complement those used in existing prioritization systems. Our metrics combine spatial data to map not just where high quality natural resources are, but also where the public would benefit the most from conservation. For example, our bird watching metric considers where experts have identified as important bird habitat, and where the public actually goes to engage in bird watching. The resulting metric recognizes both important habitat, and where bird watchers go, but gives the highest scores to locations where both occur.

Our research provides conservation practitioners with the data and tools to quickly assess the environmental benefits of a parcel, and how those benefits compare to hundreds of thousands of other parcels in the state. By assessing all of the parcels in the state, practitioners will be able to identify the best parcel to meet their objectives and cost-effectively provide multiple benefits to all Minnesotans.

Project Results Use and Dissemination

Dissemination

We have been presented this research to conservation practitioners at organizations including:

- UMN Natural Resources Research Institute (they agree to include our metrics in their spatial data atlas)
- The Nature Conservancy Freshwater and Land teams
- Lessard-Sams Outdoor Heritage Council working group on impact assessment
- BWSR
- DNR Easement stewardship working group
- Authors of the MN Gulf nutrient reduction strategy
- Minnesota Land Trust

We will continue to communicate with these groups to ensure they are able to make the most of our research products.

In addition to traditional outreach through presentations, we also produced a professionally developed website (pebat.umn.edu), with a particular focus on explaining our methods in a simple, non-technical way. While the site has online been online for a month, it has had 100 visits and 25 downloads of the tool. We will continue to track visits and downloads. Furthermore, will also be publishing an article on the UMN Institute on the Environment site that publicizes the research products from this project. It will be produced in the same style as the post we used to publicize the manuscript that was produced in activity 1 of this project: <http://environment.umn.edu/news/new-study-conservation-investments-working-harder-minnesotans/>



Environment and Natural Resources Trust Fund (ENRTF) M.L. 2015 Work Plan Final Report

Date of Report: August 17, 2018
Date of Next Status Update Report: Final Report
Date of Work Plan Approval: June 11, 2015
Project Completion Date: June 30, 2018

PROJECT TITLE: Conservation Easement Assessment and Valuation System Development

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Location: Statewide

Total ENRTF Project Budget:	ENRTF Appropriation:	\$250,000
	Amount Spent:	\$247,000
	Balance:	\$3,000

Legal Citation: M.L. 2015, Chp. 76, Sec. 2, Subd. 09k

Appropriation Language:

\$250,000 the first year is from the trust fund to the Board of Regents of the University of Minnesota to assess the effectiveness of existing conservation easements acquired through state expenditures at achieving their intended outcomes of public value and ecological benefits and to develop a standardized, objective conservation easement valuation system for guiding future state investments in conservation easements to ensure the proposed environmental benefits are being achieved in a cost-effective manner. This appropriation is available until June 30, 2018, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Conservation Easement Assessment and Valuation System Development

II. PROJECT STATEMENT:

An easement is a legal instrument that transfers one or more property rights to a third party, thereby imposing restrictions on the future uses of the property, typically in perpetuity. On rural lands, most permanent easements are conveyed for conservation purposes. Such easements commonly prohibit certain land-use practices (e.g., agricultural crop production, development), require the maintenance of specific vegetative cover conditions (e.g., grassland, wetland, forest), and/or restrict future land sale conditions (e.g., prohibit parcel subdivision).

The state of Minnesota has made a significant investment in using permanent conservation easements to further the public's interest in private land conservation. To date, state-funded conservation easements protect approximately 600,000 acres in Minnesota. Based on their size, location, and management, easements will vary in the ecological, social, and economic benefits they provide. Requests for easements often exceed the resources available to pay for them. More efficient and effective screening of easements depends on information about the magnitude of all public benefits and all costs associated with specific parcels protected by permanent conservation easements.

The goals of this project are to assess the benefits and costs of past investments in easements funded by the Natural Resources Trust Fund, and to develop a tool to score future proposed easements or acquisitions based on their potential to provide public benefits. Such estimates will provide information that should be helpful in prioritizing easements to pursue and, in some cases, might lead to no longer pursuing a potential easement that does not measure up as well. The focus of this study will be on permanent conservation easements funded by the Natural Resources Trust Fund. The tool has the potential to inform other types of easements and acquisitions including Reinvest in Minnesota (RIM) and working forest easements. The project will achieve this goal by carrying out the following tasks: 1) acquire data on existing easements from relevant state agencies, non-profit conservation easement program managers, and LCCMR staff, 2) determine the types of easements evaluated and the public benefits and costs to be estimated, 3) assess the benefits and costs associated with a subset of existing permanent conservation easements acquired with Environmental Trust Fund proceeds; and 4) develop a web-based tool that can be used to score specific parcels of land under consideration for permanent conservation easement based on their potential benefits and costs.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of [January 2016]:

Dr. Keeler and co-PI's hired an Assistant Scientist to supported this project (Ryan Noe). Noe initiated the work by reviewing the data and methods used by different conservation organizations in Minnesota to make prioritization decisions on land acquisitions for conservation. The project team reached out organizations that acquire land for conservation purposes in Minnesota and used these responses to identify the metrics most frequently used to score easement investments. The project team has requested information on funded easements from LCCMR and is working to develop an approach to sample and analyze these documents.

Results from this assessment were shared with LCCMR staff in December and are being prepared for publication and dissemination. In addition to an analysis of metrics used by different agencies to make conservation easement decisions, the project has also assembled spatial data for Minnesota that may be useful in identifying high priority areas for future investments in easements. These data are being stored at the University of Minnesota's Institute on the Environment and are being considered for use in a spatial prioritization or dashboard tool as outlined in Activity 2.

Project Status as of [July 2016]:

After a review of the current practices, the project team has produced a draft of a manuscript that describes ecosystem service principles both in current programs and the enabling legislation for those programs. This manuscript forms the basis for identifying opportunities for further integration of ecosystem services into the decision making process of conservation easement acquisition practitioners. With it we have observed that, while water quality is a priority for state funds such as the ENRTF, it is not always specified in the enabling legislation of programs, nor is it considered in the prioritization of easement acquisitions. Programs currently focused on a single environmental benefit, such as habitat for game species, could potentially produce more benefits per dollar of investment by actively targeting multiple benefits.

In response to this gap, we have begun formulating tool designs that would reduce the technical barriers to incorporating more ecosystem services into decisions. We have reached out to practitioners, both in the initial interviews and in a meeting with DNR staff at the end of July to learn more about their workflows and the challenges they face. These discussions will help inform the design a tool to streamline the assessment of multiple benefits.

We have also begun collecting statewide data and developing a list of candidate metrics that could be used to score or rank easements (past or future). Our next task is to narrow down this list of metrics and then “score” past easement projects to evaluate return on investment and the appropriateness of our candidate metrics.

Project Status as of [January 2017]:

Consistent with the objective of Activity #1, we have completed our review of state agency programs that invest in conservation easements and acquisitions. In December we presented the draft of the manuscript derived from the first phase of this work to the LCCMR staff, and solicited feedback with regards to metrics selection, data availability, and research priorities. In response to this meeting, we are in the process of adding three additional programs to our review: 1) Minnesota Land Trust, 2) Ducks Unlimited, and 3) Dakota County. Over the next month we will integrate our review of these three additional programs into the final report.

We are devoting most of our effort to identifying the most relevant scoring metrics that capture the public benefits provided by easements and determining the data needed to calculate scores. Our aim is to score all past easements on a suite of metrics that describe their potential value in terms of multiple ecosystem services. The candidate metrics are designed to capture the environmental benefits that are derived specifically from easements, that is, benefits that are currently supplied but are in danger of disappearing without protection, and benefits that have public value even without access to the land (e.g. runoff prevention). We are also designing these metrics to fill a key gap identified in our review of methodologies currently used by state agencies and non-profits, that there are opportunities to use existing data to better link environmental changes from land protection to human wellbeing.

User interface software development and dissemination activities were on hold during this period as we focused on the development and iteration of candidate metrics for scoring easements. However, we continue to follow our colleagues' work on data visualization closely to identify any methods that could be adapted for this project.

Project Status as of [July 2017]:

We submitted a manuscript describing the results of Activity #1 or peer-reviewed in the open-access journal Ecology and Society. The manuscript, complete with revisions called for by peer reviewers and the journal editor are attached to this report as a supplement. We have submitted the edited manuscript to the editor and anticipate it will be accepted for publication shortly. In addition to the peer-reviewed journal article, we are also preparing an appendix that will specifically review metrics and scoring systems used by the Minnesota Land Trust, Ducks Unlimited, and Dakota County. These scoring systems were not quantitative, and therefore did not fit within the scope of the submitted journal article. As requested by LCCMR, these programs will be reviewed in the final report submitted at the project end date.

We continue to refine and develop metrics for ecosystem services that can be used to score past or future easements statewide. Draft metrics for lake recreation and groundwater nitrate are complete and coded into a prototype tool. Work on a suite of 3-6 additional metrics is ongoing as data are downloaded, processed and reviewed by subject matter experts. We will be reaching out to LCCMR staff in the August to discuss the final list of metrics, as well as our plans to analyze and visualize them in a web interface.

Critical to the development of a tool, we have created a framework for scoring parcels on multiple service dimensions and combining them into a single prioritization. This framework improves on previous index-based approaches such as the Environmental Benefits Index by adding three elements; providing a reference for index values by scoring all parcels in the state, allowing the user to combine the indices by dynamically specifying importance weights, and visualizing a proposed acquisition relative to the cost and benefits of prior LCCMR funded acquisitions. These improvements are further explained in the Activity #2 section.

Finally, we have finalized plans for the development of a web tool as described in Activity #3. An amendment request to support a rebudget request in support of Activity #3 is described below. In short, we have decided to use funds for tool development in-house as opposed to paying an external contractor. We have a software developer on our team who has extensive experience in spatial modeling and web development, including developing user interfaces for another recent Natural Capital Project-branded decision support tool. More details on our plans for the tool development, including programming languages and specifications are detailed in the Activity #3.

Amendment Request (07/31/2017):

There will be substantial cost savings if we hire an internal software developer at the University of Minnesota as opposed to an outside contractor as originally budgeted. At the time of proposal submission, we did not have the capacity for software development in-house. That has since changed and we now believe the most efficient and cost-effective strategy to deliver the tool described in Activity #3 is to work with an internal developer. We have cleared other tasks off this individual's schedule such that he can begin work on the tool in September. To do this an amendment is required to reclassify the \$50,000 in the budget allocated for software development contracts into personnel at the University of Minnesota. The money would remain a part of Activity #3 and there would be no changes to deliverables. In order to accommodate the software development schedule, we are also requesting a no-cost extension to the project until June 2018. The developer we would like to hire has to balance this project with other projects and therefore we can't get his full support until early 2018. To address any concerns with this extended timeline, we plan to give LCCMR staff frequent updates on the progress of the tool, beginning in September with a project proposal and prototype tool demonstration.

Amendment Approved by LCCMR 8/8/2017

Project Status as of [January 2018]:

The manuscript documenting the work completed in Activity 1 was published in *Ecology and Society* - a peer-reviewed journal. The published copy is included as a supplement. We have shared the publication with LCCMR staff and partners that participated in the research. Based on feedback from partners and stakeholders, the paper has been well-received and generated interest from agency staff and local NGOs.

We made significant progress in the metric development aspect of our work. We have implemented the framework for scoring parcels in code, allowing us to rapidly make changes to our metrics and score parcels. This code is also capable of generating the figures and numbers that will make up the parcel report. With the analysis framework in place we returned to our prototype metrics to further refine them. The key changes from our previous approach are to de-emphasize the weighted combined score, breaking out some components of multiple scores to avoid double counting, providing more context on the values we calculate for each parcel, and aggregating some related metrics. The rationale for these changes is detailed under activity 2.

Concurrently with metric development, our web developer has completed functional interactive front-end interfaces for each of the interface elements we envisioned. See activity 3 for a discussion of the interface elements and the supplemental files for screen shots. While these interfaces are functional, we still need to deploy the back-end server before some of the more advanced scoring functions can be performed outside of our local machines. Project deliverables remain on track for completion by the project end date. We include an updated gantt chart as an attachment describing our timeline for all remaining project deliverables.

Overall Project Outcomes and Results:

Our research sought to address a problem that conservation practitioners and the LCCMR face; how do we know that a proposed easement acquisition is a good use of resources? What benefits does it provide, and is it the best parcel to provide those benefits? We set out to understand existing approaches, and create a tool to complement their strengths and improve conservation targeting.

After researching the methods state agencies and NGOs use to prioritize acquisitions in the state, we designed a tool to complement existing approaches in two ways. First, we observed that existing systems all use a rubric to score proposed acquisitions on a parcel-by-parcel basis. Detailed local knowledge gathered in site visits is important for decision making, however, it is impossible to gather site-level data for the entire state. Valuable parcels will be missed without a statewide, landscape-level perspective. To complement existing rubrics, our approach scored over 300,000 privately held, undeveloped parcels to provide the context of how a proposed acquisition compares to all other parcels in the state.

Second, our approach created 11 environmental benefit metrics, designed to complement those used in existing prioritization systems. Our metrics combine spatial data to map not just where high quality natural resources are, but also where the public would benefit the most from conservation. For example, our bird watching metric considers where experts have identified as important bird habitat, and also where the public actually goes to engage in bird watching. The resulting metric recognizes both important habitat, and where bird watchers go, but gives the highest scores to locations where both occur.

Our research provides conservation practitioners with the data and tools to quickly assess the environmental benefits of a parcel, and how those benefits compare to hundreds of thousands of other parcels in the state. By assessing all of the parcels in the state, practitioners will be able to identify the best parcel to meet their objectives and cost-effectively provide multiple benefits to all Minnesotans.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Identify easements, benefits and costs

Description: We will first review existing spatial targeting or scoring systems for restoration or conservation (e.g. Conservation Reserve Program Benefits Estimators, Ecological Benefits Index, Air and Water Economic Decisions Tool). This review of existing tools will ensure our work is leveraging the best available science and adding value above and beyond existing scoring systems. We will also review the literature and identify potential data sources documenting the types of ecosystem services (e.g., increased/improved wildlife habitat, reduced soil erosion, improved water quality) generated by land use and management in Minnesota, as well as studies that estimate the value of these ecosystem services. We will consult with relevant state agencies, non-profit conservation easement program managers, LCCMR staff, and other data providers to determine the types of easements to evaluate and the types of public benefits and costs to be estimated. For example, the project team will request parcel-specific easement data on easement terms, location, and aerial extent, parcel land cover and habitat conditions (on both the eased land and adjacent lands), and easement acquisition, maintenance, and monitoring costs. The project team will then identify the appropriate subset of easements to evaluate and the costs and benefits to include in the study.

Summary Budget Information for Activity 1:

ENRTF Budget: \$ 40,400

Amount Spent: \$ 40,000

Balance: \$ 400

Outcome	Completion Date
<i>1. Project team will review existing scoring systems, data resources, and previous studies on the costs and benefits of easements.</i>	September 2015
<i>2. Project team will acquire data on a subset of existing easements, including costs, location, and other attributes of each parcel.</i>	September 2015
<i>3. Project team will identify the types of conservation easements that will be evaluated and the ecosystem service benefits and costs that will be included in the final scoring tool.</i>	December 2015

Activity Status as of [January 2016]:

Descriptions of prioritization methodologies were obtained for the following organizations or programs within an organization: DNR Wildlife Management Areas, DNR Scientific and Natural Areas, DNR, Prairie Bank, DNR Forests for the Future, DNR Forest Legacy Program, DNR Tullibee Watersheds Project, DNR Aquatic Management Areas, BWSR Wetland Easements, BSWR Grassland Easements, BSWR Riparian Buffer Easements for Wildlife, the Conservation Reserve Program, the Trust for Public Land, The Nature Conservancy, USFWS, Ducks Unlimited, the MN Land Trust, and the Conservation Fund. We collected data on these methods and aggregated metrics into categories such as habitat quality, spatial context, or water quality. The results of this analysis were shared with LCCMR and are being prepared for publication.

Spatial data and summary records of all acquisitions were obtained from the LCCMR. The project is currently selecting a subset of these easements to obtain a sample that covers a range of organizations and the dollars per acre. We will examine the easement language of this subset in greater detail to match easement language with potential public benefits provided by easements.

Activity Status as of [July 2016]:

The manuscript produced from reviewing existing prioritization systems underwent several rounds of internal review by the project team. Comments and feedback on the methodological approach and the writing were incorporated by the lead author.

Activity Status as of [January 2017]:

We have largely completed the specified outcomes in activity #1. We have completed our review of state agency programs that invest in conservation easements and acquisitions. We reviewed existing scoring systems, data resources, and previous studies on the costs and benefits of easements, with an emphasis on state agency programs active in Minnesota. In December we presented the draft of the manuscript derived from the first phase of this work to the LCCMR staff, and solicited feedback with regards to metrics selection, data availability, and research priorities. In response to this meeting, we are in the process of adding three additional programs to our review: 1) Minnesota Land Trust, 2) Ducks Unlimited, and 3) Dakota County. Over the next month we will integrate our review of these three additional programs into the final report. Project PI's have provided detailed comments on the manuscript that the lead author incorporated. We expect to submit the final manuscript for publication by Spring 2017.

The project team has acquired data from the LCCMR on a subset of existing easements, including costs, location, and other attributes of each parcel. We have migrated this information into a GIS and are actively exploring these data along with other spatial environmental data. Our team has clarified focus on conservation easements to be evaluated and have identified a set of candidate ecosystem service benefits and costs that will be included in the final scoring analysis.

A current draft of the manuscript, as well as supporting appendices is included as a supplement to this report.

Activity Status as of [July 2017]:

We submitted the manuscript that is the outcome of activity #1 to the journal of Ecology and Society. The manuscript was peer-reviewed and only minor revisions were suggested. We have completed those revisions and re-submitted to the journal. The final version and associated appendices is included as a supplement to this report. All promised activities in Activity 1 have been completed. Only funds remaining are for travel (\$400) that may be used to cover costs of presenting the metrics analysis at a regional conference later this year.

Activity Status as of [January 2018]:

The manuscript completed for activity 1 was published as an open access, peer reviewed, article in Ecology and Society on October 11th, 2017. The article and supporting information can be accessed at this link:

<https://www.ecologyandsociety.org/vol22/iss4/art4/>

The final published version of the manuscript and supporting information is also included as a supplement to this report.

Final Report Summary:

In activity 1 we interviewed practitioners at state agencies and NGOs that acquire land for conservation purposes. We reviewed the documents and methods they use when deciding whether or not to acquire a parcel. We synthesized our findings in an open access peer-reviewed publication available as a supplement to this report and at this URL: <https://www.ecologyandsociety.org/vol22/iss4/art4/>

Our peer-reviewed publication focused only on programs that have a quantitative scoring system so that we could analyze the weight place on different metric categories. At the request of the LCCMR, we also prepared an appendix describing the methods of programs that do not use a quantitative scoring system, which is included a supplement to this report.

The key finding from this report is that existing programs heavily weight habitat and biodiversity related metrics (Figure 1 of publication), and score parcels at the site level. This research was instrumental in the design of our tool in activity 3. We created human wellbeing metrics specifically to complement the habitat focused metrics already in use. To complement the detailed data acquired in site visits required by existing approaches, we developed data and a tool to quickly compare a parcel to all other parcels in the state.

By interviewing practitioners early in the project, we were able to both develop an approach in response the challenges they face in their current approach and developed a network of potential users.

ACTIVITY 2: Assess the benefits and costs of existing easements.

Description: Based on the types of conservation easements and public benefits and costs to be evaluated as identified in Activity 1, the project team will assess the public benefits and costs of existing conservation easements will using data, models, and tools available through the University of Minnesota-affiliated Natural Capital Project (<http://naturalcapitalproject.org>) and other sources. The models will be spatially explicit and incorporate easement cost data (i.e., easement acquisition, on-going maintenance, monitoring costs). We will apply the models to existing parcels from a subset of permanent conservation easements that were acquired with Environmental Trust Fund proceeds. Model refinements will be made, as necessary, based on the types of easements and benefits outlined in Activity 1.

Summary Budget Information for Activity 2:

ENRTF Budget: \$ 121,700
Amount Spent: \$ 120,000
Balance: \$ 1,700

Outcome	Completion Date
1. Identify existing models and data that can be used to score easements.	January 2016

2. Apply the models to the subset of existing easements to estimate benefits and costs.	December 2016
3. Expand modeling approach to develop a generalized model that can be applied to score future easements.	June 2017

Activity Status as of [January 2016]:

The project is beginning to compile relevant publically available biophysical data and spatial data on existing easements for the state of Minnesota. We will soon begin review of models used to evaluate multiple benefits of potential protection and restoration projects.

Activity Status as of [July 2016]:

All of the spatial datasets available on the Minnesota Geospatial Data Commons were reviewed for their relevance to prioritizing conservation easement acquisition. Those that were deemed to have any relevance were downloaded and further reviewed to determine the spatial extent of the usable data and other potential limitations. Ways the data could be summarized (e.g. distance to feature, distance of adjacency, area in buffer of feature) were recorded based on the data type and the relevance to conservation easements. The review of these datasets will support the selection and aggregation of the datasets best suited for prioritizing conservation easements.

Activity Status as of [January 2017]:

We have reviewed existing models and data sources that can be used to score easements. We are in the process of developing metrics based the insights from this review. The candidate metrics at this stage include lake recreation, ground water nitrate risk mitigation, habitat provisioning for hunting and wildlife viewing, scenic quality, greenhouse gas emissions, and pollinator habitat. We solicited input on these metrics from LCCMR staff in December, and will continue to iterate on their design so that they best capture public benefits derived from easements. These metrics are designed to go beyond more traditional metrics of proximity and land cover changes, to capture changes in attributes people value directly, such as lake recreation or safe drinking water.

We have begun to apply the metrics and models to the subset of existing easements to estimate benefits and costs. We have developed draft versions of lake recreation, ground water nitrate, and greenhouse gas emissions. *These are still in the draft stage, and their underlying assumptions may change.*

- *Lake recreation:*
 - In contrast to metrics that prioritize based on where there is the greatest potential per acre prevention of contaminants (e.g. phosphorus or sediment), our metric targets land that has the potential to prevent increased contaminants in lakes that are frequently used and valued for recreation. Furthermore, we incorporate an ecosystem services approach by considering the spatial distribution of both scarcity of recreation opportunities and the spatial demand of Minnesota residents.
 - To measure the quality of lake recreation, we use data on lake clarity, amenities (e.g. beaches, boat ramps, restrooms), and size. Dr. Keeler’s previous research has used similar data to predict lake visitation in Minnesota.
 - To measure scarcity, we integrate high resolution spatial population data with the location of lakes and their recreation quality scores.
 - Areas with few high quality lakes and many people are prioritized over areas with more high quality lakes or lakes with fewer people nearby.
 - Last, we use the DNR’s catchments layer to identify the land that is hydrologically connected to the priority lakes and use this to prioritize easement acquisition.
- *Groundwater Nitrate:*

- Our groundwater nitrate contamination metric is designed to identify areas where an easement would add protection to a drinking water supply area that serves vulnerable populations. This metric uses data from the Minnesota Department of Health to identify areas that contribute to drinking water, census data to identify vulnerable populations, and the cropland data layer to identify agricultural patterns. A high priority easement would be:
 - In the wellhead protection area of a public water supply
 - Underlying geology leaves aquifer highly susceptible to surface contamination
 - The wellhead protection area supplies water for a high number of people per hectare
 - A high proportion of the population served pays > 2% of their income for water
 - The wellhead protection area has extensive agricultural area
 - There is a high probability of further conversion to agriculture
- *Greenhouse Gas Emissions:*
 - Unlike lake recreation and groundwater nitrate, the spatial distribution of greenhouse gas emissions, and benefits from their reduction, is global. This means that prioritization can be based simply on the amount of greenhouse gasses that would be emitted under changes in land cover.

Metrics for wild life populations, pollinators, and scenic quality are under development; specific models and data have not yet been identified.

Activity Status as of [July 2017]:

We have coded the lake recreation and groundwater nitrate metrics in python so they can be modified and re-run as we further refine the metrics. We have also completed code that allows us to change the weight place on model components and functions that make up the final easement scores. We have developed a list of candidate metrics for the final tool. This list will be presented to LCCMR staff in August or September. Currently, we are in the process of coding and testing models for the following services:

- Lake recreation
- Groundwater nitrate protection
- Waterfowl production/hunting
- Bird watching
- Trout angling
- Carbon storage
- Trail aesthetics
- Wild rice production
- Pollination

After researching the factors that contribute to deer population and hunting we determined that easements are not likely to influence the service of hunting in a measurable way. Deer population is strongly influenced by the severity of winter and hunting pressure. While some natural vegetation is important, deer thrive in agricultural and other disturbed environments and thus would not benefit from protection of small individual parcels of natural vegetation. If an easement allowed for public hunting access, there could be a measurable public benefit, however, this is unlikely given that it is common practice to lease hunting rights on private land. An easement that allowed public hunting access would effectively remove any incentive to retain ownership of the land.

Another milestone in scoring methodology development is the creation of a framework to meaningfully score parcels across metrics measured in different units. Past approaches have used unitless indices to score different services. We build and improve on this approach by adding three elements:

1) We will score all potential parcels in the state to create a frame of reference

One of the biggest limitations of scoring using indices is the values lack a frame of reference to be able to differentiate between a parcel that is marginally better than alternatives and a parcel that is truly outstanding. We intend to address this by scoring all of the parcels in the state, thus giving the user a frame of reference for what are the best and worst parcels for all of the service we are scoring. While not every parcel is available, scoring all of them can both provide perspective on what is available and identify potential parcels that haven't been considered. Potential acquisitions do not need to be derived from the parcel map, it is only a starting point providing a realistic land management unit.

2) Our approach will allow the user to define importance weights dynamically

Even when working with indices, combining multiple metrics requires some assumption about the value of one service relative to another. Past approaches often weight all services equally, or have the weights fixed in the final product. Our framework will allow the user to explore the changes in parcel prioritization given different service preferences.

3) Present potential acquisition results relative to past acquisitions

In addition to exploring statewide maps of indices, our approach will include data on past acquisitions, and their cost to provide both a comparison of ES value, and a measure of cost effectiveness relative to past acquisitions.

In summary, we have almost completed the generalizable approach described in Activity #2 that can be applied to score any past or future easements for a range of ecosystem services.

Activity Status as of [January 2018]:

Early in this reporting period we completed a set of draft metrics that acted as a proof-of-concept for developing the overall scoring framework. These metrics are detailed in the supplemental document "metrics_v1-2" (since the proof-of-concept stage we have developed a version 3 of our metrics which are detailed in the "metrics_v3" supplemental document). We used the version 1 and 2 metrics to construct a scoring framework in response to obstacles we identified when reviewing other scoring processes. Specifically, we designed the scoring framework and interface to address:

- The LCCMR would benefit from consistent quantitative scores on all applications for easement funding, but multiple agencies and non-profits seek funding, and organizations may not have capacity to take on additional modeling and reporting.
 - Our tool will allow organizations to quickly generate a report for a broad suite of services that can be included with funding requests.
 - We are pre-processing our analysis that makes uses large datasets such as EPA's 30m population map and DNR catchments layer so they can be included in comparisons without running the analysis for the entire state each time.
 - Our web interface will allow users to obtain a scores derived from dozens of data sources quickly. We are enabling any organization to leverage our extensive data preparation and analysis efforts with minimal expenditure on their part.

- Valuable parcels could be missed because traditional scoring systems are on a parcel by parcel basis and do not consider a full suite of benefits and a statewide extent. The magnitude and rarity of a parcels benefits are not clear when evaluating a single parcel.
 - Site-level evaluations are necessary for decision making, but should be complemented by statewide analysis available in our tool.
 - We prepare data for a broad suite of benefits and make it available so that organizations can easily explore co-benefits outside of their area of focus.
 - We generate scores for every parcel in the state so we can provide the context necessary to understand how exceptional a parcel is.
- Data and methods evolve, and tools need to be able to incorporate changes.
 - We are designing the tool to be able to incorporate any statewide raster that is on a 0-1 scale.
 - Changes to the metrics we develop can be performed quickly by changing the parameters of the code and re-running it.
 - The code is designed to take in and process standard datasets the government produces and updates regularly. Updates can be performed without replicating a complicated and time consuming workflow in a traditional GIS environment.

Since sharing outputs and the workflow of our scoring tool with LCCMR staff on November 3rd 2017, we have continued to iterate on both which metrics are used to score easements and how the metrics are constructed. In response to feedback we have opted to make several changes to the way we construct and present scores that are outlined below.

- Setting weights for approximately ten metrics proved to be a confusing task that obscured the values of individual metrics. We are de-emphasizing the use of weighted combination scores for the parcel level report and instead reporting the relevant values for individual metrics.
- Incorporating information on where a service is generated, the quality of the service, the local scarcity of the service, and the demand for the service into a single 0-1 metric obscured the value of each of the components, thus preventing their use in the decision-making process. Although we intend to continue to combine multiple datasets into scores using the processes we have described in previous reports, when we identify information that is best conveyed separately, we will provide those values separately from the score along with context on their meaning and interpretation.
- In an effort to make the components of scores more transparent and to avoid double counting, we are adding two metrics that are common to the majority of the metrics, but are not ecosystem services; population and risk of change.
 - An ecosystem services perspective considers the number of people that have access to a given service, so it would be redundant to include this in every service. Instead, we will report the number and proportion of the state's population that are within a day trip of the service endpoint. While people may travel further for a benefit, the day trip metric captures how many people the end point of a service is relatively accessible to.
 - Risk of change is particularly important for the decision context of easements, where it is important to protect resources before land use change occurs, and use resources efficiently by not protecting parcels that are not at risk. We are including preliminary results from work developed at the Institute on the Environment, however, we intend for this variable to be updated as projections are improved.
- We opted to aggregate our waterfowl and pheasant metrics into a single hunting access metric. Due to the lack of public access on easements, any hunting benefit would be derived only when habitat is

protected near a place with public hunting access. We used the existing network of Wildlife Management Areas to identify public access and scored WMAs higher if more game species were present or if there was evidence of more visitation than other WMAs.

After further refinement, we will use these metrics and scoring system to generate scores for all past LCCMR funded acquisitions. Metrics will be distributed as part of the web tool interface and in associated documentation available through the tool website. Work is in progress on evaluating how past easements perform relative to these ecosystem service metrics and summarizing findings in a report to LCCMR staff.

Final Report Summary:

Activity 2 required the development of a suite a metrics to evaluate past acquisitions against. We developed 11 metrics, 9 focused on ways humans benefit from conservation activities, and 2 metrics relevant to acquiring land for conservation; nearby population and risk of conversion. A user-friendly description of each metric is available at this URL: <http://pebat.umn.edu/metrics>.

These metrics prioritize all land in the state from highest to lowest priority for each of the metrics. We are making this data available to allow practitioners so they can build analyses on top of our work, allowing them to quickly assess benefits that might not have the time, resources, or expertise to assess in their normal operations.

We then used these metrics to score all past ENRTF funded conservation easements, as well as every other undeveloped parcel in the state. We compared ENRTF funded acquisition benefit scores to the scores you would expect if you acquired undeveloped parcels randomly. We found that past acquisitions on the whole performed better than random. Approximately half of past acquisitions had fewer than 5 parcels in the state that scored better than them on all metrics. Under 10% had over 100 parcel in the state that scored better on all metrics. These parcels were either acquired to support a benefit we did not have data for (e.g., duck production) or were not efficiently targeted. See the report for this activity 'past_acquisitions_report_August_2018.pdf' for an in-depth exploration of the benefit trends observed in past acquisitions.

In this activity we proposed analyzing the costs of an acquisition inclusive of maintenance and monitoring costs. After interviewing practitioners we elected not to incorporate maintenance and monitoring costs. Organizations responsible for stewardship of easements do not typically breakdown their expenses by parcel. The most consequential action in the process is acquiring the parcel with the most benefits. We did not monetize the benefits of an acquisition, because the uncertainty in valuation methodologies of produces a range of values that is too large to be useful for decision making. We were able to produce more precise data and better support conservation prioritization by opting for an index based approach. In our tool we include the price per acre of past acquisitions to provide a point of reference for what benefit scores were achieved for a given price in the past. For more information on the advantages of our approach, see the included past acquisitions report, or read about it on the tool website: <http://pebat.umn.edu/howitworks>

ACTIVITY 3: Develop a web-based easement benefits tool

Description: We will work with software developers and experts in user-interface design to develop a web-based tool that operationalizes the easement valuation model developed in Activity 2. Once developed, the tool will be demonstrated and made available to LCCMR staff and conservation easement program managers.

Summary Budget Information for Activity 3:

ENRTF Budget: \$ 87,900
Amount Spent: \$ 87,000
Balance: \$ 900

Outcome	Completion Date
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1. <i>Public benefits models developed in Activity 2 will be converted into a user-facing web-based conservation easement screening tool.</i>	December 2017
2. <i>Tool demonstrated and made available to LCCMR and conservation easement program managers for testing and refinement.</i>	December 2017

Activity Status as of [January 2016]:

A team member met with a web programmer who developed a web-based decision support tool for The Nature Conservancy that could serve as a model for our tool. If a web-based tool is determined to be the most appropriate way to achieve the goals of this project, he could potentially be a sub-contractor.

Activity Status as of [July 2016]:

No development actions were taken while we work to determine the specific needs of practitioners. As part of a meeting with DNR staff in July 2016 to share preliminary findings from this research, we also solicited input on their workflows.

Activity Status as of [January 2017]:

We did not take any action on user interface development during this period. However, we have continued to have scoping conversations with potential developers both within the University of Minnesota and through partners. We have identified a potential software engineer with experience in user interface design. When the scope and audience for the tool are clarified in Activity #2, we will proceed with hiring the staff on software development.

Activity Status as of [July 2017]

We identified an individual with skills well suited to both the web development aspect of this project, and the coding of some of the more advanced underlying analyses. Justin Johnson is a senior scientist at the Natural Capital Project with experience in software development, web development, and ecosystem service assessment. Dr. Johnson has recently completed user-interface design and implementation for two other Natural Capital Project tools – ROOT (Restoration Opportunity Optimization Tool) and MESH (Modeling Ecosystem Services and Human wellbeing). His experience in software development, web design and ecosystems services modeling make him the most efficient choice for software development tasks as part of Activity #3.

We have developed a prototype for what information will be displayed in the web tool, including potential visualizations of easement scores and benefits. We are using a combination of Python, Django, and D3.js as the languages to build the user interface and display. The back-end calculations will be performed in Python on data pre-generated and hosted on a remote server, with dynamic results calculated and returned to the user. We will be scheduling a meeting in early fall with LCCMR staff to demonstrate the prototype tool and receive feedback.

Activity Status as of [January 2018]:

At our Nov. 3rd 2017 meeting with LCCMR staff, we shared a static mock-up of the tool interface we are developing that had four main elements; landscape level service explorer, parcel report generator, past acquisition viewer, and trade-off explorer.

The development of the web tool is comprised of two processes, the front-end interface, and the back-end calculations. The front-end interface is built with javascript and html and runs entirely in the browser. This enables the elements to be fast, but does not have the ability to query the large datasets that hold our metrics and pre-processed scores. In order to store and query these datasets we need to configure a back-end server to host our data, accept uploads, and perform basic queries. Updates on the specific elements are below.

- Landscape level service explorer (supplemental figure 1)

- This interface allows users to see where in the state specific services are found. The user can specify weights for individual services so that they can visualize where multiple benefits occur. The user can zoom in to identify local trends.
- The necessary data for this interface are stored entirely within the front-end HTML file, which enables the unique weighted combinations to be calculated in real time.
- Parcel report generator (supplemental figure 2)
 - This interface requires upload capabilities and server side calculations, so it is not yet available for distribution. However, a local development copy is already being used to generate figures that we are using to solicit feedback.
- Past acquisitions (supplemental figure 3)
 - This interface allows the user to find previous LCCMR funded acquisitions on a map and few the scores it received for each of the metrics we developed.
- Tradeoffs (supplemental figure 4)
 - This interface allows the user to view any two of the metric scores for potential acquisitions throughout the state in a scatter plot form. Organizations focused on a particular metric can use this interface to identify parcels that score highly for multiple metrics in addition to their metric of interest.
 - Users will be able to hover over a point to learn its location.

The front-end interface for the tool is in working prototype phase, and we are in the process of collecting feedback on its design. We are exploring hosting the webtool at the University or on a pay-per-service platform such as Amazon webservises.

Final Report Summary:

After several iterations in the development process, we developed two versions of our tool in order to eliminate any barriers to running it; a web version available here: <http://pebat.umn.edu/> and a desktop version available here: <http://pebat.umn.edu/desktop>

We produced a desktop version of the tool that comes with all of the base data needed to run it. The user only needs to supply a shapefile of their parcel's boundaries to run the tool and generate a report. The report visualizes how the proposed acquisition compares to all viable parcels in the state, and how it compares to past acquisitions with the price is taken into account.

Although the tool is very simple to run, we wanted to further reduce the barriers associated with downloading large file and creating shapefiles. We pre-calculated the results for every parcel and put the results in a web application. The user only needs to know the address or latitude and longitude of a parcel to get the score to generate a report for the nearest 40 acre parcel.

We designed these tools after interviews with practitioners indicated they did not always have capacity to run complicated models. Our tools were designed to produce a report for 11 benefits within seconds without adding any addition technical capacity. Advanced users can access the underlying data and perform new analyses.

V. DISSEMINATION:

Description:

After co-development and iteration on the tool design and user interface with LCCMR members and staff, the conservation easement valuation tool will be made publicly available online to LCCMR, its staff, conservation easement program managers, and others as requested.

Status as of [January 2016]:

Not yet started.

Status as of [July 2016]:

Visit to DNR in July 2016 to discuss the project and share preliminary findings.

Status as of [January 2017]:

Beyond our presentation to LCCMR staff, we did not take any dissemination actions during this period.

Status as of [July 2017]:

We did not engage in dissemination of our metrics or tool as they are still under development. However, as described above, our manuscript reviewing current prioritization practice in Minnesota was peer reviewed at the journal Ecology and Society. Pending minor revisions, we hope it will be accepted and published within a few months.

Status as of [January 2018]:

In an effort to make the findings from our manuscript more accessible to the public, we wrote a brief, non-technical, blog post covering the key findings of our work. The post is available here:

<http://environment.umn.edu/news/new-study-conservation-investments-working-harder-minnesotans/>

We have sent copies of the manuscript to all of our contacts at state agencies and NGOs that contributed in any way to the paper, and continue to disseminate the manuscript and/or blog post to new contacts as an entry point to our research and tool development.

We also have given presentations that include both the manuscript and prototypes of our easement prioritization tool to staff at the DNR, the Minnesota Land Trust, and the McKnight Foundation.

Final Report Summary:

We have been actively disseminating this work to practitioners for several months. Key groups that we have presented to include:

- UMN Natural Resources Research Institute (they agree to include our metrics in their spatial data atlas)
- The Nature Conservancy Freshwater and Land teams
- Lessard-Sams Outdoor Heritage Council working group on impact assessment.
- BWSR
- DNR Easement stewardship working group
- Authors of the MN Gulf nutrient reduction strategy
- Minnesota Land Trust

Individual at many of these organizations have expressed interest in following up and analyzing the data further.

Our dissemination efforts also include a professionally developed website (pebat.umn.edu), with a particular focus on explaining our methods in a simple, non-technical way. We also produced extensive technical documentation to accommodate users that need to fully understand our assumptions before using our tool.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	\$ Amount	Overview Explanation
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Personnel:	\$ 247,000	1 scientist at 12% FTE per year for 2.5 years; 2 scientists at 4% FTE per year (each) for 2.5 years; 1 scientist at 2% FTE per year for 2.5 years; 2 assistant scientists at .4 FTE per year (each) for 2.5 years; 1 scientist at .5 FTE for 1 year
Printing:Professional/Technical/Service Contracts:	\$500\$50,000	Printing of reports and project materials1 contract for software development/ programming (TBD) through competitive bid
Travel Expenses in MN:Printing:	\$2,500\$500	Mileage, lodging, mealsPrinting of reports and project materials
TOTAL ENRTF BUDGET:Travel Expenses in MN:	\$250,000\$2,500	Mileage, lodging, meals
TOTAL ENRTF BUDGET:	\$250,000	

Explanation of Use of Classified Staff: NA

Explanation of Capital Expenditures Greater Than \$5,000: NA

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: 2.95 FTEs-3.95 FTEs

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: NA

B. Other Funds:

Source of Funds	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
Non-state			
	\$	\$	
State			
	\$	\$	
TOTAL OTHER FUNDS:	\$	\$	

VII. PROJECT STRATEGY:

A. Project Partners: (not receiving funds)

- MN DNR
- MN Board of Water and Soil Resources
- US Fish and Wildlife Service
- MN Land Trust
- Ducks Unlimited
- Local government representatives
- Other land trusts and conservation organizations that acquire permanent conservation easements

B. Project Impact and Long-term Strategy:

The project will result in the development of a tool that can be used by land management and conservation organizations to prospectively estimate the public benefits and costs associated with acquiring a permanent conservation easement on specific parcels in Minnesota. The tool will help these organizations better identify and prioritize resources permanent conservation easement opportunities that will produce the greatest net public benefits.

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	\$ Amount
LCCMR pending project 33-B "Informed Water Management: Mapping Scarcity, Threats, and Values"	Pending legislative approval, starting July 1 2015, ending June 30 2018.	\$234,000
Sub-award to co-investigator Steve Polasky as part of LCCMR 2010 project 04i "Reconnecting Fragmented Prairie Landscapes" led by the Nature Conservancy. Funds to Polasky were used to estimate the goods and services provided by grasslands in western MN.	Project began in July 2010 and was completed in June 2014	\$380,000
		\$

VIII. FEE TITLE ACQUISITION/CONSERVATION EASEMENT/RESTORATION REQUIREMENTS: NA

IX. VISUAL COMPONENT or MAP(S):

Public Benefits/Costs of Conservation Easements

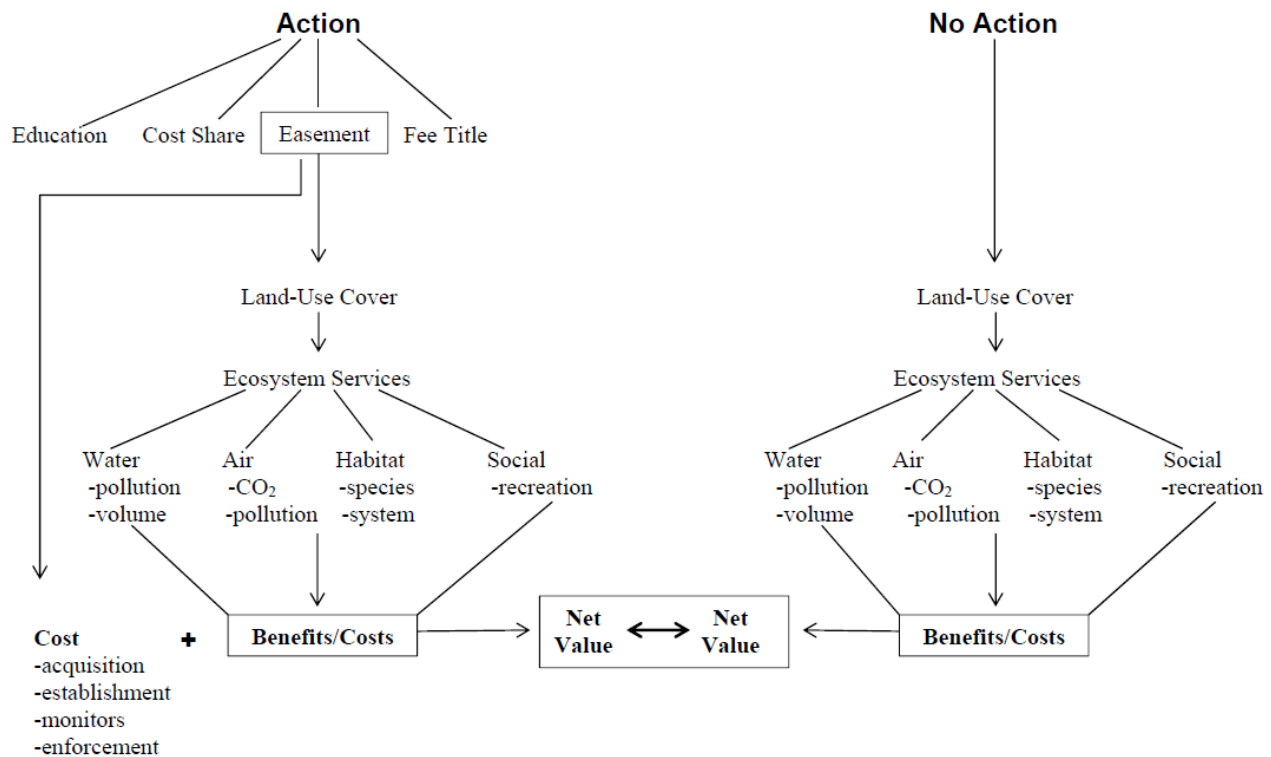


Figure Caption: There are multiple actions or interventions that can be taken that affect land-use cover including easements, education, cost share, and fee title. This project will focus on easements as the action under investigation. For each easement we will assemble data on the costs (acquisition, establishment, monitoring, enforcement) and the ecosystem service benefits (water, air, habitat, recreation). This will facilitate a comparison of benefits and costs under scenarios of action (easements) vs. non-action (baseline or business-as-usual).

X. RESEARCH ADDENDUM: NA

XI. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted no later than *January 2016*, July 2016, January 2017, July 2017, and December 2017. A final report and associated products will be submitted between June 30 and August 15, 2018.

**Environment and Natural Resources Trust Fund
M.L. 2015 Project Budget**

Project Title: Conservation Easement Assessment and Valuation System Development

Legal Citation: M.L. 2015, Chp. 76, Sec. 2, Subd. 09k

00053432 Through 1/17/18

Project Manager: Bonnie Keeler

Organization: Natural Capital Project, IonE, University of Minnesota

M.L. 2015 ENRTF Appropriation: \$ 250,000

Project Length and Completion Date: 2.5 Years, December 31, 2017

Date of Report: January 31st 2018

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance
BUDGET ITEM	<i>Identify easements, benefits, and costs</i>			<i>Assess the benefits and costs of existing easements</i>			<i>Deploy and test a web-based easement benefits tool</i>		
Personnel (Wages and Benefits)	\$40,000	\$40,000	\$0	\$120,000	\$120,000	\$0	\$87,000	\$87,000	\$0
<i>Bonnie Keeler, Project Manager and Scientist, \$30,000 (67% salary, 33% benefits) 12% FTE per year for 2.5 years.</i>		\$7,867			\$30,386			\$2,660	
<i>Mike Kilgore, Scientist, \$19,000 (67% salary, 33% benefits) 4% FTE each year for 2.5 years</i>		\$0			\$7,774			\$10,366	
<i>Steve Taff, Scientist, \$19,000 (67% salary, 33% fringe) 4% FTE each year for 2.5 years.</i>		\$9,897			\$6,738				
<i>Steve Polasky, Scientist, \$19,000 (67% salary, 33% fringe) 2% FTE each year for 2.5 years.</i>		\$10,117			\$10,000			\$16,163	
<i>2 Assistant Scientists, \$110,000 (74% salary, 26% fringe) 40% FTE per year (each) for 2.5 years.</i>		\$12,119			\$65,102			\$57,811	
Professional/Technical/Service Contracts							\$0		\$0
<i>Software professional services (development and programming), \$50,000.</i>									
Printing									
<i>Report and project material printing.</i>	\$75	\$0	\$75	\$225	\$0	\$225	\$200	\$0	\$200
Travel expenses in Minnesota									
<i>In-state travel to meet with project partners and field visits. Mileage: \$1,700; lodging: \$500; meals: \$300</i>	\$325	\$0	\$325	\$1,475	\$0	\$1,475	\$700	\$0	\$700
COLUMN TOTAL	\$40,400	\$40,000	\$400	\$121,700	\$120,000	\$1,700	\$87,900	\$87,000	\$900