2013 Project Abstract
For the Period Ending June 30, 2015

PROJECT TITLE: Conservation Easement Stewardship Program, Phase III
PROJECT MANAGER: Don Kilberg
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2013, Chp. 52, Sec. 2, Subd. 3(e)

APPROPRIATION AMOUNT: $200,000

Overall Project Outcomes and Results

This was the last phase of a three-phase project to establish procedures and tools to effectively monitor conservation easements held by the DNR. One project goal was to monitor and create baseline reports for 75 existing conservation easements—actual attainment was 85 easements. As detailed in the Phase III Supplemental Report, additional goals were to investigate the use of image processing software coupled with LiDAR and current imagery to improve the efficiency of conservation easement stewardship. Two areas were explored: 1) can these tools be used to accurately redraw stream centerlines after changes in stream courses; and 2) can remote sensing tools be written to automatically identify possible violations of easement terms? DNR trout stream easement boundaries are typically 66' from stream centerlines and move with stream course changes. It is essential to have accurate maps of easement boundaries for monitoring, but it is time consuming to edit boundaries manually. Staff created a novel approach to generate stream centerlines from LiDAR and adjust them with imagery where stream course changes had occurred. Tests of a 15km stream section demonstrated the accuracy and usefulness of this approach. Manual effort of 90 minutes to digitize the stream section was reduced to 11 minutes. In the second problem area, staff utilized eCognition image analysis software to classify land cover in easement corridors utilizing imagery with three levels of resolution and LiDAR and identify objects/conditions that could be easement violations. Staff concluded that to effectively monitor easements remotely would require image resolution no coarser than 6" and LiDAR that had been acquired at the same time. Possible violations identified in this fashion still need on-site verification, but this technique can highlight areas of concern and reduce on-site visit time. Tools developed in this project have potential application for statewide riparian buffer mapping and monitoring.

Project Results Use and Dissemination

Results for Activity 1 of the project are being assembled in a fashion where they can be presented to personnel in Fish and Wildlife who are responsible for the maintenance of the stream centerline GIS layers for possible broader application. In addition, a presentation is being planned for BWSR and DNR personnel involved in mapping the public waters and ditches as part of the new 50 foot buffer legislation. There is potential for applying both the centerline and land cover techniques developed for this project to buffer mapping and monitoring.

Results for Activity 2, using tools developed in project phases I and II to visit 75 additional easements for the purposes of collecting baseline property information and creating those reports, was disseminated primarily to DNR management for the purposes of directing monitor efforts. One update was generated for the Conservation Easement Stewardship User Manual during the project for staff training use. During the project, wild and scenic river easement baseline property reports were signed and mailed to fee title owners of the properties.

Periodic project updates and preliminary results were presented to the Conservation Easement Stewardship committee for the purposes of gathering additional direction from that group during the project. A conservation easement stewardship cost calculator was disseminated to DNR fiscal staff. Information about the calculator was presented to the LCCMR on June 25, 2015.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2013 Work Plan Final Report

Date of Status Update Report: 8/17/2015

Final Report: 8/17/2015

Date of Work Plan Approval: 6/25/2013

Project Completion Date: 6/30/2015

PROJECT TITLE: Conservation Easement Stewardship Program, Phase III

Project Manager: Don Kilberg

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Location: Statewide

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$200,000**
	Amount Spent:	**$199,292**
	Balance:	**$708**

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 3(e)

Appropriation Language: $200,000 the first year is from the trust fund to the commissioner of natural resources for the final phase to bring conservation easements held by the Department of Natural Resources up to minimum conservation standards, through monitoring, baseline data collection, and baseline report preparation.

I. PROJECT TITLE: Conservation Easement Stewardship Program, Phase III

II. PROJECT STATEMENT:

This is Phase III of a multi-phase project. Phase I (Conservation Easement Stewardship and Enforcement Program Plan-DNR, July 1, 2008 – June 30, 2011) included an inventory of DNR's conservation easements, an assessment of DNR's needs to bring its conservation easements up to minimum standards, and development of a conservation easement stewardship plan for both DNR's existing conservation easements and future acquisitions. Phase II, which is currently in process, includes monitoring and preparation of baseline property reports for 180 existing conservation easements, development of a conservation easement stewardship training program, development of conservation easement enforcement protocols and identification of current fee title owners of all properties subject to DNR conservation easements.

Minimum standards for conservation easement stewardship include baseline property reports for all easements, regular monitoring and record keeping. As the holder of 1003 conservation easements, the DNR must maximize efficiencies to meet its stewardship obligations. The main focus of Phase III is the development of technology to enhance conservation easement monitoring efficiency. In addition, Phase III accelerates the DNR's ongoing efforts to bring stewardship of all existing conservation easements up to minimum standards, focusing primarily on conservation easements that were acquired before current minimum standards were developed. Project goals are to develop GIS tools that will enhance conservation easement stewardship efficiency and to evaluate the efficacy of these tools; to monitor some existing DNR conservation easements through remote sensing and others through traditional on-site methods; to prepare baseline property reports for at least 50 existing DNR conservation easements (trout stream easements and wild and scenic river easements); and to improve and standardize conservation easement stewardship agency-wide. Goals will be achieved through development and evaluation of the efficacy and cost benefit of GIS tools to automate some mapping and violation detection functions that are essential components of conservation easement stewardship; through easement monitoring by remote sensing (using GIS, aerial photographs and LiDAR, acquired satellite imagery and LiDAR) and evaluation of the efficacy of this monitoring method; through on-site easement monitoring and baseline data collection; and through completion of baseline reports that document property conditions in relation to easement terms. In addition, project staff in the DNR Division of Lands and Minerals will coordinate agency-wide conservation easement stewardship activities and assist DNR staff with their transition to use of the conservation easement application in the DNR's new land records system.

III. PROJECT STATUS UPDATES:

Amendment Request (July 23, 2013): This amendment request is to reallocate funds from reduced direct and necessary support services costs. Funds totaling $1,571 are reallocated to personnel. Direct and necessary costs totaling $15,606 are split evenly between activities 1 and 2.
Amendment Approved: July 24, 2013

Amendment Request (October 24, 2013): The original work plan specifies that the trout stream easements covered by this project will be those administered by the Division of Fish and Wildlife, Duluth Area Fisheries Office. Project staff has already visited nearly all of the streams administered by the Duluth Area Fisheries Office. (Most of this work was done with Phase II project funding). To take advantage of the remaining field season, we are asking for an amendment to enable staff to conduct visits to trout stream easements in other areas of the state for the purpose of monitoring and baseline data collection.

Amendment Approved: October 25, 2013

Amendment Request (December 31, 2013):
The current project manager, Susan Damon, has been appointed to a new classified position at the DNR, Land Acquisition and Legal Services Manager, Division of Lands and Minerals. In light of this new appointment, we are requesting that Don Kilberg, who has worked on ENRTF-funded conservation easement stewardship projects at the DNR since 2011, replace her as project manager. **Approved by LCCMR January 2, 2014**

Project Status as of December 31, 2013:

Most project work during this reporting period has focused on the monitoring and baseline report generation as detailed in Activity 2. With regard to Activity 1, staff investigated pricing methods for satellite imaging products and how they may affect the selection of test areas for remote sensing of easement violations. Staff confirmed previous price quotations from the software vendor in preparation for placing an order in the spring of 2014 for the one-year lease of the object based image analysis software. Plans are to have this software leased and installed by June 1, 2014 and to have the aerial and satellite imagery acquired for the test areas in early spring of 2014.

A total of 46 conservation easements were monitored during this reporting period. The project specialist based in the Duluth Area Fisheries Office was able to obtain assistance from other Fisheries staff (funded through sources other than projects funds) early in the project. These staff members captured data and took photos on some easement sites while the project specialist managed the database activities for this work. The project specialist also conducted numerous easement site visits.

The DNR's new land records system became operational in September. For the time being, the actual monitoring of easements will continue to be accomplished using the prototype Access monitoring application developed in Phase II of the Conservation Easement Stewardship and Enforcement Program (M.L. 2011, First Special Session, Chp. 2, Art. 3, Sec. 2, Subd. 04m).

Amendment Request (March 28, 2014):
Project staff is currently in negotiation with suppliers of the aerial and satellite imagery to determine the best mix of study areas to capture as well as types of imagery available in support of activity 1. It is anticipated that the costs will be slightly higher than the estimated $12,500. To allow room for negotiation we are requesting an amendment to increase the imagery budget from $12,500 to $20,000. The staff budget for activity 1 will be reduced by $7,500. **Approved by LCCMR April 8, 2014**

Project Status as of June 30, 2014:
Staff is positioned to begin working on Activity 1 elements beginning July 1, 2014. The image analysis software, eCognition, was ordered and installed on staff computing resources and the license server tested to ensure all elements should become operational for the annual test period beginning July 1. Staff selected 92 DNR-administered test easements for remote easement monitoring in collaboration with division representation on the Conservation Easement Stewardship committee. BWSR staff expressed interest in project participation, including contribution of funds, and project staff worked with BWSR staff to select 16 BWSR conservation easements to be included in the testing. Staff worked with DNR Resource Assessment to order and acquire leaf off aerial imagery of all 108 test sites which BWSR agreed to partially fund. This imagery was acquired during the week of May 5, 2014. Staff selected two satellite test areas that met minimum order requirements for vendors while at the same time maximized the number of test easements which could be acquired. Staff requested vendor bids and imagery with 4 spectral bands of information was ordered and successfully acquired during the last week of April 2014. A total of 43 DNR-administered easements and 1 BWSR-administered easement are included in the two test areas.

In support of Activity 2, project staff visited an additional 11 conservation easements during the period bringing the total easements visited during the project to 57. Because of subdivisions, these easements have a total of 119 individual landowners, each requiring monitoring reports. Project staff has completed baseline report work on 52 of the 57 easements and area management has approved 94 of the 119 reports. During the visits, project staff noted 33 concerns related to compliance with easement terms and conditions. Area management has addressed 15 of these concerns and the rest are under current review as part of the approval process.

Project Status as of December 19, 2014:
Software for Activity 1 was successfully activated on July 1 for the annual license term. Image preparation is said to be 80% of any remote sensing project and this project is no different. Project staff estimates they have completed about 75% of this pre-work.

Project staff has completed baseline property reports for all but of DNR's five wild and scenic river easements. Three of these are awaiting review of easement legal descriptions and two are awaiting Parks and Trails Division approval. The remaining 131 baseline reports have been completed and copies sent to 259 individual landowners. When they were acquired, these wild and scenic river easements did not restrict subdivisions. Default terms and conditions of some easement types such as native prairie banks, forest for the future and forest legacy do restrict subdivisions.

While no additional trout stream easements were visited by project staff during the period, Fisheries Section staff visited and completed data entry for 124 trout stream easements utilizing tools developed and refined by project staff to capture and manage baseline property information. Because of subdivisions since acquisition, these 124 easements required visits to 158 separate owner parcels to capture complete information. Project staff continue to support Fisheries employees using project tools to enter baseline visit information and approve those reports.

MNIT staff completed modifications to the land records system to allow completed legacy baseline property reports to be appended to the appropriate easement acquisition record in Land Records. MNIT staff also completed an initial test version of a data query that will allow new entries in Land Records to be extracted and automatically added to the Conservation Easement GIS and Access databases.

Amendment Request (January 6, 2015):
The necessary satellite and aerial imagery has been acquired to complete the project. We are asking to transfer the unspent imagery budget of $10,007 in Activity 1 to unclassified staff salary so we can apply the funds to additional conservation easement monitoring and baseline property report preparation in the spring of 2015. The Object Base software annual license was $154 less than anticipated so we would ask to add that surplus to salary as well. We anticipate completing an additional 25 baselines with this funding.
Amendment Approved by the LCCMR 1/9/2015

Project Status as of June 30, 2015:
Project staff completed image preprocessing for Activity 1 and developed eCognition software programs to identify land cover in easement areas, to automatically identify possible easement violations, and to automatically draw updated digital stream centerlines based on LiDAR and optical imagery. Staff monitored 143 easements with 219 landowners utilizing the automated program and created updated stream centerlines for a 15km test area along Rush Creek in Winona County. Cost benefit analyses were created for both activities. Staff concluded that to effectively monitor easements using only automated remote would require image resolution no coarser than 6"and LiDAR that had been acquired at the same time. Review of aerial imagery with coarser resolution can still provide important information to the monitor such as potential concerns to follow-up during the on-site visit.

Computer generation of updated digital stream centerlines showed the potential to be of considerable use to easement staff in the future. While the total time to generate these centerlines is only slightly better, much of the labor time is shifted to a computer where unattended processing can be run at night.

Using Phase III funding, staff completed baseline reports for 20 wild and scenic river easements. (Baselines have now been completed for all but one wild and scenic river easement, which has pending changes in the legal description of the easement.) Using Phase III funding, Fisheries staff visited 65 easements for the purposes of collecting baseline property report data and completed the reports.

Overall Project Outcomes and Results:
This was the last phase of a three-phase project to establish procedures and tools to effectively monitor conservation easements held by the DNR. One project goal was to monitor and create baseline reports for 75 existing conservation easements—actual attainment was 85 easements. As detailed in the Phase III Supplemental Report, additional goals were to investigate the use of image processing software coupled with LiDAR and current imagery to improve the efficiency of conservation easement stewardship. Two areas were explored: 1) can these tools be used to accurately redraw stream centerlines after changes in stream courses; and 2) can remote sensing tools be written to automatically identify possible violations of easement terms? DNR trout stream easement boundaries are typically 66' from stream centerlines and move with stream course changes. It is essential to have accurate maps of easement boundaries for monitoring, but it is time consuming to edit boundaries manually. Staff created a novel approach to generate stream centerlines from LiDAR and adjust them with imagery where stream course changes had occurred. Tests of a 15km stream section demonstrated the accuracy and usefulness of this approach. Manual effort of 90 minutes to digitize the stream section was reduced to 11 minutes. In the second problem area, staff utilized eCognition image analysis software to classify land cover in easement corridors utilizing imagery with three levels of resolution and LiDAR and identify objects/conditions that could be easement violations. Staff concluded that to effectively monitor easements remotely would require image resolution no coarser than 6" and LiDAR that had been acquired at the same time. Possible violations identified in this fashion still need on-site verification, but this technique can highlight areas of concern and reduce on-site visit time. Tools developed in this project have potential application for statewide riparian buffer mapping and monitoring.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Development of GIS Tools for Conservation Easement Stewardship; Conservation Easement Monitoring Through Remote Sensing

Description:

This activity will develop and evaluate GIS tools used in conjunction with fused LiDAR (Light Detection and Ranging) and remote sensing imagery (1) to identify buildings, structures and other conditions that would warrant special attention during monitoring visits; and (2) to automatically adjust digital riparian conservation easement shapes (which are used for mapping and automatic updating of ownership information) to match changes in water courses over time. (Riparian easements usually describe the easement boundaries as being located a certain number of feet from the stream centerline.) This activity will utilize object based image analysis software to develop the automated algorithms. The goal is to improve both the quality and cost-effectiveness of DNR's conservation easement monitoring through use of the GIS tools by (1) targeting specific easements or areas of concern for on-the-ground inspections; and (2) reducing staff time needed to manually adjust riparian conservation easement shapes to match changes in water courses.

Remote sensing methods, all incorporating object based image analysis with GIS, will be used on at least 50 existing conservation easements to assess compliance with easement terms. Methods will include use of GIS with current aerial imagery and/or DNR's existing LiDAR data to evaluate easement properties. Monitoring of

up to 20 of the easement sites will evaluate the use of high-resolution (.5m) satellite imagery combined with the existing LiDAR. The same sample of easement sites will be evaluated utilizing (1) existing FSA aerial imagery (leaf on); and (2) leaf-off aerial imagery (acquired for the National Wetland Inventory, if available for the easement site, or acquired from a vendor). On-site visits will be conducted on a sample of the easements to evaluate the efficacy of detecting violations through these remote sensing methods. A cost-benefit analysis of the various image sources will be conducted as well. Monitoring reports will be provided to easement administrators for follow up, and the results of the evaluation of efficacy and cost-effectiveness will be documented.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 89,030
Amount Spent: $ 88,322
Balance: $ 708

Activity Completion Date:

Outcome		Budget
1. Develop and evaluate GIS tools to identify buildings, structures and conditions for special attention during monitoring visits and to automatically adjust digital shapes of riparian conservation easements to changes in water courses	6/30/2015	$ 62,665
2. Monitor at least 50 existing conservation easements with remote sensing methods; prepare monitoring reports	6/30/2015	$ 11,926
3. Conduct on-site visits to a sample of easements monitored to evaluate efficacy of remote-sensing methods; document results of evaluation	6/30/2015	$ 10,925
4. Develop a cost-benefit analysis of the use of automated tools to improve efficiency of conservation easement monitoring and to revise riparian easement GIS shapes	6/30/2015	$ 3,514

Activity Status as of December 31, 2013:

Staff investigated pricing for satellite imaging products and how they may affect the selection of test areas for remote sensing of easement violations. Staff confirmed previous price quotations from the software vendor, Trimble, in preparation for an order and one-year lease of the object based image analysis software (eCognition).

Because funding to lease the eCognition software is limited to a single year, we are waiting until late in May 2014 to order and install the software. Acquisition of the imagery for the easements will be timed with leaf-off conditions in early spring of 2014

Activity Status as of June 30, 2014:
eCognition software was ordered and installed on a staff computer. The vendor provided a two week trial license that allowed staff to work with MNIT to install the necessary licensing and verify that the software functions as expected. The purchased annual license is set to become active on July 1. Staff and BWSR personnel have collaborated to do joint tests on the efficacy of remote easement monitoring and a set of easements has been identified (see Attachment 1) that include DNR and BWSR easements. Aerial imagery was commissioned through the Forest Resources Unit of DNR for the above set of easements as well as an expanded set that includes other BWSR easements and other DNR easements. BWSR paid for a portion of this imagery acquisition which reduced DNR costs to $4505. A satellite imagery vendor was selected through bids and Pleiades satellite imagery was obtained for two easement test areas of interest on April 22, 2014. Satellite imagery is available and initial work to prepare it for processing it has begun.

Activity Status as of December 19, 2014:

Because of vendor software upgrades between installation and activation on July 1, staff needed to work with MNIT staff to resolve licensing issues when we attempted to activate the software on July 1. eCognition software utilizes a concept called the "workspace" to manage all of the image and LiDAR assets that it will analyze. In a project that contains complex and large data, as does this, the design of the workspace can have significant impact on the efficiency of processing later. Staff spent a considerable effort during this period evaluating various designs, running tests and collaborating with personnel at the University of Minnesota Remote Sensing Geospatial Analysis Laboratory on options and approaches. A detailed discussion of individual project steps accomplished during this reporting period can be found in Attachment 2. Staff created a final workspace design depicted in Attachment 3 which organizes the workspace around individual images available for each test easement. After all imagery is created and prepared, staff will begin writing the program steps to classify the land cover within the easement boundaries looking for objects that may indicate violations of conservation easement terms.

Activity Status as of June 30, 2015:

Outcome 1: Revise riparian easement shapes. Staff developed a novel process to utilize a combination of LiDAR imagery and aerial imagery available through the MnGEO website to re-draw stream centerlines in a test area along 15km of Rush Creek in Winona County. This technique started by processing the LiDAR using standard hydrology tools (i.e. Fill Sinks, Flow Direction, Flow Accumulation and Stream Definition tools)to create stream centerlines. These LiDAR derived centerlines were then used as a "seed" on top of optical imagery to create bank filled polygons of the streambed using eCognition image analysis software. Since the LiDAR for the test area was acquired in November of 2008, many changes have occurred since that time to streambeds because of flood events and the eCognition program was able to modify the LiDAR centerlines to take into account these changes. Thiessen polygon[1] processing was then done on the bank filled polygons to create the final centerlines using a Python script. Project staff developed a process that was completely automated with the exception of a final visual inspection and editing of the bank filled polygons to ensure the stream was defined as a contiguous unit. In the test there were thirteen areas where the computer could not accurately identify the streambed because of overhanging trees or riffles that looked like dry land to the automated routines. The process that staff developed produced outstanding results with a minimum of manual effort. Because of computer memory constraints, the test area chosen represented an appropriate amount of stream that could be processed at one time by the computer. More detailed information about this procedure is contained in the Phase III Supplemental Report.

Outcome 1: Develop GIS tools to identify easement concerns. This outcome focused on creating spatial tools utilizing LiDAR and optical imagery that will assist staff in detecting possible easement violations without visiting the easements. Staff completed the remaining image preparation work as described in Attachment 2 and revised the processing steps to improve performance within the eCognition program. These revisions are described further in the Supplemental Report and are significant because they represent a novel way to utilize eCognition when test areas of interest are not contiguous, as in this project. A single rule set was written that loaded the LiDAR and processed any and all imagery that was available for that easement. A separate section of that rule set was used to process each of the three imagery types. Staff tested the rule set on several easements during its development to ensure it would effectively analyze all easements with all imagery types.

eCognition has a server product which would have automatically run the rule set on all 143 easements in the workspace, but it is not available on the software version that staff rented. As a result, staff used manual techniques to run the rule set on an easement by easement basis. This capability was available in the software level that staff rented for the project and took about eight hours to accomplish. The 143 analyzed easements have 219 landowners as described in the table below:

[1]Thiessen polygons are geometric shapes that are constructed based on the points of the bank filled polygons that have unique properties where one edge of the polygon can be used to approximate the center of the original polygon

Easement Type	# of Easements	# of Landowners	# of Easements Monitored On Site	# of Landowners Monitored On Site
Forest Legacy	22	27	22	27
Native Prairie Bank	9	12	4	5
Other Conservation	7	10	0	0
Trout Stream	92	151	58	96
Water Bank	2	2	0	0
Wild and Scenic River	7	13	1	1
Fee Interest	4	4	0	0
Total	**143**	**219**	**85**	**129**

During the remote sensing monitoring analysis, the following was observed:

- 49 tillage violations
- ten possible structures in easement corridors
- one possible junk pile
- six easements where the stream corridor needs to be re-drawn to match the current location of the stream.

Twelve tillage violations detected in remote sensing were recorded during on-site monitoring on those same easements. In addition, one building and one bridge were noted in remote sensing and not recorded during on-site monitoring. Twenty-nine tillage violations and two structures were observed in remote sensing on easements that were not monitored on site by staff.

Of the violations observed during the on-site monitoring done by project and other DNR staff, all eight tillage violations were identified in the remote sensing analysis. Tree cutting, a no trespass sign, barrels, bank erosion, a derelict shack and deer stands in a forest legacy easement were not identified by remote sensing analysis. A car and port-a-potty were visible in the aerial imagery but were not classified by the automated routines. A recently installed turret watering system on a forest legacy easement was not identified because the LiDAR data pre-dated the optical imagery.

Project staff required 14 hours to run the programs and prepare the automated results (not including the time to program eCognition) and 21 hours to assess the results of the automated routine. It is estimated that project and other DNR staff required 214 hours of field time to travel to and monitor the 129 landowner locations examined during the project.

Outcome 2: Monitor 50 easements using remote sensing. Project staff reviewed/analyzed the remote sensing assessments for all 143 conservation easements in the test area. Of these, 57 easements were due for monitoring but were not visited on site during the test. Project staff entered monitor reports into the Conservation Easement Management System (CEMS) for 28 of the 57 easements and completed these reports. Project staff entered monitoring data for the remaining 29 easements due for monitoring. In order to complete monitoring reports for these 29 easements in CEMS, baseline reports for the easements will first need to be completed. (CEMS is designed to require that baseline conditions be available prior to the completion of a monitoring report).

Final Report Summary:

Outcome 1: Develop GIS tools to identify easement concerns. Staff purchased a single year software license for eCognition Developer 9.0 software from Trimble. For each easement in the test areas the following imagery was assembled and preprocessed for further use:

- Optical imagery of the easement (one or more of the following image types: Pleiades satellite imagery, customer CIR imagery acquired by DNR's Resource Assessment group in Grand Rapids or a spring leaf off imagery mosaic available from MnGEO). All of the test easements had at least spring leaf off imagery

available. Thirty-eight easements had all three image types and 61 had Resource Assessment as well as spring leaf off imagery available.

- LiDAR point cloud data[2] downloaded from MnGEO's web site acquired as part of the statewide LiDAR acquisition project.
- A digital elevation model (DEM) created from the LiDAR point cloud using eCognition tools. This surface represented the height above sea level across the test easement.
- A normalized digital surface model (nDSM) from the LiDAR point cloud derived using eCognition tools. This surface represents the height about the ground from objects in the easement boundary such as buildings, trees and other objects not a ground level.

Staff developed two additional eCognition rule sets to accomplish the first goal stated in Activity 1. The first looked at the imagery available above and programmatically (i.e. automatically) identified structures, tillage and other concerns that may be violations in each of the test easements. Identification of easement concerns was determined using each of the image types available for a given easement using optical information merged with the LiDAR surfaces.

Staff has arrived at several conclusions as a result of the remote monitoring portion of Activity 1:

- It is extremely important to have imagery and LiDAR that match temporally, that is, they should be acquired at the same time. Several forest legacy easements had older LiDAR where buildings and irrigation structures did not show up in the nDSM and were missed in the land cover classification.
- Image resolution of at least 6" is required to actually be able to identify what some objects are, such as junk, barrels, small sheds and the like. Especially if the object is in the trees, it is easily missed with ½ meter or grosser resolution imagery.
- The basic resolution of LiDAR acquired as part of the statewide project does not support fine (6") resolution optical imagery. Five pts per meter LiDAR makes it too easy to miss the height of small objects such as saplings or other small objects. In counties that upgraded to better resolution LiDAR, this issue was alleviated.
- Programmatically searching for easement violations, while time effective, is not sufficiently accurate to stand as the sole monitoring technique. There are several contributing reasons for this. First, if all of the imagery is not acquired with the same atmospheric conditions (e.g., humidity and air clarity) or if it is acquired at different times of day with different sun angles, it becomes difficult, if not impossible, to use the same program to search for violations across a wide range of easements. The subtle differences mentioned can drastically affect reflectance of different spectral layers and the program uses these values to assess violation thresholds. An object might be interpreted by the computer as pasture under some lighting and as crop land under others--one allowed by terms of the easement and the other not. Secondly, areas in an easement may show up as tillage in an entire section of the easement and be a violation of terms, but there may also be other smaller areas in the easement that have the same spectral characteristics but are not plowed fields. Vegetation is readily identifiable using the computer program but it is more difficult to determine if this vegetation is an easement violation. For example, corn vegetation in a field can look very similar to the computer as natural vegetation in the easement area. Both may be located within the easement corridor but both are not necessarily violations.
- Remote sensing is an outstanding way to quickly examine an easement for riparian tillage violations. Fields are readily identified in the spring before "green up" and distances to the stream centerline are readily measured. Many stream banks can be quite deep and it is easy for a monitor to walk by tillage violations because they cannot be seen if one is in the stream. In stream areas with high banks, the monitor must walk on the bank, something that is not always possible, to see violations at the edge of the easement corridor. Having noted this, any suspected violation still needs to be confirmed with a site visit. Stream centerlines may be more complex than they appear from the air and measurements to

[2]A LiDAR point cloud is a collection of points each with x, y and z coordinates describing points on the earth that reflected a LiDAR pulse back to sensors in the aircraft from the original beam. A typical point cloud contains many millions of individual points.

tillage should be confirmed, especially if there are elevation differences between the streambed to the crop tillage. Surveys may be necessary to determine definitively whether tillage is a violation. In addition, learnings from this project may be applicable to developing monitoring maps and tools in support of the recently enacted riparian buffer legislation. Project staff is pursuing contact with agency personnel associated with that effort.

- Finally, while eCognition has powerful image recognition capabilities, it still falls short when compared to the human eye. The eye can immediately detect a plowed field in two distinct images even if they have lighting differences. Because of this, staff concludes the ideal way to utilize remote sensing would be to acquire 6" or better resolution imagery, processed to provide 3D viewing with the appropriate equipment. Imagery would be acquired in the spring of the monitoring season and would be viewed by a human for possible violations that should be verified on the ground. Violations such as tillage, trash and buildings in the easement can readily be identified by visual image interpretation. For smaller easements, programmatically analyzing a scene by automatically classifying land cover type, does not gain much efficiency as compared to visual interpretation. In the case of large forest easements though, it does make sense to compare imagery across years to look for changes, something a computer analysis can readily do.

Outcome 1: Revise riparian easement shapes. Project staff developed the final eCognition rule set to automatically adjust stream centerlines based on new optical and LiDAR imagery of a 15km length of Rush Creek just south of I-90 in Winona County. This technique started with the latest available LiDAR DEM surface and used traditional hydrology tools available in ArcGIS to create a Stream Definition from the LiDAR. The eCognition rule set used this Stream Definition as a seed and overlaid it with the most recently available optical imagery. In many cases, there were several years between the LiDAR and optical imagery during which flood events could have changed the stream bed. The eCognition program was instructed to fill the stream bank pixel by pixel with water starting with the LiDAR centerline and using the optical imagery to "constrain" the stream to its current banks. Staff needed to edit the resulting stream bank polygon to make sure it was continuous and not blocked by overhanging trees nor riffles. Once this minimal manual effort was accomplished, staff wrote a Python script that utilized Thiessen polygons to create a stream centerline. This operation was fast and accurate. While not demonstrated, the next step would be to build automatic processing that would move existing stream corridors so they aligned on this new, accurate centerline.

Outcome 2: Monitor 50 easements using remote sensing. To fulfill this objective of Activity 1, staff reviewed/analyzed the computer classifications of all 143 test easements and compiled them in a spreadsheet Attachment B. Each easement's land cover classification was examined by staff and its quality was assessed subjectively. When multiple imagery sources were available for an easement, project staff compared those as well as shown in the spreadsheet. Of these 143 easements, 57 were due for easement monitoring, but were not visited on site during the test. Project staff entered monitor reports into the Conservation Easement Management System (CEMS) for 28 of the 57 easements and completed these reports. Project staff entered monitoring data for the remaining 29 easements due for monitoring. In order to complete monitoring reports for these 29 easements in CEMS, baseline reports for the easements will first need to be completed. (CEMS is designed to require that baseline conditions be available prior to the completion of a monitoring report).

Outcome 3: *Conduct on-site visits to a sample of easements.* To fulfill the third objective of Activity 1, DNR staff visited 129 different landowner segments of the total 219 landowner segments of the 143 test easements. (A single easement may have multiple landowner segments after any subdivisions that occur since its acquisition.) Results from the on-site monitoring visits were categorized on the spreadsheet Attachment B as well.

Outcome 4: *Cost Benefit Analyses.* Staff developed two cost benefit studies relating to remote monitoring and automated shape correction. The time to monitor the 129 landowner segments using traditional approaches was approximately 214 hours. The time for project staff to review these same 129 segments using remote sensing remotely was approximately 21 hours. While this is an impressive time savings, accuracy of a remote

sensing only approach is notably limited. Any concerns identified in the fashion using remote sensing would require on-site visits to confirm and document for possible enforcement actions. These limitations noted, remote sensing can be an important part of a monitoring plan. Prior examination of aerial imagery can provide the monitor with the location of areas requiring additional examination on the ground. Further, with the new stream buffer legislation, a stream profile could be developed using several years of imagery at different seasons to more accurately identify crop areas. The eCognition program developed for this project could provide the basis for such further work.

Project staff evaluated automatically adjusting digital riparian centerlines by comparing the program run times to manually digitizing centerlines from the same aerial imagery. For the Rush Creek test stream, staff digitized the centerline manually from the Spring Leaf Off imagery in 90 minutes. To accomplish the automatic centerlines for the same stream area, staff required the following times:

- 11 minutes, 3 seconds to create the stream definition from LiDAR DEM to create the centerline from the LiDAR (computer time)
- 23 minutes, 52 seconds to create the Bank Filled Polygons (computer time)
- 11 minutes of manual time to edit the 13 areas of the bank filled polygons
- 29 minutes, 51 seconds to create the final centerline shapes (computer time)
- Total elapsed time of 75 minutes 46 seconds of which 11 minutes was manual effort.

While the overall elapsed time was only slightly better with the automated approach, we should really compare only the manual efforts for each approach, that is, the 90 minutes to hand digitize to the 11 minutes to edit the bank filled polygons. This is a significant reduction in manual effort. The computer time could easily be scheduled to run in the overnight hours with no human intervention.

While there were some quality differences between this manually digitized centerline and the centerline created automatically, most of these were minor and resulted from interpretation differences where tree canopy and brush covered the stream. The automated routines generated two centerlines split around islands. This interpretation would be subject to legal review; if the island was a permanent feature there would indeed should be two centerlines, if the island was frequently awash then legally the centerline creation would ignore the island.

In conclusion, the automatic generation of stream centerlines should be considered a useful approach to re-draw these features each time new optical imagery is flown and made available.

ACTIVITY 2: Monitoring, Baseline Data and Reports; Agency-Wide Conservation Easement Stewardship Coordination

Description: Stewardship of at least 50 (amended to 75) existing DNR conservation easements will be brought up to minimum standards through on-site monitoring visits, collection of baseline data and completion of baseline property reports. The conservation easements will be wild and scenic river easements administered by the Division of Parks and Trails and trout stream easements administered by the Division of Fish and Wildlife, Duluth Area Fisheries Office and other areas to the extent that project funding allows. (Baseline data collection and report preparation for north shore trout stream easements is expected to require substantially more staff time than is required for typical trout stream easements in southeastern Minnesota. This is because many of the easements are in remote, wooded and difficult-to-access areas. In addition, some north shore trout stream easements acquired on tax-forfeited lands cover multiple parcels on one or more streams.) Methods and forms for conservation easement monitoring and baseline property report preparation developed in Phase I and refined in Phase II will be used for Activity 2.

Project staff in the Division of Lands and Minerals will coordinate agency-wide conservation easement stewardship. This outcome will include planning and facilitating regular meetings of DNR's conservation

easement stewardship working group and providing assistance to divisional staff with their easement stewardship activities. In addition, delivery of a portion of the DNR's new land records system, including an application for conservation easement administration, is expected to be complete in FY 2014. Lands and Minerals Division project staff will provide technical and other assistance to DNR conservation easement monitors and supervisors during transition to the use of the conservation easement application.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 110,970
Amount Spent: $ 110,970
Balance: $ 0

Activity Completion Date:

Outcome		Budget
1. Monitor at least 50 existing DNR conservation easements and collect data for baseline property reports	6/30/2015	$ 21,564
2. Complete baseline property reports for at least 50 conservation easements	6/30/2015	$ 73,726
3. Coordinate agency-wide conservation easement stewardship; provide assistance to DNR staff in the use of the new land records system for conservation easement administration	6/30/2015	$ 15,680

Activity Status as of December 31, 2013:

Staffing: The project specialist hired to work on wild and scenic river easements in the Phase II project (M.L. 2011, First Special Session, Chp. 2, Art. 3, Sec. 2, Subd. 04m) transferred to Phase III project work on October 9. The project specialist hired in the Phase II project to monitor and prepare baseline reports for trout stream easements managed by the Duluth Area Fisheries Office transferred to the Phase III project on September 25. He resigned his position effective December 4 to accept a permanent position with the Minnesota Pollution Control Agency.

Monitoring and baseline property reports: Staff visited five wild and scenic river easements (with a total of five landowner segments) on the St. Croix River in Washington County. Data for these visits have been entered into the Access application developed in Phase II of the project. Creation of the baseline reports is in process for these easements and baselines are expected to be approved in the first half of 2014.

Fisheries project staff, in collaboration with Fisheries staff funded through other sources, visited 41 trout stream easements with 79 landowner segments in the Duluth and Bemidji areas, took baseline photographs and acquired other data about the condition of the easements. Staff has entered all data for 40 of the 41 easements into the Access system. Baseline reports from these are ready for Fisheries management approval.

Activity Status as of June 30, 2014:

Staffing: No staffing changes during the period

Monitoring and baseline property reports: Staff visited 10 additional wild and scenic river easements (with a total of 22 landowner segments) on the Mississippi, Minnesota, Rum, Cannon and St. Croix Rivers in Wright, Redwood, Mille Lacs, Isanti, Goodhue, Sherburne and Washington counties. Data for these visits have been entered into the Access application developed in Phase II of the project. Creation of the final baseline reports is in process for these easements; five have been prepared by staff and four have been approved by Parks and Trails Division management. Another five baselines are in the final process of preparation. To date, 15 wild and scenic river easements (with 27 owner segments) have been visited during Phase III. Fifteen baselines have been prepared by staff and 14 have been approved by Parks and Trails Division management.

Fisheries project staff visited one additional trout stream easement during the period for the purposes of obtaining baseline photographs and acquiring other data about the condition of the easements. To date the total number of easements visited during Phase III is 42 with 92 landowner segments. Data for all 92 landowners (42 easements) have been entered into the system by staff and of these 79 have been approved by local management. Sixty-eight of these landowner segments have received final baseline approval by regional Fisheries section management, which represent a total of 31 easements approved.

Activity Status as of December 19, 2014:

Staffing: Project funds for the unclassified Parks and Trail employee dedicated to the project were depleted on November 4, 2014. This employee is continuing to work on wild and scenic river easement stewardship under other funding.

Monitoring and baseline property reports: Project Staff visited an additional five wild and scenic river easements for the purposes of obtaining baseline photographs and acquiring other data about the conditions of these easements. This brings the total number of wild and scenic easements visited to 20 during Phase III. Staff have now completed baseline monitoring of all 136 wild and scenic river easements. Baseline reports have been completed for 131 of these easements. Baseline reports for two of the remaining five easements are awaiting Parks and Trails Division approval. The three remaining easements have apparent errors in their legal descriptions and will likely need to be amended following survey review. The baseline reports for those three easements will be finalized after resolution of the legal description errors. Copies of baseline reports have been sent to 259 wild and scenic river easement landowners to date as a result of work completed during phases II and phase III of the project.

No additional trout streams were visited by project staff during this reporting period. However, during the period, Fisheries Section staff visited and completed data entry for 124 trout stream easements which required visits to 158 individual owner parcels. During these visits, Fisheries Section staff utilized tools developed and refined by project staff to capture and manage baseline property information.

Coordinate agency-wide conservation easement stewardship: Project staff facilitated training on November 5th in New Ulm of eight Fisheries Section managers in Region 4 on approval procedures for baseline reports. Several enhancements were made to the Access easement application to improve the format of reports available to staff during subsequent monitoring visits to easements. Project staff received a test version of the new land record update query from MNIT staff. This query will enable project staff to automatically add newly acquired conservation easements into the GIS and Access databases used by the stewardship tools. MNIT staff also completed requests to allow conservation easement stewardship staff the ability to append completed legacy baseline reports to easement acquisition transactions in the land records system.

Activity Status as of June 30, 2015:

Staffing: Project funds for an unclassified Fisheries section employee dedicated to the project were assigned in January and continued through March of 2015.

Monitoring and baseline property reports: Project Staff in Fisheries section visited an additional 23 easements for the purposes of completing baseline reports during this reporting period. No additional wild and scenic river easements were visited during the period.

During this reporting period, MN-IT staff completed the capability to upload completed baseline reports into the appropriate easement acquisition transaction in DNR's land records system. With this capability, project staff completed 43 baseline reports and assembled and uploaded three baseline property report packets into the

land records system. Fisheries section staff in the northeast region will be uploading the additional baseline pdfs into land records.

Coordinate agency-wide conservation easement stewardship: Project staff implemented and tested the new land records query to support the GIS functionality within the Conservation Easement Stewardship System. The remaining system changes to reflect the GIS in the Access databases will not begin until July of 2015.

Staff coordinated the development of an agency-wide excel spreadsheet that can be used by divisions to estimate their cost of stewardship for newly acquired easements. Divisions can specify their easement specific parameters within this spreadsheet and the output will be used to objectively determine appropriate funding to be requested along with acquisition funds for new easements. These funds will be added to the conservation easement stewardship account established by 2015 legislation.

Final Report Summary:

Project staff visited and completed collection of baseline report data for a total of 85 existing easements in support of Activity 2 during the project, exceeding the amended target goal of 75. These easements required visits to 145 individual landowner segments. Twenty of these easements were wild and scenic river easements, 63 were trout stream easements and two aquatic management area easements. Computer generated baseline reports were prepared for 60 easements. One wild and scenic river easement needs to have legal descriptions amended. Monitoring and baseline reports for 21 trout stream easements are under review by Fisheries section management for possible enforcement action.

V. DISSEMINATION:

Description: Monitoring data and baseline property reports created as part of this project will be entered into and stored in DNR's land records system, where they will be accessible to staff who monitor or administer conservation easements. Baseline property reports will be provided to fee title owners of properties subject to conservation easements. Monitoring reports from remote sensing will be provided to the DNR administrators of the easements monitored. GIS/remote sensing tools developed in Phase III, information about their use in the project and results of efficacy testing will be provided to GIS staff in other DNR divisions for possible adaption of the tools for other uses.

Status as of December 31, 2013:

No dissemination of project information has occurred during this period.

Status as of June 30, 2014:

Thirteen wild & scenic river baseline property reports were signed by DNR Parks and Trails Division management and sent to fee title owners of properties subject to conservation easements during this period.

Status as of December 19, 2014:
Twenty-five wild and scenic river easement baseline property reports were signed by DNR Parks and Trails Division management and sent to fee title owners of properties subject to conservation easements during this period. Training materials were provided to Fisheries section management employees as well.

Status as of June 30, 2015:
The training manual was updated in June, 2015 to reflect changes made to the Conservation Easement Management system Access application.

Final Report Summary:
During the project, thirty-eight wild and scenic river easement baseline property reports were signed and mailed to fee title owners of the properties. Project staff disseminated updated training manuals to conservation easement stewardship staff. Preliminary study results of the remote sensing work have been presented to members of the DNR's conservation easement stewardship committee. The conservation easement stewardship cost calculator was disseminated to DNR fiscal staff. Information about the calculator was presented to the LCCMR on June 25, 2015.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget:

Budget Category	$ Amount	Explanation
Personnel:	$ 156,994	Unclassified staff (project manager, project specialist, project specialists/field staff)
Travel Expenses in MN:	$1,000	Mileage, fleet, lodging, meals
Other:	$26,400	One-year license for object based image analysis software for remote sensing; high-resolution satellite and leaf-off aerial imagery of up to 20 selected easements for remote sensing
Direct and necessary services:*	$15,606	DNR costs for the appropriation
TOTAL ENRTF BUDGET:	**$200,000**	

* Direct and Necessary expenses include both Department Support Services (Human Resources, IT, Financial Management, Communications, Procurement, and Facilities) and Division Support Services. Department Support Services are described in Agency Service Level Agreements, and billed internally to divisions based on indices that have been developed for each area of service. Department leadership (Commissioner's Office and Regional Directors) are not assessed. Division Support Services include costs associated with Division business offices and clerical support. Those elements of individual projects that put little or no demand on support services such as large single-source contracts, large land acquisitions, and funds that are passed-thru to other entities are not assessed Direct and Necessary costs for those activities.

Explanation of Use of Classified Staff: N/A

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

Number of Full-time Equivalent (FTE) funded with this ENRTF appropriation: 1.65

Number of Full-time Equivalent (FTE) estimated to be funded through contracts with this ENRTF appropriation: N/A

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
	$ 0	$	
State			
Various	$ 2,000	$550	In-state travel expenses (mileage, fleet, lodging, meals) for project staff to

			monitor conservation easements and collect baseline field data (Activity 2)
		$59	Equipment expenses
TOTAL OTHER FUNDS:	**$ 2,000**	**$609**	

VII. PROJECT STRATEGY:

A. Project Partners: Project staff in the Lands and Minerals Division will be responsible for overall project coordination, quality control, report writing, some baseline report preparation and development of GIS tools and remote sensing under Activity 1. Field staff, who will be based in the DNR Parks and Trails and Fish and Wildlife Divisions, will be hired for most monitoring, baseline data collection and baseline report writing. Project staff will collaborate with all DNR divisions that administer conservation easements on Outcome 3 of Activity 2.

B. Project Impact and Long-term Strategy: Activity 1 of this project will develop and evaluate GIS tools that have the potential of reducing the amount of staff time needed to monitor conservation easements and to update riparian easement GIS shapes, which are used for easement monitoring and landowner identification. The tools also have other potential uses in connection with DNR land management. Activity 2 of project will address approximately 12% of DNR's unfunded conservation easement baseline property report backlog identified in the Phase I project.

C. Spending History:

Funding Source	**M.L. 2007 or FY08**	**M.L. 2008 or FY09**	**M.L. 2009 or FY10**	**M.L. 2010 or FY11**	**M.L. 2011 or FY12-13**
A $15,000 appropriation from the Legislature partially funded a minimum standards report	Ch. 57, art. 1, § 4, subd. 2				
A $520,000 appropriation from the ENRTF funded the Conservation Easement Stewardship and Enforcement Program Plan—DNR (Phase I)		Ch. 367, § 2, subd. 5(h)			
A $500,000 appropriation from the ENRTF funded the Conservation Easement Stewardship and Enforcement Program, Phase II					First Special Session, ch. 2, art. 3, § 2, subd. 4(m)

VIII. ACQUISITION/RESTORATION LIST: N/A

IX. MAP(S): N/A

X. RESEARCH ADDENDUM: N/A

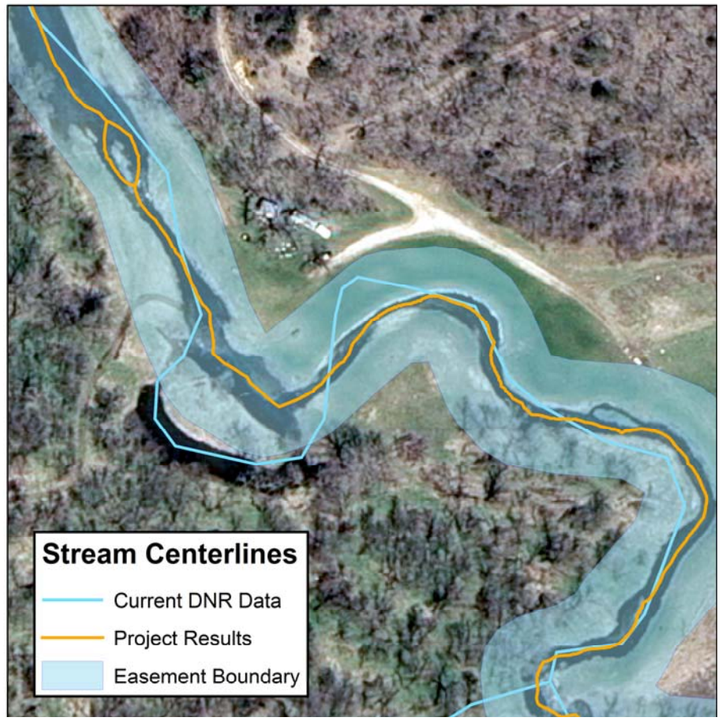
XI. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted not later than December 31, 2013, June 30, 2014, December 31, 2014, and June 30, 2015. A final report and associated products will be submitted between June 30 and August 15, 2015 as requested by the LCCMR.

Final Attachment A: Budget Detail for M.L. 2013 Environment and Natural Resources Trust Fund Projects									
Project Title: Conservation Easement Stewardship Program, Phase III									
Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 3(e)									
Project Manager: Don Kilberg									
M.L. 2013 ENRTF Appropriation: $200,000									
Project Length and Completion Date: June 30, 2015									
Date of Update: August 17, 2015									
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	**Revised Activity 1 Budget 12/19/2014**	**Amount Spent**	**Balance**	**Activity 2 Budget**	**Amount Spent**	**Balance**	**TOTAL BUDGET**	**TOTAL BALANCE**	
BUDGET ITEM	**Conservation Easement Remote Sensing**			**Monitoring, Baseline Data & Reports**					
Personnel (Wages and Benefits)	$63,988	$63,988	$0	$103,167	$103,188	-$21	$167,155	-$21	*
Project manager 1/6 FTE 2 yrs 72% salary/28% benefits (est. $25,156)						$0	$0	$0	
Project specialist .5 FTE 2 yrs 65% salary/35% benefits (est. $66,148)						$0	$0	$0	
2 project specialists/field staff .5 FTE up to 2 yrs 63% salary/37% benefits (est. 65,690)						$0	$0	$0	
Direct and Necessary Services for the Appropriation	$7,803	$7,584	$219	$7,803	$7,782	$21	$15,606	$240	
Travel expenses in Minnesota mileage, lodging, fleet, meals	$1,000	$511	$489		$0	$0	$1,000	$489	
Other			$0			$0	$0	$0	
Object based image analysis software license 1 yr	$6,246	$6,246	$0			$0	$6,246	$0	
High resolution satellite and leaf-off aerial imagery	$9,993	$9,993	$0			$0	$9,993	$0	
COLUMN TOTAL	**$89,030**	**$88,322**	**$708**	**$110,970**	**$110,970**	**$0**	$200,000	**$708**	
	* Due to rounding error in accounting adjustments								

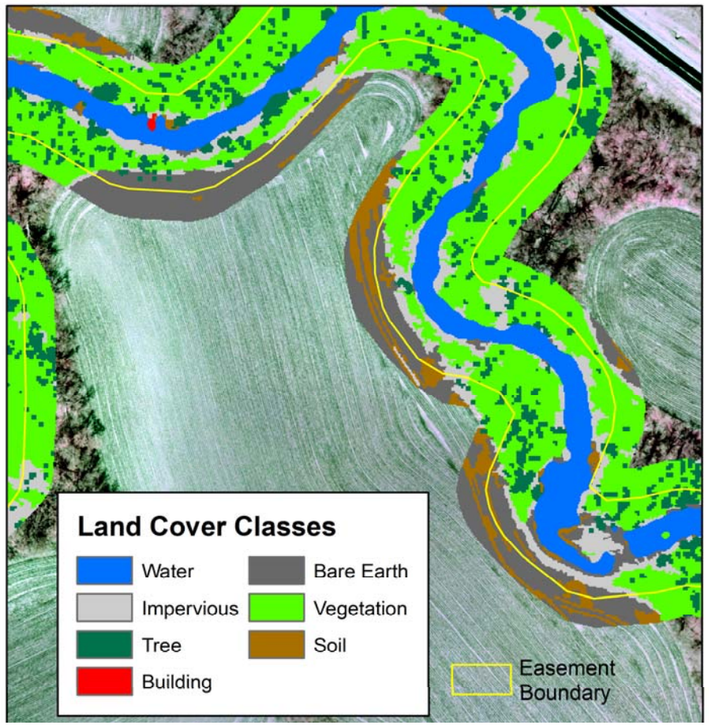
Conservation Easement Stewardship Program, Phase III

Develop and evaluate GIS tools to automatically adjust digital shapes of riparian conservation easements to changes in water courses



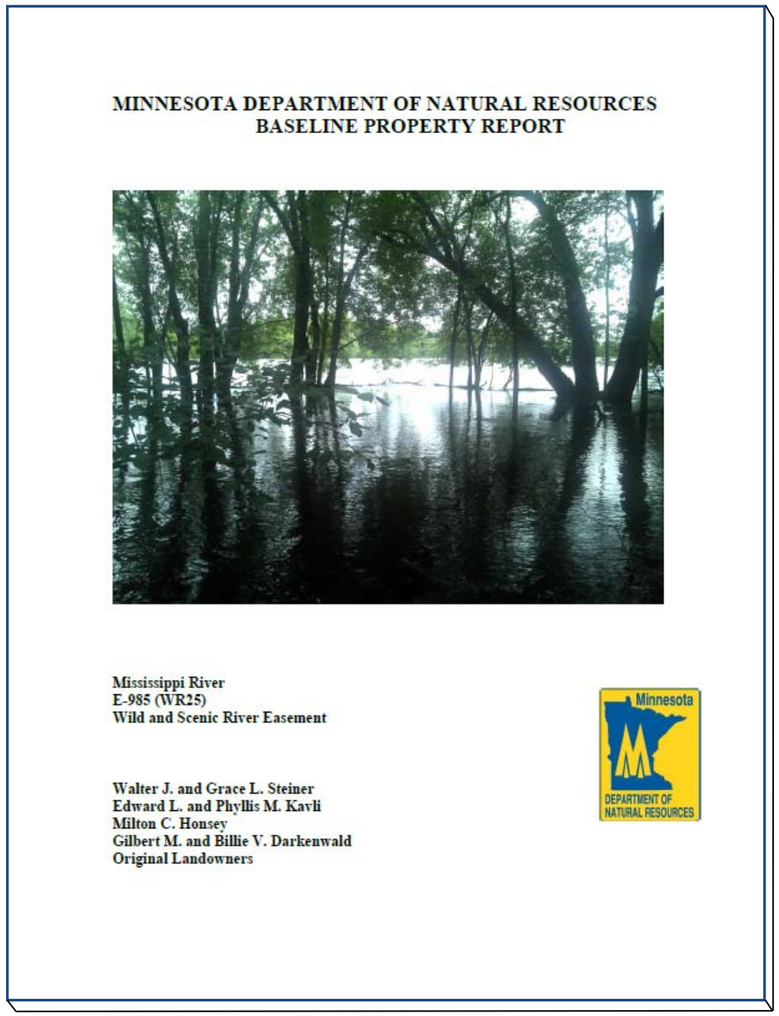
Statewide LiDAR is becoming outdated around riparian features due to natural flooding events. Staff developed a novel process to create stream centerlines from LiDAR using ArcGIS Hydrology tools and adjusting these centerlines to current stream positions based on recent optical imagery and object based image interpretation software. The solution developed by staff for this project may have direct application to the newly enacted riparian buffer legislation.

Develop and evaluate GIS tools to identify buildings, structures and conditions for special attention during monitoring visits.



Staff tested 3 different resolutions of imagery (6", 1/2 meter and 2 meter) along with available LiDAR to develop object based land cover classification in and around easement areas. This example clearly shows crop land (bare earth and soil) in the easement corridor. Possible violations such as this still require a field visit to confirm details, but this tool has the potential to reduce overall time to monitor easements and may be useful in enforcing the newly enacted riparian buffer legislation.

Monitor at least 75 existing conservation easements held by DNR and collect data for and prepare baseline property reports of those easements.


MINNESOTA DEPARTMENT OF NATURAL RESOURCES
BASELINE PROPERTY REPORT

Mississippi River
E-985 (WR25)
Wild and Scenic River Easement

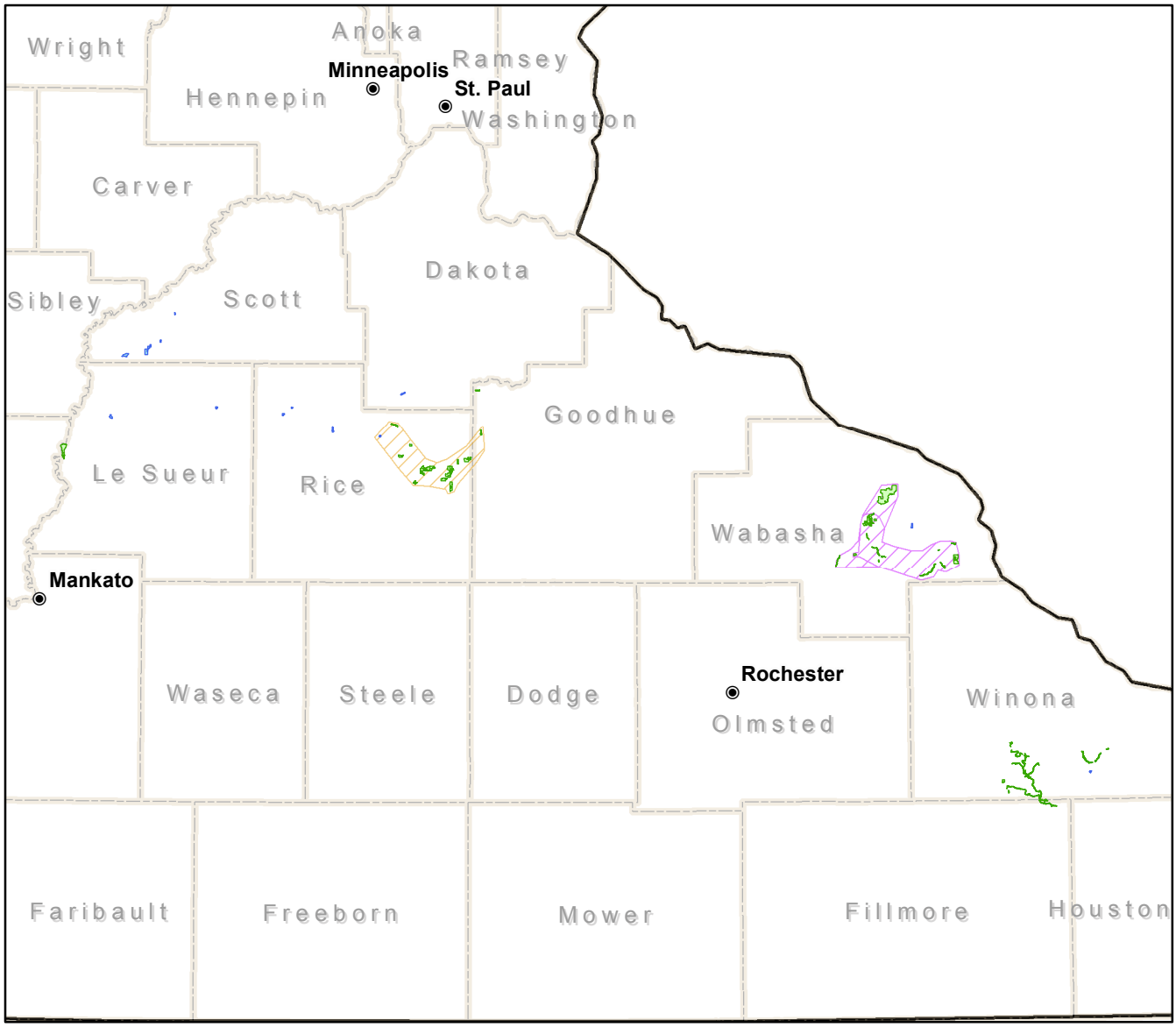
Walter J. and Grace L. Steiner
Edward L. and Phyllis M. Kavli
Milton C. Honsey
Gilbert M. and Billie V. Darkenwald
Original Landowners

Minnesota
DEPARTMENT OF NATURAL RESOURCES

Staff exceeded the target goal and created an additional 85 baseline property reports using project funding along with the tools developed during project phases I and II.

Conservation Easement Stewardship Phase III

Pleiades Satellite and Aerial Imagery Test Areas



Legend

- Eastern Satellite Test Area
- Western Satellite Test Area
- BWSR Easements
- DNR Easements

Western Satellite test area (104.7 SqKm in Rice county) contains 23 DNR easements and 1 BWSR easement

Eastern SatelliteTest Area (100.7 SqKm in Wabasha county) contains 20 DNR easements no BWSR easements

All easements on map also acquired on Forest Resources 4 band imagery:

DNR Easements-92
- Forest Legacy-22
- Native Prairie Banks-4
- SNA-2
- Other-1
- Trout Stream-60
- Fee-3

BWSR easements-16

Detailed Steps Accomplished in Activity 1

Each test easement is identified with its test region (East, West, South, MiscCentral, MiscSouth, MiscWest –see Attachment 4). Each of these test regions contains LiDAR imagery as well as a mix of satellite imagery, imagery provided by DNR Resource Assessment in Grand Rapids, and/or existing high resolution aerial imagery obtained from Steve Kloiber, Wetlands Monitoring Coordinator, DNR. eCognition software can automatically load the available and correct imagery into the workspace once the test area for the easement under study is identified. All of the imagery is clipped to a shape that is a 200 meter buffer beyond the boundary of the easement in question. This extra buffer ensures there are no "edge effects" that will distort the automatic processing of information around the easement.

Once workspace design was completed, staff began writing the program that processes the raw LiDAR clouds for each of the six study areas. These LiDAR clouds, funded by previous ENRTF projects, were obtained from the MnGEO website and a collection of thousands of points each identified with a location and elevation parameter. Staff utilized algorithms provided in the eCognition software to create Normalized Digital Surface Model (nDSM) raster images. These are an extremely important derivative from the LiDAR cloud that represents the height of any objects above ground level in the scene. It is derived by subtracting the last return for each LiDAR post from the first return for that post. A post represents a single pulse coming from the LiDAR in the aircraft (see Figure 1). Many pulses may bounce back to the airplane from each initial downward post. For example, if the post hits a tree, the first return may come back from a branch at the top of the tree, a second from a branch midway down the tree and the final pulse from the ground under the tree. By subtracting the last (ground) pulse elevation from the first (top of tree) elevation, we can derive the height of the tree. An example of a scene showing buildings near an easement boundary is included in Attachment 5.

What is LiDAR? (Light Detection and Ranging) is a remote sensing technology that collects 3-dimensional point clouds of the Earth's surface. This technology is being used for a wide range of applications including high-resolution topographic mapping and 3-dimensional surface modeling as well as infrastructure and biomass studies. Airborne LIDAR instrumentation uses a laser scanner with up to 400,000 pulses of light per second. The laser transmits pulses and records the time delay between a light pulse transmission and reception to calculate elevation values. These values are integrated with information from the aircraft's Global Positioning System (GPS) and orientation (pitch, roll, and yaw) data from inertial measurement technology to produce point cloud data.

Source: USGS- https://lta.cr.usgs.gov/LIDAR

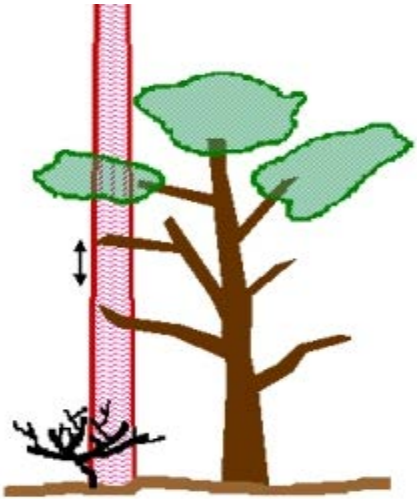


Figure 1 LiDAR Post from aircraft in red (Source: ASPRS)

Staff has written a program in eCognition's programming language to create the following LiDAR derived surfaces from the raw LiDAR Clouds:

- DEM digital elevation model represents elevation of bare earth in the scene
- DSM digital surface model-represents the elevation of the first pulse returned. In other words, the highest object found above bare earth
- nDSM normalized digital surface model-represents the height in meters of any objects found above ground and
- Intensity- showing the average intensity of returns to the aircraft sensor

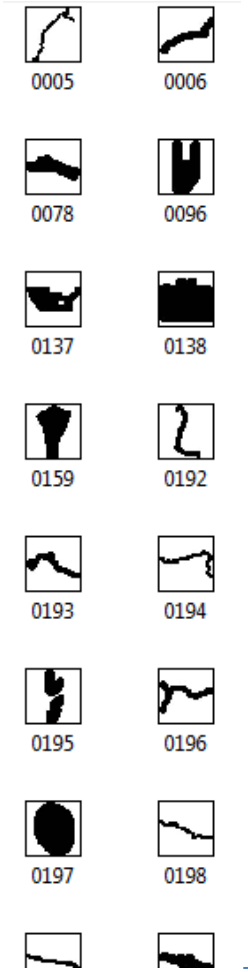
A copy of this program, also called a rule set, is Attachment 6. Staff has successfully created the DEM, DSM, nDSM and Intensity raster for each of the 143 easements being studied. Staff is currently in the process of modifying this rule set to create the optical imagery for each of the easements as well.

The project entails a considerable amount of image preparation for the imagery acquired from the aircraft as well as the Pleiades satellite. First, staff combined all of the individual aerial images taken in a given test region into a single mosaic data set for each type of aerial imagery in the project (Resource Assessment and Kloiber imagery). Because of how it is acquired and processed, LiDAR is considered the most accurate imagery being used in the project. Staff then made slight spatial adjustments to the two types of aerial imagery used in the project to ensure that each lines up exactly with the LiDAR imagery. Staff did additional processing to the Pleiades imagery to utilize the 0.6m panchromatic information to "pan-sharpen" the multispectral bands of the imagery which are 2.4m in resolution. This pan sharpening process results in distributing the spectral information contained in the 2.4 meter bands across the higher resolution 0.6 meter band. Staff then georeferenced the pan–sharpened image so it would display properly with other GIS information and layers. Finally, the georeferenced image was adjusted spatially so it would align exactly with the LiDAR layer. Staff has completed about 90% of the georeferencing of the Pleiades imagery. Staff estimates that about 75% of the total image preparation work has been completed for the project as of 12/19/2014.

Attachment 3

eCognition Workspace

Thumbnail of each of 142 test easements



West (24 Easements)

- Pleiades
- Kloiber Aerial
- Res Assess Aerial

MiscCentral (19 Easements)

- Kloiber Aerial

East (20 easements)

- Pleiades
- Kloiber Aerial
- Res Assess Aerial

MiscWest (13 Easements)

- Kloiber Aerial

MiscSouth (21 Easements)

- Kloiber Aerial

South(46 Easements)

- Kloiber Aerial
- Res Assess Aerial

For each thumbnail, Program creates LiDAR nDSM surface

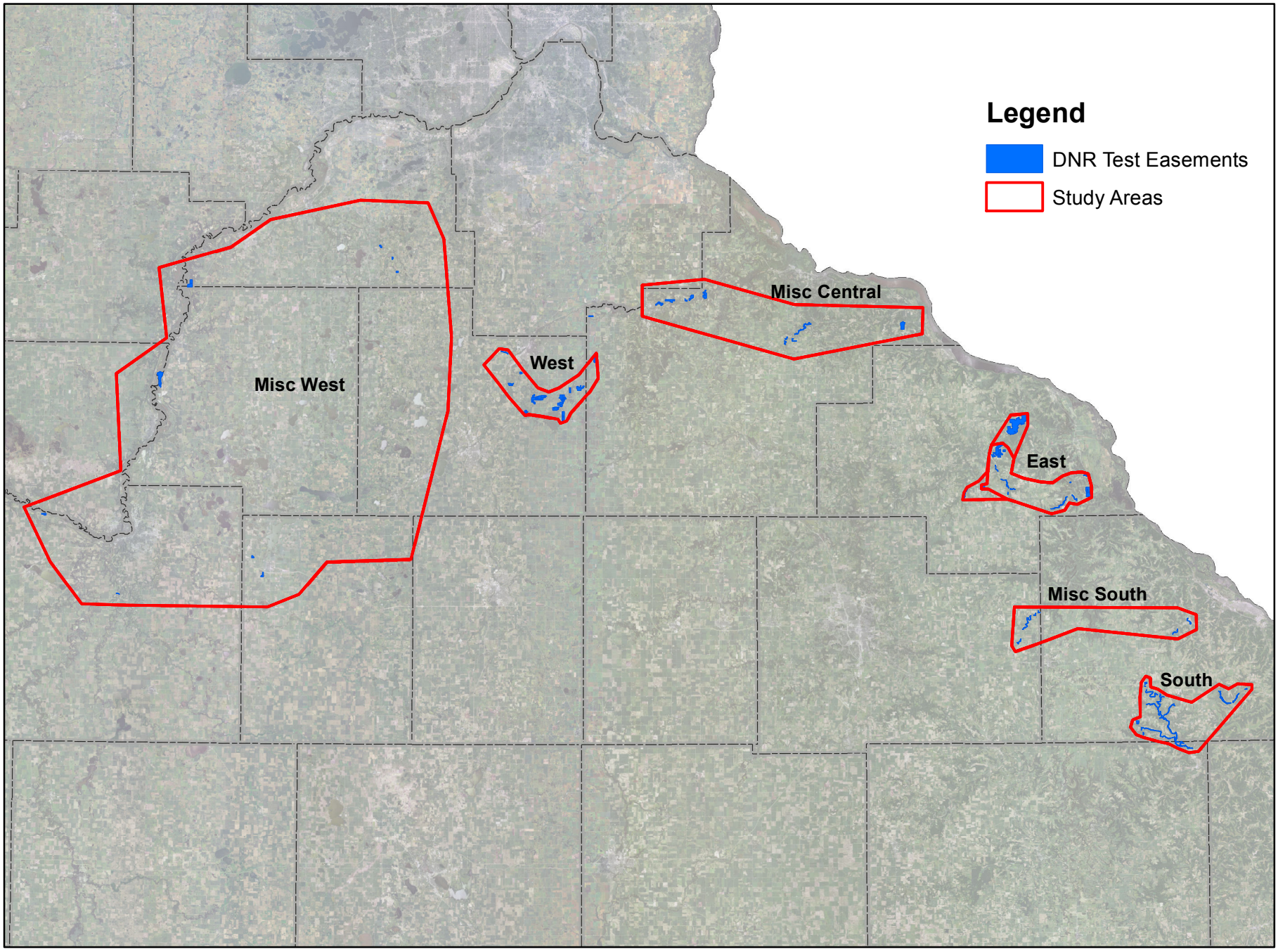
Program determines study area above and clips imagery for easement shape

Program examines nDSM and imagery for easement and looks for concerns

Conservation Easement Stewardship - Phase III Project

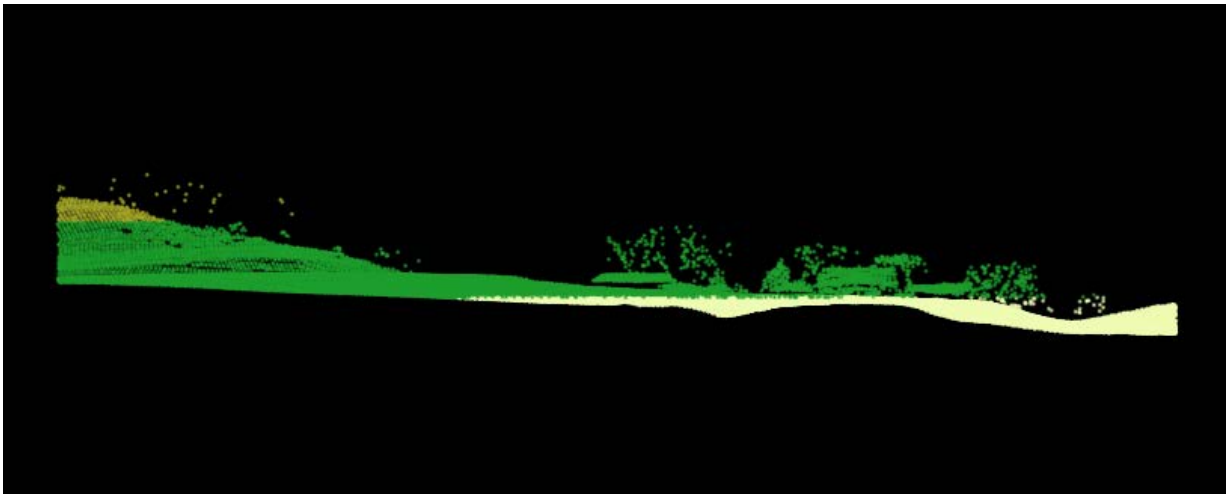
Attachment 4

Study Areas and Test Easements

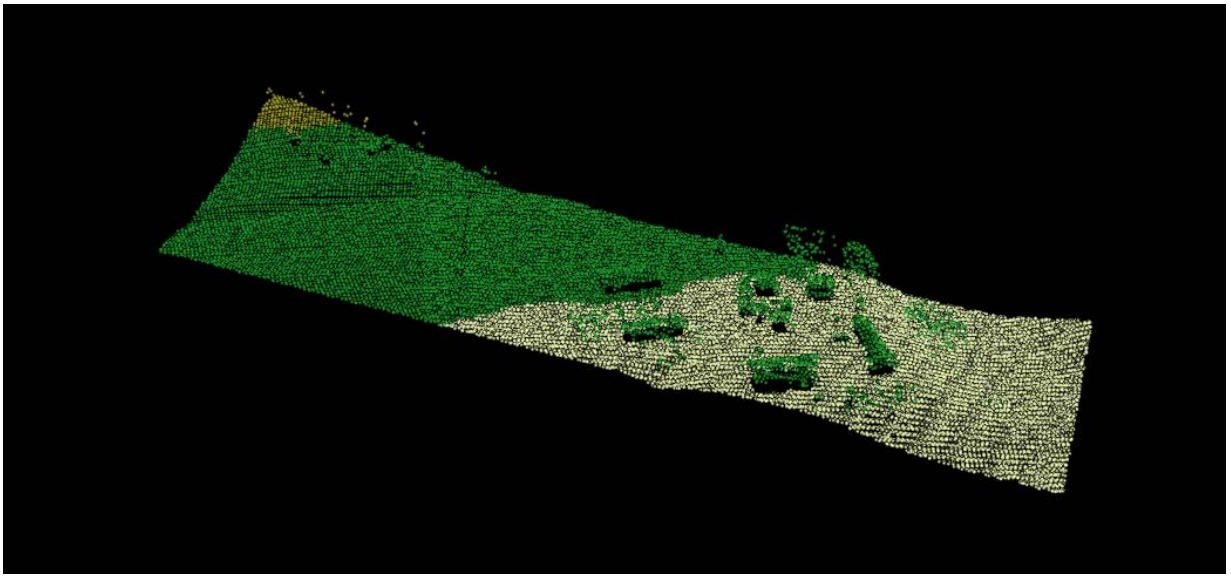


Attachment 5

Original scene with red selection box



Profile view along center red line



3D view of red selection box area

Attachment 6

eCognition rule set that will create DEM, DSM and nDSM surfaces surrounding each test easement from a LiDAR cloud

```
Classes:
   _Temp1
   Above Ground
   Building
   Impervious
   Tall
   Tree
   Water

Process: Main:
   \\ Reset
   \\
   Create surfaces from LiDAR
      Reset
         delete image object level: delete 'Level 1'
         delete layer: delete image layer 'nDSM'
         delete layer: delete image layer 'DSM'
         delete layer: delete image layer 'DEM'
         delete layer: delete image layer 'Blue'
         delete layer: delete image layer 'Red'
         delete layer: delete image layer 'Green'
         delete layer: delete image layer 'NIR'
         delete layer: delete image layer 'NDVI'
         delete layer: delete image layer 'LAS'
      Create Thematic easement Boundary
         set rule set options: set rule set options
         chessboard segmentation: chess board: 999999 creating 'Level 1'
         assign class: unclassified with "OBJECTID": DNR Easements > 0  at  Level 1: _Temp1
         pixel-based object resizing: 50x: _Temp1 at  Level 1: grow into unclassified
         merge region: _Temp1 at  Level 1: merge region
      \\ LAS Cloud processing
      Load LAS Cloud for Study Area
         \\ East
         if: if Smallest actual pixel value Selection = 1
            then: then
               create/modify project: create\modify project
               update variable: StudyArea = 1
            else: else
               \\ West
               if: if Smallest actual pixel value Selection = 6
```

```
            then: then
                create/modify project: create\modify project
                update variable: StudyArea = 6
            else: else
                \\ South
                \\
                if: if Smallest actual pixel value Selection = 5
                    then: then
                        create/modify project: create\modify project
                        update variable: StudyArea = 5
                    else: else
                        \\ MiscCentral
                        if: if Smallest actual pixel value Selection = 2
                            then: then
                                create/modify project: create\modify project
                                update variable: StudyArea = 2
                            else: else
                                \\ MiscSouth
                                if: if Smallest actual pixel value Selection = 3
                                    then: then
                                        create/modify project: create\modify project
                                        update variable: StudyArea = 3
                                    else: else
                                        \\ Misc West
                                        if: if Smallest actual pixel value Selection = 4
                                            then: then
                                                create/modify project: create\modify project
                                                update variable: StudyArea = 4
                                            else: else
                                                throw: throw: No Area
                                                update variable: StudyArea = 0
show user warning: show warning: StudyArea
DEM
    LiDAR file converter: LiDAR converter - write Elevation Average all returns on LAS  include class(2,8)
    chessboard segmentation: _Temp1 at  Level 1: chess board: 1
    assign class: _Temp1 with Mean DEM > 0  at  Level 1: unclassified
    merge region: _Temp1 at  Level 1: merge region
    fill pixel values: loop: _Temp1 at  Level 1: fill pixels in DEM using pixels classified as unclassified
    export image: export image to to DEM
DSM
```

LiDAR file converter: LiDAR converter - write Elevation Maximum first returns on LAS
chessboard segmentation: chess board: 1 creating 'Level 1'
assign class: with Mean DSM = 0 at Level 1: _Temp1
merge region: _Temp1 at Level 1: merge region
fill pixel values: loop: _Temp1 at Level 1: fill pixels in DSM using pixels classified as unclassified
export image: export image to to DSM
[DSM (Based on Mean instead of Max- Test only)]
LiDAR file converter: LiDAR converter - write Elevation Average first returns on
chessboard segmentation: chess board: 1 creating 'Level 1'
assign class: with DSMMean = 0 at Level 1: _Temp1
merge region: _Temp1 at Level 1: merge region
fill pixel values: loop: _Temp1 at Level 1: fill pixels in DSMMean using pixels classified as unclassified
nDSM
\\ We don't want any anomolous -ive values, so multiple both layers by 10 and subtract into an unsigned integer intermediate result layer
layer arithmetics: layer arithmetics (val "DSM*10 - DEM*10", layer nDSM16[16Bit unsigned])
\\ Then divide the result by 10. We get a raster with 0.1m resolution and no negative values
layer arithmetics: layer arithmetics (val "nDSM16\10", layer nDSM32[32Bit float])
export image: export image to to nDSM
Intensity
LiDAR file converter: LiDAR converter - write Intensity Average all returns on LAS
chessboard segmentation: _Temp1 at Level 1: chess board: 1
assign class: _Temp1 with Mean Intensity > 0 at Level 1: unclassified
merge region: _Temp1 at Level 1: merge region
fill pixel values: loop: _Temp1 at Level 1: fill pixels in Intensity using pixels classified as unclassified
export image: export image to to Intensity
set custom view settings: set custom view settings on all panes
[Add Optical Imagery layers]
create/modify project: create\modify project
create/modify project: create\modify project
create/modify project: create\modify project
create/modify project: create\modify project
[create/modify project: create\modify project]
[layer arithmetics: layer arithmetics (val "(NIR - Red)\(NIR + Red)", layer NDVI[32Bit float])]
set custom view settings: set custom view settings on all panes
[do]
multiresolution segmentation: 20 [shape:0.2 compct.:0.5] creating 'Level 1'
assign class: _Temp1 at Level 1: unclassified
assign class: unclassified with Mean nDSM >= 1 at Level 1: Above Ground
assign class: Above Ground with Mean NDVI >= 0.3 at Level 1: Tree
assign class: Above Ground with Rectangular Fit >= 0.93 at Level 1: Building

assign class: _Temp1, unclassified with Mean nDSM >= 3 at Level 1: Tall
merge region: _Temp1 at Level 1: merge region
assign class: _Temp1 with Rectangular Fit < 0.9 at Level 1: Tall
assign class: unclassified at Level 1: Impervious
assign class: unclassified with Mean NDVI <= 0 and Brightness <= 60 at Level 1: Water