Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2016 Work Plan

Date of Report: June 02, 2016

Date of Next Status Update Report: January 1, 2017

Date of Work Plan Approval: June 7, 2016

Project Completion Date: June 30 2019

Does this submission include an amendment request? No

PROJECT TITLE: Development of Innovative Cost-Saving Methodology for Forest Inventory

Project Manager: Dennis Kepler

Organization: Minnesota Department of Natural Resources

Mailing Address: 483 Peterson Road

City/State/Zip Code: Grand Rapids, MN. 55744

Telephone Number: (218) 322-2512

Email Address: dennis.kepler@state.mn.us

Web Address:

Location: Northern Cass County

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$800,000**
	Amount Spent:	**$0**
	Balance:	**$800,000**

Legal Citation: M.L. 2016, Chp. 186, Sec. 2, Subd. 03o

Appropriation Language:

$800,000 the second year is from the trust fund to the commissioner of natural resources to develop and pilot a new and more cost-effective methodology for an enhanced stand-based forest inventory, with the goal of extending the methodology statewide. This appropriation is available until June 30, 2019, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Development of Innovative Cost-Saving Methodology for Forest Inventory

II. PROJECT STATEMENT: Minnesota has an extensive and diverse forest land base important to multiple agencies and stakeholders, such as the U.S. Forest Service, DNR, counties, tribes, non-government organizations, and private citizens. **Using cutting-edge technologies, a less expensive and highly robust inventory of the forest land base will be developed through a pilot study across a diverse ecological landscape with multiple ownerships.** This pilot will assess methodology, accuracy, and costs, to evaluate the anticipated extension of this methodology statewide. After evaluation, we fully expect to establish and implement this cutting-edge inventory, thereby eliminating the need to return to the ENRTF for forest inventory funding.

➢ All agencies and stakeholders rely on forest inventory data for a wide variety of natural resource management purposes, including: assessing climate and landscape change, ecosystem fire and health risks, wildlife habitat, water resources, forest recreation, biomass estimations, and renewable timber assessments.
➢ Costs for accomplishing such forest inventories are increasingly expensive -- over $35 million is needed to inventory just the 5 million acres of DNR forest land, out of Minnesota's 17 million acres of forest land.
➢ Forest inventories are completed once every 10 to 20 years, making it difficult to respond to emerging issues.
➢ Technological advances in remote sensing and computing have now made it possible to rapidly collect, analyze, and characterize, in detail, ecological condition over large landscapes with very little ground data.
➢ Given these advancements, it is now possible to refine and apply these technological improvements to develop a revolutionary methodology for statewide forest inventory across diverse types of land ownerships.
➢ Ultimately, this project will demonstrate a highly effective, detailed, and robust method of achieving a comprehensive, accurate and regularly updated forest inventory at dramatically lower costs for the state.

The goal of this project is to create an updated, efficient, and revolutionary forest inventory technique by:
1. Developing a stand based forest inventory, including species composition, detailed attributes of the vegetation and forest structure, and characteristics that relate to wildlife and ecological habitat suitability.
2. Estimating a suite of tree attributes per stand (e.g., height, diameter at breast height (DBH), crown size, age, basal area, biomass, and volume) that relate to those ecological suitability characteristics.

Both the stand characteristics in (1) and the tree estimates in (2) are generated by acquiring cutting-edge, high density LiDAR data in concert with aerial and sub-meter satellite imagery and fewer, more detailed field reference information. The proposed work uses and builds on other recent ENRTF-funded projects such as Improved Rapid Forest Ecosystem and Habitat Inventory (Ek 2013), Mapping Landscapes for Better Land and Water Management (Knight et al. 2014), and the statewide light detection and ranging (LiDAR).

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of January 31, 2017:

Project Status as of July 31, 2017:

Project Status as of January 31, 2018:

Project Status as of July 31, 2018:

Project Status as of January 31, 2019:

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Acquisition, processing, and utilization of remotely sensed and ground data
Description: We will use an object-based individual forest stand segmentation (polygon mapping) approach with newly acquired high density LiDAR (this proposal) and other remotely sensed imagery to identify a suite of forest

2

stand attributes and tree estimates. Each stand will be populated with detailed forest metrics using a statistical imputation process developed by Dr. Alan Ek derived from newly collected and existing inventory data. The pilot project area will consist of 500,000 acres across multiple landowners in northern Cass County. The LiDAR cost estimate is based on information from several possible vendors currently acquiring this type of data. Because remote sensing technologies change very quickly, the cost of the LiDAR acquisition may be less than our current estimate. Therefore, if LiDAR acquisition costs are less than the expected $375K, we would ask that those dollars be reallocated, through the amendment process, to either additional remote sensing analysis (activity 1) or more outreach and analyses of the methodology (activity 3).

Summary Budget Information for Activity 1:   **ENRTF Budget:** $ 653,532
                                                    Amount Spent: $ 0
                                                         Balance: $ 653,532

Outcome	Completion Date
1. Acquire high density LiDAR data for 500,000 acres in the pilot study area ($0.75/acre)	October 2016
2. Segment the forested land-cover data to individual stand polygons	April 2017
3. Develop forest stand metrics based on imputation with existing plots	June 2018
4. Develop stand metrics based on new LiDAR data	February 2019

Activity Status as of January 31, 2017:

Activity Status as of July 31, 2017:

Activity Status as of January 31, 2018:

Activity Status as of July 31, 2018:

Project Status as of January 31, 2019:

Final Report Summary:

ACTIVITY 2: Relating field plot data to remotely sensed data for tree level forest metrics
Description: Extensive plot information will be collected (~300 plots) across the project pilot area to build a strong relationship between ground reference data and high density LiDAR and other imagery. We will use this large dataset to examine the use of Alan Ek's imputation methodology to populate stand inventory with detailed tree attributes pertinent to wildlife and ecological applications. A sample of these plots will also be assessed with very high resolution aerial photography taken from an unmanned aerial system (UAS) provided by partners at Northland Community and Technical College (NCTC) to assess the cost savings for such a data collection method. Additional plots will be collected by County, Forest service, and other DNR Division personnel for in-kind contributions.

Summary Budget Information for Activity 2:   **ENRTF Budget:** $ 134,825
                                                    Amount Spent: $ 0
                                                         Balance: $ 134,825

Outcome	Completion Date
1. Establish and collect field plot data for use with LiDAR and imagery data (Fig. 1)	September 2017
2. Training and verification of new and existing LiDAR data and imputation on new field data	June 2018

3

3. Acquisition of very high resolution photography via UAS, including training, verification, and analysis of this imagery with LiDAR and imputation from field data (performed by NCTC)	December 2017

Activity Status as of January 31, 2017:

Activity Status as of July 31, 2017:

Activity Status as of January 31, 2018:

Activity Status as of July 31, 2018:

Project Status as of January 31, 2019:

Final Report Summary:

ACTIVITY 3: Analyses of the methodology: comparing accuracies, cost, and value
Description: To determine cost savings and identify overall efficiencies and information gains achieved using the above approaches, a simple cost-benefit analysis and a simple accuracy assessment will be conducted to compare traditional inventory methods to our use of high density LiDAR and high resolution imagery using fewer ground reference plots. Additionally, a brief report will be written to discuss our results.

Summary Budget Information for Activity 3:	**ENRTF Budget:**	**$ 11,643**
	Amount Spent:	**$ 0**
	Balance:	**$ 11,643**

Outcome	Completion Date
1. Develop a cost-benefit analysis comparison to forest inventory methods from 2010-2015	June 2018
2. Develop a manual with protocols for practical application	May 2019
3. Submit final reports, including methods of outreach and technology transfer	June 2019

Activity Status as of January 31, 2017:

Activity Status as of July 31, 2017:

Activity Status as of January 31, 2018:

Activity Status as of July 31, 2018:

Project Status as of January 31, 2019:

Final Report Summary:

V. DISSEMINATION:
Description: we will conduct an analysis of the newly acquired high density LiDAR and any high resolution aerial photography with the 300 newly acquired field plots and whatever existing plot data is easily accessed and statistically/spatially accurate. If possible, all of the newly acquired data will be provided free to the public and will be hosted through the most effective acceptable internet website (e.g., http://www.mngeo.state.mn.us/, https://gisdata.mn.gov/). A brief report will be prepared to summarize the project research and development, including a condensed version of an accuracy assessment.

4

Activity Status as of January 31, 2017:

Activity Status as of July 31, 2017:

Activity Status as of January 31, 2018:

Activity Status as of July 31, 2018:

Project Status as of January 31, 2019:

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:
A. ENRTF Budget Overview:

Budget Category	$ Amount	Overview Explanation
Personnel:	$ 261,517	DNR project manager: 8% FTE for 3-yrs. ($32,020), remote sensing analyst 1: 36% FTE for 3-yrs. ($94,000), remote sensing analyst 2: 22% for 3-yrs. ($79,400), biometrician: 3% FTE for 3-yrs. ($10,037), forester: 4% FTE for 3-yrs. ($13,060), and 6 interns: 1.15 FTE for 1-yr. ($33,000).
Professional/Technical/Service Contracts:	$ 435,650	Acquisition of remotely sensed data, high density LiDAR data & possibly aerial photography, over ~500,000 acres in northern Cass County ($375,000); technical contract with UofM to segment the remote sensing data into stands ($50,000); technical contract with Northland Technical College to collect high resolution imagery using Unmanned Aerial Systems ($10,650)
Equipment/Tools/Supplies:	$	
Capital Expenditures over $5,000:	$ 45,000	Purchase 3-survey grade GPS units to tie field plot data to LiDAR data ($30,000), purchase developer eCognition software for LiDAR classification ($15,000)
Travel Expenses in MN: *	$ 33,400	Activity1 ($0), meetings and outreach for project manager and remote sensing analysts; Activity2 ($33,400), forester and interns field work; Activity3 ($0), meetings and outreach for project manager and biometrician.
Other: DNR direct & necessary **	$ 24,433	Costs cover HR support ($4,860), Safety Support ($1,146), Financial Support ($10,009), Communication Support ($1,236), IT Support ($6,119), Planning Support ($829), Procurement Support ($235).
TOTAL ENRTF BUDGET:	**$ 800,000**	

Explanation of Use of Classified Staff: This funding will be used to pay project-associated costs for classified and unclassified staff paid with special project funds. Each year these positions are assigned work based on the particular combination of soft funding available to address DNR Program activities. These classified positions (Project Manager, Remote Sensing Analysts, Biometrician, and Forester) are all currently available within RA and paid through independently funded project assignments. The Biometrician position and one Remote Sensing Analyst position are currently vacant and soon to be filled. Resource Assessment (RA) is a government enterprise within the DNR Division of Forestry per statute 89.421. This LCCMR project and the LCCMR funding structure are both well suited to enhance RA's soft funded project based business model, staffing structure, professional expertise and future forest inventory service potential.

Explanation of Capital Expenditures Greater Than $5,000: For accurate results, survey grade GPS's are critical in connecting field plots to high density LiDAR. eCognition software is a major component to accurately and successfully segment and classify aerial imagery and LiDAR data.

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: Professional staff: ~0.8 average FTE's per year over the 3-year grant period (~2.4 FTE's total), temporary forest interns: ~1.15 FTE for 1-year, total number of FTE's funded by this grant is ~3.5.

*Overall travel expenses changed significantly for both professional outreach and field work; the elimination of meetings and outreach for the Project Manager, Remote Sensing Analysts, and Biometrician resulted in a $7,000 reduction, and the reduction in field plots decreased overall field assessment work from $57,000 to $33,400. The total reduction in travel expenses is $30,600. Total travel expenses are all field work for the Forestry interns and the Forester training and assessing the data collection

**DNR's direct and necessary costs cover HR support ($4,860), Safety Support ($1,146), Financial Support ($10,009), Communication Support ($1,236), IT Support ($6,119), Planning Support ($829), Procurement Support ($235) that are necessary to accomplishing funded programs/projects.

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

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
Cass County	$30,000	$0	Contribution to LiDAR acquisition.
Cass County	$10,000	$0	In-kind inventory and QA field work.
Chippewa National Forest	$20,000	$0	In-kind inventory and QA field work.
Fish & Wildlife Service	$20,000	$0	In-kind sub-meter satellite imagery + contribution for LiDAR data.
State			
	$	$	
TOTAL OTHER FUNDS:	**$80,000**	**$0**	

VII. PROJECT STRATEGY:
A. Project Partners: Collaborators include the University of Minnesota, providing expertise, resources, and staff time (professors Alan Ek, Joe Knight, and Michael Falkowski); U.S. Fish & Wildlife Service providing free sub-

6

meter satellite imagery and feedback; Chippewa National Forest and Cass County Land Department will also be giving in-kind and financial support; Northland Community and Technical College will provide high resolution imagery via UAV; and the Minnesota Forest Resources Council will be providing a venue for information dissemination and feedback; Ronald McRoberts from the USFS Northern Research Station will also provide analytical and feedback support.

B. Project Impact and Long-term Strategy: The long-term strategy is to benefit Minnesota's natural resource stakeholders by developing a revolutionary, enhanced forest inventory method at a significantly reduced cost that can be used across all ownerships. This project will enable Minnesota to continue its leadership role of using emerging technologies to collect and maintain modern and valuable information for a plethora of natural resource management objectives. It also coincides well with other long-term initiatives, such as the permanent plots being established by DNR project partners in the 2016 ENRTF proposal; *A statewide Monitoring Network for Changing Habitats in Minnesota.*

C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	$ Amount
General Fund (1000) and Forest Management Investment Account (2113): AC1:23402-FOR Forest Inventory Direct Activity Charge ($407,415), Areas CSA Inventory General Operations & Admin Allocation ($309,432), FOR Resource Assessment CSA Inventory amount; AC1: FY15=23700 ($310,000)	July 1, 2014 – June 30, 2015	$ 1,026,848
General Fund (1000) and Forest Management Investment Account (2113): AC1:23402-FOR Forest Inventory Direct Activity Charge ($382,290), Areas CSA Inventory General Operations & Admin Allocation ($297,039), FOR Resource Assessment CSA Inventory amount; AC1: FY14=23700 ($238,566)	July 1, 2013 – June 30, 2014	$ 917,896
General Fund (1000) and Forest Management Investment Account (2113): AC1:23402-FOR Forest Inventory Direct Activity Charge ($170,024), Areas CSA Inventory General Operations & Admin Allocation ($130,918), FOR Resource Assessment CSA Inventory amount; AC1: FY13=23654 ($233,058)	July 1, 2012 – June 30, 2013	$ 534,000

7

Environment and Natural Resources Trust Fund

M.L. 2016 Project Budget

Project Title: Development of Innovative Cost Saving Methodology for Forest Inventory

Legal Citation: M.L. 2016, Chp. 186, Sec. 2, Subd. 03o
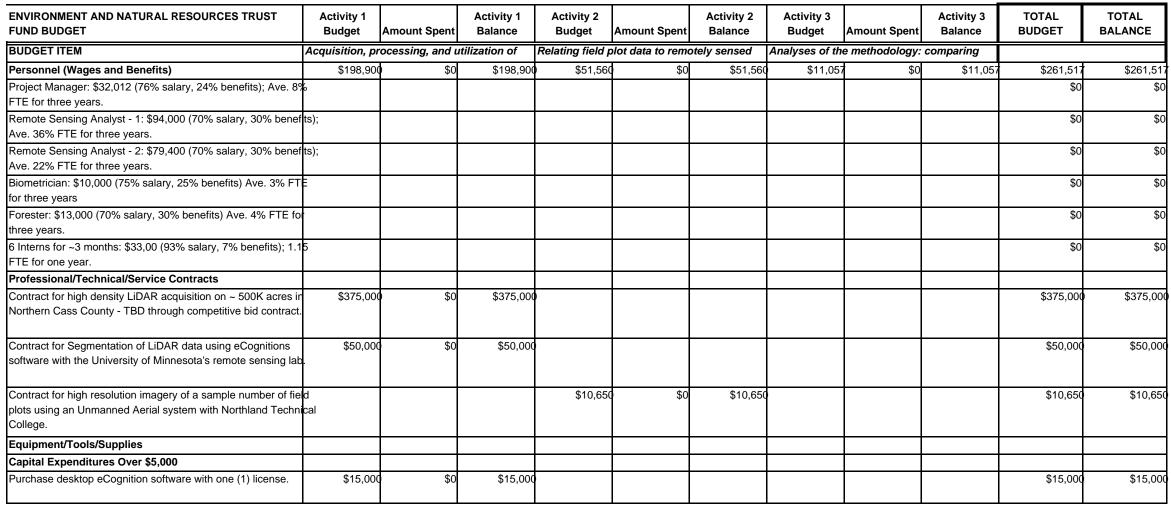
Project Manager: Dennis Kepler

Organization: Department of Natural Resources, Division of Forestry, Resource Assessment
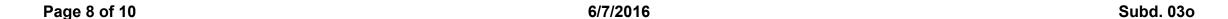
M.L. 2016 ENRTF Appropriation: $800,000

Project Length and Completion Date: 3 Years, June 30, 2019

Date of Report: June 02, 2016

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	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	*Acquisition, processing, and utilization of*			*Relating field plot data to remotely sensed*			*Analyses of the methodology: comparing*				
Personnel (Wages and Benefits)	$198,900	$0	$198,900	$51,560	$0	$51,560	$11,057	$0	$11,057	$261,517	$261,517
Project Manager: $32,012 (76% salary, 24% benefits); Ave. 8% FTE for three years.										$0	$0
Remote Sensing Analyst - 1: $94,000 (70% salary, 30% benefits); Ave. 36% FTE for three years.										$0	$0
Remote Sensing Analyst - 2: $79,400 (70% salary, 30% benefits); Ave. 22% FTE for three years.										$0	$0
Biometrician: $10,000 (75% salary, 25% benefits) Ave. 3% FTE for three years										$0	$0
Forester: $13,000 (70% salary, 30% benefits) Ave. 4% FTE for three years.										$0	$0
6 Interns for ~3 months: $33,00 (93% salary, 7% benefits); 1.15 FTE for one year.										$0	$0
Professional/Technical/Service Contracts											
Contract for high density LiDAR acquisition on ~ 500K acres in Northern Cass County - TBD through competitive bid contract.	$375,000	$0	$375,000							$375,000	$375,000
Contract for Segmentation of LiDAR data using eCognitions software with the University of Minnesota's remote sensing lab.	$50,000	$0	$50,000							$50,000	$50,000
Contract for high resolution imagery of a sample number of field plots using an Unmanned Aerial system with Northland Technical College.				$10,650	$0	$10,650				$10,650	$10,650
Equipment/Tools/Supplies											
Capital Expenditures Over $5,000											
Purchase desktop eCognition software with one (1) license.	$15,000	$0	$15,000							$15,000	$15,000

Activity											
Purchase three (3) survey grade GPS units to be used by field crews to accurately tie the field data to the high density LiDAR data.				$30,000	$0	$30,000				$30,000	$30,000
Travel expenses in Minnesota											
In-state travel expenses: fleet ($4,160), lodging ($17,000), and meals ($12,240) for interns & Forester field reconnaissance.	$0	$0	$0	$33,400	$0	$33,400	$0	$0	$0	$33,400	$33,400
DNR's direct and necessary costs cover HR support ($4,860), Safety Support ($1,146), Financial Support ($10,009), Communication Support ($1,236), IT Support ($6,119), Planning Support ($829), Procurement Support ($235) that are necessary to accomplishing funded programs/projects.	$14,632	$0	$14,632	$9,215	$0	$9,215	$586	$0	$586	$24,433	$24,433
COLUMN TOTAL	$653,53	$0	$653,53	$134,82	$0	$134,82	$11,64	$0	$11,64	$800,00	$800,00

6/7/2016