



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

Date of Status Update Report: October 2, 2012

Date of Next Status Update Report: January, 2014

Date of Work Plan Approval:

Project Completion Date: June 30, 2015

Is this an amendment request? No

PROJECT TITLE: Rapid Forest Ecosystem and Habitat Inventory by Imputation

Project Manager: Alan R. Ek

Affiliation: Department of Forest Resources,
College of Food, Agricultural and Natural Resource Sciences
University of Minnesota

Mailing Address: 1530 Cleveland Avenue N., Rm 115

City/State/Zip Code: St. Paul, MN 55108

Telephone Number: (612) 624-3098

Email Address: aek@umn.edu

Web Address: <http://www.forestry.umn.edu>

Location: Statewide

Total ENRTF Project Budget:

ENRTF Appropriation: \$262,000

Amount Spent: \$0

Balance: \$262,000

Legal Citation: M.L. 2013, Chp. xx, Sec. xx, Subd. xx

Appropriation Language:

DRAFT

I. PROJECT TITLE: Rapid Forest Ecosystem and Habitat Inventory by Imputation

II. PROJECT STATEMENT: Minnesota has 15.9 million acres of timberland managed in large part by county, state and federal agencies and private landowners. The breakdown of this ownership per the 2011 USDA Forest Service Forest Inventory and Analysis (FIA) reporting is:

County & Municipal	2,649,098
State	3,683,398
National Forest	1,841,155
Other Federal	205,137
Other local government	6,837
Private including forest industry	<u>7,543,346</u>
Total	15,928,971 acres

Additionally, 12.5 million acres of this timberland lies in northern Minnesota. Further, most of the private acreage is in small private ownerships; forest industry timberland acreage comprises approximately 5% of the total timberland acres.

Forest inventory is a major concern of all of these ownerships with the county, state and national forest and forest industry ownerships actively involved with using these data. Additionally, there is increasing interest in inventory data for small private ownerships. This project addresses these forest inventory interests with emphasis on county and state lands. However, the methodology will be applicable to and benefit all ownerships as the project databases are developed and the methodology adopted.

Why the emphasis on forest inventory? Forest management is for diverse purposes including timber, wildlife habitat, and ecological considerations. Yet much of the forest inventory data for management is too far out of date for efficient operations and effective planning for sustainability. Why? Because forests are continually changing through natural and human processes such as succession, growth, mortality and harvesting.

For most agency users, the typical once per decade cost and time of inventory efforts have become prohibitive and effectively precluded regular attention to such data collection, despite their importance to forest management. This project examines and develops a new approach to forest inventory to dramatically reduce costs, speed updates and improve usability. The primary benefits of the project will be a savings of approximately one-half of the typical inventory effort, capability for rapid inventory updates to current conditions, increased data detail and commonality in describing forest conditions, and improved projection capability and planning (for future decades).

Three types of forest inventory efforts are common in practice:

(1) *Statewide strategic inventories*—such as the US Forest Service Forest Inventory and Analysis (FIA) program which has established and re-measures a large number of permanent field plots on an annual basis across each state annually. In Minnesota the FIA program has 6,139 such plots with 1/5th re-measured annually. Further, this data is readily available and free. FIA describes overall forest conditions and FIA plots are the gold standard for field data. However, the FIA sample size does not provide for localized map detail.

(2) *Map based inventories*—MnDNR and county inventories map each forest stand (a polygon) and describe them by covertype, site quality, age or size class, ecological conditions plus timber characterizations, as determined by several to many field plot measurements in most if not all stands. These inventories provide the operational detail needed for ownership wide forest management for sustainability and diverse other purposes. However, it has become increasingly difficult for agencies to fund such efforts.

(3) *Timber sale appraisals*—typically intensive examinations of specific mature forest stands or sale units. These are precise and detailed assessments of stand conditions and sale quantities for establishing and administering a sale. In any one year, there may be many such sales in similar forest conditions, e.g., 45-50 year old aspen stands.

Because of their large size and considerable tree, stand and ecological detail, FIA field measurement costs are typically \$200-\$300+ per plot. While individual map based inventory field plots are smaller and cost much less (\$30-\$60 each), each agency may employ thousands of these plots at rates of 1-10 per stand. This reality has slowed the frequency of updates for map based inventories. Appraisals utilize numerous plots in each stand or sale or may record data on each tree and the conditions affecting harvesting operations and follow up.

Research hypothesis:

This project recognizes that the map based inventories can be broken into two parts: (1) updating maps and (2) measurements on field plots. Further, we *hypothesize* the latter, the most expensive part, can largely be replaced using FIA data correlated with stand map classifications by covertype, site quality, age or size class, etc. Here we assume state of the art and practice remote sensing and GIS inputs. In fact, FIA data provide stand classifications in much the same way that map based inventories classify stands. Thus the detailed measurement data from FIA plots may be imputed to “similar” stands classified and mapped on specific ownerships. Additional sources of data for imputation are past inventory stand classifications and timber sale appraisals. Such imputation is possible because per acre averages for many covertype, site quality, and stand age groupings (classifications) will not change appreciably with time. The key question is the precision and accuracy of the imputation for various management and planning purposes.

Should these study results prove truly useful, the savings in field data collection efforts would dramatically reduce map based inventory costs and time and allow for much more frequent inventory updates—and increased usage of such data in operations and planning. The attached graphic illustrates the concept. Additionally, forest covertype and size class are often key predictors of forest habitat values and ecological conditions. Thus imputation based on existing data could add considerably to the description of habitat and ecological considerations for many stands and ultimately over large areas. Finally, the focus on FIA and other precisely measured plot and stand data provides the opportunity to employ high quality, standardized and detailed information at very low cost.

III. PROJECT STATUS UPDATES:

Project Status as of (January 15, 2014):

Project Status as of (September 15, 2014):

Project Status as of (February 15, 2015):

Project Status as of (June 30, 2015):

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Assemble data--map based forest stand inventory data from cooperating agencies and FIA data statewide, including timber, habit and ecosystem data.

Description: FIA data will be assembled for use in imputation trials. These data will include all FIA plot data statewide from inventory dates encompassing 1977, 1990, 2003, 2008 and 2012. Past and recent forest inventory (plot and/or stand data) data from cooperating agencies will also be assembled for at least a large county (St. Louis), a small county (Carlton) and MnDNR Forestry state lands in northern Minnesota. We anticipate the MnDNR will be able to provide an old and a recent inventory for some parts of the state. We further anticipate such data being available from at least three additional counties. In at least two counties data will be available from an old and a recent inventory. We expect the MnDNR and these counties will also be able to provide recent timber sale appraisal data. Data from additional counties will also be assembled as available and time permits. As an added test of methodology, 1959, 1964, 1976, 1982, 1990 and 2000 permanent plot inventory data from the University of Minnesota Cloquet Forestry Center (CFC) will be included. We also anticipate the data assembled here will have descriptions and formats sufficient to allow analysis as described in Activity 2. However, we expect to visit and/or otherwise contact these sources to ensure the understanding of data descriptions and formats. Ultimately, we seek to create one large database for the entire project, specifically to speed trials as described in Activity 2 and 3.

Summary Budget Information for Activity 1:**ENRTF Budget: \$ 61,000****Amount Spent: \$ 0****Balance: \$ 61,000****Activity Completion Date:**

Outcome	Completion Date	Budget
1. Collection of FIA, county, state and university data files for inventories and appraisals, etc. for the subject study areas and dates.	November 2013	\$ 31,000
2. Verification, data processing/organization and preparation of these data for subsequent trials.	January 2014	\$ 30,000

Activity Status as of (January , 2014):**Activity Status as of (September 2014):****Activity Status as of (February 2015):****Activity Status as of (June 2015):****Final Report Summary:****ACTIVITY 2: Evaluate the precision and accuracy--of imputation for forest ecosystem and habitat description, including additional map attributes that may improve imputation.**

Description: Imputation trials will be conducted to test the statistical precision and accuracy of imputation of FIA data, past and recent inventory data, appraisal data, and other data sources to estimate key attributes of the mapped polygons on county and state lands. Precision and accuracy will be developed for actual field plot data and imputation results for the subject polygons for a range of measurements or observations that might be desired as part of the field data. To the extent that imputation provides useful precision and increased detail and at a much reduced cost for forest covertype by age by site class estimates, the methodology will be successful and widely adopted. Results will be developed separately for FIA data, past and recent inventory data, and timber appraisal data. With FIA and perhaps other data, we will also examine the utility of imputing habitat and ecological classification data. A last step will be evaluation of existing map and remote sensing data that may further improve imputation.

Summary Budget Information for Activity 2:**ENRTF Budget: \$ 91,000****Amount Spent: \$ 0****Balance: \$ 91,000****Activity Completion Date:**

Outcome	Completion Date	Budget
1. Trials of imputation from FIA to map based inventories.	June 2014	\$ 35,000
2. Incorporation of appraisal, past inventory data, etc. to further improve imputation.	September 2014	\$ 32,000
3. Evaluation of existing and potential map data that can improve imputation ((including remote sensing (e.g., lidar) and thematic map inputs).	February 2015	\$ 24,000

Activity Status as of (January , 2014):**Activity Status as of (September 2014):****Activity Status as of (February 2015):****Activity Status as of (June 2015):**

Final Report Summary:

ACTIVITY 3: Evaluate the practical utility--and savings of imputed inventory data.

Description: This analysis will examine results for forest inventory and planning across the subject county and state areas, e.g., for a MnDNR Sustainable Forest Resource Management Planning (SFRMP) area. Additionally, we would include an examination for the smaller but intensively measured Cloquet Forestry Center. Comparisons would be made for inventory and planning results with actual field data for subject polygons and alternatively with imputed data. In this effort we would examine costs and benefits of imputation and, for each application, whether imputation provided truly useful and cost effective results. These evaluations would involve participating agency staff evaluations of relevant costs, practical feasibility, and utility for various inventory and planning needs. Trials would also include examination of the utility of imputation for habitat description using a recently developed forest wildlife habitat model for native Minnesota species. Reporting would include a range of inventory designs and types and extent of imputation such that users could ultimately choose the type and extent of imputation for their own choice of inventory approach.

Summary Budget Information for Activity 3:

ENRTF Budget: \$ 110,000
Amount Spent: \$ 0
Balance: \$ 110,000

Activity Completion Date:

Outcome	Completion Date	Budget
1. Identification of cost savings and practical utility of imputation for inventory.	February 2015	\$ 30,000
2. Identification of cost savings and practical utility of imputation for planning.	April 2015	\$ 55,000
3. Final report submitted, development of further outreach and technology transfer.	June 2015	\$ 25,000

Activity Status as of (January , 2014):

Activity Status as of (September 2014):

Activity Status as of (February 2015):

Activity Status as of (June 2015):

Final Report Summary:

V. DISSEMINATION:

Description: Project cooperators will receive regular summaries of study progress and findings plus notice of publications. These summaries and reports/publications will be provided via the already established Interagency Information Cooperative (IIC) website (<http://iic.umn.edu>). This website is part of a state chartered information cooperative effort directed by the Project Manager. IIC members (county, state and federal and industry personnel) will also receive regular electronic notices of progress reports and new information. Technical journal articles will also be developed to convey the findings and operational approaches. Additionally, findings and specific model practices for using existing data and imputation for inventory design and execution will be conveyed through workshops planned to reach county, state, federal and private forest management staff statewide. Finally, project personnel will assist county land departments and MnDNR staff in developing future forest inventory proposals for their respective ownerships.

Activity Status as of (January , 2014):

Activity Status as of (September 2014):

Activity Status as of (February 2015):

Activity Status as of (June 2015):

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget:

Budget Category	\$ Amount	Explanation
Personnel:	\$ 244,561	<p>A) Faculty: One month of summer salary and fringe (0.397) for two years (University of Minnesota Co-PI faculty on 9-month appointments – H. Hoganson (\$28,560), and J. Knight (\$23,355); 0.1 FTE each); Totals 0.2 FTE, \$51,915.</p> <p>B) Research support: Research Fellow D. Wilson for one year; Totals 1.0 FTE, \$59,160.</p> <p>C) Graduate Students: Salary and fringe (0.8636) for two University of Minnesota graduate students for 1.5 years, each at 50% time (20 hours/week). Graduate fringe is budgeted at 0.87 of salary load and includes tuition for the academic year, health care for the fiscal year, and social security and Medicare for summer pay periods. Work will be conducting imputation trials under guidance of PIs and Research Fellow with a focus on planning and improving map information, respectively. Totals 3.0 FTE, \$120,926.</p> <p>D) Undergraduate students: Salary and fringe (0.0743) for two University of Minnesota students for 3 months for field data verification at the Cloquet Forestry Center and assisting project staff. Totals 0.5 FTE, \$12,560.</p>
Equipment/Tools/Supplies:	\$ 8,939	<p>Equipment/Tools/Supplies: Expendable field measurement and data capture equipment and supplies; for data verification at the Cloquet Forestry Center, on cooperator sites and for demonstration, such as, for example: ...Criterion RD 1000 Electronic BAF-scope/Dendrometer @ \$1,470; ...Haglöf Laser Vertex Hypsometer @ \$2,140; ...Juniper Systems ruggedized field data recorder with GPS receiver @ \$1,600.</p>
Travel Expenses in MN:	\$ 8,500	Travel Expenses in Minnesota: Travel - to pay mileage (75%) and per diem costs (25%) for project personnel to collect project data and meet with study cooperators on results and in workshops.
TOTAL ENRTF BUDGET:	\$ 262,000	

Explanation of Use of Classified Staff: N/A

Explanation of Capital Expenditures Greater Than \$3,500: Field measurement and data capture equipment for testing, demonstration and training of county, state and other project participants, e.g., in workshop settings.

Number of Full-time Equivalent (FTE) funded with this ENRTF appropriation: 4.7

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

B. Other Funds:

Source of Funds	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
Non-state			
Cooperating Counties, notably St. Louis and Carlton	In kind	0	Providing forest past forest inventory data files and data descriptions
State			
MnDNR	In kind	0	Providing forest past forest inventory data files and data descriptions
University of Minnesota	\$77,524	0	Project manager and project faculty time providing project research leadership
TOTAL OTHER FUNDS:	\$77,524	\$	

VII. PROJECT STRATEGY:

A. Project Partners: The University of Minnesota will receive the funding and also contribute substantial time and effort to the project. Project team members are from the University’s Department of Forest Resources and include Professors Alan Ek, Thomas Burk and Howard Hoganson and Assistant Professor Joseph Knight. Cooperators include land departments from a large county (St. Louis) and a small county (Carlton) and the MnDNR. The USDA Forest Service Northern Research Station Forest Inventory and Analysis unit will be a research collaborator in terms of FIA database access and tabulations. Additional counties are also expected to participate with their inventory and/or appraisal data as project resources and time permits, e.g., Aitkin, Crow Wing and Lake counties. The cooperators will provide their respective ownership forest inventory data, supporting map and data compilations, and user review in the evaluation of project outputs. Those evaluations will include making data available for evaluations of feasibility, utility and costs savings of the new inventory approach.

B. Project Impact and Long-term Strategy: A Two-year project length is needed to be able to collect existing agency data, develop imputation methodology and trials, and to identify the utility and costs savings of these approaches for timber inventory, ecological assessments, habitat characterization and planning purposes.

C. Spending History: Aspects of the new approach to forest inventory have been under development since 1997 at the University of Minnesota with funding as part of various research projects sponsored by the Minnesota Agricultural Experiment Station. However, no ENRTF and MRRF funds have been in used in those efforts.

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

(add or remove rows and columns as needed)

VIII. ACQUISITION/RESTORATION LIST: Not applicable.

IX. MAP(S): Not applicable.

X. RESEARCH ADDENDUM: Not applicable.

XI. REPORTING REQUIREMENTS:

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

GRAPHIC: Rapid Forest Ecosystem and Habitat Inventory by Imputation

Intro: Map based forest inventories typically involves two efforts:

- (1) Development or updating a base map of forest stands (polygon boundaries) and descriptions (e.g., cover type, age, tree size class, site quality, habitat type, ecological classification)
- (2) Field plots to describe the per acre stand characteristics at the inventory point in time (tree species, sizes, product potentials, on-the-ground management details)

Below is a graphic describing the location of 6,139 FIA plots in Minnesota (each consisting of four 1/24th acre subplots) and the type of information collected...data that can be used to impute the characteristics of the forest stand polygons in map based inventories...potentially saving the cost of the field plot effort (2) above. Imputation is the substitution of known values from an existing dataset to another which lacks some of the existing dataset details.

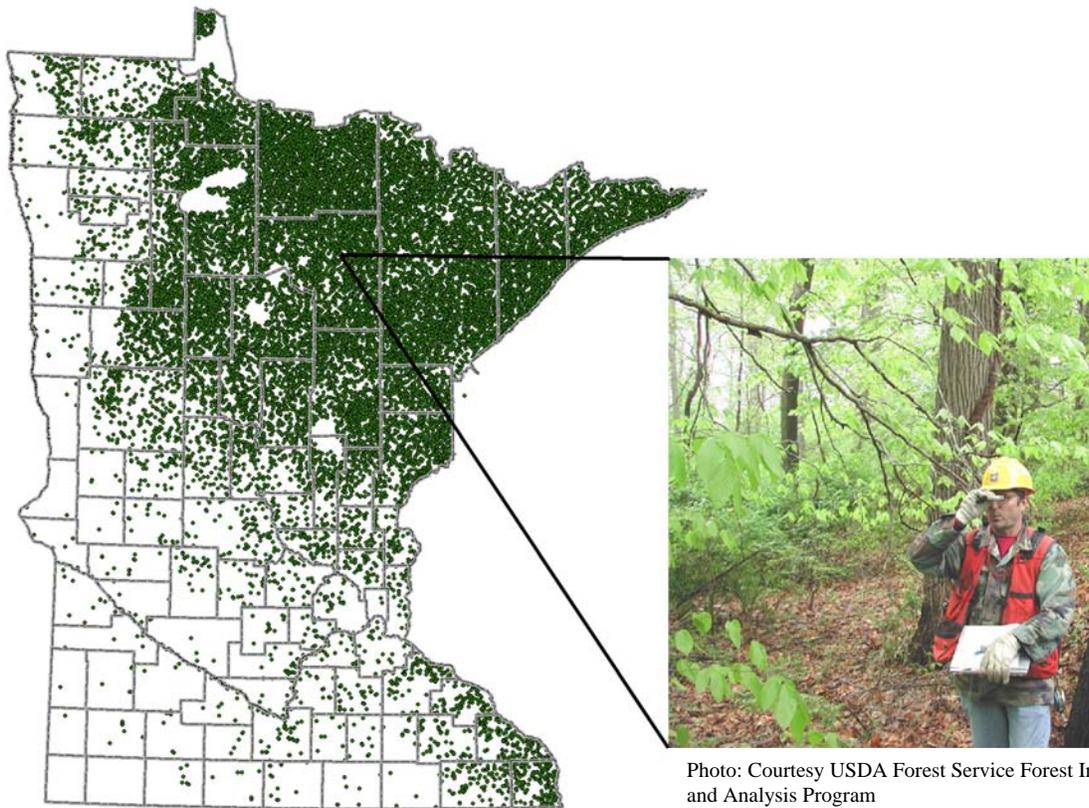


Photo: Courtesy USDA Forest Service Forest Inventory and Analysis Program

Figure 1: FIA plots in Minnesota. Plots are remeasured every 5 years on a rotating basis thus providing annually updated estimates of forest area, cover type area, and including ecological conditions, habitat indicators, and numerous other measures.

Project Activity: Correlate the large FIA data set to a subset of similar stand data in map based inventories and conduct trials of imputation precision and accuracy for timber, wildlife habitat, and ecological conditions. Additionally, the project will examine the utility of the imputation approach for forest planning and also ways to increase the speed, precision and accuracy in updating base maps.

Results: Improved timeliness of map based forest inventories for assessment, planning and management and dramatically reduced the cost of such inventories.

Attachment A: Budget Detail for M.L. 2013 Environment and Natural Resources Trust Fund Projects

Project Title: Rapid Forest Ecosystem and Habitat Inventory by Imputation											
Legal Citation: M.L. 2013 Chp. xx, Sec. xx, Subd. Xx											
Project Manager: Alan R. Ek											
M.L. 2013 ENRTF Appropriation: \$ 262,000											
Project Length and Completion Date: June 30, 2015											
Date of Update: October 2, 2012											

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Balance	Activity 2 Budget	Amount Spent	Balance	Activity 3 Budget	Amount Spent	Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	<i>Assemble data</i>			<i>Evaluate the precision and accuracy</i>			<i>Evaluate the practical utility</i>				
Personnel (Wages and Benefits):	\$ 53,500		\$ 53,500	\$ 90,000		\$ 90,000	\$ 101,061		\$ 101,061	\$ 244,561	\$ 244,561
A) Faculty: One month of summer salary and fringe (0.397) for two years (University of Minnesota Co-PI faculty on 9-month appointments - H. Hoganson (Activity 2&3 \$28,560), and J. Knight(Activity 2&3 \$23,355); 0.1 FTE each); Totals 0.2 FTE, \$51,915.										51,915	51,915
B) Research Fellow: D. Wilson for one year (Activity 1,2 &3); Totals 1.0 FTE, \$59,160.										59,160	59,160
C) Graduate Students: Salary and fringe (0.8636) for two University of Minnesota graduate students for 1.5 years, each at 50% time (20 hours/week). Graduate fringe is budgeted at 0.87 of salary load and includes tuition for the academic year, health care for the fiscal year, and social security and Medicare for summer pay periods. Work will be conducting imputation trials under guidance of PIs and Research Fellow with a focus on planning and improving map information, respectively. (Activity 1,2 &3) Totals 3.0 FTE, \$120,926.										120,926	120,926
D) Undergraduate students: Salary and fringe (0.0743) for two University of Minnesota undergraduate students for 3 months for field data verification at the Cloquet Forestry Center and assisting project staff. (Activity 1) Total 0.5 FTE, \$12,560.										12,560	12,560
Equipment/Tools/Supplies: Expendable field measurement and data capture equipment and supplies. for data verification at the Cloquet Forestry Center, on cooperators sites and for demonstration, such as, for example: ...Criterion RD 1000 Electronic BAF-Scope/Dendrometer @ \$1,470; ...Haglf Laser Vertex Hypsometers @ \$2,140; ...Juniper Systems ruggedized field data recorder with GPS receiver @ \$1,600.	4,500						4,439			8,939	8,939
Travel expenses in Minnesota: Travel - to pay mileage (75%) and per diem costs (25%) for project personnel to collect project data and meet with study cooperators on results and in workshops.	3,000			1,000			4,500			8,500	8,500
COLUMN TOTAL	\$61,000		\$61,000	\$91,000		\$91,000	\$110,000		\$110,000	\$262,000	\$262,000