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

PROJECT TITLE: Evaluation of Biomass Harvesting Impacts on Minnesota's Forests
PROJECT MANAGER: Anthony D'Amato
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WEBSITE: http://www.forestry.umn.edu/silviclab/index.htm
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 03h

APPROPRIATION AMOUNT: $350,000

Overall Project Outcome and Results

Minnesota's forests are currently being viewed as potential feedstocks for production of renewable energy. A primary concern about harvesting forest biomass to generate renewable energy is the long-term impacts these harvests will have on soil nutrients and long-term ecosystem productivity, particularly in forests growing on nutrient poor soils. This project was designed to increase our understanding of the ecological impacts of biomass harvesting through establishment of a network of research sites in forests on nutrient poor soils. Treatments representing various levels of biomass removal and live-tree retention were implemented at four large-scale (80 acre) research sites in Becker, Hubbard, and Wadena Counties and were used to evaluate the importance of post-harvest slash and live-tree retention in maintaining the resilience and sustainability of jack pine forests under different biomass harvesting regimes. Treatments included current site-level guidelines for slash retention to allow for evaluations of the effectiveness of this practice at reducing impacts on long-term soil nutrients and forest vegetation. Field measurements from these sites were used to model the long-term effects of repeated biomass removals on ecosystem productivity. Results from this project indicate that there is no difference in post-harvest slash levels between areas in which slash was retained to meet current site-level guidelines and in places in which whole trees were harvested (i.e., no slash deliberately retained). The overall levels of slash retention in these areas were half those found after similar treatments in aspen-dominated forests on nutrient rich sites, highlighting the potential for greater nutrient depletion following biomass harvesting on nutrient poor sites and suggest a need for refinement of site-level guidelines to increase retention levels for nutrient poor soils. Long-term field data and model results indicate that biomass harvests that retain less than 40% of available residues may result in lower soil carbon stocks after several harvest rotations.

Project Results Use and Dissemination

The results of this project have been shared on numerous occasions with resource professionals, policy makers, citizens, and scientists over the past three years in efforts to inform forest conservation decisions regarding biomass harvesting impacts. These dissemination activities have included the development of a fact sheet for LCCMR members that was distributed on the LCCMR tour of Itasca State Park on July 18, 2013. In addition, an overview of the project and results were shared with private forest landowners through a University of Minnesota Extension Webinar to private forest landowners and county, state, and federal natural resource managers on December 9, 2013, as well as through a meeting of the Forest Operations and Planning Section of the Minnesota DNR Division of Forestry on January

8, 2014. Results were also presented at the Annual Meeting of the Ecological Society of America in Minneapolis, MN on August 5, 2013. Finally, results regarding the impact of different levels of post-harvest slash retention on soil nutrients have been discussed with members of the Minnesota Forest Resources Council and are being used to inform future guideline revisions. Publications resulting from this work are available for download from the Department of Forest Resources web site (www.forestry.umn.edu). Additional publications from this work that are currently in development will also be posted on this site and shared with LCCMR staff for dissemination.

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

Date of Status Update: 8/11/2014
Date of Next Status Update: Final Report
Date of Work Plan Approval: 6/23/2011
Project Completion Date: 6/30/2014 **Is this an amendment request?** _No____

Project Title: Evaluation of Biomass Harvesting Impacts on Minnesota's Forests

Project Manager: Anthony D'Amato
Affiliation: U of MN
Address: 1530 N Cleveland Ave
City: St Paul **State:** MN **Zipcode:** 55108

Telephone Number: (612) 625-3733
Email Address: damato@umn.edu
Web Address: http://www.forestry.umn.edu/silviclab/index.htm

Location:

Counties Impacted: Aitkin, Becker, Beltrami, Benton, Carlton, Cass, Clearwater, Cook, Crow Wing, Hubbard, Itasca, Koochiching, Lake, Lake of the Woods, Mahnomen, Marshall, Morrison, Otter Tail, Pennington, Pine, Polk, Red Lake, Roseau, St. Louis, Todd, Wadena

Ecological Section Impacted: Northern Minnesota and Ontario Peatlands (212M), Northern Minnesota Drift and lake Plains (212N), Northern Superior Uplands (212L), Southern Superior Uplands (212J), Western Superior Uplands (212K)

Total ENRTF Project Budget:

ENRTF Appropriation $:	350,000
Amount Spent $:	350,000
Balance $:	0

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

Appropriation Language:
$175,000 the first year and $175,000 the second year are from the trust fund to the Board of Regents of the University of Minnesota to assess the impacts biomass harvests for energy have on soil nutrients, native forest vegetation, invasive species spread, and long-term tree productivity within Minnesota's forests. This appropriation is available until June 30, 2014, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Evaluation of biomass harvesting impacts on Minnesota's forests

II. PROJECT SUMMARY:

Minnesota's forests are currently being viewed as potential feedstocks for the production of renewable energy. A primary concern about harvesting forest biomass to generate renewable energy is the long-term impacts these harvests will have on soil nutrients and long-term ecosystem productivity. In particular, repeated nutrient removals in harvested material may result in soil nutrient depletion with negative cascading effects on important forest benefits by decreasing future forest growth, carbon storage, and reducing wildlife habitat.

This project is designed to increase our understanding of the ecological impacts of biomass harvesting through the establishment of a network of research sites in forests on nutrient poor soils in northern Minnesota. Treatments representing various levels of biomass removal and green-tree retention will be implemented at each site to evaluate the importance of site-level legacies (green trees and harvest residues) in maintaining the resilience and sustainability of these systems under different biomass harvesting regimes. In addition, empirically derived estimates of nutrient removals from these sites will be used to model the long-term effects of repeated biomass removals on ecosystem productivity. This project will establish treatment sites, collect and analyze baseline data, and implement harvest treatments to facilitate long-term monitoring of the ecological impacts of biomass harvesting. Results from this project will (1) provide critical information for informing management recommendations aimed at mitigating impacts of biomass harvesting on nutrient poor soils, and (2) will provide long-term predictions of the effects of this practice on the productivity of forest systems growing on nutrient poor sites.

III. PROJECT STATUS UPDATES:

PROGRESS SUMARY AS OF 9/8/11:

Amendment Request (9/8/11)

Amendment is requested to rebudget funds ($15,000) from personnel to Professional/Technical Contracts. This amendment is being requested to support the hiring of a consulting forester to locate field research sites on nutrient poor soils for assessing the impacts of biomass harvesting (Activity 1). Hiring this contractor is the most cost-effective and efficient way to locate and establish these sites due to their vast experience working with forest lands on these soil types and evaluating the impacts of biomass harvests.

Amendment Approved: September 13, 2011

Project Status as of January 2012:

We have located and established 4 study sites within jack pine forests on nutrient poor soils in Hubbard, Wadena, and Becker County. These sites include lands administered by the Minnesota Department of Natural Resources Division of Forestry, Becker County Land Department, and Hubbard County Land Department. We are currently working with these project partners in establishing timber sales to carry out the experimental treatments we have designed for examining the impacts of biomass harvesting.

Project Status as of September 2012:

We have completed pre-harvest measurements of vegetation across 3 of the 4 study sites within jack pine forests on nutrient poor soils in Hubbard, Wadena, and Becker County and will complete measurements on the remaining site by October 2012. In addition, baseline soils measurements have been collected across all 4 study sites and have confirmed the nutrient poor status at each of these areas. Lysimeters for measuring the levels of nutrient export following harvesting have been installed at each site across all treatments and will allow for a better characterization of biomass harvesting impacts on soil fertility.

Project Status as of January 2013:

We have completed pre-harvest measurements of vegetation and soils across all of the study sites within jack pine forests on nutrient poor soils in Hubbard, Wadena, and Becker County. Experimental treatments have been marked and all timber sales for carrying out treatments have been sold and will

be completed by March 2013. Preliminary comparisons and modeling of the impacts of different levels of biomass removal from nutrient poor sites suggest that removal of all harvesting residues will result in declines in aspen forest regrowth relative to harvests retaining these residues. Measurements from the 2013 field season (June-September) will be used to examine the impacts of these treatments on jack pine forest regrowth.

Project Status as of September 2013: We have completed the establishment of four study sites within jack pine forests on nutrient poor soils in Hubbard, Wadena, and Becker County, including implementation of all experimental treatments. Preliminary assessments of slash levels retained in these areas indicate that harvesting operations in the spring/summer remove a higher level of biomass than winter harvests in other ecosystem types. As a result, biomass harvesting on these sites may remove a greater proportion of ecosystem nutrients than for other forest types or soils (i.e., aspen on nutrient rich soils). Preliminary comparisons and long-term (100 year) modeling of the impacts of different levels of biomass removal from nutrient poor sites suggest that removal of all harvesting residues will result in future soil calcium and potassium deficiencies. We are currently examining how these declines in soil nutrients may impact the growth of jack pine.

Project Status as of January 2014: We have completed synthesis of slash retention data collected from our experimental study sites examining the ecological impacts of forest biomass harvesting on nutrient poor soils in northern Minnesota. Results from these syntheses indicate that there is no difference in post-harvest slash levels between areas in which slash was retained to meet current site-level guidelines and in places in which whole trees were harvested (i.e., no slash deliberately retained). Both of these areas had significantly less slash than areas in which all slash was retained on site. In addition, the overall levels of slash retention in these areas (no slash retained and recommended guideline levels) were half those found after similar treatments in aspen-dominated forests on nutrient rich sites, highlighting the low levels of incidental breakage on nutrient poor jack pine sites. These differences underscore the potential for greater nutrient depletion following biomass harvesting on nutrient poor sites and suggest higher levels of deliberate retention (i.e., different guidelines) may be necessary to sustain long-term productivity of these areas. We are currently examining how these different levels of slash removal impact native plant biodiversity and growth of jack pine. In addition, we have finished calibrating models for simulating long-term impacts of nutrient removals via biomass harvesting on long-term soil nutrient availability and are currently finalizing model runs evaluating the long-term impacts of these practices.

FINAL PROJECT STATEMENT:

Minnesota's forests are currently being viewed as potential feedstocks for production of renewable energy. A primary concern about harvesting forest biomass to generate renewable energy is the long-term impacts these harvests will have on soil nutrients and long-term ecosystem productivity, particularly in forests growing on nutrient poor soils. This project was designed to increase our understanding of the ecological impacts of biomass harvesting through establishment of a network of research sites in forests on nutrient poor soils. Treatments representing various levels of biomass removal and live-tree retention were implemented at four large-scale (80 acre) research sites in Becker, Hubbard, and Wadena Counties and were used to evaluate the importance of post-harvest slash and live-tree retention in maintaining the resilience and sustainability of jack pine forests under different biomass harvesting regimes. Treatments included current site-level guidelines for slash retention to allow for evaluations of the effectiveness of this practice at reducing impacts on long-term soil nutrients and forest vegetation. Field measurements from these sites were used to model the long-term effects of repeated biomass removals on ecosystem productivity. Results from this project indicate that there is no difference in post-harvest slash levels between areas in which slash was retained to meet current site-level guidelines and in places in which whole trees were harvested (i.e., no slash deliberately retained). The overall levels of slash retention in these areas were half those found after similar treatments in aspen-dominated forests on nutrient rich sites, highlighting the potential for greater nutrient depletion following biomass harvesting on nutrient poor sites and suggest a need for refinement of site-level guidelines to increase retention levels for nutrient poor soils. Long-term field

data and model results indicate that biomass harvests that retain less than 40% of available residues may result in lower soil carbon stocks after several harvest rotations.

Project Results Use and Dissemination

The results of this project have been shared on numerous occasions with resource professionals, policy makers, citizens, and scientists over the past three years in efforts to inform forest conservation decisions regarding biomass harvesting impacts. These dissemination activities have included the development of a fact sheet for LCCMR members that was distributed on the LCCMR tour of Itasca State Park on July 18, 2013. In addition, an overview of the project and results were shared with private forest landowners through a University of Minnesota Extension Webinar to private forest landowners and county, state, and federal natural resource managers on December 9, 2013, as well as through a meeting of the Forest Operations and Planning Section of the Minnesota DNR Division of Forestry on January 8, 2014. Results were also presented at the Annual Meeting of the Ecological Society of America in Minneapolis, MN on August 5, 2013. Finally, results regarding the impact of different levels of post-harvest slash retention on soil nutrients have been discussed with members of the Minnesota Forest Resources Council and are being used to inform future guideline revisions. Publications resulting from this work are available for download from the Department of Forest Resources web site (www.forestry.umn.edu). Additional publications from this work that are currently in development will also be posted on this site and shared with LCCMR staff for dissemination.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Develop a network of research sites on nutrient poor soils to assess impacts of biomass harvesting on biodiversity and productivity

Description: Currently, little information exists on the potential impacts of biomass harvesting on aspen-dominated systems growing on nutrient poor soils. To address this need, we will establish large-scale manipulations of pine-dominated forests on nutrient poor sites allowing us to assess the ecological impacts of biomass harvesting on these systems, and to evaluate potential management recommendations for sustaining the ecological functions of these site types within the context of this management regime. In particular, research will be conducted at 4 pine forest sites on nutrient poor outwash sands within northern Minnesota. Each site will be a minimum of 120 acres to accommodate each treatment, as well as buffers between treatment units. Study sites will be located on lands owned by county land departments and Minnesota Department of Natural Resources.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 127,439
Amount Spent: $ 127,439
Balance: $ 0

Activity Completion Date: April 1, 2013

Outcome	Completion Date	Budget
1. *Nutrient poor sites identified through work with MNDNR and counties*	October 2011	$20,189
2. *Pre-harvest measurements of forest and soil conditions completed*	October 2012	$81,879
3. *Timber sales completed on sites*	March 2013	$10,000

Activity Status as of January 2012: We have located and established 4 study sites within jack pine forests on nutrient poor soils in Hubbard, Wadena, and Becker County (Outcome 1). These sites are each at least 80 acres in size and are on lands administered by the Minnesota Department of Natural Resources Division of Forestry, Becker County Land Department, and Hubbard County Land Department. The smaller total stand size was chosen in response to the rarity of large blocks of mature jack pine within this portion of the state resulting from past jack pine budworm outbreaks. Given the

speed with which we were able to find suitable study areas, we are on schedule to meet all proposed completion dates under Activity 1.

Activity Status as of September 2012:
We have completed pre-harvest measurements of vegetation across 3 of the 4 study sites within jack pine forests on nutrient poor soils in Hubbard, Wadena, and Becker County and will complete measurements on the remaining site by October 2012. In addition, baseline soils measurements have been collected across all 4 study sites and have confirmed the nutrient poor status at each of these areas. Lysimeters for measuring the levels of nutrient export following harvesting have been installed at each site across all treatments and will allow for a better characterization of biomass harvesting impacts on soil fertility. Experimental treatments have been marked at 3 of the 4 research sites and will be completed by December 2012. We are on schedule to meet all proposed completion dates under Activity 1.

Activity Status as of January 2013:
We have completed pre-harvest measurements of vegetation and soils across all of the study sites within jack pine forests on nutrient poor soils in Hubbard, Wadena, and Becker County (Outcome 2). Experimental treatments have been marked and all timber sales for carrying out treatments have been sold and will be completed by March 2013. We are on schedule to meet all proposed completion dates under Activity 1.

Activity Status as of September 2013: We have completed the establishment of the research sites (Outcome 3) and all outcomes under Activity 1.

Activity Status as of January 2014: We have completed all outcomes under Activity 1.

Final Report Summary: Four large-scale (80 acre) study sites were established in jack pine forests on nutrient poor soils in Hubbard, Wadena, and Becker County. Two sites were located on the Minnesota Department of Natural Resources landbase, whereas the other two sites were on Becker and Hubbard County lands, respectively. At each study area, ten different harvest treatments were assigned and implemented in spring/summer 2013. These treatments included three different levels of overstory tree retention (none, dispersed retention of live trees, and aggregate retention of live trees) crossed with three levels of biomass removal (no slash retained, 20% slash retained, and all slash retained) and also included unharvested control areas. The overstory tree retention treatments were based on Minnesota Forest Resources Council (MFRC) site-level guidelines with a minimum of 6-12 live trees per acre in dispersed tree treatments and a minimum of 5% of the harvested area in live-tree aggregates > 0.25 acres for aggregate retention treatments. The 20% slash treatment was also based on the current MFRC guideline for minimizing the impacts of biomass harvesting. All timber sales for implementing the treatments were conducted by the same logger minimizing the influence of logger preferences and equipment differences on our outcomes. Prior to treatment implementation, pre-harvest measurements of vegetation, downed woody debris, and soils were collected from all areas.

ACTIVITY 2: Determine the impacts of biomass harvesting on regeneration and growth of ecologically important tree species and spread of invasive species

Description: We will measure soil nutrient availability and monitor the survival and growth of planted tree regeneration and invasive plants in treatment areas. Seedlings monitored will consist of a mix of long-lived conifers, allowing us to address questions related to how these harvests affect potential restoration of those species. Results concerning the immediate impacts of biomass harvesting on soils, forest growth, and tree regeneration will be summarized in project reports and conveyed to managers through outreach activities.

Summary Budget Information for Activity 2:		
	ENRTF Budget:	**$ 181,956**
	Amount Spent:	**$ 181,956**
	Balance:	**$ 0**

Activity Completion Date: June 30, 2014

Outcome	Completion Date	Budget
1. *Post-harvest measurements of soils and vegetation conducted*	October 2013	$100,450
2. *Assessment of soil nutrients and forest vegetation for 2 years*	October 2013	$30,506
3. *Data synthesis and final report completion*	June 2014	$51,000

Activity Status as of January 2012: We are currently establishing research plots within the four study sites for examining post-harvest conditions related to soils and vegetation. Measurements will begin in October 2013 to assess these impacts. We are on schedule to meet all proposed completion dates under Activity 2.

Activity Status as of September 2012: We have completed the establishment of research plots for examining post-harvest conditions related to soils and vegetation at 3 of the 4 research sites. We have also installed lysimeters at each site to monitor post-harvest nutrient export. We are on schedule to meet all proposed completion dates under Activity 2.

Activity Status as of January 2013: We have completed the establishment of research plots for examining post-harvest conditions related to soils and vegetation across all research sites. We are on schedule to meet all proposed completion dates under Activity 2.

Activity Status as of September 2013: We have completed measuring the post-harvest response of soils and vegetation on 3 of the 4 research sites and will be completed with these measurements by September 30. We are on schedule to meet all proposed completion dates under Activity 2.

Activity Status as of January 2014: We have completed measuring post-harvest soil and vegetation conditions (Outcome 1) and our assessments of soil nutrients of forest vegetation over the two field seasons in this study (Outcome 2). We are currently analyzing the impacts of biomass harvesting on these soil nutrients and vegetation and are on schedule to meet all proposed completion dates under Activity 2.

Final Report Summary: The impacts of biomass harvesting on forest vegetation, soil nutrients, carbon, and forest regrowth were measured for two years at the four research sites established under Activity 1. Although these measurements are from a relatively short time period in relation to long-term forest dynamics, there are several important findings in relation to how different levels of biomass harvesting may impact future forest productivity and diversity. In particular, slash (tops and branches) retention data collected from our experimental study sites indicate that there is no difference in post-harvest slash levels between areas in which slash was retained to meet current site-level guidelines (20% retention) and in places in which whole trees were harvested (i.e., no slash deliberately retained). This lack of difference reflects the influence of incidental breakage of harvested trees in maintaining slash levels of sites where whole trees are harvested. Treatments in which all slash was retained on site had significantly greater levels of slash than areas applying current guidelines or where no slash was deliberately retained. The overall levels of slash retention areas with no slash retained and at recommended guideline levels were half those found after similar treatments in aspen-dominated forests on nutrient rich sites, highlighting the low levels of incidental breakage on nutrient poor jack pine sites. These differences underscore the potential for greater nutrient depletion following biomass harvesting on nutrient poor sites and suggest higher levels of deliberate retention (i.e., different guidelines) may be necessary to sustain long-term productivity of these areas. Findings from this aspect of Activity 2 are currently being considered in refinement of site-level guidelines for biomass harvesting to ensure adequate levels of post-harvest slash are retained on similar sites. Jack pine and red pine seedlings were planted across all sites during year 3 of this project and will continue to be monitored to assess the influence of biomass harvesting on forest growth and regeneration.

ACTIVITY 3: Model long-term sustainability of biomass harvesting on nutrient poor soils
Description: The ecological sustainability of biomass harvesting hinges on nutrient availability and potential nutrient limitations. We will integrate findings from Result 2 into ecological models to simulate multiple levels of biomass harvesting on a range of soil qualities. Results concerning sustainability of alternative biomass harvesting strategies will be summarized in project reports, conveyed to managers through outreach activities, and used to inform future revisions to Minnesota's forest management guidelines.

Summary Budget Information for Activity 3:

ENRTF Budget: $ 40,605
Amount Spent: $ 40,605
Balance: $ 0

Activity Completion Date: June 30, 2014

Outcome	Completion Date	Budget
1. *Characterization of initial ecological impacts of biomass harvesting completed*	November 2013	$8,000
2. *Results incorporated into ecological models of long-term impacts*	November 2013	$22,605
3. *Project summaries published*	June 2014	$10,000

Activity Status as of January 2012: We have begun parameterizing several ecological models, including PnET and Landis-Century, to examine the long-term sustainability of biomass harvesting on forest soils. Measurements collected under Activities 1 and 2 will be integrated into these models to allow for field-based assessments of harvesting impacts. We are on schedule to meet all proposed completion dates under Activity 3.

Activity Status as of September 2012: We are currently conducting preliminary evaluations of the suitability of several ecological simulation models for examining the long-term sustainability of biomass harvesting on soils. These evaluations are being based on the ability of a given model to account for the impacts of varying levels of biomass retention on soil nutrient cycling. We are on schedule to meet all proposed completion dates under Activity 3.

Activity Status as of January 2013: Based on our evaluations of model performance, we have selected the Landis-Century model as the primary model for examining the long-term sustainability of biomass harvesting on forest soils. This selection was based on the ability of this model to account for the impacts of biomass harvesting on fine and coarse woody debris and the resultant effects on forest soil nutrient status. We are on schedule to meet all proposed completion dates under Activity 3.

Activity Status as of September 2013: We have completed initial long-term (100 year) models of the impacts of different levels of biomass removal from nutrient poor sites and are currently examining how projected declines in soil nutrients may impact the growth of jack pine. We are on schedule to meet all proposed completion dates under Activity 3.

Activity Status as of January 2014: We have completed characterizations of the initial ecological impacts of biomass harvesting (Outcome 1) and integrated these results into the Landis-Century model for evaluating long-term (100 year) effects of these initial impacts. We are currently examining how projected declines in soil nutrients may impact long-term ecosystem productivity and are on schedule to meet all proposed completion dates under Activity 3.

Final Report Summary: The long-term impacts of biomass harvesting on soil nutrient availability and forest productivity were examined by integrating field data collections from the research areas established under Activity 1 into ecological models. Comparisons between the three different slash

retention scenarios were used to evaluate the impacts of different levels of slash retention on long-term nutrient availability. These modeled scenarios were also compared with long-term (> 15 year) measurements of soil nitrogen and carbon following biomass harvesting on different soil types (sand, loam, and clay soils) to provide empirical validation of model results and further examine the long-term impacts of biomass harvesting on forest soils. Long-term (100 year) models of the impacts of different levels of biomass removal indicated that removal of all harvesting residues depletes soil nutrient levels below natural deposition and weathering rates, particularly soil calcium, nitrogen, and potassium. In several instances, retention of current recommended slash levels also resulted in deficiencies in these nutrients, particularly when sites contained an aspen component, suggesting the need for greater levels of retention on these soils. Long-term field data and model results indicate that biomass harvests that retain less than 40% of available residues may result in lower soil carbon stocks after several harvest rotations. The impacts of these lower nutrient levels on forest regrowth and productivity were observed in field measurements of aspen forests growing on nutrient poor, sandy soils where aboveground productivity was lower on sites experiencing slash removals relative to sites were all slash was retained. Future integration of field measurements of jack pine seedling growth under Activity 2 will be used to examine how long-term productivity of these forests are impacted by biomass harvesting.

V. DISSEMINATION:

Description: The final product of this project will be an interpretive report describing (a) the early initial impacts of forest biomass harvesting on the plant communities and nutrient status of forest systems growing on nutrient poor soils in northern Minnesota and (b) predictive models of the long-term impacts of repeated biomass removals on these sites. This report will be made available on the internet as a Department of Forest Resources Staff Paper Report. In addition, several manuscripts will be written based on this research and submitted for publication in peer-reviewed journals. A fact sheet summarizing principal findings of this project will be distributed to LCCMR members and legislators at the state and federal level. Results will be presented at state and national forest management and forest health conferences, and notably to agency and individual participants in the Sustainable Forests Education Cooperative. All reports and publications from this project will be made available via the Department of Forest Resources web site (www.forestry.umn.edu).

Status as of January 2012: No activities to report at this time.

Status as of September 2012: No activities to report at this time.

Status as of January 2013: No activities to report at this time.

Status as of September 2013: A fact sheet summarizing the scope and initial findings of this project was developed and shared with LCCMR members during a tour of Itasca State Park on July 18, 2013.

Status as of January 2014: Results from this project were presented as part of a University of Minnesota Extension Webinar to private forest landowners and county, state, and federal natural resource managers on December 9, 2013. In addition, an overview of the project and results pertaining to post-harvest slash levels were presented at the meeting of the Forest Operations and Planning Section of the Minnesota DNR Division of Forestry on January 8, 2014

Final Report Summary: The results of this project have been shared on numerous occasions with resource professionals, policy makers, citizens, and scientists over the past three years in efforts to inform forest conservation decisions regarding biomass harvesting impacts. These dissemination activities have included the development of a fact sheet for LCCMR members that was distributed on the LCCMR tour of Itasca State Park on July 18, 2013. In addition, an overview of the project and results were shared with private forest landowners through a University of Minnesota Extension Webinar to private forest landowners and county, state, and federal natural resource managers on December 9, 2013, as well as through a meeting of the Forest Operations and Planning Section of the Minnesota DNR Division of Forestry on January 8, 2014. Results were also presented at the Annual

Meeting of the Ecological Society of America in Minneapolis, MN on August 5, 2013. Publications resulting from this work are appended to this final report and are also available for download from the Department of Forest Resources web site (www.forestry.umn.edu). Additional publications from this work that are currently in development will also be posted on this site and shared with LCCMR staff for dissemination.

VI. PROJECT BUDGET SUMMARY:

The total budget request is 350,000 over a three-year period (July 2011-June 2014). This budget includes salary and fringe (0.1812) for one post-doctoral research associate is budgeted for two years. This post-doc will assess the initial impacts of biofuels harvests on soil nutrient availability, forest regeneration, and plant community composition. Salary and fringe (0.3230) for one research associate (0.1 FTE) is budgeted for 3 2 years. This research associate will assist with field sample processing and project coordination. One month of summer salary and fringe is budged for three years for the PI on this project, Dr. Anthony D'Amato. This salary will be used to pay for time spent on coordinating researchers, as well as analyzing and summarizing research results from this project. Salary and fringe (0.0743) for a work study student is budgeted for three years and this student will assist with summer field sampling and the processing of collected samples during the school year.

The subcontract with the U.S. Forest Service, Northern Research Station in Grand Rapids is to support salary and fringe for one full-time field technician for all three years of the study. This technician will be responsible for collecting field data, as well as for coordinating field crews. This subcontract also includes salary and fringe for two undergraduate summer employees for two years. The technician and summer students will be employed by the US Forest Service because that is the most cost-effective approach and our need to have personnel dedicated to this research study who are located close to the field sites. Finally, $12,000 of this subcontract is for lab analysis of soil samples that will be conducted in the analytical laboratory at the Northern Research Station in Grand Rapids, MN.

The subcontract with a consulting forester is to support salary for locating and establishing research areas on nutrient poor soils in northern Minnesota. This consultant will be chosen out of a candidate pool of foresters that are qualified for conducting work of this nature; however, given the contract total ($15,000) a competitive bid process is not required by the University of Minnesota.

Due to the high number of study sites and logistics associated with establishing the harvest treatments and baseline data collection, $18,000 is budgeted for domestic travel within Minnesota. This money will be used to pay for mileage (75%) and lodging (25%) for researchers, the field technician, graduate students, and undergraduate students. Equipment for permanently marking research plots, collecting regeneration and soil samples, and measuring soil nutrient availability are budgeted at $5999.

A. ENRTF Budget:

Budget Category	$ Amount	Explanation
Personnel:	$184,001	-One month of faculty summer salary and fringe (0.1934) for three years(D'Amato, PI; 0.1FTE) -Salary and fringe (0.1812) for a post-doctoral researcher for two years (1.0 FTE) -Salary and fringe (0.3230) for a research associate for 2.0 years (0.1 FTE) -Salary and fringe (0.0743) for a work-study undergraduate student for 3 years
Professional/Technical Contracts: U.S. Forest Service	$127,000	This contract to Brian Palik includes: -funds for hiring one half-time field technician for all three years of the study (0.5 FTE; $87,000). -salary and fringe for two undergraduate summer employees for two years ($28,000).

		The technician and summer students will be employed by the US Forest Service because that is the most cost-effective approach and our need to have personnel dedicated to this research study who are located close to the field sites. -lab analysis of soil samples ($12,000; **reduced rate** donated by US Forest Service)
Contracts: Consulting forester	$15,000	This contract includes: -funds for hiring a consulting forester to locate and identify candidate research sites on nutrient poor soils in Minnesota -funds support salary for hired consultant at $50/hour
Equipment/Tools/Supplies:	$5,999	- Equipment includes rebar for permanently marking plot centers ($350), supplies for constructing resin bags for soil nutrient measurements ($4000), soil cores and corer ($110), Haglof distance measuring equipment ($700), stake whiskers for marking subplots ($110), scintillation vials for soil analyses ($730)
Travel Expenses in MN:	$18,000	- This money will be used to pay for mileage (75%) and lodging (25%) for researchers, the field technician, graduate students, and undergraduate students working at the field research sites.
TOTAL ENRTF BUDGET:	**$350,000**	

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: 3.1

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
USDA Grant	$1,810,500	$	Personnel for ecological simulation modeling, collection of field data, and processing of samples.
TOTAL OTHER FUNDS:	**$1,810,500**	**$**	

VII. PROJECT STRATEGY:

A. Project Partners:

In addition to the Project Manager, other project team members are noted below.

Charlie Blinn

Department of Forest Resources
University of Minnesota
St. Paul, MN

John Bradford
USDA Forest Service
Northern Research Station
Grand Rapids, MN

Shawn Fraver
USDA Forest Service
Northern Research Station
Grand Rapids, MN

Robert Slesak
Minnesota Forest Resources Council
St. Paul, MN

Brian Palik ($127,000)
USDA Forest Service
Northern Research Station
Grand Rapids, MN

Randy Kolka
USDA Forest Service
Northern Research Station
Grand Rapids, MN

B. Project Impact and Long-term Strategy:

Due to the large component of Minnesota's forested landbase on nutrient poor soils, there is a critical need for research that can assess the potential impacts of biomass harvesting on our forests, as well as generate management strategies for sustaining the functioning of these systems in light of these management practices. This project is intended to be a 3-year study. This time period is necessary to allow for research site identification, treatment implementation, and 1 year of post-treatment measurements. This proposed project will build upon an existing project examining the impacts of biomass harvesting on nutrient rich sites within northern Minnesota established with $294,000 in grants from the Minnesota Forest Resources Council (MFRC). Given the long-term nature of forest growth and management, we will seek additional funds to continue monitoring these sites beyond the 3 year project period. In particular, project participants are committed to long-term maintenance and monitoring of sites established in this proposed project. Although we anticipate subsequent proposals to LCCMR, we are also seeking additional funds from the USDA, DOE, US Forest Service Forest Health Monitoring Program, and the National Science Foundation to support this work.

C. Spending History:

Funding Source	**M.L. 2008 or FY 2009**	**M.L. 2009 or FY 2010**	**M.L. 2010 or FY 2011**
USDA grant			$525,000
MFRC grant	$98,000	$98,000	$98,000
USDA Forest Service			$30,000

(add or remove rows and columns as needed)

VIII. ACQUISITION/RESTORATION LIST: N/A

IX. MAP(S):

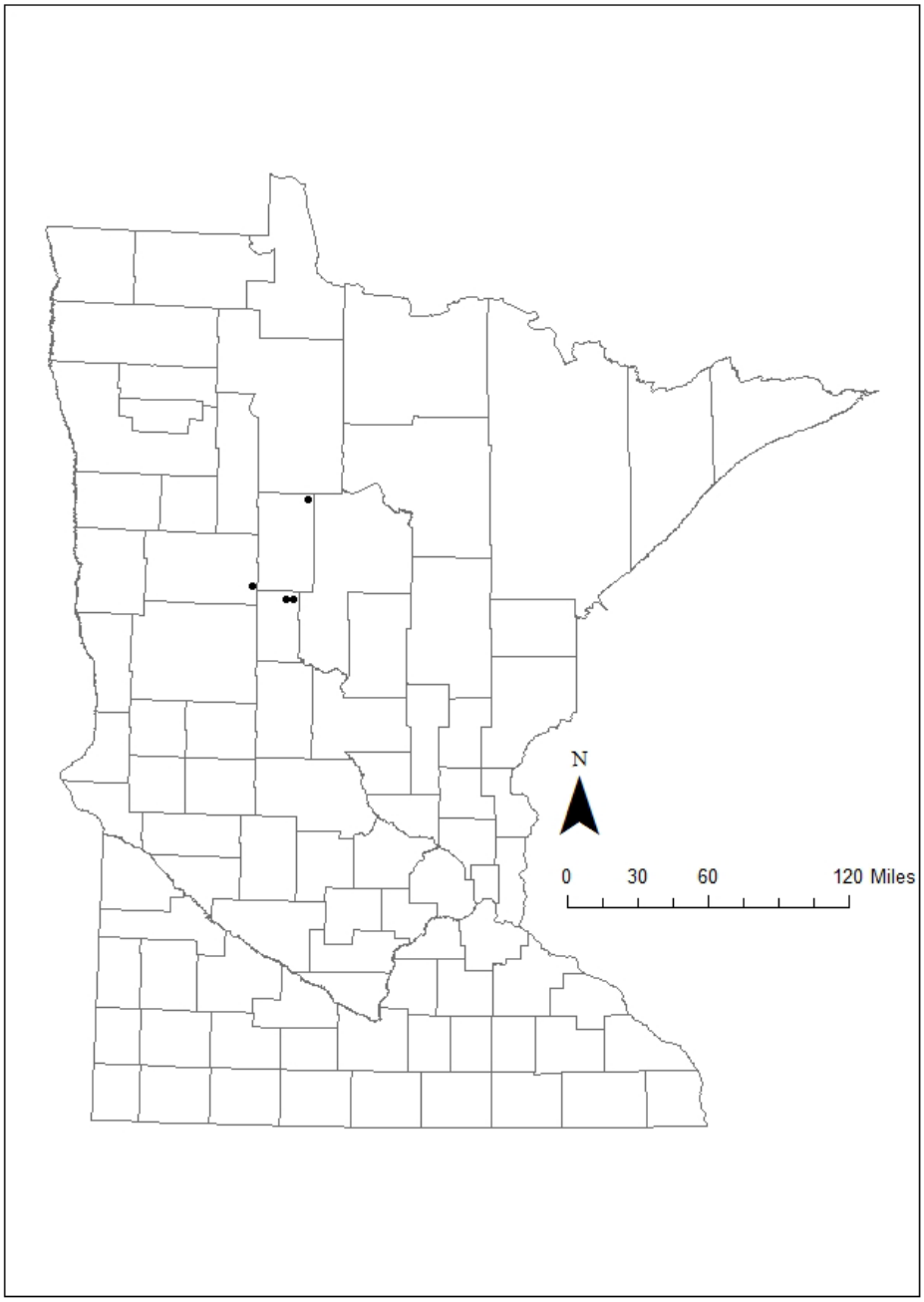
X. RESEARCH ADDENDUM: See Research Addendum

XI. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted not later than January 2012, September 2012, January 2013, September 2013, and January 2014. A final report and associated products will be submitted between June 30 and August 30, 2014 as requested by the LCCMR.

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

Project Title: Evaluation of Biomass Harvesting Impacts on Minnesota's Forests
Legal Citation:M.L. 2011, First Special Session, Chp. 2, Art.3, Sec. 2, Subd. 03h
Project Manager: Anthony D'Amato
M.L. 2011 (FY 2012-13) ENRTF Appropriation: $ 350,000
Project Length and Completion Date: 3 years; August 30, 2014
Date of Update: January 14, 2014

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	**Develop a network of research sites on nutrient poor soils to assess impacts of biomass harvesting on biodiversity and productivity**			**Determine the impacts of biomass harvesting on regeneration and growth of ecologically important tree species and spread of invasive species**			**Model long-term sustainability of biomass harvesting on nutrient poor soils**				
Personnel (Wages and Benefits)	30,000	30000	-	121,474	116033	5,441	32,527	23041	9,486	184,001	14,927
Anthony D'Amato, Project Manager; $30,999 (81% salary, 19% benefits); 10%FTE					20,666						
Post-doctoral researcher; $100,709 (82% salary, 18% benefits); 100%FTE					79,667			11,387			
Research associate; $40,605 (68% salary, 32% benefits); 10%FTE		30,000			15,700			11,654			
Undergraduate work-study; $26,688 (93% salary, 7% benefits); 50%FTE											
Professional/Technical Contracts											
US Forest Service (Dr. Brian Palik): funds for hiring one half-time field technician for all three years of the study (0.5 FTE; $87,000); salary and fringe for two undergraduate summer employees for two years ($28,000); lab analysis of soil samples ($12,000; reduced rate donated by US Forest Service	67,979	67979	-	50,943	46438	4,505	8,078	2284	5,794	127,000	10,299
Contract with consulting forester to locate field sites on nutrient poor soils in northern Minnesota. Funds are to support salary at $50/hour.	15,000	15000	-							15,000	0
Equipment/Tools/Supplies										0	0
Equipment tools and supplies, such as rebar for permanently marking plot centers ($350), supplies for constructing resin bags for soil nutrient measurements ($4000), soil cores and corer ($110), Haglof laser distance measuring equipment ($700), stake whiskers for marking subplots ($110), scintillation vials for soil analyses ($730)	3,000	3000	-	2,999	2999	-				5,999	0
Travel expenses for travel in Minnesota. This money will be used to pay for mileage (75%) and lodging (25%) for researchers, the field technician, graduate students, and undergraduate students working at the field research sites. Reimbursement of expenses is based on the University plan for travel expenditures and reimbursement.	11,460	11460	-	6,540	4500	2,040				18,000	2,040
COLUMN TOTAL	**$127,439**	**$127,439**	**$0**	**$181,956**	**$169,970**	**$11,986**	**$40,605**	**$48,366**	**$15,280**	**$350,000**	**$27,266**



Map 1. Location of large-scale (80 acre) study sites established in jack pine forests on nutrient poor soils in Becker, Hubbard, and Wadena County. At each study area, ten different harvest treatments designed to evaluate the impacts of biomass harvesting on soil nutrients and forest vegetation were implemented in 2013.

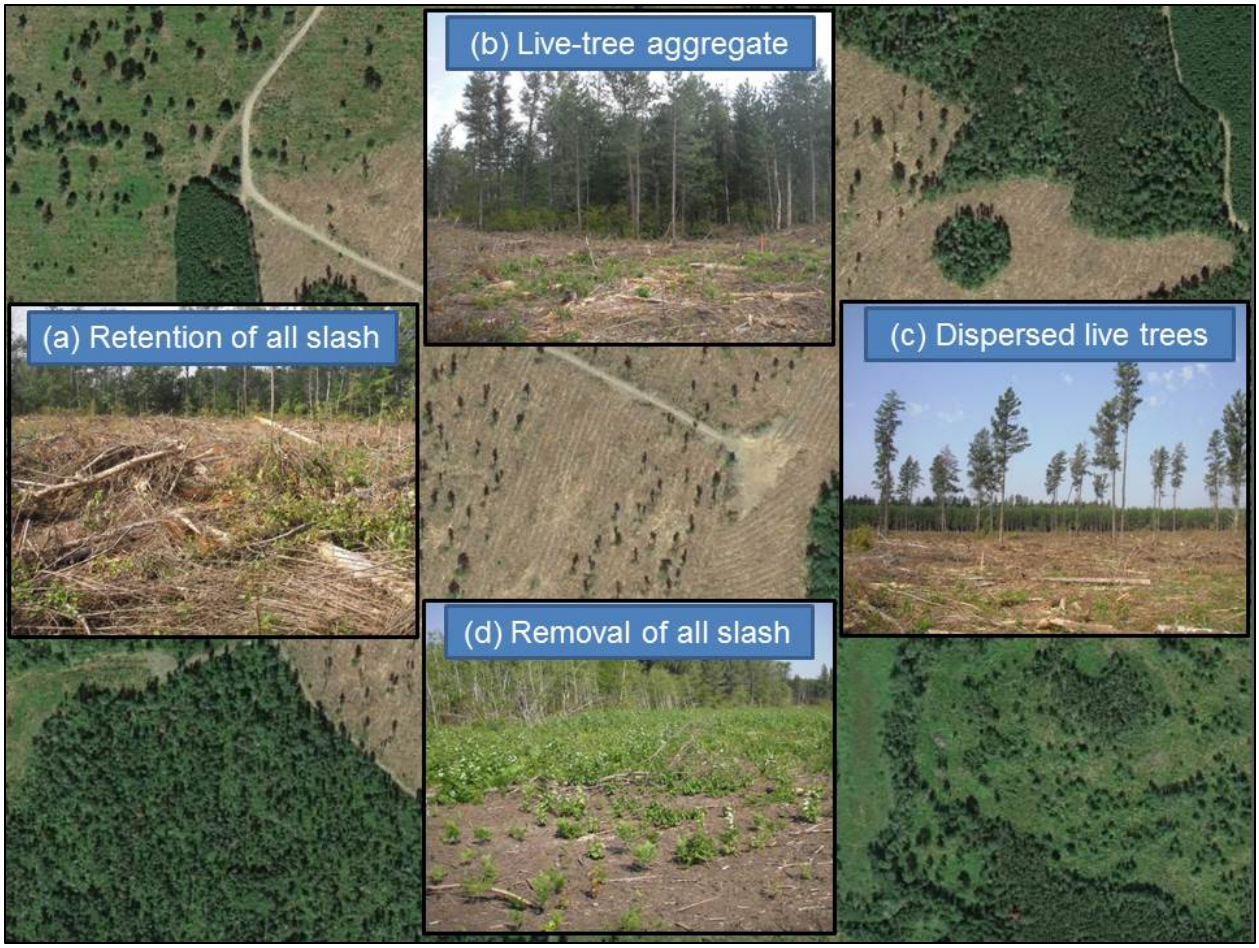


Figure 1. Biomass harvesting, by removing nutrient-rich tree branches and tops (i.e., slash) from the forest has the potential to negatively impact soil nutrients and forest plant communities. This project demonstrated that management practices, including retaining harvest slash (a) and living trees, both in groups (b) and singly (c) across harvested areas can minimize these negative impacts on jack pine forests growing on nutrient poor soils. Removal of all slash from these areas (d) is not recommended, as results indicate potential for long-term depletion of soil nutrients and carbon under this practice. Background photo is aerial image of one of four large-scale study areas established by this project.