Research Addendum for Peer Review

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Evaluation of Biomass Harvesting Impacts on Minnesota's Forests

Project number: **146-F**

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I. Abstract - 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 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. Despite these concerns and current plans for widespread application of biomass harvests across Minnesota, little is known about the long-term ecological impacts of forest biomass harvesting, particularly on nutrient poor soils.

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 aspen forests on nutrient poor soils in Minnesota. Treatments representing various levels of biomass harvest residues and live-tree retention will be implemented at each site to evaluate the importance of site-level legacies (live residual 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 using the PnET model. Most importantly, 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 at several spatial scales. Results from this proposed project will (1) provide critical information for informing management recommendations aimed at mitigating the impacts of biomass harvesting on nutrient poor soils, and (2) provide long-term predictions of the effects of this practice on the productivity of aspen systems growing on nutrient poor sites. Finally, this proposed project complements a similar study we are currently conducting on nutrient-rich sites in Minnesota. The combination of the two studies will allow us to better understand the ecological impacts of biomass harvesting across a broad range of levels of site productivity. Study results will be key to informing future revisions of Minnesota's biomass harvesting guidelines.

II. Background

There is considerable interest in expanding energy production from forest-derived biomass within Minnesota and across the nation. In particular, Minnesota has substantial forest resources that could be utilized for biofuel production, thereby lessening carbon dioxide emissions from fossil fuels while simultaneously providing much-needed economic vitality (Becker et al. 2009). Nonetheless, little is known about the long-term environmental impacts of increased harvesting of forest-derived energy feedstocks in the region. This lack of information greatly limits our ability to ensure the long-term sustainability of these practices and forecast sustainable biomass feedstock supply within the region.

A fundamental concern about using forest biomass to generate renewable energy is the potential for soil nutrient depletion as a consequence of repeated nutrient removals in harvested material (Hendrickson et al. 1989, Walmsley et al. 2009). In particular, it has been hypothesized that increasing removals of nutrient-rich branches and foliage for use as feedstocks may have negative effects on site nutrient availability (e.g., Hendrickson et al. 1989, Johnson and Todd 1998, Sverdrup and Rosen 1998). If harvesting operations remove soil nutrients faster than they are replenished via atmospheric deposition, chemical weathering, and biological N fixation ecosystem nutrient stocks will decline, eventually reducing site productivity. These decreases in

site productivity would lead to reductions in biomass production, requiring longer time periods between subsequent harvests and ultimately threatening the environmental sustainability of feedstock harvests (Proe and Dutch 1994, Egnell and Leijon 1999, Gough et al. 2007). Of particular concern are the impacts of these practices on nutrient poor sites where the risk of long-term nutrient depletion is greatest (Grigal 2004).

Beyond soil nutrients, understory plant communities can be directly impacted by the disturbance of forest harvesting operations, although the impacts of intensive biomass harvests are uncertain. These communities play a central role in the dynamics and functioning of forest ecosystems by influencing long-term patterns of productivity and succession (George and Bazzaz 1999, Royo and Carson 2006, Gilliam 2007) and contributing to forest nutrient and carbon cycles(Zak et al. 1990, Anderson and Eickmeier 2000, Chastain et al. 2006). The abundance of several tree and understory plant species is positively related to the levels of woody debris on the forest floor (Mladenoff and Stearns 1993, McGee 2001, Marx and Walters 2008), making these species particularly sensitive to increased levels of feedstock removal. In addition, the increased levels of physical disturbance associated with feedstock harvests may physically displace certain species or create opportunities for colonization by exotic, invasive plant species (Hobbs and Huenneke 1992, Parendes and Jones 2000, Sumners and Archibold 2007, Wolf et al. 2008). Once established, invasive species can cause dramatic changes to ecosystem structure (Asner et al. 2008) and site productivity (Allison and Vitousek 2004, Ashton et al. 2005), as well as placing native vegetation at risk. Together, the potential shifts in native plant species composition and the risk of invasive species have important consequences for long-term forest sustainability and resilience, thus making these critical response variables to measure when assessing the sustainability of biomass harvesting.

This proposal seeks to increase our understanding of the ecological impacts of biomass harvesting on nutrient poor sites by establishing a network of research sites on nutrient poor soils in Minnesota. Treatments representing various levels of biomass removal and live-tree retention will be implemented at each site to evaluate the importance of site-level legacies (live trees and harvest residues) in maintaining the resilience and sustainability of these systems under different biomass harvesting regimes. Specifically, we will impose three levels of harvest slash retention (100%, 20%, and 0% retained) along with three levels of live-tree retention (trees retained in clumps, trees dispersed, and no trees retained) (Figure 1). In addition, empirically derived estimates of nutrient removals from these research sites will be used to model the long-term effects of repeated biomass removals on ecosystem productivity using the PnET model. Importantly, 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 at several spatial scales. In addition, this proposed project complements a companion study established on nutrient rich soils within northern Minnesota and established through funding by the Minnesota Forest Resources Council (MFRC) and United States Department of Agriculture (USDA). Collectively, results from these areas will be critical for assessing the sustainability of biomass harvesting across the full range of forest conditions in the state and will be central to informing future revisions of Minnesota's forest harvesting guidelines.

III. Hypotheses

We put forth the following hypotheses regarding the impacts of biomass harvesting on aspen-dominated systems growing on nutrient poor soils in northern Minnesota:

a. The amount of post-harvest slash retained will influence the size and abundance of tree regeneration, with whole-tree harvesting (no slash retained) treatments being the greatest, compared to the 20% and 100% slash retained treatments. This difference will be due to the inhibitory influence of logging slash on aspen sprouting, as well as the lower levels of exposed soil for the establishment of other tree species within the 20% and 100% slash retained treatments.

b. The arrangement of retention trees will influence tree regeneration, with dispersed retention tree treatments resulting in the lowest regeneration densities and heights compared to no retention and clumped retention treatments, due to great stand wide competitive inhibition with dispersed retention.

c. Retained clumps of trees within harvest areas will maintain understory vegetation communities similar to those in unharvested intact stands.

d. The presence of exotic, invasive plant species will be greatest within the treatments receiving the highest levels of biomass removal.

e. There will be no detectable short-term differences in soil nutrient levels between biomass harvesting treatments**.**

f. Repeated removals of nutrients in logging slash over multiple rotations can, under certain conditions, result in declines in ecosystem productivity.

IV. Methodology

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

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 aspen-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 four aspen dominated 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 the St. Louis County Land Department and Minnesota Department of Natural Resources. The following treatments will be replicated across each site using a randomized complete block design:

a) ***Woody biomass removal*:** Four levels of woody biomass removal will be implemented: no harvest (control), bole-only harvest (all slash retained), whole-tree harvest (no slash retained), and biomass removal following MFRC guidelines (purposefully leaving 20%

slash; Figure 1). For biomass removal treatments following MFRC guidelines, trees will be whole-tree harvested, and 20% of limbs and tops will be either left in the woods or transported from the landing and scattered in the harvest area (MFRC 2007). Long-term comparisons between these treatments will allow us to assess whether different levels of woody biomass harvesting have lasting effects on forest regeneration, nutrient availability, and stand productivity. In addition, comparisons of woody biomass treatments following MFRC guidelines with whole-tree harvests will allow us to evaluate the importance of deadwood legacies in mitigating the ecological impacts of biomass harvesting operations.

b) ***Retention of live trees*:** Three levels of live-tree retention will be evaluated: no retention, dispersed retention, and clumped retention. For the live-tree retention treatments, we will follow MFRC guidelines in clearcut stands, which recommend either 6-12 scattered trees per acre or one or more clumps (1/4-acre or larger) comprising in total at least 5 percent of the treated area (MFRC 2005). Long-term comparisons between stands with and without retention trees will allow us to assess the importance of retention trees in maintaining community resilience and sustainability following roundwood (bole-only) and biomass (whole-tree) harvests. Moreover, comparisons of treatments with differing retention patterns will test the differential ability of these spatial patterns to influence productivity and ameliorate the ecological impacts of roundwood and biomass harvesting treatments. Importantly, examination of the interactive effects of live tree and harvest residue retention treatments will evaluate the relative importance of each of these factors in mitigating the ecological impacts of harvesting operations. Collectively, these long-term analyses represent the first formal evaluation of the MFRC's recommended tree retention levels and will thus serve to inform future refinement of those guidelines.

Importantly, the experimental design for this research is identical to an ongoing large-scale study in aspen systems on nutrient rich soils in Minnesota, allowing us to integrate the findings of this work into a broad context that represents a significant portion of the forested conditions in the state.

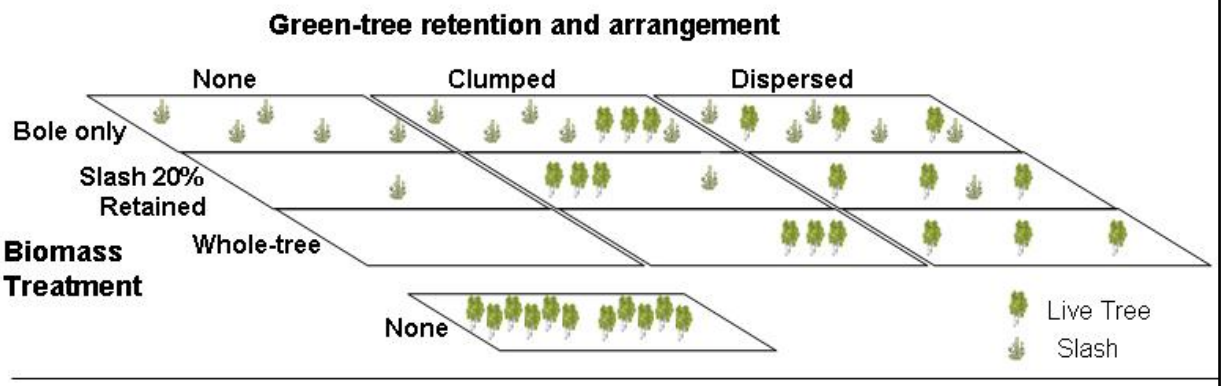

Figure 1: Conceptual diagram of treatments to assess the impact of biomass harvesting on saproxylic communities, nutrient cycling, and productivity in aspen ecosystems. Treatments include 3 levels of biomass harvesting, three levels of green tree retention, and an untreated control. All 10 treatment combinations will be included at each site, and will cover at least 10 acres.

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

Vegetation measurements

Within each treatment, six 400 m^2 circular sampling plots will be established for collecting vegetation data,. All vegetation will be measured annually within a series of nested plots. The largest plot (400 m^2) will be used for sampling living and standing dead overstory trees (DBH $\geq$ 10 cm), recording species and DBH for all trees. Species and DBH will be recorded for all saplings (DBH $\geq$ 2.54 cm and < 10 cm) occurring within three nested 25 m^2 plots. Advance tree regeneration and shrubs (< 2.54 cm DBH and $\geq$ 0.15 cm tall) will be tallied by species and measured (diameter at 15 cm) in three, 10 m^2 subplots nested within the sapling plots. Tree seedlings (<15 cm tall) within these plots will be tallied by species. Dead stems will be included in advance regeneration and shrub measurements on one of the 10 m^2 subplots per sampling plot. One litterfall trap will be randomly placed in each 400 m^2 plot for deriving estimates of litterfall rates. Published biomass equations will be used for estimating aboveground biomass within each plot (Jenkins et al. 2003), as well as for determining aboveground carbon stores. Finally, percent cover of groundlayer vegetation will be measured in eight randomly located 1m^2 plots. All plot locations will be marked and photographed to allow for repeated measurements and interpretation of results over the duration of the study.

Soil measurements

Soil sampling will be conducted in three circular 25 m^2 subplots radiating from plot center at azimuths of 90, 210 and 330° . An individual forest floor and mineral soil sample will be taken from each subplot and composited at the plot-level. Soil sampling locations will be randomized within each subplot and marked with pin flags to avoid re-sampling the same areas in future measurements. O horizon or forest floor material will be collected from 25 cm diameter PVC rings, where litter depth will be measured and the entire sample from within the ring collected. Following the removal of the forest floor, a soil core with a known volume will be collected to a depth of 20 cm. Forest floor material will be dried at 65^{o}C, and mineral soils dried at 105^{o}C for preparation of the analysis of total C and N in the forest floor and total C and N and exchangeable Ca, Mg, Na, K, P and N in mineral soils. Also, depth of forest floor measurements and soil core volume will be used for calculating bulk density of forest floor and mineral soil layers, allowing us to determine the soil mass per unit area of all analyzed nutrients . Herbaceous biomass will be determined by clipping and collecting all herbaceous material within one soil sampling location per plot. This collection will also occur within a 25 cm diameter PVC ring.

Coarse woody debris measurements

Within each 400 m^2 plot, species, height, and DBH will be recorded for all snags (standing dead trees $\geq$ 7.5 cm DBH and $\geq$ 1.5 m tall). Downed coarse woody debris (CWD; $\geq$ 7.5 cm diameter at the large end and $\geq$ 1 m in length) will be measured within each plot using the line intercept method (Harmon and Sexton 1996). In each plot, three 20-m transects radiating from plot center at azimuths of 30, 150, and 270 degrees will be established and used for sampling CWD (Figure 1). Intercept diameter, species (when possible), and decay class will be recorded for all CWD pieces encountered along these transects. In order to convert CWD volumes to biomass estimates, we will use published density values from Harmon et al. (2008). In addition, nutrient

and carbon content of these samples will be determined using the methods outlined in Sollins et al. (1987) and used for estimating deadwood carbon and nutrient pools.

Fine woody debris measurements

Fine woody debris (FWD; < 7.5 cm diameter at large end) will be measured along a portion of the three CWD transects using the line-intercept method (Figure 1, Brown 1974). Transect lengths will be varied based on FWD size classes following the protocol outlined by Brown (1976). In particular, species and diameter for FWD $\geq$ 2.5-7.5 cm in diameter will be recorded along a 4 m transect, whereas all FWD 0.63-2.5 and < 0.63 cm in diameter will be recorded along 2 and 1 m subsections of this transect, respectively. Volumes of FWD will be determined for each species using equations in van Wagner (1968). FWD biomass and nutrient and carbon content will be determined following the same procedures as CWD. Data from these samples will be integrated with aboveground biomass estimates derived using the equations in Jenkins et al. (2003) to determine the levels of nutrient and carbon removed in biomass harvesting operations.

Statistical analyses: The immediate and long-term impacts of biomass harvests on nutrient availability and cycling rates, as well as tree regeneration density and size, will be evaluated using mixed-model and repeated-measures mixed-model ANOVAs, respectively. Non-metric multidimensional scaling will be used to evaluate changes in community composition for understory and groundlayer vegetation over time and across biomass harvesting levels. In addition, multi-response permutation procedures will be used to compare the species composition of each of these communities between different levels of harvestings.

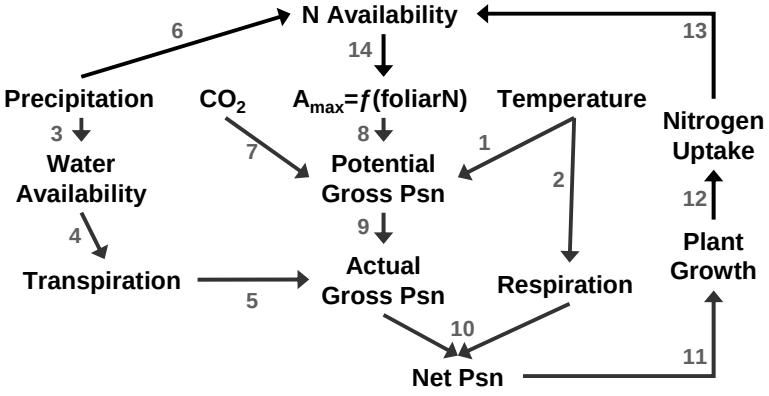

Figure 2: Conceptual diagram illustrating physiological processes included in PnET-CN. Temperature downregulates gross photosynthesis (1) based on deviations from optimal temperatures limiting maximum photosynthesis rates and high vapor pressure deficit limiting stomatal conductance. In addition, temperature impacts foliar respiration rates through a Q_{10} relationship (2) (Aber and Federer 1992). Precipitation alters soil water availability (3), which, combined with estimates of water use efficiency and vapor pressure deficit, limit transpiration (4) and downregulate actual gross photosynthesis (5). Precipitation influences the rate of nitrogen leaching and thus overall nitrogen availability (6). CO_2 concentration impacts production primarily by altering the maximum rate of photosynthesis (7). Internal CO_2 concentrations (Ci) are calculated from ambient CO_2 levels (Ca) and Ci/Ca ratios, which are linearly related to foliar nitrogen concentration. For a given Ca, Ci is used to estimate relative photosynthesis rates, which are translated into a proportional change in maximum photosynthesis rates (Ollinger et al. 2002). Foliar nitrogen plays a central role in PnET-CN by dictating maximum photosynthetic rate (A_{MAX}), A_{MAX} is combined with temperature and CO_2 to estimate potential gross photosynthesis (8), which, along with transpiration, dictates actual gross photosynthesis (9). Net photosynthesis is the difference between gross photosynthesis and respiration (10) and is used to generate monthly estimates of plant growth (11). Plant growth influences nitrogen update (12), nitrogen availability (13) and foliar nitrogen concentration (14).

Activity 3: Model long-term sustainability of biomass harvesting on nutrient poor soils

The ecological sustainability of biomass harvesting hinges on nutrient availability and potential nutrient limitations. We will integrate findings from Activity 2 into a well-validated ecological computer model (PnET) to simulate multiple levels of biomass harvesting on a range of soil qualities (Figure 2). This activity integrates soil

nutrient and ecosystem productivity measurements collected under Activity 2 into an ecological simulation model to generate estimates of the long-term impact of biomass harvests on forest productivity. Building on our insights about environmental impacts and sustainability from field measurements, we will simulate long-term forest growth and feedstock production in aspen forests growing on nutrient poor sites.

Simulations of long-term impacts of feedstock harvests: We will utilize the PnET-CN ecological simulation model to assess the long-term impact of biomass harvesting on forest productivity. PnET-CN is an ecological simulation model that uses physiological algorithms to simulate productivity and biomass accumulation in response to variability in temperature, precipitation, and CO_2 concentration as well as natural disturbances and human land-use practices (Figure 2). PnET-CN was designed around observed relationships between nitrogen concentration in leaves and photosynthesis rate (Aber and Federer 1992, Aber et al. 1995, Aber et al. 1997) and simulates forest growth, carbon and nitrogen allocation and cycling as well as soil water balance and water limitation. As a part of an ongoing research effort, members of our group are currently working to parameterize PnET-CN for aspen forests of the northern Lake States and validate the model with an independent dataset of forest growth for over 150 sites (Reich et al. 1997, Reich et al. 2001 and Reich et al. unpublished). Preliminary analyses suggest that PnET-CN output agrees within 10% with measured stand level carbon gain and provides a near 1:1 prediction across a range of stands varying in productivity rates.

PnET-CN is ideally suited for simulating the long-term sustainability of biomass harvesting because it simulates ecosystem nitrogen cycling and the effect of nitrogen limitation on productivity. Results concerning the short-term consequences of biomass harvesting for nitrogen abundance and availability from Activity 2 will be integrated into PnET-CN by modifying parameters specifying the amount of nitrogen removed in harvesting events. To assess the long-term sustainability of biomass harvesting, we will use the parameterized PnET-CN to simulate harvesting regimes with varying intensity (i.e. amount of biomass removed) and rotation lengths for 100 years in the future. This will identify the intensity of biomass harvesting (in terms of both amount removed and frequency of harvest) that can be sustained without adversely affecting nitrogen availability and forest productivity.

V. Description of the results and deliverables to produced from the proposed research

Deliverables from this project will be (1) operational-scale field experiments that will inform scientists and land managers on the impacts of biomass harvesting on the structure and function of aspen forests on nutrient poor soils; (2) datasets that enable an evaluation of the plant community, tree seedling, and soil nutrient responses of aspen systems under different levels of biomass removal; (3) predictions regarding the long-term impacts of repeated biomass removals on the productivity of aspen systems growing on nutrient poor soils; (4) policy-maker, land manager, and public education accomplished via conferencing, reports, seminars, per-reviewed publications, and web-based information; and (5) information provided to the MFRC to inform future revisions of Minnesota's biomass harvesting guidelines.

VI. Timetable for the proposed research (organized by project results)

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

Date	Milestone
July 2011	Project begins
August 2011	Nutrient poor sites identified through work with MNDNR and St. Louis County
November 2011	Treatment and plot layout completed
March 2013	Treatment implementation completed (timber sales carried out)

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

Date	Milestone
July 2011	Project begins
October 2012	Pre-harvest measurements of soils and vegetation completed
October 2013	Post-harvest measurements of soils and vegetation completed
June 2014	Data synthesis complete, final report complete, project end

Activity 3: Model long-term sustainability of biomass harvesting on nutrient poor soils

Date	Milestone
July 2011	Project begins
November 2013	Characterization of initial ecological impacts of biomass harvesting completed
November 2013	Results incorporated into ecological models of long-term impacts
June 2014	Project summaries published

VII. Dissemination and Use

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 aspen 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 University of Minnesota Department of Forest Resources web site.

VIII. Budget

The total budget request is 350,000 over a three-year period. This budget includes salary and fringe (0.1812) for one post-doctoral research associate, 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 three 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. 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.

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 and undergraduate students. Equipment for permanently marking research plots, collecting regeneration and soil samples, and measuring soil nutrient availability is budgeted at $5999.

BUDGET ITEM	**AMOUNT**
Personnel: One month of faculty summer salary and fringe (0.1934) for 3 years(D'Amato, PI; 0.1FTE)	$30,999
Salary and fringe (0.1812) for a post-doctoral researcher for 2 years (1.0 FTE)	$100,709
Salary and fringe (0.3230) for a research associate for 2.75 years (0.1 FTE)	$40,605
Salary and fringe (0.0743) for a work-study undergraduate student for 3 years	$26,688
Contracts: U.S. Forest Service, including: -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)	$127,000
Equipment/Tools/Supplies: 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)	$5,999
Travel: $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	$18,000
TOTAL PROJECT BUDGET REQUEST TO LCCMR	$350,000

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Sollins, P., S. P. Cline, T. Verhoeven, D. Sachs, and G. Spycher. 1987. Patterns of log decay in old-growth Douglas-fir forests. Canadian Journal of Forest Research **17**:1585-1595.

Sumners, W. H., and O. W. Archibold. 2007. Exotic plant species in the southern boreal forest of Saskatchewan. Forest Ecology and Management **251**:156-163.

Sverdrup, H., and K. Rosen. 1998. Long-term base cation mass balances for Swedish forests and the concept of sustainability. Forest Ecology and Management **110**:221-236.

van Wagner, C. E. 1968. The line intersect method in forest fuel sampling. Forest Science **14**:20-26.

Walmsley, J. D., D. L. Jones, B. Reynolds, M. H. Price, and J. R. Healey. 2009. Whole tree harvesting can reduce second rotation forest productivity. Forest Ecology and Management **257**:1104-1111.

Wolf, A. T., L. Parker, G. Fewless, K. Corio, J. Sundance, R. Howe, and H. Gentry. 2008. Impacts of summer versus winter logging on understory vegetation in the Chequamegon-Nicolet National Forest. Forest Ecology and Management **254**:35-45.

Zak, D. R., P. M. Groffman, K. S. Pregitzer, S. Christensen, and J. M. Tiedje. 1990. The vernal dam: plant-microbe competition for nitrogen in northern hardwood forests. Ecology **71**:651-656.

IX. Credentials

Biographical Sketches of Senior Personnel on Project

BIOGRAPHICAL SKETCH – Anthony W. D'Amato

Assistant Professor – Department of Forest Resources, University of Minnesota
1530 Cleveland Ave. North, St. Paul, MN 55108 – (612) 625-3733 – damato@umn.edu

Education and training

University of Maine	Forest Ecosystem Science	B.S., 2000
Oregon State University	Forest Science	M.S., 2002
University of Massachusetts	Forest Resources	Ph.D., 2007
University of Massachusetts	Forest Resources	Post-Doc, 2007

Research and professional experience

2007 –	Assistant Professor	University of Minnesota, St. Paul, MN
2007	Post-Doctoral Fellow	University of Massachusetts, Amherst, MA
2002–2006	Research Assistant	Harvard Forest, Harvard University/University of Massachusetts, Amherst, MA

5 Publications related to proposed project:

Domke, G.M., A.J. David, A.W. D'Amato, and A.R. Ek. In press. Hybrid aspen growth response to shearing in Minnesota: implications for biomass production and carbon sequestration. *Northern Journal of Applied Forestry.*

D'Amato, A.W., B. Palik, and C. Kern. 2010. Growth, yield, and structure of extended rotation *Pinus resinosa* stands in Minnesota. *Canadian Journal of Forest Research* 40: 1000-1010.

Bradford, J., A.W. D'Amato, B. Palik, and S. Fraver. 2010. A new method for evaluating forest thinning: growth dominance in managed *Pinus resinosa* stands. *Canadian Journal of Forest Research* 40: 843-849.

D'Amato, A.W., D.A. Orwig, and D.R. Foster. 2009. Understory vegetation in old-growth and second-growth *Tsuga canadensis* forests in western Massachusetts. *Forest Ecology and Management* 257: 1043-1052.

Puettmann, K.J., A.W. D'Amato, M. Arikian, and J.C. Zasada. 2008. Spatial impacts of soil disturbance and residual overstory on density and growth of regenerating aspen. *Forest Ecology and Management* 256: 2110-2120.

5 other peer-reviewed publications

Puettmann, K.J., A.W. D'Amato, U. Kohnle, and J. Bauhus. 2009. Growth dynamics of *Abies alba* during repeated group shelterwood (Femelschlag) cuttings. *Canadian Journal of Forest Research* 39: 2437-2449.

D'Amato, A.W., D.A Orwig, and D.R. Foster. 2008. The influence of successional processes and disturbance on the structure of *Tsuga canadensis* forests. *Ecological Applications* 18: 1182-1199.

D'Amato, A.W., and D.A. Orwig. 2008. Stand and landscape-level disturbance dynamics in western Massachusetts. *Ecological Monographs* 78: 507-522.

Orwig, D.A., R.C. Cobb, A.W. D'Amato, M.L. Kizlinski, and D.R. Foster. 2008. Ecosystem response to hemlock woolly adelgid outbreaks in southern New England forests. *Canadian Journal of Forest Research* 38: 834-844.

D'Amato, A.W., and K.J. Puettmann. 2004. The relative dominance hypothesis explains interaction dynamics in mixed species *Alnus rubra*/*Pseudotsuga menziesii* forests. *Journal of Ecology* 92: 450-463.

Synergistic Activities

- Member, Education Advisory Committee, Sustainable Forestry Education Cooperative, 2009-2010.
- Member, Black ash management guidelines development group, Minnesota Department of Natural Resources, 2009.
- Chair. Education Development Committee, Minnesota Chapter of the Society of American Foresters, 2010.
- Session organizer, Ecological classification systems in forests. 7th North American Forest Ecology Workshop, 2009.
- Field tour organizer and leader, Improving Productivity of Minnesota's Forest Resources. Workshop coordinated by the Minnesota Forest Resources Partnership, 2007.
- Member, Silviculture Task Force, coordinated by the Minnesota Forest Resources Partnership, 2007.
- In-coming chair, Forest and Range Ecology Working Group, Society of American Foresters
- Reviewer for several interdisciplinary scientific journals, including *Ecology, Ecological Applications, Forest Science, Journal of Ecology, Journal of Forestry, Northern Journal of Applied Forestry, Forest Ecology and Management, Annals of Forest Science, The Journal of the Torrey Botanical Society,* and *Western Journal of Applied Forestry*

BIOGRAPHICAL SKETCH – Charlie Blinn

Professor and Extension Specialist
Department of Forest Resources, University of Minnesota
1530 Cleveland Ave. North, St. Paul, MN 55108 – (612) 624-3788 – cblinn@umn.edu

Education and training

Bethany College	Biology	B.S., 1975
University of Tennessee	Forest Soils	M.S., 1978
Virginia Tech	Forestry and Forest Products	Ph.D., 1984

Research and professional experience

1984 – Present Professor and Extension Specialist University of Minnesota, St. Paul.

5 Publications related to proposed project:

Steil, J. C., C. R. Blinn, and R. K. Kolka. 2009. Foresters' perceptions of windthrow dynamics in northern Minnesota riparian management zones. Northern Journal of Applied Forestry. 26(2):76-82.

Palik B., K. Cease K., L. Egeland, and C. R. Blinn.. 2003. Aspen regeneration in riparian management zones in Northern Minnesota: Effects of residual overstory and harvest method. Northern Journal of Applied Forestry 20(2):79-84.

Smidt, M. F. and C. R. Blinn. 2002. Harvest caused soil disturbance decreases suckering capacity of quaking aspen (*Populus tremuloides* Michx.) following growing season harvests in Minnesota, USA. Forest Ecology and Management 163(1-3):309-313.

Bates, P. B., E. I. Sucoff, and C. R. Blinn. 1998. Soil flooding effects on root suckering in aspen. Northern J. of Applied Forestry. 15(4):169-173.

Bates, P. B., C. R. Blinn, and A. A. Alm. 1993. Harvesting impacts on quaking aspen regeneration in northern Minnesota. Canadian J. of Forest Research. 23:2403-2412.

5 other peer-reviewed publications

Blinn, C. R., P. J. Jakes, and M Sakai. 2007. Forest landowner cooperatives in the US: A local focus for engaging landowners. Journal of Forestry. 105(5):245-251.

Haworth, B. K., C. R. Blinn, and D. T. Chura. 2007. Assessment of logger education programs and programming in the US. Journal of Forestry. 105(7):358-363.

Kilgore, M., J. Leahy, J. Donnay, C. Hibbard, and C. R. Blinn. 2007. Evaluating logger certification attitudes and preferences: a Minnesota case study. Forest Products Journal 57(1): 84-90

Olson, K. D., J. A. Skuza, and C. R. Blinn. 2007.Extension educators' views of scholarship and performance evaluation criteria. Journal of Extension [Online], 45(4) Article 4RIB1. Available at: http://www.joe.org/joe/2007august/rb1.shtml

Phillips, M. J., and C. R. Blinn. 2007. Practices evaluated and approaches used to select sites for monitoring the application of Best Management Practices: A regional summary. Journal of Forestry. 105(4):179-183.

Synergistic Activities

- Associate Editor, Northern Journal of Applied Forestry, 2001–Present

- Minnesota Sustainable Forestry Implementation Committee, 1997-Present
- Board of Directors, Minnesota Logger Education Program, 1995–Present
- Member, New Brighton Forestry Board, 1993–Present
- Reviewer for several interdisciplinary scientific journals, including *Forest Products Journal, Forest Science, Journal of Forestry, Journal of Environmental Management, Northern Journal of Applied Forestry,* and *Western Journal of Applied Forestry*

BIOGRAPHICAL SKETCH – John B. Bradford

Research Ecologist: USDA Forest Service Northern Research Station
1831 Hwy 169 E., Grand Rapids, MN 55744 -- (218) 326-7105 -- jbbradford@fs.fed.us

Education

Ph.D.	2004	Ecology	Colorado State University (Graduate Degree program in Ecology)
B.A.	1996	Biology	Cornell University

Professional Positions and Experience

2006 –	Research Ecologist	USDA Forest Service, NRS, Grand Rapids, MN
2004 – 2006	Research Ecologist (postdoc)	USDA Forest Service, RMRS, Fort Collins, CO
1998 – 2004	Research Associate	Colorado State University, Fort Collins, CO

5 Publications related to proposed project

Bradford, J. B. and D. J. Kastendick. 2010. Age-related patterns of forest complexity and carbon cycling in pine and aspen ecosystems of Northern Minnesota, USA. Canadian Journal of Forest Research 40(3): 401–409.

Bradford, J.B., Weishampel, P., Smith, M.L., Kolka, R. K, Birdsey, R.A., Ollinger, S.V. and M.G.Ryan. 2009. Detrital Carbon pools in temperate forests: magnitude and potential for landscape-scale assessment. Canadian Journal of Forest Research 39: 802-813.

Bradford, J.B., and B.J Palik. 2009. A comparison of thinning methods in red pine: consequences for stand-level growth and tree diameter. Canadian Journal of Forest Research 39: 489-496.

Bradford, J.B., Birdsey, R. A., Joyce, L. A., and M. G. Ryan. 2008. Tree age, disturbance history, and carbon stocks and fluxes in subalpine Rocky Mountain forests. Global Change Biology 14: 2882-2897.

Bradford, J.B. and W. K. Lauenroth. 2006. Controls over cheatgrass invasion: the importance of climate, soils, disturbance and seed availability. Journal of Vegetation Science 17: 693-704.

5 other peer-reviewed publications

Bradford, J.B., D'Amato, A. W., Palik, B. J., and S. Fraver. 2010. A new method for evaluating forest thinning: growth dominance in managed *Pinus resinosa* stands. Canadian Journal of Forest Research 40: 843-849

Bradford, J.B., Weishampel, P., Smith, M.L., Kolka, R. K, Birdsey, R.A., Ollinger, S.V. and M.G.Ryan. 2010. Carbon pools and fluxes in temperate forests: spatial variability and sampling requirements. Forest Ecology and Management: 259: 1245-1254.

Lauenroth, W.K. and J.B. Bradford. 2009. Ecohydrology of dry regions of the United States: Precipitation pulses and intraseasonal drought. Ecohydrology 2: 173–181.

Bradford, J.B. Lauenroth, W.K., Burke, I.C. and J.M. Paruelo. 2006. The influence of climate, soils, weather and land-use on primary production and biomass seasonality in the U.S. Great Plains. Ecosystems 9: 934-950.

Bradford, J.B., Lauenroth, W.K., and I.C. Burke. 2005. The impact of cropping on net primary production in the U.S. Great Plains. Ecology 86(7) 1863-1872.

Synergistic Activities

- Memberships**:** Ecological Society of America, American Geophysical Union, International Association for Landscape Ecology
- Journal Reviewer: Ecological Applications, Ecology, Ecosystems, Global Change Biology, Biogeochemistry, Global Ecology and Biogeography, Oecologia, Nature, Diversity and Distributions, Remote Sensing of Environment, Forest Ecology and Management, Research Letters in Ecology, International Journal of Remote Sensing, Canadian Journal of Forest Research, Sustainability Science
- Proposal Reviewer: NASA postdoctoral program, British Columbia Forest Science Program, NSF Long-term Research in Environmental Biology Program, NSF Ecosystem Science Program
- Awards: Northern Research Station Early Career Scientist Award (2009), USFS Performance awards for 2007, 2008, 2009

BIOGRAPHICAL SKETCH – Shawn Fraver

Research Ecologist -- US Forest Service, Northern Research Station
Grand Rapids, MN 55744; (218) 326-7133; sfraver@fs.fed.us

Education and training

Pennsylvania State University	Biology	B.S., 1987
North Carolina State University	Forestry	M.S., 1994
University of Maine	Forest Resources	Ph.D., 2004

Research and professional experience

2007 –	Research Ecologist	US Forest Service, Northern Research Station
2004-06	Post-Doc	Mid-Sweden University, Sundsvall, Sweden
1999–04	Research Assistant	University of Maine, Orono, ME
1995-98	Investigator	Universidad Austral de Chile, Valdivia, Chile
1994-95	Research Assistant	Manomet Center for Conservation Science, MA
1992-93	Research Assistant	North Carolina State University, Raleigh NC

5 Publications related to proposed project:

Bradford, J., A.W. D'Amato, B. Palik, and S. Fraver. 2010. A new method for evaluating forest thinning: growth dominance in managed *Pinus resinosa* stands. *Canadian Journal of Forest Research* 40: 843-849.

Fraver, S., A. Ringvall, and B.G. Jonsson. 2007. Refining volume estimates of down woody debris. *Canadian Journal of Forest Research* 37: 627-633.

Jönsson, M., S. Fraver, B.G. Jonsson, M. Dynesius, M. Rydgård, and P.-A. Esseen. 2007. Eighteen years of tree mortality and structural change in an experimentally fragmented Norway spruce forest. *Forest Ecology and Management* 242: 306-313.

Fraver, S., R.G. Wagner, and M. Day. 2002. Dynamics of coarse woody debris following gap harvesting in the Acadian forest of central Maine, USA. *Canadian Journal of Forest Research* 32(12): 2094-2105.

Fraver, S. 1994. Vegetation responses along edge-to-interior gradients in the mixed hardwood forests of the Roanoke River Basin, North Carolina. *Conservation Biology* 8(3): 822-832.

5 other peer-reviewed publications

Fraver, S. A.S. White, and R.S. Seymour. 2009. Natural disturbance in an old-growth landscape in northern Maine, USA. *Journal of Ecology* 97: 289-298.

Fraver, S., B.G. Jonsson, M. Jönsson, and P.-A. Esseen. 2008 Demographics and disturbance history of a boreal old-growth *Picea abies* forest. *Journal of Vegetation Science* 19: 789-798.

Fraver, S. and A.S. White. 2005. Disturbance dynamics of old-growth *Picea rubens* forests of northern Maine. *Journal of Vegetation Science* 16: 597-610.

Fraver, S. and A.S. White. 2005. Identifying growth releases in dendrochronological studies of forest disturbance. *Canadian Journal of Forest Research* 35(7): 1648-1656.

Fraver, S., N.V.L. Brokaw, and A.P. Smith. 1998. Delimiting the gap phase in the growth cycle of a Panamanian forest. *Journal of Tropical Ecology* 14(5): 673-681.

Synergistic Activities

- Member, Nordic Working Group on the Ecology of Primeval Boreal Forests (PRIFOR), 2006-2010 (northern Europe).
- Co-instructor and co-organizer, Second and Fourth Fennoscandian Dendroecological Fieldweeks (Sweden, 2003, and Norway, 2009).
- Field tour organizer and leader, Southern Temperate Biota and Ecosystems: Past Present and Future. II Southern Connection Congress, Valdivia, Chile.
- Granting Agency Referee: Research Council of Norway, 2009.
- Reviewer for scientific journals: *Ecology, Global Change Biology, Conservation Biology, Journal of Vegetation Science, Forest Ecology and Management, Forest Science, Canadian Journal of Forest Research, Journal of Forestry, Scandinavian Journal of Forest Research, Plant Ecology, Ecological Bulletins, Castanea, Annales Botanici Fennici, Bosque*

BIOGRAPHICAL SKETCH – Randall K. Kolka

Research Soil Scientist – USDA Forest Service Northern Research Station
1831 Hwy. 169 E., Grand Rapids, MN 55744 – (218) 326-7115 – rkolka@fs.fed.us

Education and training

University of Wisconsin Stevens Point	Soil Science	B.S., 1990
University of Minnesota	Soil Science	M.S., 1993
University of Minnesota	Soil Science	Ph.D., 1996

Research and professional experience

2002 – Present	Research Soil Scientist	USDA Forest Service, Grand Rapids, MN
1998-2002	Assistant Professor	University of Kentucky, Lexington, KY
1996-1998	Post Doctoral Soil Scientist	USDA Forest Service, Aiken, SC
1991-1996	Research Assistant	University of Minnesota, St. Paul, MN
1995	Instructor	University of Wisconsin – Eau Claire, WI

Faculty appointments

Adjunct Professor, Department of Biological Sciences, North Dakota State University
Associate Faculty, Department of Natural Resource Ecology and Management, Iowa State University
Adjunct Professor, Department of Forest Resources, University of Minnesota
Adjunct Professor, Department of Soil, Water and Climate, University of Minnesota
Graduate Faculty, Department of Forestry, University of Kentucky
Adjunct Faculty, School of Forest Resources and Environmental Science, Michigan Technological University

5 Publications related to proposed project:

Bradford, J., P. Weishampel, M.L. Smith, R. Kolka, R.A. Birdsey, S.A. Ollinger, and M.G. Ryan. 2010. Carbon pools and fluxes in small temperate forest landscapes: variability and implications for sampling design. Forest Ecology and Management, 259: 1245-1254.

Weishampel, P., R. Kolka, and J.Y. King. 2009. Estimates of carbon pools and productivity in a heterogeneous forest and peatland landscape. Minnesota, USA. Forest Ecology and Management, 257: 747-754.

Pelster, D.E., R.K. Kolka and E.E. Prepas. 2009. Influence of overstorey vegetation on the flux of nitrogen and dissolved organic carbon from the atmosphere to the forest floor: Boreal Plain, Canada. Forest Ecology and Management, 259: 210-219.

Fissore, C., C.P. Giardina, C.W. Swanston, M. Torn, G.M. King, and R.K. Kolka. 2009. Variable temperature sensitivity of soil organic carbon in North American forests. Global Change Biology, 15: 2295-2310.

Bradford, J., P. Weishampel, M.L. Smith, R. Kolka, R.A. Birdsey, S.V. Ollinger, and M.G. Ryan. 2009. Detrital carbon pools in temperate forests: magnitude and potential for landscape-scale assessment. Canadian Journal of Forest Research, 39: 802-813.

5 other peer-reviewed publications

Kolka, R.K., S.S. Sebestyen, E.S. Verry, and K.N. Brooks. 2010. *Peatland Biogeochemistry and Watershed Hydrology at the Marcell Experimental Forest: Results from 50 Years of Scientific Research.* CRC Press, in process.

Kolka, R.K., M.C. Rabenhorst, and D. Swanson. 2010. Chapter 6.2. Histosols. In Handbook of Soil Science, M.E. Sumner (ed). CRC Press, Boca Raton, FL. (in press)
Kolka, R.K., C.P. Giardina, J.D. McClure, A. Mayer, and M.F. Jurgensen. 2010. Partitioning hydrologic contributions to an 'old-growth' riparian area in the Huron Mountains of Michigan, USA. Ecohydrology, 3:315-324.
Witt, E.L., R.K. Kolka, E.A. Nater, and T.R. Wickman. 2009. Forest fire effects on mercury deposition in the boreal forest. Environmental Science and Technology, 43(6): 1776-1782.
Fissore, C., C.P. Giardina, R. Kolka, C. Trettin, G.M. King, M.F. Jurgensen, C. Barton, D.S. McDowell. 2008. Temperature and vegetation effects on soil organic matter quality along a forested mean annual temperature gradient in North America. Global Change Biology, 14: 193-205.

Synergistic Activities

- 2008-present. Co-NRS Representative on the Natural Resources Research Institute (NRRI) Advisory Board (University of Minnesota - Duluth)
- Ecosystems Restoration and Creation Annual Conference Editorial Review Committee, 1997-present
- Subject Area Representative Ecology and Biology Subject Area, and Member of the Forest Science and Technology Board – Society of American Foresters, 2006-2010
- Associate Editor, *Wetlands*, 2006-2009
- 2009. Review of Wisconsin Water Quality Guidelines for Forestry Operations
- 2008. Department of Natural Resources and Ecology Review, Iowa State University
- 2005-2008. Riparian Science Technical Committee, Minnesota Forest Resources Council
- EPA STARS Scholarship Review Panel, 1999, 2000, 2001, 2004, 2005, and 2010
- British Columbia Forest Science Grant Program Panel, 2004-2008
- 2007. Poster Session Organizer, Annual Society of American Foresters Conference, Portland, Oregon
- 2007. Symposium Organizer on Ecohydrology, Ecosummit 2007, Beijing, China
- 2007. Symposium Organizer on Linking Aquatic Sciences and Management: Small Watershed Studies in North American Forested Landscapes, Congress of the International Association of Theoretical and Applied Limnology, Montreal, Canada
- Reviewer for several interdisciplinary scientific journals, including *Ecology, Soil Science Society of American Journal, Journal of Environmental Quality, Climate Change, Wetlands, Environmental Science and Technology, Geoderma, Journal of Hydrology, Ecological Engineering, American Water Resources Association Journal, Environmental Pollution, Landscape Ecology, Water, Air and Soil Pollution, Forest Ecology and Management, Canadian Journal of Forest Research, Biogeochemistry, and Journal of Forestry.*

BIOGRAPHICAL SKETCH – Brian J. Palik

Team Leader and Research Ecologist - USDA Forest Service, Northern Research Station
1831 Hwy. 169 E, Grand Rapids, MN 55744 - 218-326-7116 - bpalik@fs.fed.us

Education

Alma College	Biology	B.S., 1983
Michigan State University	Plant Ecology	M.S., 1988
Michigan State University	Forest Ecology	Ph.D., 1992
Organization for Tropical Studies	Tropical Ecology	1987

Research and professional experience

2007-present	Team Leader	Northern Research Station, USFS, Grand Rapids, MN
2002-2007	Project Leader	North Central Research Station, USFS, Grand Rapids, MN
1996-2002	Research Ecologist	North Central Research Station, USFS, Grand Rapids, MN
1993-1996	Assistant Scientist	Joseph W. Jones Ecological Research Center, Newton, GA

Adjunct Faculty: University of Minnesota, Michigan Technological University, Iowa State University, Lakehead University

5 Publications related to proposed project

Palik, B., R. J. Mitchell, S. Pecot, M. Battaglia, and P. Mou. 2003. Spatial distribution of overstory retention influences resources and growth of longleaf pine seedlings. Ecological Applications 13: 674-686.

Palik, B., K. Cease, L. Egeland, and C. Blinn. 2003. Regeneration in Riparian Management Zones of Northern Hardwood-Aspen Forests: Effects of Residual Overstory and Harvest Method. Northern Journal of Applied Forestry 20: 79-84.

Kern, C., B. Palik, and T. Strong. 2006. Ground-layer plant community responses to even-age and uneven-age silvicultural treatments in Wisconsin northern hardwood forests. Forest Ecology and Management 230: 162-170.

Tarpey, R. A., M. F. Jurgensen, B. J. Palik, and R. K. Kolka. 2008. The long-term effects of silvicultural thinning and partial cutting on soil compaction in red pine (Pinus resinosa Ait.) and northern hardwood stands in the northern Great Lakes Region of the United States. Canadian Journal of Soil Science 88:849-857.

Palik, B. J. and D. Kastendick. 2009. Woody plant regeneration after blowdown, salvage logging, and prescribed fire in a northern Minnesota forest. Forest Ecology and Management 258: 1323-1330.

Five other publications

Palik, B. J., P. C. Goebel, L. K. Kirkman, and L. West. 2000. Using landscape hierarchies to guide restoration of disturbed ecosystems. Ecological Applications 10: 189-202.

Palik, B. J., R. J. Mitchell, and J. K. Hiers. 2002**.** Modeling silviculture after natural disturbance to maintain biological diversity: balancing complexity and implementation. Forest Ecology and Management: 155: 347-356.

D'Amato, A. W., B. J. Palik, and C. C. Kern. 2010. Growth, yield, and structure of extended rotation red pine stands in Minnesota. Canadian Journal of Forest Resources 40: 1000-1010.

Powers, M. D, K. S. Pregitzer, B. J. Palik, and C. R. Webster. 2010. Wood $\delta^{13}C$, $\delta^{18}O$ and radial growth responses of residual red pine to variable retention harvesting. Tree Physiology 30: 326-334.

Montgomery, R., P. Reich, and B. Palik. 2010. Untangling positive and negative biotic interactions: views from above and below ground in a forest ecosystem. Ecology (In press).

Synergistic Activities

- 2008-present: Research Needs Advisory Panel, Minnesota Forest Resources Council
- 2008-present: Chair, Forest Ecology Working Group, Society of American Foresters
- 2007-present: Science Advisory Committee, Natural Resources Research Institute, U of MN
- 2006: Technology Transfer Award, Northern Research Station, USFS
- 2004-present: Riparian Science Technical Committee, MN Forest Resources Council
- 2003-2009: National Experimental Forest Working Group, USDA Forest Service
- 2008-present: Resource Management and Use Research Advisory Panel, USDA For. Serv.
- 1998: Presidential Award for Early Career Scientists and Engineers
- 1997: Chief's Early Career Scientist Award, USDA Forest Service
- Member, Society of American Foresters, Forest Guild, IUFRO Uneven-age silviculture group
- Peer Reviewer: Ecology, Can. J. For. Res., J. of Ecol., Am. Midl. Nat., J. of Veg. Sci., Biotropica, For. Ecol. Manage. J. of For. Res., Plant Eco., For. Sci., Cons. Ecol., Land. Ecol., For. Snow, Lands. Res., J. of For., J. Biog., Northwest Sci., New Forests, USDA Competitive Grants, NSF Competitive Grants, British Columbia Forest Service Competitive Grants, USDOD SERDP Competitive Grants

Robert A. Slesak

Minnesota Forest Resources Council
2003 Upper Buford Circle, St. Paul, MN 55108

Education

Ph.D. (2008) Forest Soil Science, Oregon State University, Corvallis, OR

M.S. (2004) Forest Ecosystem Science, State University of New York College of Environmental Science and Forestry, Syracuse NY

B.S. (2002) Forest Resources Management, SUNY ESF, Syracuse, NY

A.A.S (2000) Forest Technology, SUNY ESF, Ranger School, Wanakena, NY

Professional Experience

Current: Site-level Program Manager, Minnesota Forest Resources Council
2008: Post-Doctoral Associate, Dept. of Forest Engineering, Oregon State University
2005-08: Graduate Research Assistant, Oregon State University
2004: Watershed Program Assistant, Skaneateles Lake Watershed Agriculture Program
2003-04: Graduate Research Assistant, SUNY
2002: Forester, USDA Forest Service, Hubbard Brook Experimental Station, NH

Publications

Slesak, R.A, S.H. Schoenholtz, T.B. Harrington, and N.A. Meehan. In Press. Initial response of soil carbon and nitrogen to harvest intensity and competing vegetation control in Douglas-fir (*Pseudotsuga menziesii*) plantations of the Pacific Northwest. Forest Science.

Slesak, R.A, S.H. Schoenholtz, and T.B. Harrington. 2010. Soil respiration and carbon responses to variable logging-debris retention and competing vegetation control in the Pacific Northwest. Soil Science Society America Journal 74:936-946.

Slesak, R.A, T.B. Harrington, and S.H. Schoenholtz. 2010. Soil and Douglas-fir (*Pseudotsuga menziesii*) foliar nitrogen responses to logging-debris retention and competing vegetation control in the Pacific Northwest. Canadian Journal Forest Research 40:254-264.

Slesak, R.A. and R.D. Briggs. 2010. Foliar mass and nutrition of *Abies concolor* Christmas trees following application of organic and inorganic fertilizer. Northern Journal Applied Forestry 27(1):28-33.

Slesak, R.A., S.H. Scheonholtz, T.B. Harrington, and B.D. Strahm. 2009. Dissolved

carbon and nitrogen leaching following variable logging-debris retention and competing vegetation control in Douglas-fir plantations of western Oregon and Washington. Canadian Journal Forest Research 39:1484-1497.
Slesak, R.A. and R.D. Briggs. 2007. Christmas tree response to N fertilization and the development of critical foliar N levels in New York. Northern Journal Applied Forestry 24(3):209-217.

Awards and Activities

Arnold and Vera Meier Fellowship, Oregon State University, 2006
Alfred W. Moltke Scholarship, Oregon State University, 2006
Forestry Graduate Fellowship**,** College of Forestry, Oregon State University, 2005
College Scholar, SUNY ESF, 2002
Salutatorian, SUNY ESF, Class 2002
New York State Scholarship of Academic Achievement, 2001
Salutatorian, SUNY ESF, Ranger School, Class 2000
Wesson Award, SUNY ESF- Ranger School, 1999
Education Advisory Committee, Sustainable Forestry Education Cooperative, 2009-2010.
Agricultural Use Team, MN Water Sustainability Framework, 2010
Incoming co-chair, Soils Working Group, Society of American Foresters
Reviewer for *Forest Science*, *Forest Ecology and Management*, *Journal of Environmental Quality, Northern Journal of Applied Forestry*