Woody Biomass Energy Research Symposium for the Northern Forest

April 28-30, 2011 • The University of Vermont • Burlington, Vermont

Funded by

The Northeastern States Research Cooperative:
A Research Program for the Northern Forest

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Special thanks to our project cooperators and steering committee members:

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www.uvm.edu/forestcarbon/symposium

Day at a Glance: Thursday April 28

Registration, check-in, breakfast
7:30 Silver Maple Ballroom

Welcome
8:15 Sugar Maple Ballroom

Session 1: Setting Stage Plenary
8:30 Sugar Maple Ballroom

Break
9:30 Fourth Floor Davis Center

Session 2: Woody Supply Plenary
9:45 Sugar Maple Ballroom

Lunch and Graduate Student Gathering
11:30 Silver Maple Ballroom

Session 3A: Sustainability Standards
1:00 Sugar Maple Ballroom

Session 3B: Community Roadmap to Renewable Woody Biomass (Panel)
1:00 Jost Family Room

Session 4A: Life Cycle Analysis
2:15 Jost Family Room

Session 4B: Human Health and Air Quality
2:15 Chittenden Bank Room

Session 5A: Scientific Impact Assessment of Harvesting Practices in the Northern Forest for Energy Biomass (Panel)
3:30 Sugar Maple Ballroom

Session 5B: Soil Dynamics
3:30 Chittenden Bank Room

Reception
5:15 Silver Maple Ballroom

Day at a Glance: Friday April 29, 2011

Check-in, breakfast
7:30 — Silver Maple Ballroom

Session 6A: Evolving Understanding of GHG Emissions
8:15 — Sugar Maple Ballroom

Session 6B: Biomass Conversion
8:15 — Chittenden Bank Room

Session 6C: Logging Contractors and Innovations in Operations
8:15 — Jost Family Room

Break
9:15 — Four Floor Davis Center

Session 7A: Harvest Impact and Field Models
9:30 — Chittenden Bank Room

Session 7B: Regional Perspectives
9:30 — Jost Family Room

Session 7C: Assessing Social Impacts and Values
9:30 — Sugar Maple Ballroom

Session 8A: Current and Future Biomass Harvesting Guidelines in the Northern Forest States (Panel)
10:45 — Sugar Maple Ballroom

Session 8B: Willow as a Source of Biomass Energy
10:45 — Jost Family Room

Session 8C: Decision Support Tools
10:45 — Chittenden Bank Room

Closing Plenary: Implications for Future Research
12:10 — Sugar Maple Ballroom

Lunch Buffet and box lunches to go
12:30 — Silver Maple Ballroom

Agenda for Future Research (over lunch)
12:45 — Williams Family Room

Tentative Schedule for the Addison County Field Tour

April 30, 2001

7:30	-	Depart from Burlington in transportation provided (vans)
8:30	-	Arrive at Mt Abraham High School, coffee and tea
8:45 - 9:00	-	Welcome & Introductions
9:00 - 9:30	-	UVM Community Biomass Project Presentation
9:30 - 10:15	-	Forest Guild Guidelines Presentation
10:45 - 11:30	-	Harvest Site 1: Karen Lueders and Jim Dumont's family forest on West Hill in Lincoln. Walk through and presentation/discussion
12:20 - 12:45	-	Lunch Stop at local waterfall, Eagle Park, Bristol
12:45 - 1:30	-	Harvest Site 2: Hogback or USFS (TBA). Walk through and presentation/discussion
2:00 - 2:45	-	Tour of A Johnson Lumber Mill and Processing facility
3:00 - 3:30	-	Tour of Mt Abraham High School wood chip heating facility
3:30 - 4:00	-	Wrap-up and discussion at high school cafeteria
4:15	-	Depart For Burlington

Full Program with Abstracts: Thursday April 28, 2011

Registration, check-in, breakfast

7:30 Silver Maple Ballroom

Welcome

8:15 Sugar Maple Ballroom

Session 1: Setting Stage Plenary

8:30 Sugar Maple Ballroom

Joint Keynote Address: Looking Back and Moving Forward: Woody Biomass Energy From Social and Natural Science Perspectives

Dr. William Keeton, The University of Vermont, Dr. Denis Becker, The University of Minnesota

Energy Perspective from the U.S. Department of Energy Biopower Technical Strategy Workshop

Mark Downing*, Elliott Levine

To explore opportunities for biopower in the United States, the U.S. Department of Energy (DOE), Office of Energy Efficiency and Renewable Energy Biomass Program conducted the Biopower Technical Strategy Workshop in Denver, Colorado, on December 2–3, 2009. The purpose of the workshop was to provide a forum for discussing technical and economic challenges; research, development, and demonstration (RD&D) priorities; and issues related to feedstocks, sustainability, and market transformation. The workshop was attended by many experts from industry, academia, national laboratories, and government, and it generated a wealth of information and ideas. This is a presentation of the results of the workshop, organized by the five topic areas shown below: 1) Pretreatment and Conversion Technologies: Pretreatment to improve combustibility and other characteristics, and conversion; 2) Large-Scale Systems: Biomass systems integrated with utility-scale power generation, such as large-scale cofiring with coal or natural gas, gasification, or direct combustion; 3) Smaller-Scale Systems: Systems that range from ~1–50+ megawatts, including industrial, community, and institutional systems; repurposed pulp and paper mills; and others; with a focus on combined heat and power; 4) Feedstocks for Biopower: Integration of biomass handling systems with power plants, use of opportunity fuels, sustainability, super-high-yield energy crops, and other issues; 5) Market Transformation: Policy, legislation and regulation, land use issues, renewable portfolio standards, tax and investment credits, permitting, markets, loan guarantees, etc The DOE Biomass Program expects to use the results of the workshop to inform planning and help map future research and development priorities in sustainable biopower.

Break

9:30 Fourth Floor Davis Center

Session 2: Woody Supply Plenary

9:45 Sugar Maple Ballroom

Factors Affecting Increases in Biomass Production from Maine Forests

Robert G. Wagner*, Jeffrey G. Benjamin, Aaron R. Weiskittel, Kenneth M. Laustsen

Maine has been identified by the National Renewable Energy Laboratory as one the highest biomass producing areas in the country. Maine also has a well-established forest products infrastructure and a tremendous forest resource on which to increase woody biomass production for rapidly emerging bioenergy markets. An important question is whether Maine can increase the production of biomass to meet these new demands. Current estimates by the Maine Forest Service indicate that woody biomass productivity can be sustainably increased by about 5.9 million green tons per year (or 67 to 188% above recent biomass harvest levels). This increase can occur primarily by increasing harvest/utilization (65%) and harvesting young stands previously considered as not commercially viable (25%), and to a lesser extent by increasing silvicultural intensity (10%). Achieving any increases, however, will likely be determined by a number of complex factors, including: 1) logging technology and capacity, 2) biomass market availability and volatility, 3) biomass retention guidelines, 4) ownership changes affecting forestland and wood supplies, 5) landowner incentives to produce more low value wood and make capital investments, 6) legacy of extensive partial cutting, 7) amount of suitable land and economics for short-rotation crops, 8) future pest outbreaks (e.g., spruce budworm), and 9) public perceptions and regulatory consequences. It is vital that we understand and quantify the degree of influence that these factors will have on the ability of Maine's forests to increase biomass production to meet future bioenergy needs. This talk will discuss these various factors and outline future research needs.

Social versus Biophysical Availability of Wood

Brett J. Butler*, Dave Damery, Paul Catanzaro, David B. Kittredge, Marla Lindsay, Zhao Ma, Tom Stevens

In this presentation, we will present the findings from two studies. First, we will discuss the broad availability of wood resources across the northern United States in relationship to social and biophysical constraints. The availability of wood from family forest lands was reduced by nearly two-thirds primarily due to social constraints such as size of forest holdings and ownership attitudes. The second study examines the willingness of family forest owners in Massachusetts to harvest biomass and the factors that increase and decrease their likelihood to do so.

Wood Supply from Forests in the Northeast and its Allocation to Energy Markets

Thomas Buchholz*, Charles Canham

There has been enormous interest in the use of forest biomass for energy applications in the Northeastern US. Concerns arise about a) the total amount of biomass available from forests for energy purposes and b) which conversion technologies and end-use applications should be pursued to efficiently tackle climate change, dependence on foreign oil, or a declining rural economy. The objectives of this study were to assess the biomass available from Northeastern forests additional to current uses and to explore several fossil fuel substitution scenarios for their potential to reduce endpipe CO2 emissions. We relied mainly on data from the U.S. Forest Service Forest Inventory Analysis (FIA) program and to some extend on the Timber Products Output database (TPO) for the biomass estimates, and on data from the Energy Information Administration (EIA) for the energy analysis. Results suggest that if (a) all current pulp harvests are diverted to biomass energy use, and (b) recent harvest rates are increased to the point where they meet recent forest net growth (a limited but intuitive estimate of sustainability), under our two different sets of assumptions about forestland availability, biomass production for energy use would range from 13.7 – 15.1 million metric tons per year over the 8-state region (Pennsylvania – Maine, excluding New Jersey). Assuming that all of the estimated sustainable forest biomass supply was used in the most efficient current technology (combined heat and power plants), forest biomass energy would only replace 1.4 – 5.0% of the region's current fossil fuel consumption.

Woody Biomass Feedstock Supply Potential in NY State

T.A. Volk*, P. Woodbury, P. Castellano, R. Germain, T. Buchholz

Potential feedstock supplies from agriculture and forest systems were assessed as part of the development of the NY Renewable Fuels Roadmap. The main focus of the assessment was potential production from perennial energy crops grown on underutilized agricultural land and woody biomass from forests under and low and high production scenario. This presentation will focus on the approach used to determine woody biomass supply from forests and will summarize results in the context the potential supply from all the sources. Estimates of woody biomass available from forests used USDA FIA and TPO data as the primary data sources and calculated potential supplies at a county level. A series of restrictions were incorporated to ensure that existing wood products industries were not affected, environmental concerns were addressed, and annual yields were sustainable. The potential supply of biomass in NY was determined to be 9.4 – 14.6 million dry tons (mdt) depending on the scenario. Woody biomass from forests contributed 4.8 mdt (51%) in the first scenario and 6.4 mdt (44%) of the supply in the second scenario. Willow biomass crops grown on marginal agricultural land were projected to provide an additional 2.1 – 4.6 mdt, with perennial grasses providing most of the rest of the supply. Assuming that the technological barriers to commercial scale production of lignocellulosic ethanol are overcome by the year 2020, the total capacity for lignocellulosic ethanol is estimated to be between 508 and 1,449 million gallons, representing 5.6% to 16%, respectively, of projected 2020 gasoline consumption in NY.

Lunch and Graduate Student Gathering

11:30 Silver Maple Ballroom

Session 3A: Sustainability Standards

1:00 Sugar Maple Ballroom

Downed Dead Wood: Assessment Tools for a Key Indicator

Mark J. Ducey*, Alexander M. Evans

Downed dead wood (DDW), also called coarse woody debris (CWD) and lying dead wood (LDW), plays essential ecological roles in northeastern forests. Some researchers have raised concerns about the potential depletion of DDW stocks following biomass harvests, while others have pointed to the abundance of DDW post-harvest as evidence of the availability of underutilized biomass stocks. We recently completed a national-scale review of DDW carbon stocks and assessment methods, and summarize our results with specific attention to northeastern forests. Although northeastern forests do generally follow a “U-shaped” trend of DDW with stand age, there is great variability around the average. This highlights the challenge of using regionally-averaged figures for site- or project-specific assessments. Direct assessment of DDW carbon stocks can be challenging, but significant progress in inventory methods has been made in the last two decades. There are now at least seven major approaches to DDW inventory, each presenting different strengths and weaknesses. Of these, only four (fixed area plots, line intersect sampling, point relascope sampling, and perpendicular distance sampling) have received extensive testing under northeastern forest conditions. One new method (line intersect distance sampling) has only been tested under western conditions but shows considerable promise. Nondetection errors, the need to assume a volume equation for irregularly shaped material, errors in measuring cross-sectional area, and errors in wood density affect all the methods to varying degrees. For these reasons, line intersect sampling and perpendicular distance sampling are probably the most useful methods for operational inventories in northeastern forests.

Developing Certification Standards and Indicators for Socially Sustainable Biofuels: Challenges and Opportunities

Theresa Selfa*, Ana Luiza De Campos Paula

Biofuels has emerged as a controversial issue at the intersection of the debates over food, energy, and climate. Concerns that the shift to energy crop production in the south was undermining both food security and carbon-sequestering landscape benefits led to recent efforts by diverse stakeholders,

including NGOs, national and regional governments, and private corporations, to create fora such as roundtables to devise a system and standards for certifying the production of "sustainable biofuels". Moreover most of the certification efforts are emerging from the European Union and from developing countries, such as Brazil. As these initiatives to certify sustainable biofuels emerge, questions abound about who will benefit and who will bear the costs and burdens of sustainability certification. How will certification efforts initiated by nation states, such as Brazil's "Social Fuel" seal interface with the objectives of global actors such as the Roundtables on Sustainable Biofuels Production? As multi-stakeholder groups of actors develop standards for sustainable biofuels, we interrogate how indicators of social and environmental sustainability are being developed, how efforts at harmonizing standards are being undertaken, and whether such standards and certifications can be applied equally well in industrializing and developing countrycontexts. Drawing upon secondary literature, the paper will critically assess the current efforts at developing standards and indicators for certifying socially sustainable biofuels and their potential applicability across developing/industrial country contexts.

Ensuring Sustainability in Ontario's Forests: An Examination of the Efficacy of Current Standards for Forest Bioenergy Production

B. Lattimore*, B.D. Titus, C.T. Smith, I. Stupak

Interest in using forest biomass as feedstock for a variety of energy and bio-based products is growing in Canada and the United States, and this has the potential to put strain on northern forest ecosystems. This paper will argue that growth in the utilization of biomass must occur in parallel with the development of effective standards and systems to guide sustainable management if negative consequences are to be avoided. We will synthesize the outcome of projects undertaken by both the International Energy Agency Bioenergy Task 43 and Environment Canada to examine how current standards and management systems address sustainable forest biomass production for bioenergy. We will present and discuss a searchable database of available mandatory and voluntary standards (international, national, regional) applicable to forest biomass production from Ontario's northern forests. We will then briefly examine the efficacy of these standards in light of current knowledge, identify gaps, and suggest improvements. Finally, we will discuss the importance of using an adaptive forest management framework for new and evolving forest management systems such as those for harvesting biomass from forests for bioenergy and bio-based products.

Session 3B: Community Roadmap to Renewable Woody Biomass (Panel)

1:00 Jost Family Room

Panel Organizer: Sarah S. Smith

Panelist: Kamalesha Doshi, Samantha Dunn

The Community Roadmap to Renewable Woody Biomass Energy (the Roadmap) is a civic decision-making tool—a document—designed to help a community or group systematically work through an information gathering and decision-making process to assess whether a woody biomass energy project is an appropriate option. The publication is chocked full of information and worksheets, which can be filled out electronically or with paper and pencil forming the basis for a full feasibility study. The "Roadmap" was developed by The New Hampshire Wood Biomass Heat and Power Task Force, which is comprised of over forty individuals, organizations and agencies with the goal of creating district heat and power systems throughout New Hampshire. The primary partners for the task force are North Country RC&D (Resource Conservation and Development Area), Plymouth State University, UNH Cooperative Extension and the Northern Forest Center. The Task Force identified five critical topics, which present barriers to communities trying to move biomass-energy projects forward. The topics include: Technology/Equipment and Suppliers; Systems Installation/Operation and Management; Funding Opportunities; Air Quality Regulations and Benefits; Fuel sources and availability; Public Policy and Regulations. In addition, the Task

Force, identified community engagement as the most important, and often neglected, piece of any successful district energy project

Session 4A: Life Cycle Analysis

2:15 Jost Family Room

Energy Return on Energy Invested of a Small-Scale Wood Fuel Harvest in Woodstock, Vermont

Eric Garza*

High energy prices and a drive towards "green technologies" have increased the pressure on North Eastern forests as sources of thermal energy. The value of biomass energy to consumers must be judged on a variety of social, economic, ecological, and energetic criteria. One criteria that is a valuable component of this assessment process is energy return on energy invested, or simply energy return. This study uses life cycle assessment to study the direct and indirect energy costs of a fuel wood harvest at the Marsh-Billings-Rockefeller National Historical Park in Woodstock, Vermont. Estimates of wood energy content are used to calculate the end-use energy return of fuel wood before it is burned in the park's Garn boiler. We estimate the energy return of wood in this contest to be roughly 10, meaning that 10 units of energy are generated by the harvesting process for each unit of direct and indirect energy used—an unambiguous energy profit. While this result is favorable, it was estimated for a very small-scale operation and more research is needed to understand the impact of forestry practices, forest health, operational scale, and wood product use on the energy return of forest energy products.

Incorporating Biodiversity Impacts into Life Cycle Analysis of Forest based Bioethanol Production

Binod Neupane*, Anthony Halog

In the current life cycle assessment (LCA) framework, biodiversity is one of the least measured impact categories. This impact category is highly important, particularly in biomass related studies such as bioethanol production. Biodiversity impact assessment requires collection and analysis of spatial and non-spatial data which can be accomplished using different tools. Combining these tools, we can assess the biodiversity impacts and integrate them into an LCA framework. In this research, we develop a novel approach that integrates LCA, geographic information systems (GIS) and landscape management systems (LMS) to assess biodiversity impacts from land use in forest based ethanol production. In our framework, LMS models different forest management and harvesting systems. LCA receives outputs from forest management activities to calculate life cycle elementary flows and biodiversity impacts. GIS is used to present biodiversity impacts spatially with appropriate biodiversity impact indicators. We consider three different scenarios of ethanol blending into gasoline: E10, E25 and E85. Based on these scenarios, we look at the level of impacts on biodiversity over time from 2010 to 2030. Biodiversity assessment of these ethanol production scenarios is based on the habitat information of focus vertebrate species. Different biodiversity impact indicators (e.g. species richness, evenness and habitat naturalness, etc.) are used to model the impacts. Our preliminary results show that biodiversity impact increases linearly as the ethanol blending level is increased. However, the selection of biodiversity impact indicators also has a prominent role in total biodiversity impact. A valid prototype model is currently under development. This methodology can be used to understand the temporal and spatial performance of different bioproducts

Assessing the environmental performance of ethanol, acetic acid, and OSB panels co-produced in a forest biorefinery

Jeffrey Earles*, Anthony Halog

The oriented strand board (OSB) biorefinery is an emerging technology which could improve the environmental profile of the transportation, chemical, and building sectors. OSB is the most common

structural building panel in the U.S. By adding hot water extraction to conventional OSB manufacturing, hemicellulose polysaccharides are dissolved from wood chips and used to produce ethanol and acetic acid. Replacing fossil-based gasoline and acetic acid with hemicellulose-derived ethanol and acetic acid could reduce greenhouse gas (GHG) emissions. Hemicellulose extracted wood flakes could also improve the environmental profile of OSB panels by reducing select volatile organic compounds, or VOCs, between 15% and 75% (Paredes, 2009). This study aims to characterize the relevance of these emission reductions to human and ecosystem health.

To do this, a simple process model was developed based on a mix of lab and industrial-level mass and energy flow data. Using this data, a life cycle assessment (LCA) model was built. Five key process parameters were identified: extraction liquid to wood ratio, heat recovery, carbohydrate concentration, VOC reduction, and acid recovery. The most sensitive impact categories to these parameters are global warming potential (GWP) and human toxicity potential (HTP). Comparing a baseline and target scenario to conventional production, under the baseline OSB biorefinery scenario, HTP reductions of nearly 19% can be achieved, with nearly 37% reductions under the target scenario. GWP, on the other hand, increases by over 11% under the baseline scenario. If technological improvements can be made to key parameters, however, nearly an 8% GHG reduction is possible.

Session 4B: Human Health and Air Quality

2:15 Chittenden Bank Room

Residential Wood Boiler Efficiency and Emissions Performance – Air Quality and Health Effects Implications

Ellen Burkhard*

The price of home heating oil (HHO) has many residents returning to wood heating for cost savings. Emissions from wood combustion are far greater with conventional wood heating equipment compared to HHO. These localized emissions coupled with meteorological and topographical effects can result in elevated ambient wood smoke concentrations in neighborhoods, villages, and valleys and have been the source of many complaints in the Northeastern US and Canada. Much more efficient and lower emitting wood boiler technologies have been developed in Europe over the past three decades and now some of those staged combustion designs are being developed by domestic manufacturers. This presentation will compare efficiency and emissions performance of conventional and advanced wood boiler technologies to those of fossil-fired boilers. The air quality and health effects implications of fuel switching will also be discussed.

Emission Measurements from Three High Efficiency Wood Boilers

Sriraam Ramanathan Chandrasekaran*, James Laing, Suresh Raja, Thomas Holsen, Philip K. Hopke

Biomass combustion is a significant source of air pollutants, including particles and gases. However, biomass has been shown to be a carbon-neutral energy source for space or water heating. Measurements were made on 3 different European designed boilers with an ouput capacities of 150kW (514000 Btu hr^{-1}) installed at Clarkson Walker Center and Schenectady; and 500 kW (1.7 mmBtu) integrated with a solar tube hot water system at Wild Center. In each case, the stack was sampled using an in-stack $PM_{2.5}$ cut size cyclon dilution sample system (Conditional Test Method CTM 039.) The diluted emissions were continuously monitored for CO, NO_x and SO_2 using ambient gas monitors. The $PM_{2.5}$ mass concentration was continously measured using a TEOM Filter Dynamics Measurement System (FDMS). THe particle size distribution was obtained suing a Fsst Mobility Particle Sizer (FMPS). Filter samples on Quartz, Teflon and PUF substrates were collected for organic and elemental carbon analysis, elemental analysis and specific organic chemical compounds, respectively.

Wood Combustion – Air Quality Issues and Analysis

Lisa Rector*

Pollution from commercial wood combustion consists primarily of carbonaceous material. Inventory and usage studies indicate that wood smoke is a large contributor to PM2.5 in the northeastern U.S. Biomass energy systems are generally market-ready alternatives to fossil fuel heating systems, especially in the Northeast where conventional fuel sources are among the most expensive in the nation. Limited regulations as compared with other heating technologies allow a variety of device types to be operated in residential, commercial, institutional and industrial applications. Though wood combustion energy systems have many attractive economic characteristics, their combustion emissions exhibit wide variation across the spectrum of available technologies due in large part to the current regulatory status. This presentation will discuss the impacts of wood combustion on air quality, an analysis of recent regulatory activity and implications for future actions.

Session 5A: Scientific Impact Assessment of Harvesting Practices in the Northern Forest for Energy Biomass (Panel)

3:30 Sugar Maple Ballroom

Panel Organizer: Thomas Buchholz

Panelists: Anna Mika, Caitlin Littlefield, William Keeton

Demand for forest biomass fuel is increasing in the northern forest region and beyond. However, the perceived benefits of this potentially sustainable resource belie the risk for both elevated stress on forest ecosystems and decreased in situ carbon storage from harvesting impacts, particularly if harvesting intensity increases. On the other hand, ecologically-based harvesting practices that seek to mimic stand development processes, structural heterogeneity, and disturbance ecology may actually improve or restore stand conditions and enhance carbon storage potential. With a growing market for woody biomass, incentives for this type of silviculture may increase. We will present studies based on an empirical data collected from 30 recent biomass fuel harvest sites (primarily in northern Vermont) – in addition to five control harvest sites where no biomass for wood energy was generated – that evaluate the economic drivers behind harvesting practices and logging impacts upon stand structural complexity and long-term carbon storage. Stand structure indicators will include overstory and ground layer metrics such as live basal area, aboveground biomass, standing snag basal area and density, coarse and fine woody debris volumes, and downed tree crown density. Multivariate statistical analyses (e.g. classification and regression trees) will enable us to describe the harvesting impacts with regard to these indicators; determine which site-specific variables best predict post-harvest structural conditions and carbon. Based on information on pre- and post-harvested stand conditions, harvest equipment used, products procured and current labor and machinery rates as well as market prices for wood products, we trace the economics of the logging operations. This dataset enables us to a) allocate logging cost factors to specific products and make assumptions on logging economics excluding and including wood chip production on the same site as well as b) outline economic gains to the forest owner and logger. Preliminary results suggest that wood chip extraction provides as much as 23% of total revenues from a given logging operation while being accountable for up to 81% of total biomass extraction by dry weight. As interest in forest biomass fuel grows, it is essential that we understand both the stand structure and carbon dynamic implications and identify how procurement standards may best be crafted to safeguard critical stand structure characteristics and carbon storage potential while still being economical.

Session 5B: Soil Dynamics

3:30 Chittenden Bank Room

Acidic Deposition-Induced Calcium Depletion Disrupts the Physiology of Trees, Predisposing Them to Reduced Growth and Decline

Paul G. Schaberg*, Gary J. Hawley, Joshua M. Halman, Paula F. Murakami, Christopher F. Hansen

Substantial evidence indicates that acidic deposition leaches and depletes calcium (Ca) from forest soils in the northeastern US. Because Ca is an essential plant nutrient and supports plant stress tolerance, Ca depletion could threaten the health and productivity of montane forests that have low soil Ca and receive elevated inputs of acid deposition. Initial evidence that Ca depletion reduces tree stress tolerance was obtained via investigation of the mechanism through which acid deposition increases freezing injury in red spruce. Experiments demonstrated that acid deposition directly leached Ca from foliar cells and that this loss of Ca destabilized cells, depleted pools of signal Ca, and increased the susceptibility of cells to freezing injury. Based on measurements across a regional acidic deposition gradient and at experimental Ca-addition and reference watersheds, soil Ca depletion was shown to be an important contributor to the region-wide winter injury event of 2003. High winter injury was associated with reduced above-ground woody biomass accumulation for two years following foliar loss. New data indicates that other tree species experience alterations in Ca nutrition and physiology similar to those documented for red spruce. For example, symptoms of sugar maple decline (crown deterioration, slow growth and reduced wound closure) can be alleviated via Ca fertilization, and paper birch decline appears greatest on low Ca sites. These data suggest that the negative influences of Ca depletion on the health and productivity of forest trees are not limited to red spruce, but have broader relevance to a variety of species.

Carbon Loss in Mineral Soil Horizons: The Effects of 120 Years of Forest Harvesting in New England

Rachel A. Neurath*, Andrew J. Friedland

New England forests are a potential source of biofuel. However, forest harvesting may have long-term effects on soil carbon storage. In temperate systems, mineral soil horizons contain more soil carbon than organic horizons or vegetation. Land-use change can physically, chemically, and biologically disturb the mineral soil, resulting in the mineralization and release of carbon as carbon dioxide to the atmosphere. The dynamics of this response are poorly understood. We examined a chronosequence of forest plots at the Bartlett Experimental Forest in New Hampshire that were harvested 3, 25, 50, 75, and 120 years ago, as well as an old growth plot, to determine the magnitude and timing of carbon loss following forest biomass harvest. Our results show a significant, long-term depletion in mineral soil carbon following harvest. Total carbon concentrations declined from the 3-yr plot (84.2 MgC/ha) to the 75-yr plot (59.7 MgC/ha), which was 31% depleted in carbon relative to the old growth plot (87.0 MgC/ha). Carbon loss through 75 years was somewhat surprising, however Diochon and Kellman (2009) observed a similar trend in Nova Scotia. Carbon isotope (δ13C) results suggest that increased microbial respiration following forest harvest is responsible for the depletion of mineral soil carbon. Our study reveals the need to consider mineral soil carbon when harvesting forest biomass in New England.

Monitoring Plots to Detect Change in Soil Carbon Pools in Vermont's Managed Forests

Donald S. Ross*, Juliette Juillerat, Sandy Wilmot

Sustainable forest management relies on understanding and maintaining site quality. Increased demands for biomass heat, energy and local wood products will increase harvesting and site disturbance, potentially reducing long-term storage of carbon. Information is limited on current forest soil stores of carbon and forest management effects on these stores. Our project goal was to establish reference plots in Vermont on actively managed forested lands. We selected 18 locations representing the major forest soil types and forest communities (northern hardwood, rich northern hardwood and lowland red spruce-balsam fir). Plots were intensively sampled by soil horizon and depth increment to bedrock or dense till. Total soil carbon, including the forest floor, ranged from 43 to 193 Mg ha-1. Above-ground carbon stores

had a similar range of 62 to 180 Mg ha-1. The distribution of carbon in the soil profile was affected by past land-use and an Ap (plow layer) horizon was often present. Near-surface carbon is more susceptible to management impacts. Extensive measurements showed that the forest floor thickness varied widely, between 1 and 11 cm. Results (www.uvm.edu/~soilcrbn) will inform land managers and the public, and be used as a baseline for additional sampling to investigate changes, if any, after harvest activity.

Comparing the Soil CO2 Flux in Short Rotation Willow Crop *(Salix dasyclados)* Stand as Affected by Tear Out and Continues Production Treatments

Renato S. Pacaldo*, Timothy A. Volk, Russell D. Briggs

In short rotation willow crop (SRWC) production system, the complete understanding of the carbon balance requires the quantification of inputs and outputs from various carbon pools. Carbon dioxide (CO2) emissions via root respiration and decomposition of organic matter constitute a major fraction of carbon losses in SRWC system. At the end of the crop's life, roots and stumps will likely be left in the soil to decompose releasing much of the accumulated carbon CO2. However, there is much uncertainty on soil respiration rate under SRWC ecosystem. Hence, there is a need to investigate belowground total respiration to refine the estimates on the carbon balance in SRWC system. This study aimed to quantify the soil CO2 flux between continues production and tear out treatments. Measurements of soil CO2 flux have been carried out using an automated soil respiration machine (LiCor 8100) and soda lime method. Survey and long term continues measurements have been conducted to address spatial and temporal variability of CO2 flux by using survey chamber, multiplexer, and long term chamber. Survey measurement has been carried out once a week and long term measurements for continues five days. Soda lime measurement has been conducted simultaneously with survey measurements. Using soda lime method, the preliminary result indicated that CO2 flux between and within rows is not significantly different, although CO2 flux within rows is always higher in values as compared to between rows flux. There is also high correlation between CO2 flux and soil temperature. CO2 flux among sites is significantly different. Before treatment application, the average soil CO2 flux ranges from 1.03 to 1.66 umol s-1 m-2, which is equivalent to 4.09 to 6.59 Mg ha-1 for a period of 104 days. Initial observations also revealed that the data obtained from soda lime method and automated CO2 flux machine are not significantly different. Increased heterothropic respiration was observed after treatment application. An increased soil CO2 flux from tear out and continue production treatments was also observed immediately after treatment application.

Reception

5:15

Full Program with Abstracts: Friday April 29, 2011

Check-in, breakfast

7:30 Silver Maple Ballroom

Session 6A: Evolving Understanding of GHG Emissions

8:15 Sugar Maple Ballroom

Toward a Global Woody Biomass Energy Greenhouse Gas Emissions Accounting Framework: Lessons from the Massachusetts Biomass Sustainability and Carbon Policy Study

John Gunn*

To address the timing and magnitude of GHG impacts of burning wood for energy, a more complete carbon accounting framework is needed. Such a framework would recognize the excess GHG emissions attributable to burning wood biomass relative to fossil fuels as a 'carbon debt'. This debt can be calculated based on a comparison of lifecycle GHG emissions from biomass and fossil fuels, and should include both stack and upstream production and transportation GHG emissions. The information provided by the carbon debt accounting framework offers policy makers greater ability to tailor wood biomass energy policies to achieve the most rapid and significant reductions in GHGs. The framework requires four key inputs to calculate the specific shape of the debt-then-dividend curve for a given state, region, country or even individual biomass facility: (1) Biomass feedstock source; (2) Form of energy generated; (3) Fossil fuel displaced; and (4) Management of the forest. We will present this framework using data and analyses from the Massachusetts Biomass Sustainability and Carbon Policy Study completed by the Manomet Center for Conservation Sciences for the Massachusetts Department of Energy Resources in June of 2010. We will also demonstrate how this framework is applicable to a wide range of forest types and geographic areas.

Forest Bioenergy or Forest Carbon? Assessing Trade-Offs in Greenhouse Gas Mitigation

Jon McKechnie*, Steve Colombo, Heather L. MacLean

The potential of forest-based bioenergy to reduce greenhouse gas (GHG) emissions when displacing fossil fuels must be balanced with forest carbon reductions from biomass harvest. Conventional life cycle assessment (LCA) studies ignore forest carbon dynamics. Conversely, forest carbon-focused analyses typically disregard emissions from bioenergy systems captured by LCA. Using these tools in isolation is inadequate to evaluate forest bioenergy. We integrate LCA and forest carbon analysis to assess total GHG emissions of forest bioenergy over time and apply this method to case studies of wood pellet and ethanol production from forest biomass in Ontario, Canada. In all cases investigated, forest carbon reductions from biomass harvest (and associated GHG emissions) initially exceed avoided fossil fuel emissions, temporarily increasing total GHG emissions. Electricity generation from wood pellets, displacing coal, reduces overall emissions in the long-term, although forest carbon losses delay net GHG mitigation by 16 years (if sourced from harvest residues) or 38 years (if sourced from standing trees). Ethanol from standing trees increases total emissions throughout 100 years of continuous production, while ethanol from harvest residues achieves a net reduction only after a 74-year delay. Forest carbon more significantly impacts bioenergy life cycle emissions when biomass comes from standing trees compared to harvest residues and when less GHG-intensive fossil fuels are displaced. Achieving timely GHG reductions with forest bioenergy therefore requires selection of appropriate biomass sources and targeted displacement

of GHG-intensive fuels. In all cases, forest carbon dynamics are significant and an integrated LCA/forest carbon approach is necessary.

Policy Mechanisms to Address GHG Emissions of Wood Biomass Energy

Dennis Becker*

The scale of wood energy production in the United States is potentially significant. The degree to which it could wreak havoc on ecological systems is also considerable if not done correctly. Current debates surrounding the future of wood energy provides a useful framework for investigating policy mechanisms aimed at maximizing benefits and reducing negative impacts. The key assumptions involved in wood energy carbon accounting form the basis for existing and potential policy interventions related to feedstock source, form of energy and conversion technology, fossil fuel displacement, and ensuing forest management. State and federal policy mechanisms are investigated in the context of maximizing forest carbon sequestration among other competing policy goals.

Session 6B: Biomass Conversion

8:15 Chittenden Bank Room

Integration of Biofuel Production with Pulp Mill Operations: Forest Biorefinery Models

G. Peter van Walsum*, Clayton Wheeler, Adriaan van Heiningen, Hemant Pendse, Byung-Hwan Um, Abigail Engelberth, Sara Walton, Rakhi Baddam, Sampath Karunarathne, Mohit Bahtia, Thomas Schwartz, Paige Chase

Production of forest-based transportation fuels can be enabled through integration of biofuel conversion technology with pulp and paper mill operations. With crude oil prices in the range of $700/tonne (~$90/bbl), biofuels may be a profitable coproduct with pulp and paper products. This presentation introduces several biofuel conversion pathways that are currently under investigation at the University of Maine. Pre-pulping extraction can be implemented to extract out of pulp wood hemicelluloses that are normally burned as components of the black liquor solution. By converting hemicelluloses to liquid biofuels, greater economic value can be derived from this component of the pulp wood. Several different pathways make use of pre-pulping extraction. Wood extracts can be fermented directly to commodity fuels and chemicals such as ethanol and lactic acid. Alternatively, current work is investigating microbial conversion of wood extracts to organic acids and triacylglicerides (TAGs). These products serve as intermediates that can be further upgraded to hydrocarbon or mixed alcohol fuels. Conversion of whole wood to biofuels can also be integrated with pulp mill operations. Processing wood chips through lime pretreatment and acidogenic fermentation benefits from the lime kiln operation at pulp mills. Likewise, chemically-derived wood acids have been shown to be converted to hydrocarbon fuels via thermal deoxygenation. Several promising wood-to-fuel conversion pathways coupled with the expertise and infrastructure of the pulp and paper industry suggest that the wood processing industry may be one of the first to start producing significant quantities of non-food crop derived biofuels.

Performance Measurements Using ASHRAE Standard 155p

Sriraam Ramanathan Chandrasekaran*, Thomas Holsen, Philip Hopke

Thermal efficiency is defined as the ratio of heat output to heat input at steady state. It is the measure of heating performance of a commercial boiler set by Hydronics Institute (HI) and American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE 90.1-99). ASHRAE standard 155p is the new performance evaluation protocol although it is still provisional. This method provides the standard for determining the thermal efficiency including the partial load efficiency of individual commercial scale boilers. It also provides a method for determining application specific seasonal efficiency under steady state conditions. The standard is applied for space heating performance and is applicable to all boilers with energy input values ranging from 300,000-12,500,000 Btu/hr. This procedure was applied to

determine the efficiency of advanced wood combustion boilers installed at Clarkson's Walker Center and Wild Center, Tupper Lake , New York. These are two boilers with output capacities of 514000 Btu and 1.7 million Btu/hr, respectively. Measurements were conducted during the heating season from January untill March 2011 under steady state conditions for heating load demands. Preliminary results from the Wild Center boiler suggest that efficiency varies between 80 and 95%. Keywords: Thermal efficiency, ASHRAE 155p, steady state, performance, boiler.

Design and feasibility analysis of biothermal energy and compost generation from forest and agricultural feedstocks

Samuel Gorton*, W. Jason McCune-Sanders*

This research seeks to quantify the biomass energy potential and ecological effects of composting forest and agricultural residues for Northern Forest enterprises. Composting transforms food waste, manures and woody biomass into stable soil amendments, generating heat as a by-product. In compost recipes, woody biomass provides porosity, dry matter, substrate and carbon. Decentralized biothermal energy processes would keep nutrients in proximity to their point of extraction, thus sustaining farm and forest soil resources, while displacing fossil fuel demand for heat. Preliminary research has uncovered data from previous applications of biothermal energy generation from composting. Jean Pain, a French farmer, forester and researcher, developed techniques for composting forest residues to produce high-quality compost while generating substantial quantities of heat. An experimental 100 yd3 brushwood compost mound yielded an average 1 gal/min of 60C water for 18 months (620 Mbtu, captured heat). Replication of Pain's methods, however, has not been reported in scientific literature. Since 2005, a commercial-scale biothermal energy generation system has been operating in Sheldon, VT. The estimated energy generation rate for this system, as 50-60C hot water for tap use and radiant flooring, is 1000 btu/hr/ton of active compost. Current research involves assessment of scenarios for integrating composting with heating agricultural, residential and municipal buildings within the Northern Forest region. Results will be reported as estimated cash flow, energy demand and carbon dynamics of biothermal energy applications. Promising results will motivate pilot-scale research projects with local community partners.

Session 6C: Logging Contractors and Innovations in Operations

8:15 Jost Family Room

Operational Assessment of Logging Residue Bundles as a Bioenergy Feedstock in Maine

Jeffrey G. Benjamin*, Robert W. Rice, Ian J. Stone

Ensuring an adequate supply of feedstock is increasingly important to the Northeast's current and emerging bioenergy and bioproducts industries. One option that has attracted attention in this region is to bundle logging residue into composite residue logs (CRL) which are then delivered to roadside and energy facilities by conventional forwarders and logging trucks. While there are a number of advantages to bundling logging residues, handling and storing this material represents a new challenge to logging contractors and bioenergy facilities in terms of production costs and the effect of storage time and condition on moisture content and fuel value. A preliminary time and motion study and a productivity analysis was conducted on a John Deere 1490D Slash Bundler in the spring of 2009. Four composite residue logs were transported to the Demerit Forest at the University of Maine for further study of storage time, storage condition, moisture content, and heat value. Results show a wide range in cycle times for CRL production and the subsequent effect on productivity levels. The results also show that environmental factors have an impact on drying conditions of logging residue in compacted form. This in turn has a negative effect on ultimate energy values that can be obtained from the raw material. The results suggest that CRLs could benefit from covered storage prior to comminution for energy generating. Using the approach outlined in this study it is possible to develop predictive models to determine optimum storage condition and time for composite residue logs.

The Impact of Innovation in the Logging Industry on Biomass Supply

Ian Stone*, Jeffery Benjamin, Jessica Leahy

A robust supply chain is critical to ensuring a sustainable supply of feedstock to the existing and emerging bioenergy and bioproducts industries. Logging contractors are a key group in this process since they provide the necessary feedstock and harvesting services and their success is directly linked with innovation activities. Surprisingly, very little is known about the innovation system in the logging industry and how it relates to the supply of biomass. Failure to understand how logging contractors adopt and implement new biomass technologies could lead to failed innovation efforts, unmet development goals, and a lack of properly equipped and willing contractors. This paper will present results from a series of case studies of highly innovative logging contractors in Maine. Many of the firms produced biomass currently or had produced it at one time. The firms had also used or currently employ multiple harvesting technologies for biomass production. This study has highlighted the variation in challenges that led to the adoption (or rejection) of biomass as a product innovation – with particular emphasis on harvesting technologies. A major finding of this study was the need for a high degree of collaboration between landowners, logging contractors, and bioenergy facilities in the innovation process. The future development of the biomass industry is highly dependent on contractors adopting biomass and related technologies. The innovation process of logging firms is an area that is understudied, and this research provides valuable insight into this important component of the bioenergy industry.

Logger perspectives on supplying Vermont's wood energy: Insights from a community-based biomass project

Matthew Peters*, Cecilia Danks, Eva Wollenberg,

Growing interest in wood energy development in Vermont and regionally has the potential to increase and qualitatively change demands on wood supply chains and the producers constituting them. Understanding existing supply chains and producers is crucial for aiding adaptation to new demands and for evaluating and improving the sustainability of forest based biomass harvesting. Understanding the characteristics and views of logging communities is increasingly recognized as important for developing market analyses, certification programs, payment models, and for solving regulatory and technical challenges. Relatively little research is available characterizing Vermont's forest workforce, particularly in the context of increasing biomass harvesting. This study was undertaken in an action research process to better inform efforts to develop sustainable wood energy systems at a community level. We used phone interviews with loggers and wood processors to examine existing operations, including their business models, perceptions of biomass markets, access to different biomass markets (e.g., firewood, chips, pellets), and the constraints and opportunities that they faced. This yielded insights into supply chain structure, current and future market trends, and barriers facing loggers at local and regional levels; and it provided a perspective to help local community-based initiatives better assess project feasibility and improve the sustainability of the existing wood energy supply system.

Break

9:15 Four Floor Davis Center

Session 7A: Harvest Impact and Field Models

9:30 Chittenden Bank Room

No Free Lunch: The Ecological Impacts of Woody Biomass Harvest

Michael Rentz*

Woody biomass harvest is growing as one potential response to global climate change and energy security, but the ecological impacts of this harvest are not fully understood. Presented here is a multi-year

study tracking the impacts of this increased harvest on understory vegetation and small mammals using a Before, After, Control, Impact (BACI) design. Three northern Minnesota forests were each divided into three treatments: control (no harvest) clearcut with slash retention, and clearcut with mechanical slash removal (biomass harvest). The plant community was surveyed before harvest and one and two years post harvest. Small mammals were trapped for two years preceding harvest and for 1 year (one site) or 2 years (2 sites) after harvest. Compared to the control treatment and pre-harvest conditions litter depth and litter coverage decreased in both harvested forests, while bare ground increased. This effect was more significant in the treatments with slash removal. Both harvested forests showed a decrease in numerous native forbs and an increase in exotic plants with a stronger effect in the slash removal treatments. This affect was particularly strong for exotic plants, which invaded 41% of biomass harvest plots but only 18% of standard harvest plots. The small mammal community shifted from a mouse dominated (Peromyscus spp) community to one with a greater vole (both Myodes gapperi and Mircortus pennsylvanicus) component. Chimpmunks (Tamias striatus) were abundant in biomass harvest sites before harvest, but absent after the biomass was removed. Populations in control and clearcut sites also declined, but not as precipitously.

Large variation in stand-scale sustainability of forest biomass harvesting in central New Hampshire

Matthew A. Vadeboncoeur*, Steven P. Hamburg, Ruth D. Yanai, Joel D. Blum, Erik A. Hobbie

Forest management in the northeastern US might intensify over the next few decades due to increased demand for bioenergy. If forests are to continue regenerating, the large amounts of N, P, Ca, Mg, and K removed from the ecosystem by whole-tree harvesting must be replaced by atmospheric inputs, the depletion of plant-available nutrients stocks in the rooting zone, weathering of primary minerals, or fertilizer inputs. We conducted an analysis to determine the number of harvest rotations required to exhaust the available soil stocks of N, P, Ca, Mg, and K in the soil across the region under various harvesting and nutrient availability scenarios. We based our analysis on quantitative soil pit data from 14 northern hardwood stands across the White Mountain region of New Hampshire. At current levels of N deposition, all modeled rotations (30-year whole-tree harvest, and 100-year stem-only and whole-tree harvests) would be sustainable in terms of N. Calcium limitation was encountered after 1-4 rotations under the 100-year whole-tree harvest scenario, and after 2-10 rotations in the 100-year stem-only scenario. However, the ability of ectomycorrhizal fungi to weather the primary mineral apatite may offer an escape from Ca and P limitation. Regenerating forests in the region already show some signs of P limitation and increased apatite weathering rates. All stands were located on granitic till, but variations soil depth and in parent material mineralogy drive a fivefold difference in available Ca, and a tenfold difference in weatherable Ca.

Simulated forest biofuel harvest decreases soil carbon and nitrogen pools

Natalie Koncki and Jeffrey D. Corbin*

Efforts to develop alternative energy sources have spurred calls to increase forest biofuel production. Subjecting forests to more frequent harvests and increased removal of coarse woody debris (CWD) may impact the surrounding ecosystem by decreasing organic material left on site to decompose. We hypothesized that such a harvest regime would decrease soil carbon and nitrogen pools. We used the quantitative biogeochemical model ForCent to simulate likely forest biofuel management in a northeastern forest to see how soil C and N pools in would respond to various treatments. We simulated a) an uncut forest; b) sawlog harvest in which 65% of the logs were removed; c) 65% biofuel harvest in which 65% of the logs + debris was removed; and d) 90% removal in which 90% of the logs + debris was removed. All three harvest regimes resulted in declines in total ecosystem and soil C and N. Accumulation of C from tree regrowth took 160 -216 years to reach pre-harvest levels, indicating that all three harvest methods require long periods between harvests before they can be considered C neutral. The effects on C

and N pools were greater as harvest intensity increased (e.g. sawlog < 65% harvest < 95% harvest). We conclude that more intense harvest of forest biomass for biofuel must consider not only the proportion of wood taken but also the proportion of debris left behind in order to be considered sustainable and C neutral on reasonable time scales.

Session 7B: Regional Perspectives

9:30 Jost Family Room

How to Cure Maine's Addiction to Heating Oil: A Roadmap to Avoiding Economic Disaster in Maine and the Other Regional States

William Strauss*

The Northeast's dependence on fossil energy (the northeastern states use 86% of the nation's entire consumption of home heating oil), nearly all of which is produced outside the region and a significant percentage of which is exported from foreign countries, exposes the northeast to extreme economic and social vulnerability in the event of price shocks, such as those seen in 2001, 2005 and 2008. It exacerbates environmental impacts including the region's contribution to global climate change, air quality and acid rain. Further, it results in significant wealth in the region being exported to support other economies instead of our own regional economic vitality. This paper proposes that 25% of all thermal energy requirements in the Northeast are met with renewable energy resources by the year 2025. This shift in our sources for thermal energy will produce extraordinary economic, social and environmental benefits for the region. Furthermore, the paper shows how three quarters of the renewable energy can come from sustainably produced biomass from forest and farm resources that are transformed into heat with clean and efficient technology. Today, renewable energy accounts for only 4.3% of the total thermal energy sources for the region. Achieving this vision will have profound implications for the region's economy, environment and quality of life. This paper sets forth immediate actions that can be taken to move our region toward achieving these ambitious goals.

Getting the Eastern US Up and Operating on the National Interactive CROP Website

Catherine M. Mater*

Several state and federal agencies joined forces in 2007 to fund the development of the nation's only continually updating biomass offering website based on the CROP (coordinated resource offering protocol) model. The CROP model, developed by Mater Ltd for this compendium of public agencies, has now been employed on 19 large landscape sites across the US encompassing 45% of all National Forests. Biomass data from these CROP analyses is now easily accessible through a national CROP interactive website (www.crop-usa.com). CROP is now used as a valued biomass assessment tool for private investors and government agencies alike in determining biomass to energy project viability. The USDOE has recently awarded millions of dollars in grant funds for projects using CROP biomass data documentation, and 11 of 15 project grant awards recently announced by the US Forest Service went to projects using CROP analyses for biomass documentation. Yet the eastern part of the US is currently un-represented in this interactive database. Mater's presentation will provide a live (on internet direct) presentation of the CROP model and interactive internet search features that make it a valued resource planning and business development tool. The presentation will also detail six CROP projects that could be undertaken in the eastern US to bring continually updating biomass supply data to that region.

Land, Climate, and Energy Implications of Woody Biomass: A Synthesis of the Fuel from the Forest Symposium – Yale School of Forestry & Environmental Studies

Shelby L. Semmes*, Grady O'Shaughnessy, Alex Barrett, David Parsons, Tania Ellersick, Lucien Bouffard

There is renewed international and domestic interest in biomass as a renewable energy resource. However, debates within forestry, energy, and climate change science and policy circles are still divisive as to whether biomass is a viable, and preferable, alternative to fossil fuels. To investigate these perspectives, a group of students from the Yale School of Forestry and Environmental Studies brought together experts from each of these three sectors to explore the nuances of woody biomass energy. This symposium, titled Fuel from the Forest, was held on January 21st, 2011 in New Haven Connecticut. This synthesis paper draws together key themes from the event's proceedings, investigates the history of biomass utilization in the Northeast, and presents a review of foundational scientific literature contextualizing the perspectives of the participants. In doing so, it summarizes the viability of woody biomass energy in the Northeast, while highlighting the opportunities and concerns facing the sound development of the sector at a national level. Symposium Panelists: Bob Perschel, North East Director, The Forest Guild; Charlie Niebling, General Manager, New England Wood Pellet; Ethan Davis, Energy Analyst, Union of Concerned Scientists; Christopher Recchia, Executive Director, Biomass Energy Resource Center; William Keeton, Associate Professor of Forest Ecology and Forestry, The Rubenstein School of Environment and Natural Resources, University of Vermont; John Gunn, Senior Program Leader, Natural Capital Initiative, Manomet Center for Conservation Sciences; Steven Hamburg, Chief Scientist, Environmental Defense Fund.

Session 7C: Assessing Social Impacts and Values

9:30 Sugar Maple Ballroom

Application of a Sustainability Assessment for (Bio)electricity Options: Multi-Criteria Analysis in a Traditional Value System Framework for an Iroquois Nation

Thomas Buchholz*, Neil Patterson, Timothy A. Volk, Valerie A. Luzadis

Availability of energy is an important aspect to the Tuscarora Nation. Recently, the Tuscarora engaged in analyzing the electricity options the nation has including a business as usual (importing electricity from the NY power mix), as well as wind, solar and biomass derived electricity from within the Nation's land. Biophysical assessments were done by an extensive use of GIS data, as well as wind speed and solar radiation maps. Biomass electricity options considered included dedicated energy crops (switchgrass, willow shrubs), food crops (soy), and forest derived biomass. Societal and economic factors were considered in this biophysical assessment and included current agricultural land requirements to satisfy demand for food production as well as the costs of each option. However, the question remained in what of these electricity options would suit the Tuscarora best. We engaged the larger Tuscarora community in examining those electricity options based on traditional Haudenosaunee values. The strong traditional value base of the Tuscarora Nation as well as its unique societal structure with a high emphasis on consensus decisions demands special tools to enable decisions in energy issues known for their complexity. This research investigated the use of Multi-Criteria Analysis (MCA) as a tool to assist the Nation in applying their philosophy to structuring their decision process on sources for home electricity and enable them to make informed choices. Embedded in a workshop setting and three survey rounds, the methodology and results were sourced in an adaptive and participatory manner. Experiences throughout the MCA application process supported the previously held notion of a strong rejection of quantification of values. At the same time, the MCA framework proofed to be useful in this traditional knowledge system and decision framework. The MCA process enabled focused discussion and raised points of concern and vagueness. The outcomes suggested a strong preference for renewable sources sourced from within the nation based on traditional values. Results enable the Nation to plan the next steps for an electricity future in accordance with their value base.

Merging Knowledge to Action Theory with Woody Bioenergy Research Development Processes

Jessica Leahy, Laura Lindenfeld, Hollie Smith*

The importance of linking research knowledge with on-the-ground action is imperative, especially as it concerns issues of sustainable energy sources. Yet, all too often there is a mismatch between research supply and demand. It is easy for the wrong information to be provided at the wrong time delivered in the wrong way. Knowledge-to-action theory aims to better align researchers and stakeholders. Using mixed methods, our study included 40 stakeholders from around the Northeast region, especially stakeholders from Maine, New York and Pennsylvania. Participants completed a survey and participated in focus groups. Survey results were analyzed using descriptive statistics, while the focus groups were transcribed verbatim and analyzed using qualitative coding. Objectives of this study included: assessing stakeholder needs and knowledge that are likely to affect the viability and sustainability of an emerging bioproducts industry in New England; fine tuning stakeholder global goals and vision from woody bioenergy research; developing a prioritized list of barriers, opportunities, research needs to woody bioenergy in the Northeast region; and evaluating stakeholders' awareness, willingness to engage in the research process, interrelationships, and attitudes towards bioproducts harvesting and supply processes. Our presentation will compare results from these objectives across the Northeast region. Furthermore, we will discuss how the stakeholder data collected in this study provided much-needed guidance for a large, interdisciplinary research proposal. The implications from this study center around issues pertaining to the need for stakeholder-driven research that begins during the proposal development stage and continues throughout the project.

The Community Roadmap to Renewable Woody Biomass Energy: A Case Study of a Decision-Making Tool for Alternative Energy Futures

Thomas K. Evans*

The Community Roadmap to Renewable Woody Biomass Energy is a tool to help communities implement alternative energy technology in ways that reduce energy costs, increase energy self-reliance, diversify regional economies, and reduce carbon emissions. The purpose of this thesis is to provide a case study of development of that tool, the collaboration it engendered, and the early outcomes of the initiative. This case study will be useful to communities interested in charting their own energy futures, and provides new understanding of the rapidly changing fields of alternative energy, public decision-making, and multi-stakeholder collaboration. In order to realize the potential of emergent alternative energy technologies, communities, households, and institutions need to find a way to navigate complex information, make decisions based on that information, communicate that information to diverse constituents, and initiate projects that may take many years to develop. That challenge requires new tools, like the Roadmap, for managing the social dynamics of such public processes. The finding of the thesis is that the Roadmap holds great promise for communities because it exhibits best practices in multi-stakeholder collaboration, transparent communications, and technological flexibility to best suit community goals. As an appendix, the document will provide assessment criteria for the Roadmap's future application.

Session 8A: Current and Future Biomass Harvesting Guidelines in the Northern Forest States (Panel)

10:45 Sugar Maple Ballroom

Panel Organizer: Bob Perschel

Panelists: Jeff Benjamin, Sarah Smith, Chris Recchia, Erhard Frost, Sean Ross

This panel session would include a review of the how well current best management practices at the state level and certification programs address the ecological effects of increased biomass harvesting. An introductory review would utilize three Forest Guild publications to set the stage for a panel discussion: Forest Biomass Retention and Harvesting Guidelines for the Northeast, June, 2010;; Ecology of Dead Wood in the Northeast, June, 2010; Revised Assessment of Biomass Harvesting and Retention Guidelines, June, 2010 Panelists would be asked to respond to the following: How well do current best management

practices and other forest policy mechanisms address the ecological effects of increase biomass harvesting? Have you thought about augmenting current practices in a voluntary approach? A non-voluntary approach? Describe any current plans to augment current practices? What are the research needs? What are the pros and cons and possibilities of adopting region wide guidelines or coordinating across states on state based guidelines? Evaluate the potential of the Forest Guild Biomass Retention and Harvesting Guidelines (the only existing set of regional guidelines) for a regional set of guidelines or as a model for state-based guidelines? The Forest Guild is operating under a Conservation Innovation Grant from the NRCS to educate and promote biomass harvesting guidelines. By April we will have more information on response to our guidelines, demonstration areas and practicality of implementation. This information can be merged into this presentation through panel practitioners and will provide a segue to the Saturday field day.

Session 8B: Willow as a Source of Biomass Energy

10:45 Jost Family Room

Effects of Planting Density on Growth, Mortality, and Yield of Short Rotation Willow Crops (*Salix spp.)*

Jesse Caputo*, Timothy A. Volk, Lawrence Abrahamson, Gregg Johnson

Shrub willow (Salix spp.) and other short rotation woody crops (SRWC) are expected to become essential to meet the future demand for biomass feedstocks in the U.S. and globally, but the development of complete production systems for these crops is still in its infancy. Significant improvements are needed to reduce the cost of production and improve the environmental attributes of the system. Establishment costs, which currently account for about 25% of the delivered feedstock price, are currently a major barrier to the deployment of willow biomass crops. Planting stock accounts for the majority of establishment costs, because of the currently recommended high planting density in these systems (15,400 plants ha-1). These recommendations are based on research from Europe, largely based on the growth of Salix viminalis, and trials in the early 1990s in North America on a single variety, 'SV1' (Salix dasyclados). Lowering the planting density would reduce establishment costs but may have possible impacts on other important management decisions and costs associated with crop production. This abstract will examine the results of an experiment designed to examine the effect of five different planting densities ranging from 5,833 to 17,498 plants ha-1on growth and yield for four shrub willow varieties in central New York.

Seasonal Dynamics of Nutrient Supply and Uptake in an Organic and Inorganic Fertilized Short Rotation Willow Coppice System

Amos K. Quaye*, Timothy A. Volk

Seasonal variations in soil and foliar nutrients of a shrub willow (*Salix Mayibeana*, SX64) that has received urea (CF), biosolid compost (BC) and dairy manure (DM) at 150 and 200 kg available N ha-1 and a non amended control (CT0) were assessed Delhi, NY. Plant Roots Simulator (PRS®) probes from Western Ag Innovations, Canada were buried in situ for a 2 week period outside of root exclusion cylinders (RECs) to measure nutrient bioavailability and inside RECs to measure nutrient supply rate. Measurements were done in September 2008 (outside RECs only), May, August and October of 2009. Manure increased soil Mg while biosolid compost increased soil Ca and S supply and bioavailability respectively but only BC1 increased P supply compared to CF and CT plots ($p < 0.05$). Soil NH4+, K, Ca, Mg and S supply were high in Aug ($p<0.05$) but their bioavailabilities followed different seasonal patterns. While bioavailable Ca and Mg increased in Aug, bioavailable K was high in May, NH4+ in Oct and S in Sept. Soil NO3- and P supply and bioavailability were high in May. Urea increased foliar Mg concentration ($p <0.05$). Foliar N, K and Ca concentrations were high in May ($p<0.05$) but decreased in Aug. Foliar S concentration was high in Aug, while P and Mg concentrations were high in Oct ($p<0.05$). The significant effect of the organic amendments on some soil nutrient supply and their comparable effects on foliar nutrient concentration

make them a better fertilization option for SRWC systems considering the cost of commercial fertilizers and the added environmental benefits of land application of organic wastes.

Above- and Below-ground Biomass and Soil Organic Carbon Inventories of Willow Biomass Crops Across a 19 year Chronosequence

Renato S. Pacaldo*, Timothy A. Volk, Lawrence P. Abrahamson, Russell D. Briggs

Assessing changes in above and below ground biomass and soil organic carbon (SOC) levels in willow biomass crops is critical for evaluating carbon and greenhouse gas balances in willow biomass crops. While data are available on long-term above ground biomass production, little is known about changes belowground. This study measured above- and below- ground biomass and SOC in a single willow variety (SV1, *Salix x dasyclados*) across a 19-year chronosequence. Below ground biomass to a depth of 45 cm was significantly different among the age classes, ranging from 11.1 in 5-year-old crops to 21.0 Mg ha-1 in 19-year-old crops. Belowground biomass decreased with soil depth in all age classes from 3.5 to 6.9 Mg ha-1 in 0-15cm depths, 1.4 to 2.2 Mg ha-1 in 15-30 cm depths, and 0.6 to 0.8 Mg ha-1 in 30-45 cm depths. There was no significant difference in fine root biomass across chronosequence. Coarse root biomass was highest in 15-30 cm soil depth and comprised from 5.5 to 18.6 % of the total below ground biomass. Coarse root biomass was not significantly different among the 12, 14, and 19-year old crops, but was lower in 5-year-old crop. Belowground stool biomass ranged from 4.93 to 10.21 Mg ha-1 for 5- and 19-year-old crops, respectively. Total aboveground biomass ranged from 7.19 Mg ha-1yr-1 for 5-year-old crop to 17 Mg ha-1 yr-1 for 19-year-old crop. Stool biomass production increased with age and ranged from 4.84 Mg ha-1 for 5-year-old crop to 10.17 Mg ha-1 for 19-year-old crop. The average below:above ground biomass ratio ranged from 1:1.8 to 1:2.9. The amount of SOC over a depth of 45 cm ranged from 163.72 to 188.15 Mg ha-1. There was no significant difference in amounts of SOC among the five age classes and SOC also decreased with depths in these systems. Keywords: *Salix dasyclados*, age, fine roots, coarse roots, belowground stool, foliage, stem, stump, biomass ratio, short- rotation willow crop

Session 8C: Decision Support Tools

10:45 Chittenden Bank Room

Supporting Community Decision-Making

Leanne Elliott*, Erin Neave

The past five years have been difficult for the forest industry in Canada, as well as the rural communities it supports; a combination of high energy costs, the decline in the economy, increased competition, and a shifting demand for traditional commodities, have all conspired to create challenges like no other period in the industry's history. The Canadian Model Forest Network is developing a suite of feasibility assessment tools to help forest-based communities assess opportunities and methodologies for the development of energy from biomass projects, which could both offset their dependence on fossil fuels, and help build capacity to support a forest sector in transition. A plain language guidebook has been produced that provides information to support decision making with respect to potential opportunities for combined heat and power projects. The guidebook is tailored to Canadian communities that may be considering the development of a bioenergy facility in their region. The guidebook also outlines a suite of economic, social and environmental factors that must be considered to evaluate community potential for sustainable biomass energy production. A supporting website provides information on policy and incentives by region as well as an array of supporting tools. The presentation will outline this Canadian Model Forest Network approach to making relevant information and resources accessible and highlight Canadian case studies from CMFN members. It will also introduce the next phase of the project: to build a decision-support tool which allows communities to impartially investigate energy from wood options that are tailored to their particular needs and capabilities.

Greenhouse Gas Assessment Tool for Community Biomass Projects

Ann Ingerson*

Many communities and institutions are interested in using woody biomass to replace fossil fuels for space heating or combined heat and power. Some are motivated by financial savings, others by local economic benefits, still others by the chance to reduce greenhouse gas emissions. A variety of tools and information is available to help communities make decisions about whether to invest and what to invest in. In 2009, "Wood Energy Options for the Mahoosuc Region: A Community Wood Energy Guide" was developed for the Mahoosuc Initiative (a collaborative group working on land conservation and community economic development in northeastern New Hampshire and western Maine). Several MI partners, led by The Wilderness Society, are following up with a more detailed tool to help community groups assess the greenhouse gas effects of switching to woody biomass fuels. Greenhouse gas accounting is complex, and results depend heavily on the assumptions made about the historic starting point, system boundaries, what kind of indirect effects to include, and how forest carbon impacts are addressed. The simplified assumption that all wood fuel is “carbon-neutral” has been replaced by a more nuanced assessment that accounts for variations in fuel type and forest practices, and the result can be substantial uncertainty about actual atmospheric impacts. The Greenhouse Gas Assessment Tool for Community Biomass Projects will use Excel spreadsheet format. Users will enter project-specific data and select among built-in options for fuel sources, technologies, transport distances, etc. for their proposed biomass facility. The assessment will include: life-cycle GHG impacts of the fuel currently being used; life-cycle impacts of wood fuel; and GHG impacts under varying forest management approaches. Once the user enters data and makes the appropriate selections, the tool will estimate greenhouse gas emissions over time for the existing and proposed new equipment. This tool will be developed in collaboration with technical content experts and the initiators of several case study projects. The “Beta version” will then be posted on the web for public use, with the invitation to add components or modules that increase its usefulness for decision-makers. The poster will illustrate the current version of the tool, including data entry sheets, computations performed, and output. We will invite conference attendees to suggest improvements or resources or to join as project advisors.

Mini Biomass Districts Feasibility Study

Jack Byrne*

Middlebury College and the Town of Middlebury have partnered with the national Biomass Energy Resource Center to conduct a five-part study to determine if mini biomass heating districts in the Town are feasible and ecological. This model could be useful for small rural towns that don’t have the kind of development density that is required but have access to biomass resources nearby and who want to produce biomass while restoring ecosystem services on marginal agricultural land and unhealthy forests.The study is looking these components: An energy profile of the Town of Middlebury to determine where mini-districts could be established; An inventory of the various types of biomass heating and power technology that would be appropriate for small, medium and larger users of biomass as a fuel; The development of a biomass purchasing cooperative; Development of a community renewable energy fund to help underwrite installations of biomass equipment; A comprehensive, field level study of the ecological capacity of farm and forestlands in the Town to produce biomass and cultivation practices that would cause more carbon sequestration in the soils where it would be produced. This project is unique in that it is developing strategies for how a Town and College can work for the greater community to develop a local energy economy based on renewable energy sources nearby that also leads to restoration of ecosystems and greater sequestration of soil carbon. A summary of the results will be provided with a focus on the ecological supply issues.

Technical Support for Schools & Institutional Scale Facilities

Roger Wallace*

The scale of biomass energy projects span four orders of magnitude, from single family residential heating to large electric and thermal power plants. Although project scales may differ by a factor of 10,000, many of the same supply logistics, market conditions and decision tools are applicable to any biomass project. Addison Biomass Energy supports small to medium-small scale (150MBH-10MMBH, 45KW-3,000KW) biomass systems used in the institutional and small district heating markets. Making a well informed decision to proceed, or not, with a biomass energy project requires accurate financial models, good risk assessment, knowledge of regulatory requirements along with biomass & fossil fuel markets, analysis of anticipated energy loads and both technical & business assessment of different equipment suppliers. An overview of these various decision factors and tools sets will be provided in the context of several thermal biomass projects.

Closing Plenary: Implications for Future Research

12:10 Sugar Maple Ballroom

Lunch Buffet and box lunches to go

12:30 Silver Maple Ballroom

Agenda for Future Research (over lunch)

12:45 Williams Family Room

Middlebury Fieldtrip Departs

1:00 Davis Center Circle