Minutes 2nd Annual Meeting

2012 Annual Meeting

NEERA1005 Multistate Research, Extension and Education Project

"Sustainable Wood Energy"

Cornell University, New York State Agricultural Experiment Station

Geneva, NY

December 19, 2012

Reports by project participants and meeting attendees

8:00 Establish WebEx conference

8:15 Welcome – Tom Burr, Director, New York State Agricultural Experiment Station

8:30 – 9:00 The Pennsylvania State University
Mike Jacobson, Prof., Dept. of Ecosystem Science and Management

Gary Thompson, Director, Pennsylvania Agricultural Experiment Station, Prof. of Plant Science

Dan Ciolkosz, Senior Extension Associate, Dept. of Agricultural and Biological Engineering

Aaron Yoder, Instructor, Dept. of Agricultural and Biological Engineering

Ed Johnstonbaugh, Educator, Energy Savings and Renewables, Penn State Extension

Gary Musgrave, Extension Associate, Penn State Extension

Tom Richard, Professor, Dept. of Agricultural and Biological Engineering and Director, Penn State Institutes for Energy and the Environment

9:00 – 9:30 Cornell University
David Weinstein, Prof., Dept. of Natural Resources

Larry Smart, Assoc. Prof., Dept. of Horticulture, NYS Ag Experiment Station

Peter Woodbury, Sr. Research Assoc., Dept. of Crop and Soil Science

Dean Sprague, Extension Educator, Cornell Cooperative Extension

9:30 – 9:40 Michigan State University
Ray Miller, Director, Forest Biomass Innovation Center, Escanaba, MI

9:40 – 9:50 Mississippi State University
Fei Yu, Department of Agricultural and Biological Engineeering

9:50 – 10:00 West Virginia University
Kaushlendra Singh, Asst. Prof., Division of Forestry and Natural Resources

10:00 – 10:15 Break

10:15 – 11:00 Further presentations and discussions of cooperation and project goals
Farm, Forest, and Fiddlehead Consulting
Karl Hallen

Energex American Inc.
David Fetzer

Not attending:
Pennsylvania State University
Charles Ray, Assoc. Prof., Dept. of Ecosystem Science and Management

Jude Liu, Assistant Professor, Dept. of Agricultural and Biological Engineering

John Carlson, Prof. and Director of The Schatz Center for Tree Molecular Genetics, Dept. of Ecosystem Science and Management

Rutgers University
Lily Y Young, Prof., Biotechnology Center for Agriculture & the Environment

Univ. of Maine
Jonathan Rubin, Prof., School of Economics

Univ. of Minnesota
Diomy Zamora, Extension Educator, Univ. of Minnesota Extension

NE 1005 Annual Meeting - **Minutes**

Intro:
This group was established to network in the NE, we have also attracted people in MN, MI, MS.
We want to encourage expansion.
The first meeting was a year ago (Penn State 8-10 people); most people not involved in multistates, but some already in some different ideas and different goals.
Agenda - each state reports - brainstorm what to accomplish networking to build something tangible.

Penn State:
Report by Dan Ciolkosz
Supplied two page written report (see Appendix), including: research on forest management; research project on biomass harvesting; breeding work by John Carlson on willow and poplar; pelletizing. There is a new regional project on short rotation woody crops. Penn State is offering a new grad education program - 4 new grad MPS course funds with scholarship money. Penn State has offered extension short courses; website; webinars (NE bioenergy); and fact sheets adaptable to region renewable energy. A new extension associate focusing on woody short rotation demonstration sites will be hired.

Report by Aaron Yoder - suggested we consider agenda topics for the next 5 years. He has previous experience with an MRP on safety - confined spaces - highway transport of machinery - collaborations with other multistate groups (ag safety and health).

Report with PowerPoint by Tom Richard
We should consider report by the Heinz endowment on health impacts of wood combustion - particulate matter in smaller systems criticized (achilles heel of combustion wood energy). This report came out a week ago - sustainability - how much wood available? What is the C impact? We should think about how to be proactive on the policy side. NEWBio (NE Woody/Warm-s season Biomass CAP) project initiated with USDA funding including: institutional participants (6 centers in US); corporate industry partners with a focus on full scale commercial development, environment, feedstock improvement, harvest & logistics, with an end product focus on liquid fuels mandated. The crops will be willow, switchgrass, and Miscanthus. Topics include: harvest, storage, densification, transport, biochemical conversion, thermochemical conversion, bioelectricity, feedstock improvement, harvest, preprocessing & logistics, human systems, sustainability, safety and health, and project leadership and evaluation. There are near term opportunities - small- to mid-scale for burning and the region has a lot of capacity for growing these feedstocks (willow, switchgrass, and Miscanthus. Will study biomass feedstock supply chains and business function (a lot on business development - new company start-up - local entrepreneurship - business school on board). Possible supply chain business models include: plantation - commodity - contract - cooperative. The conversion partners are aiming for 20M gal/yr plant = 100K - 300K acres of feedstocks (have a few 1000, but need more). Need to coordinate research and extension on feedstock characteristics: 1) common questions and approaches, 2) how to measure commonly among projects; and 3) coordination of data.

Cornell:
Larry Smart (New York State Agricultural Experiment Station, Geneva report, see appendix) only one to work on wood energy at this Station

Studying biomass characteristics of willow, which vary by environment, making this a good topic to be coordinates as a multistate project. The main focus is willow breeding program. This is a clonal crop,

tested across wide range of sites since 2005, including yield trials with collaborators in US, Canada, and Europe (Ireland, Denmark, Sweden) across hardiness zones yields. The top 5 cultivars show and overall 36% increase after one round of breeding. Looking at wood characteristics, such as wood density: among 76 genotypes there was up to 50% difference in density (0.49-0.33 g/cm), which impacts harvesting efficiency and transport. There is also genotype x site interaction, but no correlation between yield and density. Density varies by cultivar and site. Using Thermogravimetric analysis which gives good correlation with chemical techniques to quantify cellulose (38-47%) and correlate with ethanol yield, also hemicellulose and lignin. On better soils with higher pH, there is higher cellulose (lignin increase with stress). Overall ethanol yield correlates with sugar yield, but initial data show no significant correlation between composition and ethanol yield. Future multistate efforts could coordinate yield trials & analysis of wood density and composition across the region.

David Weinstein (Cornell University Agricultural Experiment Station, Ithaca report - see appendix) Studying wood removal that will not affect new growth over time and diversity of habitat wildlife species. We need to address new technologies to be sustainable, in light of new types of forest owners/managers. US Forest Service models show Central NY has 9% wood available, but expect new growth (8-12 tons/A) could be doubled if conditions are stable. Modeling climate trajectory and invasive pest problems: climate change (pushing forests to 50 yrs dominated by oak) need management techniques to est oak but deer pressure problem 2. insect explosion will increase over next 20-50 years ash and hemlock=20% of forest avail due to pest pressure kind of replacement is important for climate tolerant spp kind of management to enhance new spp for sustainable harvest w/o deterioration, pests, support diversity plants and animals want to expand this work 6K acres cornell forest for modeling representative of NY forests - trial scenarios for management max extraction with sustainable forests

Question: combination of pests and climate - asian beetle 45% northern forest in jeopardy - what replaces spp are hemlock and beech both have insect problems

Peter ? new to project (Cornell) - not member yet Bioenergy projects: roadmap for NY - assessment of feedstock production and analysis - land use project yields - forest analysis project coordinator DOE and Sungrant - ending next year (potential feed stock supply)

**Data coordination and Integration - could be topic here - common data framework in place - Oak Ridge data center - Idaho National Lab (chemical and physical data for food stocks) build off previous efforts or tie into these projects

New Bio project - sustainability - target commercial or near commercial dev - how do these fit into regional potential GHG regional analysis - Ag and Forest systems C sequestration - sustainability with different bioenergy options

Question - extension and ed in Cornell? Yesterday willow meeting was ext.
Willowpedia website and youtube: fact sheets on willow cvs - Ag Progress days and farm shows - desire to build online tools for individual forest owners to assist with management w/ visualization of change over type and extraction over time - tools for input and projection with yield - visualization is key to get buy-in Education - less coordinated - seminar classes (marginal land question; year ago) no large enrolled UG course but one in Engineering -

**New proposal Cornell Extension (biofuel tool boxes for land owners to use) might want to hook up with this group - Bioenergy resource development (educator with state-wide Mary Regge?) - USDA Bioenergy funded education grant K-UG to bring educators to train trainers program (Ohio, Del, WV, PA, NY)

A lot of gaps with this group - a lot of people not participating - how to encourage others to be a part of this project

Gary? (new) Cornell - writing fact sheets - pest control weeds and establishment - chicken-egg to get commercial acreage developed to get enterprise established?

Ray Miller - Michigan State
between 2 regions (NE Sungrant) (Lake States USDA & Forest Service)
2 handouts: book 2013 release 400 authors - summary about characteristics of poplars/willows world-wide report from MSU on wood energy projects in past year (station report) did not include extension activities but will correct this - projects focused on wood energy projects summary of MSU - AgBioResearch - goal to inform legislature - rebranded the AES - MSU Extension coordinated activities - MSU bioeconomy network - whole university approach MSU Technologies - Spartan Innovation - ????? IP commercialization or start-ups

MBI - Michigan Biotech Industry : 2 entities Coord for forest biomass projects = Ray Miller

Project categories: Natural forest biomass potential
- revise biomass predictor equations for C stocks of forests (national project
- forest engineering for storage and modeling cost of harvest (most expansive part of supply chain)
- Willow poplar silver maple plantation systems - environmental impacts of nat forests or plantations (increased management on wildlife populations)
- feedstocks upgrading (chem engineering) green woody biomass full of water upgrade at local depots that can be shipped to be more commodity, decrease variability of the feedstock
- certificate program post grad for Forest Carbon Science (est national or regional programs for C trading teaching: fall semester 1st enrollment) establishing 2nd certificate wood energy production and supply chain

Question: online? No, these are on campus but potential is there for online; format for wood systems module has not been determined -

**The MSU course could be online as part of this effort

Fei Yu (Mississippi State)
Research: conversion process at sustainable energy center
3 groups (didn't get them all)

**requests help in feedstocks - hardwood chips is starting material - this is important for his conversion research

biomass gasification and catalytic conversion

gasification: developed 2nd process syngas cleaning unit added gasification - cleaning - compression - conversion syngas catalytically converted to hydrocarbon products pilot-scale tested process - just developed

Kaushlendra Singh (West VA)
Conversion work
Report - based on objective listed on NERA website
conversion:
feedstock project WVA involved but not going to talk
conversion: gasification how much coal can be added mobile system (pickup truck) 20% coal 10kW electricity max - no problems of engery conversion direct liquification technology - adding coal 50:50 to liquid biomass pyrolysis technology - oils and phenols must dry biomass 100% 103C - 500C pyrolysis - biochar and one phase bio-oil: 22mjoules/kg - moisture is not desirable in bio-oil GAS can be recycled back as a heat source

objective 1: ID people - team working on refining, catalysis, fuel-cell technology, engine testing - 3 industry partners - project didn't get funded obj 2 - improved communication: conf call - highlight in midterm report obj 3 - coord research ext edu - new collab - one ug and grad biobased energy systems - see meeting below - wood energy standard being developed (working group-will share drafts with this group)

**July 23, 2013 Bioenergy Day Kansas City, MO (panel discussions)

position doc affect of wood combustion on GHG emission being developed

Question: need a report. Coal question and biochar - bring down cost of conversion of coal to wood; low cost of natural gas impediment to conversion coal to wood area of research to bring price down - working on this in PA target plant steam plant to state prison and electricity, multiyear to get permitting system allows burning coal and biomass longer life between maintenance and lower emissions also more even operation NO emission control improved - tight $ but is working tree trimmings with waste coal and wood chips got one plant converted and sister plant in the works.
Air pollution permitting is a challenge (uncharted territory - State level regulations due to size of boiler)
Sustainability is the challenge

**Useful to involve biochar groups

BREAK

Comments from Industrial Partners:
1. Karl? land owner perceptions are key - putting research to reality owns and sells biomass burners willow and densified grass trials

2. David? - make hardwood pellets - staying current with tech advances ash content of feedstocks - factor in pelletizing
4 mills - hardwood dies - problem with pine - diff spp affect pelletizing dies are expensive $500 per and 500 hrs use is good

3. Judy? - product development from biomass - NY state dev roadmap for NY supply chain and sustainability (update - why their numbers differ from others -explanation) - another roadmap: ? biomass usage (equipment, public health, emissions) - survey of biomass usage and industry in general, looking for opinions, only have 75 responses, Brookhaven National Labs involves as well as others

NY Biomass Alliance - PA Biomass Association - MD/MICH/Ohio?
**Would it be good to interact with these groups - yes

15 minutes
Themes:
short rotations vs natural forests - what is the feedstock conversions and emissions - different issues with different spp - ties into the database whitepaper on emissions - academic perspective
idea: state of the industry/research/extension- what is going on out there? to encourage involvement - what are the needs?
wood energy short course -Springer book state of art wood energy Northern forests 15 chapters - project development -science C issues -emissions - middle of next year to be released (sign up for reviewers? Springer will send out for review)

idea: pelletizing different feedstocks - focus on genetic properties - composition - mechanical features - preprocessing mostly interested in particle side and density - transportation guys wants different data creat a fact sheet of properties
Tom- yes would be a great thing to do - bulk density, particle density, chip size and wood properties - what scale/quantity does variability disappear specifications for International Markets - feedstocks req becomes National and International question Standards being developed in other countries is this too big for the regional project?

Pick couple of things to focus on:
Broad overview of who is doing what in Eastern US Assemble information; SWOT for bioenergy in E US

Not keen on whitepaper - official stamp but on the cheap - computer Wiki to aggregate information - awkward at first but self-organizes - need to get a resource as to what is being done.

Grant opportunities for the group? RDI funded and announced in March How to obtain a large grant - regional and rural development; what is in common with the region?
-land use changes
climate changes - energy demand changes
all linked together
population changes
Ag and forest usage in common for NE
craft an outline with strong impact on rural common land and population base build on strength of the group and land grant mission

central information repository with info management system bring projects together regional feedstock partnership

What is our question? Where do we start? How to tie in forest energy issue?
Database is already in place

KDF structure create communities but are invisible in the beginning and eventually become public KDF - ambitious undertaking - everything for everyone - DOE with substantial resources - is it meeting the needs for data sharing? - reason to join forces with existing group

How to move forward? Database - Clearinghouse - Coordinate toward a grant? Benefits to improve regional communication & data sharing - prioritize - proposal does this - who starts this...rough ideas and distribute - clearinghouse WIKI to figure out who is doing what - expanding the group

1-2 sentence idea for proposal, circulate and comment - central question for a proposal

1. send ideas for focus area grant
2. smaller group to talk about commonalities 3. WIKI space - reports and discussion (NewBio internal Wiki?)

Next annual meeting?
Possibly 6 mos rather than 1 yr. State College Aug 16-17 - NewBio Annual Meeting.
Bioenergy meeting in KC? Travel costs substantial.
CAPs meeting in Jan (Oregon) - Tom will be attending

NEERA 1005 Sustainable Wood Energy Regional Project
Progress Report for 2012 - Prepared 18 December, 2012
The Pennsylvania State University

Research Activities

Forest Management - we have concluded a study that examines the impact and effectiveness of different biomass harvesting methods (PI: Marc McDill).

Species Development - we are conducting breeding studies of short rotation willow in an effort to develop improved varieties of the crop (PI: John Carlson).

Densification - we are conducting studies of the mechanics of biomass densification, with an eye towards better understanding and ultimately optimizing the pelletization process (PI: Hojae Yi).

Education Activities

We teach one undergraduate and are in the process of obtaining approval for four graduate=level online courses in bioenergy – all of which have wood energy relevance:

- A B E 497A Biomass Energy
- A B E 884 Biomass Energy Systems (online)
- FOR 880 Biomass Feedstocks (online)
- A B E 885 Biomass Harvest and Logistics (online)
- A B E 888 Biomass Conversion (online)

NEWBio funds provide for scholarships for students taking the online graduate-level bioenergy courses over the next five years.

Extension Activities

Short Courses - We organized several short courses in the past year that were devoted to wood energy topics (Research Symposium, Combustion Emissions Health Impacts), as part of the Penn State Bioenergy Short Course series (Contact: Dan Ciolkosz).

Website - We continue to maintain our wood energy extension website (Site Maintenance: Dan Ciolkosz). The NEWBio site was created, and holds information on shrub willow among other things (M Jacobson, http://www.newbio.psu.edu).

Webinars – Our wood energy webinar series has been expanded to all bioenergy topics, but continues to include wood energy projects (Host: Mike Jacobson). See http://extension.psu.edu/energy/wood-energy/northeast-wood-biomass-energy-program/webinars

Fact Sheets - We have developed a series of wood energy fact sheets that are designed to be easily adapted to and used in other states (Coordinator: Mike Jacobson). See http://extension.psu.edu/energy/news/spotlight/factsheets

Renewable Energy Academy – We deliver a series of half-day webinars (in person and online), several which are devoted to topics relevant to wood energy (i.e. Biomass CHP for Industry & Institutions, Renewable Liquid Biofuel Technologies and their applications). See http://extension.psu.edu/energy/renewable-energy-academy

We are working with industrial partners interested in adopting biomass energy systems for their facilities, including Greensburg Thermal and Alcoa Corp.(Ed Johnstonbaugh).

Efforts are underway to hire an extension associate to work with the NEWBio project – one task will be to assist with short rotation willow business development.

Efforts are also underway to develop short rotation woody crop demonstration sites in central and northwest PA.

Publications (incomplete):

Jacobson, M., and D. Ciolkosz. 2012. Transformative Regional Approaches for Northeast Bioenergy. Presented at the 2012 Sun Grant National Conference, October 2-4, New Orleans, LA.

Yi, H., Karamchandani, A., Puri, V., and D. Ciolkosz. 2012. Determination of Mechanical Properteis of Pelletized Biomass and Fundamental Mechanical Properties of Granular Biofeedstock. Presented at the 2012 Sun Grant National Conference, October 2-4, New Orleans, LA.

Ciolkosz, D. E., 2012. Is Biomass Heat Right for You? Penn State Renewable and Alternative Energy Fact Sheet Series. The Pennsylvania State University. #EE0031. University Park, PA.

Ciolkosz, D. E., 2012. Wood Energy Kids' Page. Penn State Renewable and Alternative Energy Fact Sheet Series. The Pennsylvania State University. #EE0030. University Park, PA.

Jacobson, M.G., and Ciolkosz, D. E., 2012. A Bioenergy Primer for the Forestry Community. Penn State Renewable and Alternative Energy Fact Sheet Series. The Pennsylvania State University. #EE0028. University Park, PA.

Jacobson, M.G., and Ciolkosz, D. E., 2012. A Bioenergy Primer for Forest Landowners. Penn State Renewable and Alternative Energy Fact Sheet Series. The Pennsylvania State University. #EE0027. University Park, PA.

Ciolkosz, D. E., 2012. Green Buildings and Bioenergy. Penn State Renewable and Alternative Energy Fact Sheet Series. The Pennsylvania State University. #EE0029. University Park, PA.

Ciolkosz, D. E., 2012. Biomass Heat for the Present and the Future. Penn State Extension Update. January, 2012.

STATION REPORT

MICHIGAN STATE UNIVERSITY

Northeastern Regional Association of State Agricultural Experiment Station Directors
Sustainable Wood Energy Multistate Project
Geneva, NY
December 19, 2012

Reported by Raymond Miller, Director, Michigan Forest Biomass Innovation Center
Michigan State University, Escanaba, MI
rmiller@msu.edu

INTRODUCTION AND BACKGROUND

Established in 1888, the Michigan Agriculture Experiment Station became Michigan AgBioResearch in 2011. Over the years it has grown to encompass the work of nearly 400 scientists in six colleges at Michigan State University: Agriculture and Natural Resources, Communication Arts and Sciences, Engineering, Natural Science, Social Science and Veterinary Medicine.

These researchers, in on-campus laboratories and at 14 outlying research centers across the state, investigate topics that range from agricultural production, alternative energy and biofuel production, food safety and environmental stewardship to childhood obesity, community development, and the quality of life of Michigan youth and families. Michigan citizens reap the benefits of this work in the form of new or improved foods and plants, new production methods and enriched lifestyles.

Collectively, AgBioResearch (www.agbioresearch.msu.edu) and MSU Extension (www.msue.anr.msu.edu) represent research and programs that serve hundreds of thousands of Michigan residents and have more than a billion dollar impact on the state each year. In addition, every dollar the state spends is leveraged with additional dollars in federal funds and external contracts, grants and other revenues to serve the state's residents.

The MSU BioEconomy Network (www.bioeconomy.msu.edu) was formed within MSU's Office of the Vice President for Research and Graduate Studies to coordinate the increasingly diverse range of bioeconomy activities on campus: research, policy, economic analysis and education, as well as corporate and government collaborations and commercialization. The network also reinforces MSU's role in expanding the bioeconomy through public and private partnerships.

In partnership with MSU Technologies (www.technologies.msu.edu), Spartan Innovations (www.spartaninnovations.msu.edu), and MSU Business-CONNECT (http://www.businessconnect.msu.edu) and working with related units like MBI (www.mbi.org) and the MSU Bioeconomy Institute (www.bioeconinst.msu.edu) in Holland, the BioEconomy Network provides a bridge between faculty and external collaborators to support MSU's role in expanding the bioeconomy. The BioEconomy Network is the university's point of contact for the DOE Great Lakes Bioenergy Research Center (www.glbrc.msu.edu) and works with faculty to develop multidisciplinary research proposals related to the bioeconomy.

MSU AgBioResearch established the position of *Forest Biomass Development Coordinator* in 2008 to facilitate the formation and function of trans-disciplinary teams of researchers and extension specialists to address issues surrounding the development of the wood energy sector of Michigan's economy. Additionally, the university's off-campus forestry research center in Escanaba, Michigan was renamed MSU's Forest Biomass Innovation Center (www.agbioresearch.msu.edu/fbic) in 2010 and repurposed to focus on wood energy feedstock and supply chain

development. This effort has resulted in the formation of several teams of forestry and wood products scientists from within MSU as well as partner universities and companies from Michigan, Minnesota, Wisconsin, New York, Connecticut, Ohio, and Pennsylvania. Together they have been and continue to address critical issues facing biomass producers and consumers as well as the communities and ecosystems effected by the transition to wood-based renewable energy.

While research and extension activities at MSU address the entire breadth of renewable energy production, what follows is a summary of sixteen selected wood energy projects that began, continued, or were completed during 2012 at MSU AgBioResearch. These are arranged in four broad groups; 1) natural forest biomass potential [#1-5], 2) short rotation energy plantation potential [#6-10], 3) environmental implications of increased woody feedstock production [#11-13 with #14 describing a new Graduate Certificate program], and 4) woody feedstock upgrading [#15 & 16]. While each project can stand on its own, most fit within the trans-disciplinary framework described above.

NATURAL FOREST BIOMASS POTENTIAL

1. Biomass Inventory and Supply for Frontier Renewable Resources' Wood Ethanol Facility at Kinross, MI

Larry Leefers (Department of Forestry) and Michael Vasievich (Tessa Systems, LLC)

The original 2011 Leefers and Vasievich study report "*Timber Resources and Factors Affecting Timber Availability and Sustainability for Kinross, Michigan*" examined the timber resources in nine 30-mile zones from 30 to 150 miles from Kinross, the location of the planned cellulosic ethanol plant. Separate zones were considered for the Upper and Northern Lower Peninsulas. This timbershed or supply region encompasses all of the Eastern Upper Peninsula (EUP) and portions of the Western Upper Peninsula (WUP) and Northern Lower Peninsula (NLP). The 150-mile radius area contains 8.3 million acres of timberland. The analysis excluded forestland that is reserved or withdrawn from timber harvesting by statute or administrative regulation and several small islands. It also excluded forest resources in Ontario, Canada, which are significant. The analysis was based on 4,975 forest inventory plots measured by the USDA Forest Service in cooperation with the State of Michigan from 2004 to 2008 (2008 data set), a 5-year measurement cycle. The work over the past year has focused principally on a comparative analysis for the 2008 data set noted above with four other 5-year forest inventory data sets: 2004, 2009, 2010, and 2011. Additional analyses related to high levels of mortality in aspen have also been developed.

2. Michigan's Non-industrial Private Forest Landowners' Willingness to Supply Biomass

Karen Potter-Witter, Brett Kuipers, and Shivan G.C. (Department of Forestry)

Project researchers analyzed the data from a 2010 survey of non-industrial private forest landowners in the eastern Upper Peninsula and the northern lower peninsula of Michigan. One analysis used a binary logistic regression to identify the factors determining landowners' willingness/unwillingness to supply biomass for bioenergy. The results indicated that a majority of the landowners in the northeastern Michigan region were aware of and had positive attitudes toward wood-based bioenergy. Many landowners, however, expected biomass prices to be much higher than the current market price of pulpwood and expressed reservation prices for their stumpage that reflected these expectations. The logistic regression model also indicated that active forest landowners who have conducted timber harvest in the past, have large forest acreage, and manage their forests with monetary or financial motivations are those who say they are more likely to harvest biomass from their forests.

A second analysis used principal component analysis (PCA) followed by a cluster analysis to separate Michigan's NIPF owners into subgroups based on their ownership reasons. The cluster analysis identified four landowner segments in the study region: consumptive use landowners, recreationists, naturalists and multiple objective

landowners. In addition to significant differences in ownership objectives the analysis found significant differences in the use of and preferences for communication materials among the landowner groups.

3. An Improved Biomass and Carbon Database for U.S. Tree Species

David MacFarlane (Department of Forestry)

This is a new, nationwide multi-investigator study funded by the USDA Forest Service, Forest Inventory and Analysis (FIA) Program. Dr. MacFarlane's part is through a joint-venture agreement with the Northern Research Station of FIA (NRA-FIA). Over multiple years the project will collect empirical data nationwide to validate existing methods and develop new models. The first year, 2012, was focused on methods development. One hardwood (Acer rubrum) and one softwood species (Abies balsamea) were selected for study in Michigan to contrast different field methods needed for trees with decurrent versus excurrent branching architecture. Trees were cut at two locations, one in the southern Lower Peninsula and the other in the Northern Lower Peninsula of Michigan. Dr. MacFarlane also proposed a new modeling framework for generalizing biomass equations to be nationally consistent and yet locally accurate.

4. Field Storage of Woody Biomass for Reliable Feedstock Supply

Fei Pan (Department of Biosystems and Agricultural Engineering)

Starting from June 2011, a new air-drying process was designed to avoid material decomposition and high cost involved in other woody biomass drying and storage methods. This process was tested in a forest stand in Escanaba, North Michigan, from June to November in 2011, which involved no chipping or movement of biomass from the harvesting site. The objective of this study was to evaluate the effect of the air-drying on moisture content (MC) and higher heating value (HHV) of roadside-piled logging residue during storage period. Results showed that residue MC kept decreasing monthly until the end of September when rainfall started soaking the residue. This result suggests that in this study region, the best time for collecting biomass is from September to October. During the storage period, MCs were proven to be uniform at different locations within a residue pile. HHV of piled green biomass remained stable during the five-month storage period. These results indicate that field piling of un-processed biomass is a reliable solution for year-round biomass supply without incurring additional costs. Results further implied that biomass MC change is a combined effect of regional temperature, rainfall, and wind speed. Future research will be focused on revealing the detailed relationship between biomass MC and other factors that could lead to variance.

5. Modeling the Cost of Wood Harvesting Based on a Survey of Michigan-Based Loggers

Fei Pan (Department of Biosystems and Agricultural Engineering)

A spreadsheet-based model that can estimate stump-to-landing harvesting operations cost, including felling, extracting, and processing was successfully developed. With the productivity data obtained from Michigan-based loggers' survey and a built-in recently updated machine hourly rate look-up table, the model is capable of performing cost calculations for user-specified equipment and systems. Moreover, this model features the capability of selecting a combination of harvesting, forwarding, and processing equipment by users and adjusting the number of machines in the entire harvesting system so that users of this model can find the optimum system configuration. All these features enable the users to find a reliable cost estimate for a given harvesting situation. In the future, this model will be improved by substituting survey-based production rates with production rate predictive equations to cover various harvesting system options and a wide range of site and terrain conditions.

SHORT ROTATION ENERGY PLANTATION POTENTIAL

6. Willow Biomass Crop Feedstock Development

Daniel Keathley (Department of Horticulture), Paul Bloese, and Raymond Miller (Department of Forestry)

Yield trails of 20-26 willow clones per site were established in Michigan from 2008 to 2011 on sites ranging from south-central Michigan north through the Upper Peninsula in an effort to evaluate the potential for the development of willow as a biofuel feedstock species in Michigan. Initial results show productivity varying greatly among clones and performance rankings shifting between harvests in year 1 and year 4. Survival was also highly variable among clones within site, ranging from 10-99%. Moisture content of the wood varied from 44-47% among the clonal lines tested. Results to date show that some clones are good "general performers" across this geographic region, while the performance of other clones is highly site specific, thus offering two different strategies for the production of commercial planting stock for the region. However, it is clear that many of the better clones are those that perform well at specific sites, indicating the importance of local adaptation and broad clonal testing in the development of planting stock recommendations for willow planting stock for biofuel plantations.

7. Poplar Biomass Crop Feedstock Development

Paul Bloese, Raymond Miller (Department of Forestry), and Daniel Keathley (Department of Horticulture)

Over the past three years a hybrid poplar clonal yield trial was established on six sites across Michigan to evaluate clones and estimate yields for the commercial production of biofuel. In 2012, 1st and 2nd-year height and survival data were compiled and analyzed from all six plantings. Results provided a preliminary assessment of the relative magnitude of genetic effects, the efficacy of clone selection, and the importance of clone x site interactions. Taxa and clone effects were significant for both 2nd-year height and survival across sites, and within each site. Early indications are that growth and survival are under sufficient genetic control to support selection (broad-sense heritabilities for 2nd-year height and survival were 0.30 and 0.47, respectively). However, these data also revealed highly significant clone x site interactions, and low Spearman rank-order correlations between pairs of site, for both height and survival. If this pattern continues to rotation age, it emphasizes the need to test clones on a variety of sites in order to accurately match clones to the appropriate planting site. As the plantings mature, volume data will be collected to validate or disprove these preliminary results.

8. Silver Maple Half-sib Progeny Testing for Biomass Crop Development

Dan Keathley (Department of Horticulture) and Paul Bloese (Department of Forestry)

Acer saccharinum seed was collected in the spring of 2010 from twenty-two seed sources throughout the northeastern US and Ontario. These seed were sown and grown in the tree nursery at Michigan State University's Tree Research Center located on Jolly Road in East Lansing, Michigan. Germination and growth were excellent, with successful establishment of planting stock from trees from Michigan, New York, Pennsylvania, Vermont, New Hampshire, Massachusetts, Connecticut, and Ontario. Seedling growth in the nursery was outstanding. Two planting sites were prepared during the fall of 2010. One at MSU's Dunbar Forest in Michigan's Upper Peninsula and the other on MSU's main campus in East Lansing. Seedlings were lifted from the nursery, prepared, and placed in cold storage in March of 2011. Seedlings were field planted at both sites in May of 2011 and are presently growing well. Survival in the plantations is excellent and they should yield useful data for projecting the desirability of silver maple as a biofuel species in Northern Michigan, as well as lead to the identification of superior seed sources. Trees at the Dunbar Forest site were heavily browsed in June of 2011. Heights of both plantations were measured in November, 2012, and data on timing of spring bud-break as well as dormancy onset were collected for the northern site in 2012. Data analysis is currently in progress.

9. Energy Plantation Density Effects on Yield and Return on Investment

Raymond Miller and Bradford Bender (Department of Forestry)

Short rotation energy (SRE) plantations on fallow open land can be highly productive and present property owners with an opportunity to participate in developing energy markets. Diversifying the agricultural base in the Northeastern and North Central United States through the introduction of SRE plantations also has the potential to improve rural economies which have declined as forestry and agriculture production has moved away. As biomass markets develop, adoption of SRE plantation systems by growers will depend to a large extent on the returns they can obtain from their investment. This, in turn, will be highly dependent on their choice of crops and cropping system. Hybrid poplars are one promising SRE crop but the interaction between varieties (taxa) and production systems (planting density and rotation length) strongly influences costs and yields and consequently, return on investment. Fifth-year growth in a replicated study of six hybrid poplar taxa planted at three densities in Escanaba, MI was examined here. Biomass yield varied significantly among taxa and densities (ranging from 37.6 Mg/ha for NM6 at 2,200 stools/ha to 14.2 Mg/ha for DN34 at 2,700 stools/ha) and a significant interaction between treatments was observed. When yields were projected to the end of an eight-year rotation, estimated rates of return ranged from +9.6% (for NM6 planted at 1,900 stools/ha) to -4.6% (for DN34 at 2,700 stools/ha). Understanding the interaction between taxa and planting densities will be critical to the profitability of SRE plantation systems.

10. Evaluating the Biomass Production of Coppiced Willow and Poplar Clones in Michigan Over Multiple Rotations and Different Growing Conditions

David MacFarlane and Zhonglei Wang (Department of Forestry)

This study reported the results of biomass yield trials at three locations in Michigan, where the average annual yield of twelve willow and two poplar clones were compared over three or four-year growth periods after coppicing. On average, fast-growing hybrid poplars (NM5 and NM6) were more productive than any of the willow clones tested by about 30%. Poplar and willow revealed different growth patterns after successive harvests; poplars grew quickly and consistently while willow growth was initially slower but increased over time. Willows at the intensively managed site in southern Michigan were usually 2 to 5 times more productive than at the two less intensively managed sites in southern Michigan and northern Michigan, but poplars at both southern sites were similarly more productive than at the northern site. The annual yield of clones was further standardized to account for differences in growing degree days (GDD) between sites in southern and Lower Michigan, which caused differences in the relative ranking of some willow clones to change. The results suggest that GDD-standardized yield rates may be useful for comparisons of clonal performance over larger regions. Decomposition of clonal yield rates into individual stool yield and survival rates revealed a strong positive correlation between them, indicating that faster-growing clones also had higher survival rates.

ENVIRONMENTAL IMPACTS OF INCREASED WOODY FEEDSTOCK PRODUCTION

11. Effects of Energy Development on Wildlife in Northern Michigan

William Porter and Andrew Crosby (Department of Fisheries and Wildlife)

The cellulosic biofuels plant proposed for Kinross, Michigan will affect wildlife in the 19,360 square mile area surrounding the plant because of the increased harvest/regeneration of forests. We propose to estimate the magnitude of these effects by linking a landscape-level forest growth model (LANDIS II) to predict future land cover with habitat models for a suite of wildlife species. This suite encompasses those species of social and economic importance and those that act as indicators of the response of a larger array of species to changing ecological conditions: white-tailed deer, American black bear, ruffed grouse, fisher, American marten, and the breeding bird community. This project will combine wildlife survey data maintained by the Michigan Department of

Natural Resources (MDNR) with Geographic Information System (GIS) data of land cover and ecological site conditions available from state and federal databases to create models to forecast the anticipated changes in relative abundance and/or distribution of wildlife. These models will be developed with the explicit intention of maximizing their applicability to other areas across the Northern Forest. We anticipate that the models will be of value to making management decisions about the future of biofuels development across the Northern Forest region.

12. An Inventory for Assessing MSU Greenhouse Gas Offsets Potential from Off-campus Forests: Carbon Sequestration and Alternative Fuels

David MacFarlane and Greg Kowalewski (Department of Forestry)

This study was funded by the MSU Office of Sustainability to investigate the potential for producing woody biomass as a fuel to offset power plant emissions via supplementing coal. The study also looked at greenhouse gas emissions offsets from forest carbon sequestration. In terms of biomass, the study suggested that routine management of MSU-owned forests in the southern Lower Peninsula could provide a sustainable yield of about 1,000 tons per year (3-4 tons per day) of green biomass fuel to the T.B. Simon Power Plant over long time periods, but it is unlikely that these forests could provide much more than this without changing land-use restrictions or repurposing significant areas of land to produce biomass more intensively. Conversion of about 830 acres of low-productivity plantations or other lands currently underemployed or devoted to failed or outdated experimental plantations to hybrid poplar plantations would allow for MSU to supply about 40 tons per day "in house" to meet this current level of green biomass fuels for the power plant. However, this would constitute devoting an area larger than the W.K. Kellogg Forest to the sole purpose of bio-energy production.

13. Carbon Sequestration and Greenhouse Gas Emissions Associated With Short-Rotation Woody Production in the Upper Great Lakes Region

David Rothstein (Department of Forestry), David Mladenoff (Univ. of Wisconsin), and Anthony D'Amato (Univ. of Minnesota)

Conversion of marginal and abandoned agricultural lands to short-rotation woody biomass crops (SRWC) has the potential to make an important contribution to the developing bioeconomy of the northern Great Lakes Region. SRWC grown on marginal lands should have far greater rates of feedstock production than existing forests and would allow forests to be utilized for C sequestration, timber, recreation and other ecological services. However, soil C loss and greenhouse gas (GHG) emissions associated with land conversion and plantation management have the potential to undermine the perceived benefits of SRWC energy production. Our project seeks to quantify the impacts of woody biomass feedstock production systems on both C sequestration in soils and biomass, and emissions of GHGs other than CO_2. Our specific objectives are to: (1) develop predictive relationships between site conditions, establishment procedures and life-cycle GHG benefits of SRWC, (2) incorporate these relationships into biogeochemical process models and Life-Cycle Assessments (LCAs) designed to predict regional-scale impacts of varying scenarios of SRWC deployment, and (3) develop geospatial tools to assist in the sustainable deployment of SRWC across existing Great Lakes landscapes.

We are using seven experimental willow and hybrid poplar plantations distributed throughout the region for intensive measurements of feedstock production, above- and below-ground C storage and GHG emissions as a function of initial site characteristics. We also are investigating reduced-tillage and no-till methods of SRWC establishment and quantifying their effects on feedstock production, C storage and GHG fluxes. These data will be used to parameterize, calibrate and validate process-based biogeochemical models and LCAs that predict feedstock production, C flows and GHG fluxes from SRWC plantations across the range of soil and climate conditions of the region.

14. Graduate Certificate in Forest Carbon Science, Policy, and Management

(Department of Forestry)

MSU's Department of Forestry has announced a new Graduate Certificate in Forest Carbon Science, Policy and Management, beginning in the fall semester of 2012. The Forest Carbon Certificate program, the first of its kind in the US, offers students the interdisciplinary tools and conceptual background to plan, implement, manage and evaluate forestry-based, climate-change mitigation projects. The certification will give students an edge in competing for employment in carbon mitigation projects of corporations, governments, and non-governmental organizations.

The program is open to a wide range of students, including students with a bachelor's degree who are not enrolled in a master's or doctoral program, as well as current master's and doctoral students at MSU and other universities. Given the need to integrate sustainability and climate change mitigation across all economic sectors, the program will consider applicants from all backgrounds, including those involved in business, law, forestry, natural resources, environmental consulting, and government. Students without experience in forestry or a related field may need to supplement the certificate courses with independent study or additional coursework. Additional information can be found on-line at:

http://www.for.msu.edu/graduate/graduate_certificate_in_forest_carbon_science_policy_and_managment

WOODY FEEDSTOCK UPGRADING

15. Torrefaction Depot Upgrading of Poplar and Willow Feedstocks

Christopher Saffron (Department of Biosystems and Agricultural Engineering)

We recently completed a project as part of the Forest Biomass Statewide Collaboration Center (FBSCC) which was funded by the DOE through the Michigan Economic Development Corporation. Torrefaction was economically assessed as a pretreatment for upgrading biomass from poplar or willow energy plantations for eventual combustion to generate electrical power. Michigan site conditions were used in this assessment which included cultivation, harvesting and transportation to decentralized torrefaction centers for upgrading. In this assessment, torrefaction followed by pelletization was found capable of lower cost electrical power than pretreatment by pelletization alone. Because of this positive outcome, my group has continued to examine torrefaction and has proposed this technology as one means of producing renewable energy in MSU's power plant.

16. Fast Pyrolysis of Poplar Coupled With Electrocatalytic Stabilization of Bio-oil

Christopher Saffron (Department of Biosystems and Agricultural Engineering)

Fast pyrolysis, a technology that rapidly heats biomass in the absence of oxygen to produce a liquid intermediate known as bio-oil, is being investigated for producing hydrocarbon fuels from poplar. To successfully decentralize fast pyrolysis, the electrocatalytic stabilization of bio-oil is being considered. Electrocatalysis uses electricity from the local power grid to reduce the reactivity and corrosiveness of bio-oil. Unlike traditional methods of catalytic upgrading, electrocatalysis can be operated at the low temperatures and pressures needed to ensure safe operation at small-scale, regional pyrolysis centers. Currently, we are exploring new catalytic cathode materials for the efficient coupling of electricity with biomass-derived bio-oil. Operation in continuous systems is also being investigated in order to develop a continuous and scalable process for producing renewable liquid fuels.

EXTENSION ACTIVITIES RELATING TO WOODY BIOMASS ENERGY PRODUCTION

In addition to the variety of research projects underway at Michigan State University, Michigan State University Extension is focused on providing outreach and education to landowners, communities, investors, and companies with stakes in the emerging wood energy sector of our economy. Mr. Bill Cook is the Forestry Extension Specialist most directly involved in these activities. He is based in the Upper Peninsula of Michigan at the Forest Biomass Innovation Center (FBIC). His activities during the past year include:

- Delivering six wood energy presentations to various audiences (academics, conservation districts, economic development groups, local governments, civic groups).
- Providing four media interviews about wood energy.
- Working with five on-site tours/demos at the FBIC with various audiences (researchers, students, open house public).
- Posting a wood energy curriculum for high schools [http://mff.dsisd.net/biomass/0-mainbiomass.htm].
- Serving in an advisory capacity to a pellet plant exploration process through the Western Upper Peninsula Planning & Development Region.
- Helping to coordinate a municipal District Energy proposal in Manistique with local governmental units, private enterprises, Johnson Controls, and various MSU services.
- Drafting short rotation culture plantation manual specifically tailored for Michigan growers, and expect finalization by spring 2013.

NEERA 1005 Sustainable Wood Energy Regional Project

Progress Report for 2012 – January 8, 2013

Mississippi State University

Research Activities

Harvesting, Handling, and Transporting Biomass (Develop and evaluate harvest, process and handling methods) PI: Brian Baldwin

- Research started with a comparison of 10 grass species. Superimposed on the species comparison were harvest regimes in 30-day increments. From this study it was apparent that either two or one harvest per growing season would be required, with one harvest (an end of season harvest) better from a sustainable standpoint than two. Of the 10 species tested, highest yields were obtained from giant miscanthus cv. Freedom, switchgrass cv Alamo, napiergrass and sorghum sudangrass, however, the later two had harvest moistures of 30-38% (12% required for hay baling). Weathering of standing stalks of these species indicated that giant miscanthus and switchgrass would loose 15% of yield in 30 days, while the tropicals (sorghum and napiergrass) lost up to 45% yield in the same 30 day period. Post-frost harvest of giant miscanthus and switchgrass were lower in total ash (4%) and much lower in potassium, calcium and sulfur than sorghum and napiergrass (8%). Data from the weathering study indicated post-frost harvested giant miscanthus and switchgrass were initially lower in potassium than sorghum and napiergrass were after four months of weathering. A direct comparison of switchgrass and giant miscanthus indicated that yield during the first two years of establishment were similar for the two, but by year three giant miscanthus yielded more than switchgrass. Yield of both species is affected by drought, but previous harvest regime magnifies the affect. For both species, those plots previously harvested twice a year had half the yield of the respective plots (of the same species) only harvested once a year. Sequential planting of switchgrass, cv Alamo, indicated optimal planting date (as indicated by subsequent yield) was the first week of April, and NOT early May, as is found in Mississippi grower's guidelines. Switchgrass can successfully be established under a nurse crop of sorghum sudangrass as long as the density of the sudangrass is less than 3 plants per linear foot of row. Population dynamics of switchgrass established as a spring monoculture indicated that under our conditions, there were 1.23 million seedlings/acre by the end of the planting season. Spring counts the following year were 80,000 plants/acre. Equilibrium was reached in the third year at 15,000 plants/acre, which coincides with peak yield. Winter hardy legumes were utilized to determine if they could replace nitrogen requirements in switchgrass. White and crimson clover established well in the test, arrowleaf and ball did not. Yield data indicated that either white or crimson could replace roughly 75 lbs/acre of nitrogen.

Thermochemical conversion processes *(Improve methods for characterization of intermediate products and process control) PI: Fei Yu*

- Novel heterogeneous catalytic systems were evaluated and tested for production gasoline range fuels from syngas. Since the nitrogen level of the biomass derived syngas can be up to 60 %, in the

catalytic converting syngas to gasoline process, work has concentrated on the development of catalysts for the production liquid fuels from nitrogen-rich syngas. Previous work demonstrated that the Mo/HZSM-5 catalyst (the 2nd generation catalyst) was active in Fischer–Tropsch synthesis (FTS) when using syngas without nitrogen component. Mo/HZSM-5 catalyst was continued evaluated for FTS, but using high level nitrogen containing syngas. Liquid hydrocarbons formed on the Mo/HZSM-5 were composed mainly of alkyl-substituted aromatics and lower branched and cyclized alkanes. Lower hydrocarbons produced included mainly methane, ethane, propane and *iso*-butane. However, the CO conversion and selectivity of liquid hydrocarbons from biomass derived syngas were not satisfied when comparing to pure syngas (without nitrogen).

Education Activities

- Transport in Biological Engineering (ABE 3303, Junior level)
- Bioprocessing Engineering (ABE 4990/6990, Senior / Graduate level)
- Biomass and Bioenergy (ABE 8990, Graduate level)
- Chemical Reaction Engineering (ABE 8990, Graduate level)

Publications:

Yan, Q., F. Yu, Z. Cai, and J. Zhang. *2012*. Catalytic upgrading nitrogen-riched wood syngas to liquid hydrocarbon mixture over a Fe–Pd/ZSM-5 catalyst. *Biomass and Bioenergy*. 47: 469-473.

Yan, Q., F. Yu, J. Liu, J. Street, J. Gao, Z. Cai, and J. Zhang. *2012*. Catalytic Conversion Wood Syngas to Synthetic Aviation Turbine Fuels over A Multifunctional Catalyst. *Bioresource Technology*.127:281-290.

Wang, H., D. Livingston, R. Srinivasan, Q. Li, P. Steele, and F. Yu. *2012*. Detoxification and fermentation of pyrolytic sugar for ethanol production. *Applied Biochemistry and Biotechnology*. 168:1568–1583.

Hu, J., F. Yu, and Y. Lu. *2012*. Application of Fischer-Tropsch Synthesis in Biomass to Liquid Conversion. *Catalysts*. 2:303-326.

Kim, H., P. B. Parajuli, F. Yu, E. P. Columbus, and W. D. Batchelor. *2012*. Economic Evaluation of Syngas Production: Model Development and Analysis. *Transactions of the ASABE*. 55(3): 1033-1045.

Wang, H., R. Srinivasan, F. Yu, P. Steele, Q. Li, B. Mitchell and A. Samala. *2012*. Effect of Acid, Steam Explosion, and Size Reduction Pretreatments on Bio-oil Production from Sweetgum, Switchgrass, and Corn Stover. *Applied Biochemistry and Biotechnology*. 167:285–297.

Street, J., F. Yu, J. Warnock, J. Wooten, and M. G. White. *2012*. Design and testing of a labview controlled catalytic packed-bed reactor system for production of hydrocarbon fuels. *Transactions of the ASABE*. 55(3): 1047-1055.

Lu, Y., F. Yu, J. Hu, and J. Liu. *2012*. Catalytic conversion of syngas to mixed alcohols over Zn-Mn promoted Cu-Fe based catalyst. *Applied Catalysis A, General*. 429–430:48-58.

Street, J., F. Yu, J. Wooten, E. Columbus, M. White, and J. Warnock. *2012.* Gasoline-range hydrocarbon production using biomass derived synthesis gas over Mo/H+ZSM-5. *Fuel.* 96:239–249.

NEERA 1005 Sustainable Wood Energy Regional Project
Progress Report for FY2011 - Prepared December 17, 2012
Submitted by: Jonathan Kays - University of Maryland

Research Activities

Hybrid Poplar / Biosolid Production Systems – we have two research projects with both at completion.

- Deep row application of biosolids to hybrid poplar – this study was started in 2002 and concluded in 2011. Different application rates of biosolids were deposited in trenches on old gravel spoils and hybrid poplar trees planted to use the nutrients. This environmental system looses no more nitrogen than a well-managed corn field on an area basis, but the footprint is only a few acres due to high application rates. It is capable of producing wood for renewable energy uses. (PI: Jonathan Kays, Co-PI: Gary Felton). The graduate student has defended her thesis and we are preparing journal papers soon based on thesis.
- Surface Application of Biosolids to Hybrid Poplar Plantations – this is the third and final year of this project. Different application rates were applied to determine effects on water quality, tree growth and production, and soil fertility. Of special interest is the effect on soil P, which must be below a certain level to allow application. In general, the application rates based on N demand of the trees will be too high to meet P nutrient management regulations in MD. Lower application rates will likely be needed to meet the regulations (PI: Jonathan Kays, Co-PI: Gary Felton).

Evaluation of a Wood Pellet Furnace System as an Alternative Heat for a Broiler Farm

Typical poultry house uses 3,000 gallons of propane per year. Wood pellet furnace reduces energy cost and results in better flock health.Wood pellet furnace being installed in a paired poultry house study. Study will run from Dec. 2012 to October 2013.

Objectives: Establish on-farm demonstration comparing a wood pellet furnace to a propane system. Perform economic analysis to compare heating cost of propane and wood pellets. Perdue Farms will assess differences in meat quality.

Partners: farmer, Lee Energy Solutions, Perdue Farms, farmer.

Final results expected in late 2013, but economic and health results available after each group of broilers are harvested.

Potential impact: major change in how poultry houses are heated on the Delmarva. Energy saving and improved flock health. (PI: Jonathan Kays, Jennifer Timmons)

Developing Best Practices for use of Outdoor Wood Boilers –project is in its third year.

Working with a private landowner with an EPA Phase 2 outdoor wood boiler to measure heat output of the boiler (in Btu's) at various parts of the heating loop throughout the heating season, along with the inputs of lbs of wood, species, and moisture content. Based on this research and past research on older outdoor wood boiler a best practices fact sheet has been developed and is in peer review. (PI: Derrick Bender, Co-Pi: Jonathan Kays).

Biomass Bio-Energy Center at UMD

Initial efforts are underway to bring together campus and extension faculty interested in biomass research and extension. One meeting has been held and the expectation is that the effort will expand. (Leader: Adel Shirmohammadi).

Extension Activities

Maryland Wood Energy Coalition

UM Extension in cooperation with the Maryland Dept of Natural Resources Forest Service has provided leadership to bring together agencies and organizations interested in increasing the adoption of wood energy in Maryland. Initiated in April 2010, the effort has resulted in:

- Maryland Wood Energy Coalition: A Prospectus for Advancing Bio-thermal Energy in Maryland. The 20-page prospectus released in February 2012 provides detailed policy recommendations and background on wood energy application and technology. The prospectus led to the initiation of a wood grant pilot program in MD to pay $400 toward a clean wood stove and $600 for a pellet stove. http://www.naturalresources.umd.edu/Documents/BiomassThermalEnergy/20120212MarylandWoodEnergyProspectus.pdf . The prospectus has been responsible for other policy efforts.
- Conference on Accelerating Wood Energy in Maryland. Held November 14, 2012 and attended by 120 participant from forest and biomass industry, environmental groups, and policy makers. It has led to a number of policy efforts moving forward. Outreach activities are in progress to capitalize on the report. (Leadership: Jonathan Kays).

Residential Wood Energy Program

- Fact sheet series completed in cooperation with the Alliance for Green Heat. Available at: www.naturalresources.umd.edu . Titles include: 1) The Wood Stove Checklist (FS-936); 2) Buying and Storing Firewood & Pellets (FS-937); 3) Buying a Second Hand Wood Stove (FS-938); 4) Buying a Clean Burning Wood Stove (FS-939); 5) Considerations for your Wood or Pellet Stove Installation (FS-940).
- More Heat – Less Wood Workshop. Evening program at two locations around state to educate people about heating with wood or pellets. Use a local wood stove retailer to help answer questions. We have worked out the agenda and plan on more workshops, webinars next year.

D. A. Weinstein, Department of Natural Resources, Cornell University Agricultural Experiment Station, Ithaca, NY

Predicting sustainably extractable biofuel from central NY forests over the next century

An enormous interest exists for increasing the use of forests to supply energy. It is expected that many forest owners will be seeking ways to manage their forests to extract greater amounts of material from them, and the long term health and sustainability of the forests will be greatly enhanced if these owners can be given a prescription for management that allows sustainable extraction of material without compromising the ability of the forest to increase carbon sequestration or the habitat support for maintenance and improvement of the biodiversity of species. Climate change is projected to alter the character of the region's forests over the coming century. Maintaining and increasing the ability of these forests to absorb carbon dioxide from the atmosphere and store it in long-lasting structures is very important to reducing the region's impact on global climate change. Further, the region is experiencing the onslaught of invasive insect species capable of killing large numbers of trees and greatly reshaping the structure of the forests. The challenge is to find the best ways to manage our forests to maximize their ability to produce large quantities of biomass material sustainably, sequester carbon, and minimize impacts to biodiversity in the face of changing conditions.

This work used the USDA Forest Service's Northeastern Decision model, NED, to project future forest development to identify the best management strategies. A method was developed for predicting the effects of insect invasion and of climate change on forest development. To simulate the changes that an altered climate will produce in these forests, the abundance of each species was modified according to the change in abundance predicted by the USDA Climate Change Tree Atlas. The predictive model was used to estimate the expected forest growth, changes in species composition, and carbon sequestration rates over the management interval. Using Cornell forests as a test case, strategies were tested to find those that could be applied practically to forests by their owners and managers to meet management goals in the face of changing climate conditions.

The study predicted impacts from each of a variety of stresses that forests are currently experiencing, the emerald ash borer, the hemlock adelgid, elimination of oak regeneration by deer, elevated CO2 concentrations in the atmosphere, and increased temperatures. Simulations identified the potential success of several management techniques, including thinning forests

to create higher light environments for red oak seedlings and planting and protecting red oak seedlings from deer browsing. In the absence of major insect or disease stresses, Cornell forests would be expected to grow 9% over the next 50 years (2011-2060). Particularly high growth rates are expected in the youngest established stands, those that are currently 50 to 69 years of age. Little size accumulation is projected for stands greater than 80 years in age, with the exception of a 12% increase in growth in hemlock-hardwoods. Elevated CO2 in the atmosphere will lead to only a modest (5%) additional increase in growth of the forests. However, this study has identified that these growth increases are unlikely to be realized.

The forests were not projected to recover over the next 50 years from infestations by emerald ash borer and hemlock adelgid, which will lead to a loss of 15% and 9% of biomass, respectively. Because of anticipated climate warming over the next 50 years associated with these elevated CO2 levels, the forests best adapted to the new conditions will be those containing large quantities of red oak. However, red oak abundance is predicted by this study to decline in these forests over the next 50 years, and this decline will be greatly accelerated by the browsing of deer on seedlings. The decline could be reversed, hypothetically, by the thinning of the canopy, increasing light available. However, thinning the forest was not predicted to regenerate red oak into the canopy over 50 years. In addition, complete elimination of oak regeneration by deer browsing in existing forests is projected to eliminate successful recruitment into older size classes. If trees were planted at a rate of 60 individuals per acre, this study projected that the abundance of red oak would increase by 35% by 2060 instead of an 8% decline. The results of the analysis indicate that thinning the forest canopy, combined with protecting seedlings, will greatly enhance the density of red oak saplings, but either alone is insufficient. Therefore, this study identified the management techniques most likely to result in the healthiest forest structure and composition fifty years from now. It will be critically important for forest managers to employ these strategies if we are to have healthy forests on the future landscape of central New York.

NEERA 1005 Sustainable Wood Energy Regional Project
Progress Report for FY2012 - Prepared Dec. 20, 2012
Submitted by Larry Smart, Associate Professor, Dept. of Horticulture, Cornell University, New York State Agricultural Experiment Station, Geneva, NY.

The activities at the New York State Agricultural Experiment Station in Sustainable Wood Energy are focused on the breeding and commercialization of shrub willow bioenergy crops with specific demonstration of their use as fuel for small-scale, on-farm heating.

- In 2012, we produced ~1,700 new progeny in 12 families through controlled or open pollinations. Those progeny were produced both the aim of generating new, improved commercial cultivars, but also will be used as mapping populations to determine the genetic basis for traits important for yield, pest and disease resistance, and bioenergy production. We fully genotyped a F_2 mapping population of *Salix purpurea* using genotyping-by-sequencing in collaboration with Ed Buckler's lab (Cornell, USDA-ARS) and Steve DiFazio (West Virginia).
- We coppiced ~12 acres of willow fields that contain three cultivars, 'Millbrook', 'Fabius', and 'Fish Creek' in a split field design across four parcels. These plantings will be harvested after the 2013 growing season to assess the yield potential of those three cultivars and to provide fuel for a wood chip boiler on the Cornell NYSAES campus.
- In collaboration with Greg Loeb (Cornell), we conducted no-choice and free-choice assays of potato leafhopper (*Empoasca fabae*) on susceptible and resistant genotypes, to learn that host choice plays a major role in cultivar damage.
- Biomass harvested from 12 acres of willow trials each year will be used as fuel in a wood chip boiler that will be installed to heat two farm unit buildings. An old pole barn was renovated to hold willow chips and the heating systems of those buildings were upgraded to accommodate the new boiler, which was commissioned in Jan. 2012.
- A 27-cultivar yield trial was established on the Geneva campus to test the yield potential of new willow genotypes selected at Cornell.
- Two TA Systems Thermogravimetric analyzers were purchased and installed. These were used to characterize significant site-by-genotype interactions for wood composition across a number of yield trial sites.