NARA Goal Four

2nd Cumulative Report

April 2013 - March 2014

Supply Chain Coalitions

Envision and delineate pilot supply chains within the NARA region.

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SUMMARY

The NARA project is designed to develop a roadmap for industry to produce biojet and co-products from forest residues. This roadmap can only become reality when regional stakeholders (businesses, government agencies, and private individuals) are empowered to actually build the industry. Involving stakeholders in the research process and using their input to shape the supply chain analysis is an integral step on the pathway to this new industry. The Outreach and Education teams are being used in key roles toward this end. Regional stakeholders are identified, organized, and/or engaged by the Outreach team working to develop regional assets and needs. The Education team then partners with these stakeholders and mentors student teams who analyze and design regional supply chains for potential biofuel production. This two-pronged alliance both engages stakeholders in the research process and develops the regional knowledge and interest to carry the industry forward. Finally, the diverse student teams researching the supply chains develop into the trained workforce of the future.

NARA is building regional capacity to implement a biofuel industry by focusing on three areas:

1. Identifying and engaging key stakeholders and incorporating them into the planning process

2. Cataloging regional supply chain assets, analyzing the logistical and economic relationship among these assets and providing recommendations and strategies on how best to employ them

3. Communicating researched-based strategies to stakeholders and facilitating business development where feasible

STAKEHOLDER ENGAGEMENT

To engage stakeholders and disseminate NARA findings and activities, NARA facilitated three conferences: Small Log Conference, Annual National Timber Symposium, and Harvesting Clean Energy conference. In addition, NARA members provided over 140 poster or oral presentations at over 50 different conference and meeting events. NARA invited key stakeholders to the NARA annual meeting to assess opportunities for a wood to biofuel industry.

PILOT SUPPLY CHAINS

Facilitating the development of pilot supply chains actually engages all NARA members; however, groups within the NARA Outreach and Education Teams have tasks dedicated to this goal. To identify regional stakeholders and incorporate them in the planning process, the NARA Outreach Team members delineate key stakeholders and mine existing efforts pertinent to the biomass and biofuel industry. This effort engages stakeholders ranging from landowners and economic development specialists to forest products industry and environmental NGOs.

To envision regional supply chain assets and provide recommendations and strategies on their utility, the Education team assists the outreach efforts by forming collaborations between students, NARA mentors, and stakeholders to provide regional analyses. NARA researchers and university students participate in a year long integrated design course called Integrated Design Experience (IDX), offered through the Institute for Sustainable Design at Washington State University. In this collaborative course, multidisciplinary student teams analyze biofuel supply chain scenarios in partnership with regional stakeholders. For this reporting period, this group consolidated their analyses covering the western Montana corridor (WMC) region onto a website at http://nararenewables.org/westernmontanacorridor/ and worked with stakeholders to identify and design a supply chain for western Oregon and Washington in a region defined as the Mid Cascade to Pacific (MC2P) region. To effectively engage stakeholders, a profile document and fact sheet were developed and distributed that describe the project's approach and goals. In addition, a webinar series provided stakeholder updates on progress. Two analyses occurred in the MC2P region: 1) an overall supply chain analysis that examines available regional feedstock for potential conversion sites; and 2) a site selection analysis that identifies specific sites for solid depots, liquid depots and integrated biorefineries (IBRs). The preferred sites identified are:

Solid Depot:
Sierra Pacific Industries; Aberdeen, WA (Former Bradley-Woodward Lumber Co; Bradwood, OR)

Liquid Depot:
Kapstone Pulp and Packaging; Longview, WA
Weyerhaeuser Bay City Log Yard; Aberdeen, WA

Integrated Biorefinery:
Cosmo Specialty Fibers; Cosmopolis, WA

Final reports will be made available in Fall 2014 (Task E-3).

A similar collaboration of students, NARA mentors, and stakeholders was employed with the Confederated Salish and Kootenai Tribes (CSKT) for whom NARA completed a 10-year biomass supply projection study. A key finding was that ecologically-prescribed forest treatments that are intended to restore the structure and function of CSKT forests to a pre-fire exclusion regime produced timber and slash volume results comparable to typical commercial harvest practices in western Montana. (Task E-1; report is listed under bioenergy literacy chapter).

TECHNOLOGIES FOR AN EFFICIENT SUPPLY CHAIN

To utilize forest residuals from remote areas where direct woody feedstock transport to a biorefinery is cost prohibitive, a distributed production scenario is being explored where forest residuals are converted into "sugar syrup" that can be transported for further product development. Achieving this goal could potentially decrease biomass transport and labor costs while extending utilization of existing facilities. Distributed production can also provide a diversified biomass source to mitigate supply risks and reduce the supply radius. To investigate this potential, experiments were conducted to investigate transforming wood residuals inexpensively into a transportable pellets, panels or sugars. Wood residual grinding options and costs were evaluated, and it was shown that a hammer mill performed superior to a knife mill. Optimal pellet strength and energy efficiency was obtained. Size reduction via extrusion of the wood particles was evaluated for energy usage and product characterization. Experiment results demonstrated that moisture content, temperature, rotation speed, and residence time have significant effect on particle size reduction and energy consumption. Milling options were tested for how they influence a wood sample's enzymatic digestibility. Preliminary tests implied that the ring and puck mill is more efficient than the planetary ball mill in disrupting wood recalcitrance for saccharification (Task E-8).

Hot water extraction (HWE) processing is also being investigated to integrate into the supply chain of converting woody biomass into biofuels and co-products. Strategy behind HWE is to 1) pretreat the woody biomass to extract hemicellulose sugars and convert the extracted biomass into high-density panels for ease of transport, and 2) to evaluate the feasibility of deriving value-added byproducts, such as cellulose nanofibers, by mild chemo-mechanical processes (Task O-1).

Forest residues constitute a majority of the wood biomass supply considered for producing biojet. Another source of wood residue feedstock is construction and demolition debris (C&D) portion of municipal solid waste (MSW). NARA completed a GIS database that identifies MSW and municipal recycling facilities (MRFs) for each state in the NARA region. This database is used to determine potential C&D volumes available and to engage C&D owners and managers (Task E-7).

Significant outputs for this reporting period are:

- An improved knowledge base is available to the public (Task O-1). http://woodtobiofuel.org/
- The western Montana corridor supply chain analyses are available online (Task E-3). http://nararenewables.org/westernmontanacorridor/
- NARA completed a GIS database that identifies MSW and municipal recycling facilities (MRFs) for each state in the NARA region. This deliverable is a NARA milestone and allows the incorporation of C&D feedstocks into biomass quantity modeling (Task E-7). http://nararenewables.org/westernmontanacorridor/docs/Volume5-2_SolidWasteAnalysis.pdf
- A supply chain analysis was initiated for western Oregon and Washington (MC2P region) and regional assets were compiled. NARA facilitated stakeholder involvement by conducting multiple meetings, seven webinars and two informational documents including a community profile document that is a NARA milestone deliverable (Task E-3).
  Profile document: http://woodsymposium.wsu.edu/documents/MC2P-ProfileBook9-6Final.pdf
  Webinars: https://www.youtube.com/channel/UCEx98IREHWvRpdUKd0y1amQ

Significant outcomes are:

- The collaborative activities of the Outreach and Education Teams towards supply chain assessment have developed strong interest and brand recognition for NARA. These efforts have encouraged a large group of stakeholders that include the Washington State Department of Commerce as well as interest from numerous corporations around the supply chain the engage with the NARA project. A highlight of these efforts is the decision by Cosmo Specialty Fibers to pursue a biorefinery business model. Cosmo is a NARA affiliate member and a pulp company based in Grays Harbor, WA. They are initially pursuing developing both biochemical and sugar products to augment their traditional pulp offerings. This development has been assisted by direct efforts of our Conversion, Education, and Outreach Team efforts.
- A 10-year biomass projection study was completed and provided to the Confederated Salish and Kootenai Tribes (Task E-1). This deliverable is a NARA milestone and provides a basis for future tribal partnerships and undergraduate and graduate educational work experience. A key finding was that ecologically-prescribed forest treatments, that are intended to restore the structure and function of CSKT forests to a pre-fire exclusion regime, produced timber and slash volume results comparable to typical commercial harvest practices in western Montana. Due to the successful completion of this report, funding for follow-up work was secured and a new study for CSKT was established to test the fire resiliency of siliviculture treatments.

Training

Name	Affiliation	Role	Contribution
Jon Potter	WSU	Undergraduate Student	IDX external fellow. Tasked with assisting with external communications for the class, including templates for presentations, printing posters, etc. Jon has also been the primary lead on the supply chain analysis for the MC2P region.
Alex Kirk	WSU	Undergraduate Student, ended in December 2013	IDX internal fellow. Tasked with assisting with internal communications for the class, including setting up standards for GIS imagery, and coordinating all supplies needed in the studio. Alex has also been the primary lead on the biomass availability calculations for the MC2P region.
Peter Gray	WSU, Economic Sciences	Graduate student (PhD)	Lead Supply Chain specialist for the IDX team. His responsibilities include an economic analysis of the supply chain for distributed and localized models of biomass collection.
Natalie Martinkus	WSU, Civil Engr.	Graduate student (PhD)	Lead GIS specialist for the IDX team. Her responsibilities include collection, documentation, and analysis of all GIS assets in the MC2P region.
McKenzie Payne	University of Idaho	Graduate student (MS)	Collecting information that will assist prospective biofuel industry leaders. Information includes standards set by the Environmental Protection Agency (EPA), the states in the Mid Cascade to Pacific (MC2P) region and a sampling of standards at the county and community level. Rules, regulations and permits identified will provide information that companies may use to guide decisions in locating a feasible biofuels facility. Co-authoring article for submission to Western Planner "From Wood to Wing: Opportunities to Build an Advanced Biofuels Industry the Pacific Northwest Utilizing its Timber-based Assets"
Scott Millman	University of Idaho	Graduate student (MS)	Refining article on historical framework for the timber industry and forest usage in the PNW to shed light on why certain decisions are made for facility locations for the NARA project. Co-authoring article for submission to Western Planner "From Wood to Wing: Opportunities to Build an Advanced Biofuels Industry the Pacific Northwest Utilizing its Timber-based Assets"
Joshual Hightree	University of Idaho	Graduate student (MS)	Working on facility and sizing needs for IBR at Cosmo Specialty Fibers and Kapstone Pulp and Paper
Jorge Jordan	University of Idaho	Graduate student (MS)	Working on transportation cost calculator with Peter Gray. Devleoping a bioport industrial park model for three sites in the MC2P region.
Tess Wolfenson	University of Idaho	Graduate student (MS) , ended December 2013	Assessed opportunities and constraints of removing pre-commercial thinning residues from forest health restoration projects and incentive programs in WA and OR for the purpose of biomass to biofuel production. Graduated from UI in December 2013 and took an internship with an airport consulting firm in Chicago, IL. Her NARA RA work got her the internship.
Gerald Schneider	WSU, Civil Engr.	Graduate student (MS)	MRF inventory analysis
Lalit Chetan	WSU, BSE	Graduate student (MS)	Process inhibitors

Rui Zhu	WSU, Civil Engr.	Graduate student (PhD)	Maintaining stakeholder list; Drafting one-pagers; compiling assets; Literature review; Research on woody biomass conversion and producing other value added products; Assisting with Knowledge Base
Sarah Dossey	CMEC, WSU	Technical Assistant	Developing Knowledge Base; assisting with conferences; producing videos; compiling database of stakeholders
Janna Loeppky	Oregon St. Univ.	Graduate student (MS)	Assisting with interviewing NARA researchers at OSU and developing outreach materials
Jinxue Jiang	WSU, Materials Science & Engr.	Graduate student (PhD)	Chemically pre-conversion, pelleting of pre-converted wood, Milling
Yalan Liu	WSU, Materials Science & Engr.	Graduate student (PhD)	Coarsely milling wood into different particle sizes, and measured energy consumption
Huinan Liu	WSU, Materials Science & Engr.	Graduate student (PhD)	Effects of extrusion on wood particle morphological changes
Kane Norton	University of South Wales, Briton	Undergraduate student	Ball-milling of wood particles and cellulose crystallinity measurement
Andrea Laguna	University of Wisconsin at Madison	Undergraduate student	Densification of bisulfite pretreated softwood and the effect of densification on enzymatic hydrolysis.
James Casey	University of Idaho	Grad Student	Will begin surveying forest residuals this spring and summer
IDX Students (52)	Washington State University and University of Idaho	Undergraduate/graduate students	Students participate in two-semester course and provide analysis and data for regional supply chain work.

Resource Leveraging

Resource Type	Resource Citation	Amount	Relationship or Importance to NARA
RA Funding	WSU, Provost Office		Support for Peter Gray and Natalie Martinkus
Scholarship	China Scholarship Council (CSC)		Support for Yalan Liu and Jinxue Jiang
RA Funding	WSU, Provost Office		Support for Huinan Liu

SUPPLY CHAIN

OUTREACH TEAM

TASK O-1: WASHINGTON STATE UNIVERSITY NARA EXTENSION INITIATIVES

Key Personnel	Affiliation
Vikram Yadama	Washington State University
Karl Englund	Washington State University

Task Description

NARA units, research, extension and industry members, will act as partners and facilitators with an ultimate goal of empowering the stakeholders to plan and implement the changes needed to build, develop, and sustain a biorefinery infrastructure. The goal of the outreach team is to promote stakeholder bioenergy literacy and build regional supply chain coalitions for development of a framework of biofuel and co-products production from woody biomass. End outcomes of this goal are sustainable production of biojet fuel and co-products and rural economic development. Following are the objectives of the outreach team to reach this goal:

I. Bioenergy Literacy, where we: a) disseminate the research-based information (on technology and markets) to our industrial stakeholders and understand the technical challenges regarding implementation at industrial scale (industry-focus); b) relate the feedstock development and logistics information to our resource-based stakeholders (local communities, forest landowners, forest managers) and hear their concerns regarding the type of information that will assist them in keeping their costs low and marketable value high (resource-focus); and, engage the organizations and partnerships in connecting with public-interest groups and policymakers (public-focus). These activities will be carried out via a variety of communication mechanisms, including social media, newsletters, briefing papers, extension publications, workshops/seminars, conferences, field trips, and stakeholder meetings. Bioenergy literacy to professionals will be achieved through the following tasks:
1) implement targeted outreach activities for engaging stakeholders and advancing bioenergy literacy to professionals;
2) catalog activity outcomes and benchmark reports and studies.

II. Build Supply Chain Coalitions (logistical support and stakeholder development and engagement), where we will form working groups with stakeholders at community and bioregion levels to involve them through collaboration across the supply chain: forestland owners and managers, environmental NGOs, businesses, regulatory facilitators, and community infrastructure working groups to interact with and inform policymakers at regional, state, and federal levels. These stakeholders will be internal and external focused around the NARA communities (NCs) selected in the four-state region. This process will rely on support from other teams, such as Education and EPP, and consider physical and social assets along with practical aspects in narrowing down the list to a manageable number of communities with the four-state region. A long list will be shortened through surveying community-based stakeholders in the PNW and intermountain region to strategically choose several NCs for studying the viability of a biofuel-based infrastructure. Once communities are identified, focus group meetings involving a wide variety of stakeholders will be held at each community to discuss feedstock specifications and logistics, technology adoptions within the existing infrastructure, and viable strategies practical and beneficial for the communities. This process will involve industrial stakeholders and NARA industry partners as well. Establishing a meaningful dialogue on what local experts perceive to be the barriers and opportunities for establishing a biorefinery infrastructure in their community is critical. Building supply chain logistics consists of two major tasks:
1) engaging stakeholders to assist in compiling supply chain assets, analyzing potential supply chain structure, and forming regional alliances.
2) assist in establishing NARA pilot supply chain (PSC) study region and coordinating activities with NARA's IDX and other research teams for conducting supply chain analysis in the region.

Activities and Results

Task O-1.1. Bioenergy Literacy

Task 1:
Teh NARA Outreach team facilitated and assisted in the organization of three regional and national conferences; Small Log Conference, Annual National Timber Symposium, and Harvesting Clean Energy. Thirty-one online newsletter stories have been disseminated through ten newsletters to 793 subscribers (this is a 562 subscriber increase since April 2013) with a 33% click rate. Stakeholders were also reached by the NARA Outreach Team members through presentations and display booths at Montana Economic Summit, Public Interest Environmental Law Conference, and regional meetings of the Western Wood Products Association and WA Loggers Association. The NARA Outreach Team has been actively involved in organizing and coordinating the NW Wood-based Biofuels + Co-Products Conference (April 28-30, 2014; Agenda) in coordination with WSU's International Wood Composite Symposium (April 30-May 1). Three policy-maker briefs were distributed through the Ruckelshaus Center and 31 news articles were written about NARA activities. Ten infographics/one-pagers have been generated and made available via the NARA website.

On the social media front, a NARA blog was initiated in June 2013 and 44 posts were made to date. In addition, the Outreach team maintains our website, Facebook page and Twitter account. The NARA website has seen 10,866 unique visits, 60,360 page-views, 54.48% new visits.

Task 2:
The NARA Outreach team maintained the NARA Knowledge Base, an information repository within the NARA website, and coordinated a NARA section in the FBN newsletter. The Knowledge Base is currently being transformed into a dynamic and searchable source at www.woodtobiofuel.org.

Task O-1.2. Build Supply Chain Coalitions

Task 1:
The Outreach team worked with the Integrated Design Experience (IDX) group to complete the Western Montana Corridor supply chain report. In defining the Mid Cascade To Pacific (MC2P) Region, the foundation was laid for the regional supply chain. A series of local meetings were implemented to engage with stakeholders in the region where their information was solicited to further augment the Outreach and Education teams' existing asset database. A communication plan has been developed to inform and engage stakeholders.

Task 2:
In collaboration with the Education Team, a roadmap document (MC2P Profile) was developed for the MC2P supply chain region (Figure O-1.1). This document outlines the activities involved in the supply chain analysis and provides an initial compilation of assets. A comprehensive list of stakeholders in the region continues to develop. Key and active stakeholders have also been engaged through follow-up regional meetings (Oregon Biomass Working Group, Washing State Forest Biomass Coordination Group, The Lewis Economic Councils General Membership Meeting) to disseminate current findings and solicit feedback. The Outreach team assisted the Education Team with webinars presented by the IDX students working in the MC2P region on the results of site selection analysis, and informed regional stakeholders about the webinar.

The environmental community was introduced to the NARA project through participation at the Public Interest Environmental Law Conference (Eugene, OR) and by discussions with regional environmental communities at the Biofuel Coffee, organized by the Gifford Pinchot Taskforce. This allowed for an open conversation on the utilization of waste wood to biofuel concepts and their implications on the forest ecosystem and the overall environment.

On the research front within the Outreach Team, Rui Zhu, a PhD candidate, is investigating hot water extraction (HWE) as an integrated pretreatment option within the supply chain for production of value added byproducts as woody biomass is converted into biofuels and co-products (Figure O-1.2). HWE pretreatment of Douglas fir wood chips were conducted in a 2L Parr reactor to extract hemicelluloses. A response surface methodology (RSM) was formed to determine the optimum reaction time and temperature for the highest hemicellulose extraction yield (HEY). Results show that the HEY increased from 19.29 to 70.81% depending on reaction time (30-120 min) and temperature (140-180 °C). Effects of the severity factor (SF) on mass removal and compositional changes were also evaluated. The compositional change in biomass was analyzed with ion chromatography and further confirmed with thermogravimetric analysis (TGA) and Fourier transform infrared spectroscopy (FT-IR). Hygroscopicity and thermal stability of wood were improved after HWE pretreatment. Colorimetric analysis showed that temperature has a greater influence on color of the wood chips during HWE pretreatment than dwell time. Overall, HWE pretreatment shows great potential for extracting hemicelluloses and altering physicochemical properties of wood in an integrated biorefinery for diversification of product portfolio.

To add value within this supply chain, the Outreach team is also evaluating the feasibility of extracting cellulose nanofibers (CNFs) from hot water extracted Douglas-fir using mild chemo-mechanical processes. CNFs can be separated from each other by overcoming the extensive and strong inter-fibrillar hydrogen bonds. However, cost effective and efficient methodology is still lacking to isolate CNFs at industrial scale. In the present work, CNFs were successfully extracted from HWE pretreated Douglas-fir by a mild chemical treatment followed by a simple ultrasonication. Besides partially dissolving hemicelluloses, HWE treatment was also effective in loosening the cell wall structure. The main objective of this preliminary work was to evaluate the effects of HWE on the ease of defibrillation process. Fourier transform infrared spectroscopy (FT-IR) results indicated that some of hemicelluloses and nearly all lignin were removed in the CNFs during HWE and chemical treatment. Transmission electron microscopy (TEM) images showed that the obtained CNFs have diameters less than 100 nm. Dynamic rheology results indicated that the modulus of CNF suspensions from HWE treated Douglas-fir were significantly higher than that of untreated Douglas-fir. Besides, CNFs also maintained the thermal stability of raw cellulose fibers as revealed by Thermogravimetric analysis (TGA). The obtained CNFs could serve as unique building blocks in various fields, such as reinforcements of matrix used in composite manufacturing. This new approach by incorporating HWE treatment may provide a convenient, versatile, and environmentally benign fabrication method for producing CNFs.

Figure O-1.1. Tentative boundaries of the MC2P supply chain study area in Year 3

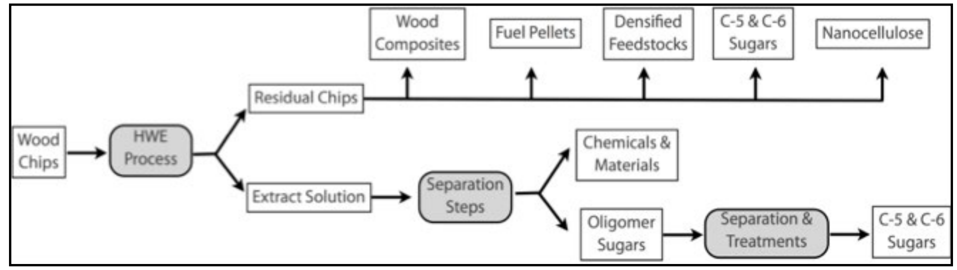

Figure O-1.2. HWE as integrated technology to derive value along the supply chain of converting woody biomass into biofuels and co-products.

Recommendations | Conclusions

Throughout the last year working with stakeholders, colleagues in the biomass utilization field, and other team members, we have observed the following:

- managing stakeholder expectations is critical to mitigate misconceptions of a physical plant being built by the end of the NARA project;
- in commercially owned forest lands, where share-holders are involved, the bottom line is the value derived from forest slash and not much emphasis is placed upon making biofuels;
- current forest products industries fear competition of their biomass supply (ex mill residues). NARA needs to continue their clear explanation of the feedstock source;
- current stakeholders are continually requesting specifications for acceptable feedstocks;
- increasing awareness of the benefits of co-products and green chemistry is becoming more common;
- stakeholders are often concerned with feedstock collection and transportation logistics.

Some things we need to consider for future work:

- more concise presentations to engage, and keep engaged, stakeholders;
- more effort in disseminating finished supply study results through established local stakeholder meet-ings;
- need to develop assessment tools to further our understanding of stakeholder engagement and awareness;
- developing a supply chain case study for a specific location utilizing all the assets of the NARA teams would be a valuable tool to frame the context of the NARA project. This case study could be presented as a stand-alone meeting or in an established work-shop or conference.

Physical and Intellectual Outputs

PHYSICAL

Examples

- NARA display booth to interact with stakeholders and disseminate information at five events in PNW region
- Sessions organized and coordinated at two regional and one national level conferences
- 10 newsletters distributed to 793 subscribers (https://nararenewables.org/news/newsletter)
- Three policymaker briefs distributed
- 10 one-pagers/factsheets/infographics produced to disseminate NARA-generated information
- 25 news articles were written about NARA activities including Imagine Tomorrow
- 44 blog posts since inception in June 2013 (http://nararenewables.org/blog/)
- The NARA website, www.nararenewables.org, had 19,363 visits with 60,360 page views and 54.5% new visits. Viewership came from all 50 states and from over 114 countries.
- The Knowledge Base repository contains unbiased information that covers all aspects related to the NARA project. It is available to the general public and during this reporting period, the site has had a total of 1,156 visits from over 23 states and 10 countries. (https://nararenewables.org/knowledge-base

CONFERENCE PROCEEDINGS AND ABSTRACTS FROM PROFESSIONAL MEETINGS

- 2013 Small Log Conference Proceedings
- NARA Presentations from the 2013 Small Log Conference

RESEARCH PRESENTATIONS

Oral, Posters or Display Presentations

Yadama, V. NARA – Northwest Advanced Renewable Alliance Biomass to Biofuel. Montana Economic Development Association (MEDA) 2013 Spring Conference, May 9, Hamilton, MT.

Rawlings, C. NARA Western Montana Corridor supply chain and the stakeholder involvement. Annual National Indian Timber Symposium, June 10, 2013, Keshena, Wisconsin.

Zhu, R. and V. Yadama. 2013. Impact of hot water extraction (HWE) pretreatment conditions on the physiochemical characteristics of Douglas-fir (DF) wood chips. Technical Poster Forum, 2013 NARA Annual Meeting, September 10-12, Corvallis, OR.

Yadama, V. 2013. Overview Talk: Community Engage-ment in the Pacific Northwest to Facilitate Develop-ment of Biofuels and Co-Products Supply Chain. 2013 NARA Annual Meeting, September 10-12, Corvallis, OR.

Yadama, V. 2013. Pacific to Cascade Supply Chain Coalition – Engagement & Analysis. Presentation to Washington Forest Biomass Coordination Group on MC2P Supply Chain Study Initiation, October 8.

Yadama, V. 2013. NARA's Outreach Efforts in Promot-ing Biofuel Infrastructure in the Pacific Northwest. AAIC 25th Anniversary Meeting on New Crops: Bioenergy, Biomaterials, and Sustainability, October 12-16, Washington DC.

Yadama, V. 2013. Cascade to Pacific (C2P): Wood-based Biofuels Supply Chain Analysis. Oregon For-est Biomass Working Group, Salem, OR, November 12.

Yadama, V. 2013. Cascade to Pacific (C2P): Wood-based Biofuels Supply Chain Analysis. Lewis Economic Develop Council's General Membership Meeting, Chehalis, WA, November 14.

Yadama, V. 2014. NARA Facility Site Selection: Mid-Cascade to Pacific Region. Progress report to Washington Forest Biomass Coordination Group, Feb. 11, 9-12pm.

Other Publications

Extension, Technical, Popular Press, Industry Trade Journals, etc.

4/15/13	USDA Press Release	Agriculture Secretary Vilsack and Transportation Secretary LaHood Renew Agreement to Promote Renewable Fuels in the Aviation Industry
5/1/13	WSU News	Tracking wood in landfills, future energy source
5/8/13	Seattle City Light "Power Lines"	Seattle City Light Sponsors High School Alternative Energy Competition
5/22/13	Washington Clean Technology Alliance	Imagine Tomorrow: The Big winner is...
5/27/13	The Star	Science teams take prizes in big competition
5/30/13	Indian Country	Sustainability Offers Tribes a Meaningful Way to Diversify Their Holdings
6/6/13	Kingston Community News	KHS team's project a winner at Imagine Tomorrow
6/11/13	Redmond reporter	STEM School students win in "Imagine Tomorrow"
6/11/13	Camas-Washougal Post-Record	CHS Students earn honors in "Imagine Tomorrow"
6/12/13	Oregon Live	Northwest biofuel researchers will have a booth at Paris Air Show
6/13/13	WSU News	WSU exhibit to open at Paris Air Show
6/18/13	AviationPros.com	Washington State's Jet Fuel Research Earns Invite To Paris Air Show
7/1/13	Western Region Cohesive Wild,and Fire Management Strategy Newsletter	Tribal Partner to reduce fuels and increase biomass utilization
7/9/13	USDA Blog	Paris Air Show a Hit for USDA Partners
7/23/13	Western Forester	No Hiding in the Woods: Biomass development requires Engagement, Integration and Innovation
7/23/13	Western Forester	From Wood to Wing: NARA Works to Harness Woody Biomass for Aviation Biofuel
8/28/13	TAPPI Ahead of the Curve: Wood to Wing	The Northwest Advanced Renewables Energy Alliance
9/5/13	Engineering Because	Cornell University Engineer's Research Could be worth $150 million
11/23/13	The Columbian	Gifford Pinchot group announces partnership

MC2P Profile – Roadmap for the Mid Coastal to Pacific supply chain study region in western Washington and Oregon – Prepared, reviewed, and in the processes of formatting to be distributed

Infographics + Fact Sheets generated based on NARA findings (10 produced during this time period)

VIDEOS AND WEBINARS

23 NARA produced YouTube Videos

Oregon State University 2013 Starker Lecture Series – Mike Wolcott Presents "Aviation Fuels From Wood."

NARA is featured in a WSU video promoting clean technologies.

Video Streaming: MC2P – Site Selection Presentation, October 14, 2013, 2-4pm

Webinar: NARA biofuel supply chain analysis for the Mid Cascade to Pacific (MC2P) Region, December 4, 2013, 2-4pm

TRAININGS, EDUCATION AND OUTREACH MATERIALS

Workshops, seminars, conferences held, field days, demonstrations, course/teacher packages, etc.

Imagine Tomorrow Competition, WSU Pullman WA, May 18th, 2013

Washington-Oregon PSC Study Region -- First Stakeholder Meeting. May 21, 2013, Vancouver, Washington, Meeting presentations

Preliminary fieldtrips in MC2P region: Members of the Outreach and Education teams visited several sites in the greater Portland area to learn more about regional resources and develop relationships with stakeholders that will shape our understanding of biomass issues in the region. Fieldtrips included visits with wood recyclers (Greenway Recycling), biofuel processors (SeQuential Pacific Biodiesel), log yard (Teevin Brothers), and environmental organization (The GP Task Force). A brief report regarding the fieldtrip can be found at NARA's Blog. This trip set the foundation for further work and research, including the generation of a profile and bioregional atlas focusing on woody biomass and the associated assets in the southwest Washington and northwest Oregon area.

TASK O-2: MONTANA STATE UNIVERSITY NARA EXTENSION INITIATIVES

Key Personnel	Affiliation
Peter Kolb	Montana State University

Task Description

Montana State University (MSU) Extension Forestry will assist with the NARA Extension Working Group by providing information about the NARA program and research updates to Montana stakeholders including industry, logging and landowner professional organizations and conferences. In addition we will produce and publish brochures, popular articles and guidelines for these groups, as well as assist with the scoping process and development of a test bed site.

Milestones Year 1:
Meet with NARA extension group and develop guidelines for selecting test bed sites. Cooperate with NARA team to develop and launch web site. Meet with Montana interest groups including Montana biomass working group, Montana Logging Association, Montana Forest Council, Montana Tree Farm, Montana Forest Owners Association and introduce the NARA project and scoping for test bed site in Montana. Develop outline for woody biomass harvesting guidelines for forest landowners.

Milestones Year 2:
Develop draft of woody biomass harvesting guidelines for review by multiple Montana interest groups. Meet with stakeholders in various communities for outline and discussion of possible test bed sites. Organize several field trips for field reviews of potential test bed sites. Write three articles on NARA project for statewide media outlets. Contribute towards NARA website.

Activities and Results

Montana State Extension Forestry assisted with the development and implementation of an educational and logistical support program across Montana for the development of a forest residue-to-energy industry. Forest landowners, managers, agency, industry and multiple western Montana community representatives have learned about the process and raw material requirements for a potential industry that converts woody debris into isobutanol – a drop-in ready jet fuel alternative. Multiple articles in landowner and professional newsletters, as well as presentations at potential partner-industry board meetings, have outlined the process and requirements. This has resulted in reaching more than 3000 private forest landowners, 8 major forest products companies, major logging contractors and tribal, state and federal forestry personal representing forest inventories on more than 2 million acres of private lands, 800,000 acres tribal lands, 800,000 acres state trust lands and 12 million acres of federal lands with wood harvesting potential. Based on conference and communications feedback, most of these stakeholders are today optimistic about the potential of selling woody debris that is a current byproduct of wildfire hazard reduction, forest restoration and traditional logging operations, and are ready to assist if further conversion research shows a feasible solution. An MSU Extension web page and a biomass stakeholder list-serve inclusive of other woody biomass conversion research and entrepreneurship has been developed and is used to update western Montana constituents of any new developments regarding forest biomass markets.

Recommendations | Conclusions

There is a surplus of woody biomass available across Montana that would benefit from an economically viable market. Such a market would increase healthy forest conservation efforts, private enterprise and rural communities. Continued research into developing a technological solution that converts forest residue into a transportable drop-in-ready liquid fuel is essential.

Physical and Intellectual Outputs

PHYSICAL

100 lbs each of ground ponderosa pine needles and branches from: 1) fresh pine, 2) recently beetle killed, and 3) 6 month-old beetle killed were delivered to the WSU Bioproducts, Sciences & Engineering Laboratory for analysis of secondary metabolites.

OTHER PUBLICATIONS

Kolb, Peter. 2013. Managing for Forest Soil Productivity, Montana Family Forest News, Issue No. 40.

http://www.msuextension.org/forestry/nara.html

http://www.msuextension.org/forestry/nara_resources.html

Created a Montana NARA listserv

TRAININGS, EDUCATION AND OUTREACH MATERIALS

"An overview of the NARA project and expected outcomes" presented to:

- Montana Forest Council
- Montana Tree Farm Board of Directors
- Montana Forest Owners Association
- Montana Logging Association
- Montana Association of County Agriculture

Participation in work meetings, including two two-day comprehensive stakeholder meetings

- NARA Open House
- Western Montana NARA Fieldtrip
- NARA Annual Conference

TASK O-4: OREGON STATE UNIVERSITY NARA EXTENSION INITIATIVES

Key Personnel	Affiliation
Scott Leavengood	Oregon State University

Task Description

NARA units, research, extension and industry members, will act as partners and facilitators with the ultimate goal of empowering the stakeholders to plan and implement the changes needed to build, develop, and sustain a biorefinery infrastructure. The goal of the outreach team is to promote stakeholder bioenergy literacy and build regional supply chain coalitions for development of a framework of biofuel and co-products production from woody biomass. End outcomes of this goal are sustainable production of biojet fuel and co-products and rural economic development. Following are the objectives of the outreach team to reach this goal:

1) Bioenergy Literacy, where we: a) disseminate the research-based information (on technology and markets) to our industrial stakeholders and understand the technical challenges regarding implementation at industrial scale (industry-focus); b) relate the feedstock development and logistics information to our resource-based stakeholders (local communities, forest landowners, forest managers) and hear their concerns regarding the type of information that will assist them in keeping their costs low and marketable value high (resource-focus); and, engage the organizations and partnerships in connecting with public-interest groups and policymakers (public-focus). These activities will be carried out via a variety of communication mechanisms, including social media, newsletters, briefing papers, extension publications, workshops/seminars, conferences, field trips, and stakeholder meetings. Bioenergy literacy to professionals will be achieved through following tasks.
   a. Develop a bioenergy literacy platform for flow of information and knowledge between NARA research teams and the stakeholders.
   b. Implement targeted outreach activities for engaging stakeholders and advancing bioenergy literacy to professionals.
   c. Catalog activity outcomes and benchmark reports and studies.

2) Build Supply Chain Coalitions (logistical support and stakeholder development and engagement), where we will form working groups with stakeholders at community and bioregion levels to involve them through collaboration across the supply chain: forestland owners and managers, environmental NGOs, businesses, regulatory facilitators, and community infrastructure working groups to interact with and inform policymakers at regional, state, and federal levels. These stakeholders will be internal and external focused around the NARA communities (NCs) selected in the four-state region. This process will rely on support from other teams, such as Education and EPP, and consider physical and social assets along with practical aspects in narrowing down the list to a manageable number of communities with the four-state region. A long list will be shortened through surveying community-based stakeholders in the PNW and intermountain region to strategically choose several NCs for studying the viability of a biofuel-based infrastructure. Once communities are identified, focus group meetings involving a wide variety of stakeholders will be held at each community to discuss feedstock specifications and logistics, technology adoptions within the existing infrastructure, and viable strategies practical and beneficial for the communities. This process will involve industrial stakeholders and NARA industry partners as well. Establishing a meaningful dialogue on what local experts perceive to be the barriers and opportunities for establishing a biorefinery infrastructure in their community is critical. Building supply chain logistics consists of four major tasks.
   a. Define stakeholders and articulate stakeholder communication mechanism.
   b. Define and establish NARA pilot supply chain (PSC) study regions to engage stakeholders in compiling supply chain assets, analyzing potential regional supply chain structure, and forming regional alliances.
   c. Stakeholder development in the four-state region and pilot supply chain study regions.
   d. Assist EPP with PSC selection process and support index study to develop a decision support tool.

Activities and Results

My primary role with respect to this project has been to serve as the key outreach liaison for Oregon. In that regard, I have focused my efforts on identifying the key stakeholders in Oregon, keeping them and others informed of the activities of the project, and working to ensure stakeholders are able to engage and participate in the project. These efforts have included giving presentations to the Oregon Forest Biomass Working Group, organizing meetings between members of the working group and NARA team members, developing newsletter articles and web pages, and serving as host for Mike Wolcott to give a lecture on the project as part of OSU's Starker Lecture Series.

The most significant accomplishment this period has been the result of shifting some of my funding to support a graduate research assistant at OSU. Janna Loeppky has focused her time on interviewing NARA researchers at OSU to produce a series of short NARA 'Research Briefs' that describe the research and its practical implications, with a particular focus on the private woodland owner audience. This target audience was selected in that I have asked my colleagues in Forestry & Natural Resources Extension at OSU to help disseminate these briefs to their stakeholders (e.g., through their newsletters) – which are primarily private woodland owners. In this period, Janna interviewed John Sessions, Darius Adams, and Greg Latta. The article on Dr. Sessions' research is online and Drs. Adams and Latta are still reviewing the draft of the article about their research. She has appointments to interview Doug Maguire and Kevin Boston in late April and early May.

Recommendations | Conclusions

As mentioned in previous quarterly reports, stakeholders have asked me for more of the details about the research efforts connected with this project, i.e., tasks related to task 1 - Bioenergy Literacy. This was what prompted me to support a research assistant to assist with developing research briefs. I will continue to focus future efforts on keeping stakeholders informed about progress with respect to efforts of the research teams.

Physical and Intellectual Outputs

REFEREED PUBLICATIONS (ACCEPTED OR COMPLETED)

Lowell, E.C. and S. Leavengood. 2013. From Wood to Wing: NARA Works to Harness Woody Biomass for Aviation Biofuel. Western Forester 58(3):12-13.

RESEARCH PRESENTATIONS

Hansen, E. and S. Leavengood. 2013. The role of the forest sector in a bio-based economy: North American Perspective. Presented 12/13/2013 at "The forest sector in a biobased economy – challenges for industry, policy and research. Rovaniemi, Finland.

OTHER PUBLICATIONS

Loeppky, J., J. Sessions. 2014. Transportation of Residues: Would you bundle?

TASK O-5: UNIVERSITY OF IDAHO NARA EXTENSION INITIATIVES

Key Personnel	Affiliation
Randy Brooks	University of Idaho

Task Description

NARA units, research, extension and industry members, will act as partners and facilitators with the ultimate goal of empowering the stakeholders to plan and implement the changes needed to build, develop, and sustain a biorefinery infrastructure. The goal of the outreach team is to promote stakeholder bioenergy literacy and build regional supply chain coalitions for development of a framework of biofuel and co-products production from woodybiomass. End outcomes of this goal are sustainable production of biojet fuel and co-products and rural economic development. Following are the objectives of the outreach team to reach this goal:

1) Bioenergy Literacy, where we: a) disseminate the research-based information (on technology and markets) to our industrial stakeholders and understand the technical challenges regarding implementation at industrial scale (industry-focus); b) relate the feedstock development and logistics information to our resource-based stakeholders (local communities, forest landowners, forest managers) and hear their concerns regarding the type of information that will assist them in keeping their costs low and marketable value high (resource-focus); and, engage the organizations and partnerships in connecting with public-interest groups and policymakers (public-focus). These activities will be carried out via a variety of communication mechanisms, including social media, newsletters, briefing papers, extension publications, workshops/seminars, conferences, field trips, and stakeholder meetings. Bioenergy literacy to professionals will be achieved through following tasks.

a. Develop a bioenergy literacy platform for flow of information and knowledge between NARA research teams and the stakeholders.
b. Implement targeted outreach activities for engaging stakeholders and advancing bioenergy literacy to professionals.
c. Catalog activity outcomes and benchmark reports and studies.

2) Build Supply Chain Coalitions (logistical support and stakeholder development and engagement), where we will form working groups with stakeholders at community and bioregion levels to involve them through collaboration across the supply chain: forestland owners and managers, environmental NGOs, businesses, regulatory facilitators, and community infrastructure working groups to interact with and inform policymakers at regional, state, and federal levels. These stakeholders will be internal and external focused around the NARA communities (NCs) selected in the four-state region. This process will rely on support from other teams, such as Education and EPP, and consider physical and social assets along with practical aspects in narrowing down the list to a manageable number of communities with the four-state region. A long list will be shortened through surveying community-based stakeholders in the PNW and intermountain region to strategically choose several NCs for studying the viability of a biofuel-based infrastructure. Once communities are identified, focus group meetings involving a wide variety of stakeholders will be held at each community to discuss feedstock specifications and logistics, technology adoptions within the existing infrastructure, and viable strategies practical and beneficial for the communities. This process will involve industrial stakeholders and NARA industry partners as well. Establishing a meaningful dialogue on what local experts perceive to be the barriers and opportunities for establishing a biorefinery infrastructure in their community is critical. Building supply chain logistics consists of four major tasks.

a. Define stakeholders and articulate stakeholder communication mechanism.
b. Define and establish NARA pilot supply chain (PSC) study regions to engage stakeholders in compiling supply chain assets, analyzing potential regional supply chain structure, and forming regional alliances.
c. Stakeholder development in the four-state region and pilot supply chain study regions.
d. Assist EPP with PSC selection process and support index study to develop a decision support tool.

Activities and Results

Efforts in the past quarter were coupled with existing Extension field based programs and youth presentations where the NARA project was introduced and basic concepts of the project were discussed.

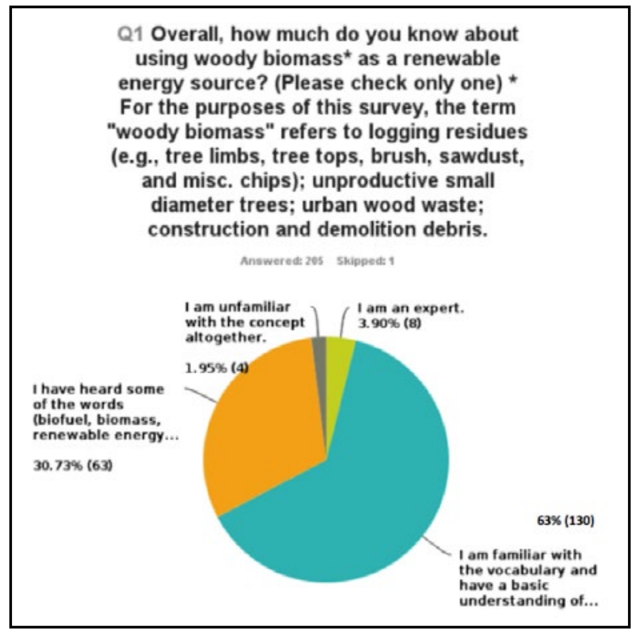

Figure O-5.1. Results at the 2013 biomass survey conducted at the University of Idaho's Logger Education to Advance Professionalism workshops.

Results of a biomass survey taken last year was presented at six locations to the University of Idaho's Logger Education to Advance Professionalism workshops. Figure O-5.1 shows that 63% percent were familiar with the term woody biomass, while 2% were unfamiliar with the concept altogether (Q1).

Figure O-5.2 shows that 58% in attendance thought they would benefit from and educational program on using woody biomass as an energy source.

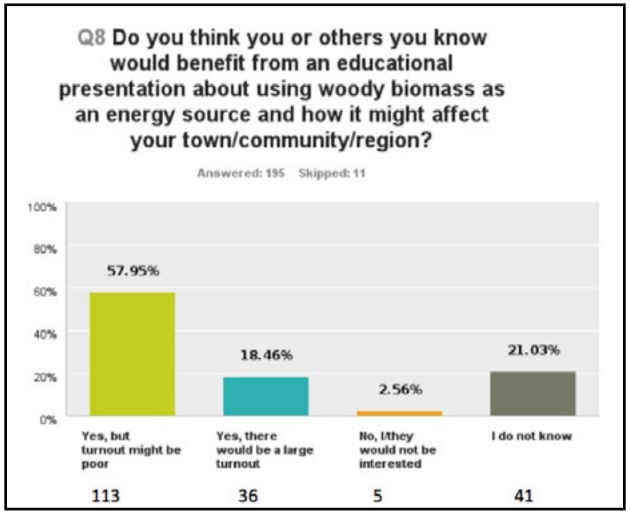

Figure O-5.2. Results at the 2013 biomass survey conducted at the University of Idaho's Logger Education to Advance Professionalism workshops.

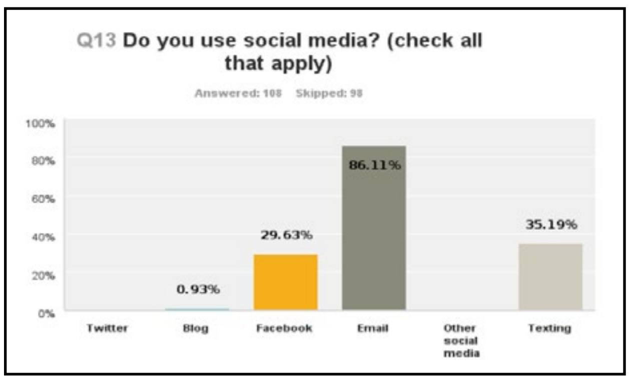

Figure O-5.3 Results at the 2013 biomass survey conducted at the University of Idaho's Logger Education to Advance Professionalism workshops.

Figure O-5.3 shows that nearly 85% of attendees agreed that a facility producing liquid biofuel would be a good option for utilizing woody biomass.

Few loggers in Idaho were using social media (Figure O-5.4). One attendee (who had a MS degree in Geology) indicated he had once read a blog. Only 86% were using email.

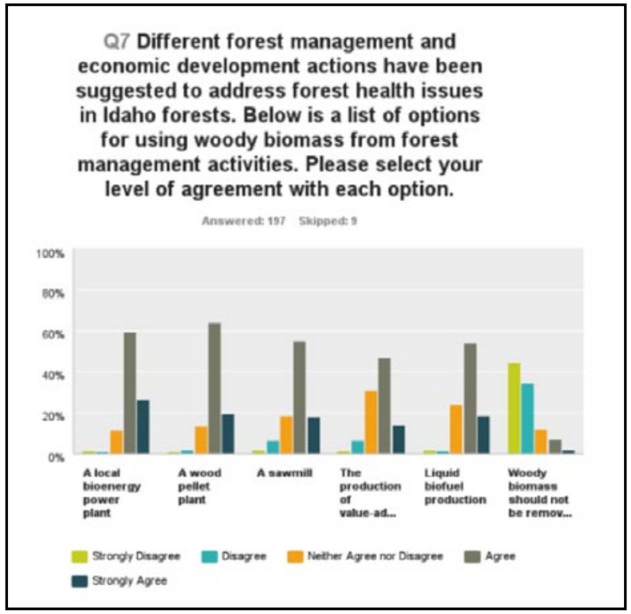

Figure O-5.4 Results at the 2013 biomass survey conducted at the University of Idaho's Logger Education to Advance Professionalism workshops.

Recommendations | Conclusions

While survey results are still being evaluated, early indicators show that relatively few stakeholders in Idaho are using electronic means to receive communications. Therefore, efforts to educate stakeholders in Idaho need to utilize every opportunity to attend face-to-face meeting to inform them about the project. Many stakeholders are familiar with the terminology and think their communities would benefit from an educational program on utilizing woody biomass. Stakeholders feel several options for utilizing woody biomass are viable.

Physical and Intellectual Outputs

PHYSICAL

- One set of forest residues was collected to be characterized for suitability to process into pellets.
- A stakeholder survey form was created and distributed to Idaho loggers regarding harvesting of biomass.
- Six presentations were made to Idaho loggers.

REFEREED PUBLICATIONS (ACCEPTED OR COMPLETED)

Brooks, R., and J. Moroney. Forestry Tour Educates Youth. 2014. Accepted. Journal of Extension.

TRAININGS, EDUCATION AND OUTREACH MATERIALS

Loggers aren't Bloggers – results of 2013 Logger Biomass Survey. Presentation made at six Idaho Pro-logger workshops. Hayden, ID (March 4), Kamiah, ID (March 13), Sandpoint, ID (March 18), St. Maries, ID (March 25), Orofino, ID (March 27), Moscow, ID (April 1).

TASK O-6: FOREST SERVICE-PACIFIC NW RESEARCH STATION

Key Personnel	Affiliation
Eini Lowell	USDA FS PNWRS

Task Description

NARA units, research, extension and industry members, will act as partners and facilitators with the ultimate goal of empowering the stakeholders to plan and implement the changes needed to build, develop, and sustain a biorefinery infrastructure. The goal of the outreach team is to promote stakeholder bioenergy literacy and build regional supply chain coalitions for development of a framework of biofuel and co-products production from woodybiomass. End outcomes of this goal are sustainable production of biojet fuel and co-products and rural economic development. Following are the objectives of the outreach team to reach this goal:

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   a. Define stakeholders and articulate stakeholder communication mechanism.
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   c. Stakeholder development in the four-state region and pilot supply chain study regions.
   d. Assist EPP with PSC selection process and support index study to develop a decision support tool.

Activities and Results

BIOENERGY LITERACY

Several forms of written output have been produced. A briefing paper on NARA was prepared for the PNW Research Station Director's annual Congressional visit to Capitol Hill (April 8-12, 2013) where he met with members of Congress, their staffers, and other policy makers. Two policy papers outlining NARA progress to date were written and distributed by the William D. Ruckelshaus Center. I co-wrote an invited article with Scott Leavengood for the Society of American Forester's publication Western Forester titled "From Wood to Wing: NARA works to harness Woody Biomass for Aviation Biofuel." The NARA project was written up in the PNW Research Station's 21013 Science Accomplishments (http://www.fs.fed.us/pnw/pubs/2013-science-accomplishments.pdf).

With other Outreach Team members, one page fact sheets and infographics providing information on research progress being made by other NARA teams continue to be being developed. These are posted on the website (http://www.nararenewables.org/about/infographics-fact-sheets) and available to NARA members for printing and distribution.

They include:
- United States Forest Service/NARA (April 2013)
- NARA Education (April 2013)
- Energy Literacy Matrix (April 2013)
- Imagine Tomorrow (January 2014)
- Sulfite Pretreatment (January 2014)
- NARA Key Accomplishments (January 2014)
- NARA Feedstock – Wood Waste (January 2014)
- Wood Chemical Composition and Products (January 2014)
- NARA General Overview (February 2014)

I attended several international conferences including the International Wood Composites Symposium in Seattle, WA (April 3-4, 2013), the 56th Society of Wood Science and Technology International Convention (June 9, 2013) and the 67th Forest Products Society International Convention, (June 9-11, 2013) both in Austin, Texas USA. Posters were presented at the latter two conferences. An Outreach and Education team poster was presented at the NARA annual meeting (Corvallis, OR, September 10-12, 2013). A NARA booth was set up at the Western Wood Products Association (WWPA) (Portland, OR) annual meeting in March. A meeting with Western Forestry Conservation Association (WFCA) (Portland, OR) included discussions on hosting future webinars and workshops.

Planning for the first NARA conference (April 28-30, 2014, Seattle, WA) was completed.

BUILDING SUPPLY CHAIN COALITIONS

Meetings involving western Oregon and Washington clients and stakeholders to identify the next Pilot Supply Chain (PSC) coalition were held at the Washington State University campus in Vancouver, WA (April 12, 2013 and May 21, 2013). Upon identifying the next PSC, field trips (Teevin Brothers sort yard in Rainier, OR; Greenway Recycling, Portland, OR; and SeQuential-Pacific Biodiesel in Salem, OR) and additional meetings with non-profits were held (Bob Dingethal, Gifford Pinchot Task Force; Kevin Cheung, WWPA; Richard Zabel, WFCA). The State of Oregon Biomass Working Group held a meeting in Salem (November 12, 2013) where Vik Yadama gave an overview presentation of NARA and discussion followed.

Stakeholders from both Washington and Oregon had identified eastern parts of their states as high priority areas in need of biomass utilization opportunities. I organized a meeting on July 15, 2013 of agency stakeholders and clients (e.g., PNW Station leadership, Forest Service Region 6, Forest Service State and Private, Oregon Department of Forestry, Oregon Department of Energy) to highlight biomass utilization research and discuss synergy among projects.

Recommendations | Conclusions

The Outreach process is continual and adaptive. Efforts to identify and engage stakeholders continue, especially in the environmental community. I am connecting with Collaborative Forest Landscape Restoration Project (CFLRP) management teams and other partnerships where the US Forest Service has a presence to ensure active participation by the agency. Opportunities to leverage outreach efforts through professional channels continues. The depot concept developed by IDX provides opportunities for rural communities to participate in this project and is of particular interest to rural communities.

Physical and Intellectual Outputs

PHYSICAL

- Visited eight stakeholders in Oregon/Washington to discuss NARA project and opportunities
- Three posters prepared and presented
- Six meetings where interaction with stakeholders took place
- Written updates on NARA progress made available plus NARA listed in PNW Research Station 2013 Accomplishment report
- Invited article written for Western Forester, a publication of the Society of American Foresters.

RESEARCH PRESENTATIONS

Lowell, E.C. and Leavengood, S. 2013. Regional Focus: Oregon and Washington Assets and Stakeholder Involvement. Vancouver, WA (May 21, 2013)

Lowell, E.C. and the NARA Outreach Team. 2013. From Wood to Wing: NARA Works to Harness Woody Biomass for Aviation Biofuel.
- 56th Society of Wood Science and Technology International Convention, Austin, Texas USA (June 9, 2013)
- 67th Forest Products Society International Convention, Austin, Texas USA (June 9-11, 2013)

Lowell, E.C. and the NARA Outreach and Education Teams. 2013. "NARA Outreach and Education - An Integrated Approach". NARA Annual Meeting, Corvallis, OR (9/10-12/2013)

OTHER PUBLICATIONS

Lowell, E.C. and Leavengood, S. 2013. From Wood to Wing: NARA Works to Harness Woody Biomass for Aviation Biofuel. Western Forester. 58(3):12-13,21. Publication available at: http://www.forestry.org/media/docs/westernforester/2013/WF_June_July_Aug2013.pdf

TASK O-7: WILLIAM D. RUCKELSHAUS CENTER

Key Personnel	Affiliation
Michael Kern	Ruckelshaus Center
Michael Gaffney	Ruckelshaus Center

Task Description

The Ruckelshaus Center senior staff members will 1). Work with the Leadership Team to assist in the creation of a "Stakeholder Advisory Board," and 2). Facilitate monthly Leadership Team meetings, quarterly Advisory Board meetings, and an annual stakeholder meeting. Additionally the Center will assist in development of process protocol agreements and help engage policy makers through distribution of quarterly web-based newsletters and briefing papers from information provided by the Project Directors and Leadership Team. 3). Participate in an assessment of public perceptions to "connect social and technical aspects" of the project through quantitative surveys and focus groups.

SUPPLEMENTAL RESEARCH PROPOSAL

The Division of Governmental Studies and Services (DGSS) has been engaged on the NARA project since its inception – as a subcontractor to the William D. Ruckelshaus Center. The original set of deliverables for DGSS consisted solely of an assessment process to inform the development of the project Advisory Committee. Over time, DGSS has also participated in stakeholder (SH) Assessment and engagement efforts as a part of the Outreach team, and has been engaged in active participation with the EPP team on physical-social asset assessment efforts, supporting the Community Asset Assessment Model development effort. In order to secure additional effort from DGSS on the development and administration of SH Assessment interviews, and to facilitate the ground-truthing of large national database application to potential NARA communities through the use of existing DGSS community-level survey databases, and new primary data collected by other NARA participants in the EPP team, DGSS requests additional funding through year four of the project. Specific deliverables from an additional $40,000 (annual basis) include:

1. Supported access to DGSS's web-survey capacity ("Remark" software) to facilitate data analysis from SH Assessment telephone interviews conducted by EPP team.
2. Substantial data aggregation, manipulation and analyses to render data from existing DGSS community surveys into a format useful for analysis to be used in conjunction with national data and SH Assessment interview results in a triangulated approach ("Ground-truthing") for NARA Region social asset assessment.
3. Continued and expanded participation by elements of DGSS on the EPP team in support of team community stakeholders Assessment efforts and to continue development of the Community Asset Assessment Model (CAAM).
4. Support and participation in preparation and submission of reports, presentations, and publications.

These efforts would be in addition to, and would complement, DGSS and Ruckelshaus participation in the Outreach team, and contracted project management support activities.

Activities and Results

Task O-7.1.

All of the Ruckelshaus Center responsibilities under this task have been completed with the exception of ongoing statistical analysis and development of the CAAM. Ruckelshaus/DGSS worked extensively with the Outreach Team, Team Leaders and the executive team to develop a structure for categorizing and engaging diverse stakeholders. The Ruckelshaus Center/DGSS completed an interview-based assessment of informed observers and senior stakeholders, to obtain input on the formation and management of an Advisory Board for the NARA project. A summary report of that effort was presented to the project's executive committee, with recommendations regarding the interests that should be considered when selecting potential board members, along with a list of individuals who had been suggested as potential members. This report was used to inform the executive committee's selection of Advisory Board members and in the management of interactions with that board. The inquiry also addressed the more general topic of stakeholder engagement, and recommendations on that topic were passed on to the executive committee and the Outreach team.

Task O-7.2.

The Ruckelshaus Center has continued to be actively engaged in facilitation and project management support – specifically supporting the project leadership with team facilitation, agenda development and establishment of ground rules and meeting protocols. Ruckelshaus senior staff facilitated the monthly leadership team meetings since the project kick-off in 2011. The monthly leadership team meetings have focused on a number of relevant topics, including the Phase & Gate process and various discussions related to the management of NARA teams and units.

The Center again assisted in the development, planning, and facilitation of the September 2013 NARA annual meetings in Corvallis, Oregon. The Center also facilitated the NARA Advisory Board meeting discussion during the 2013 annual meeting.

The Center, with the NARA leadership committee, communications team and outreach team, continued to work closely with the Advanced Hardwood Biofuels Northwest (AHB) project to prepare a series of quarterly briefing papers aimed at jointly informing policy-makers in Washington, Oregon, Idaho, Montana and Northern California about the projects' progress. Three more briefings were sent out July 2013, September 2013, and January 2014.

Task O-7.3.

The Ruckelshaus Center/DGSS has been working with the NARA Environmental Preferred Products team on the assessment of potential NARA communities and targeted engagement of stakeholders in those communities, using a variety of research and outreach methods to develop the CAAM model. This effort is focused on the identification and refinement of several social asset tools to better focus on these NARA communities. Included in the process of NARA community assessment will be the use of numerous existing DGSS survey data sets to validate the use of national-level data sets in the selection process, as informed by new primary data collected by other EPP team members in the region.

Recommendations | Conclusions

- Continue to facilitate the monthly Leadership Team meetings, plan and facilitate the NARA annual meetings, and potentially help facilitate team or unit discussions if mutually agreeable.
- Continue to produce joint quarterly policy-maker briefings with the University of Washington's Advanced Hardwood Biofuels (UW AHB) project.
- Continue to work with the EPP team on NARA community assessment model development and testing.
- Continue participation on the Outreach Team regarding stakeholder engagement

Physical and Intellectual Outputs

- Continue to facilitate the monthly Leadership Team meetings, plan and facilitate the NARA annual meetings, and potentially help facilitate team or unit discussions if mutually agreeable.
- Continue to produce joint quarterly policy-maker briefings with the UW AHB project.
- Continue to work with the EPP team on NARA community assessment model development and testing.
- Continue participation on the Outreach team regarding stakeholder engagement

RESEARCH PRESENTATIONS

Smith, Paul, Season Hoard, Michael Gaffney, Tammi Laninga and Jillian Moroney, 2014. The NARA Community Assessment Model. Poster, WSU 2014 Academic Showcase.

SUPPLY CHAIN

EDUCATION TEAM

TASK E-3: BIOREGIONAL INTEGRATED DESIGN EXPERIENCE (IDX)

Key Personnel	Affiliation
Tamara Laninga	University of Idaho
Michael Wolcott	Washington State University
Michele Vachon	University of Idaho
Karl Olson	Washington State University

Task Description

IDX is an integrated design studio experience for graduate students in engineering, design (architecture, landscape architecture, etc.), natural resources, and land use planning disciplines, focusing on technical assistance to communities interested in participating in the emerging biofuel economy. IDX involves a year long integrated design course delivered jointly through the University of Idaho (UI) and Washington State University (WSU). The course is a trans-disciplinary planning and design studio that addresses planning and infrastructure needs of communities exploring their role in biofuel supply chain. Aimed at upper-level BS and MS students, the course is organized around service-learning experiences that link teams of students with communities. PhD students from around NARA with special expertise in required areas will act as a consultant to the design teams, improving the level of analysis and providing interdisciplinary experiences to the students.

Five different pilot supply chain regions will be served, one each year of the project, with a focus on identifying regional supply chain assets, optimizing sub regional biofuels supply chains, and designing interventions at specific locations within the supply chain (e.g., depot sites, conversion facilities, multi-modal transportation hubs, etc.). The goals for this studio are:

- every student exits with strong collaborative research, questioning, and design methods to utilize in their academic and professional work within their discipline;
- to provide technical assistance to communities interested in participating in the emerging biofuel economy. We will assist these communities begin the process of transformation necessary for them to be engaged in the biofuels supply chain.

Activities and Results

During 2013/2014 (NARA Year three), IDX has worked in southwest Washington and Northwest Oregon, in an area referred to as the Mid-Cascade to Pacific (MC2P) region. Two analysis occurred in this region: 1) an overall supply chain analysis that examines available regional feedstock for potential conversion sites in the MC2P region; and 2) a site selection analysis that identifies specific sites in the MC2P region for solid depots, liquid depots and integrated biorefineries (IBRs).

SUPPLY CHAIN ANALYSIS

The overall supply chain analysis is a step by step process that begins with identifying available feedstock and ends with scenarios that show the amount of biomass available at depot locations and IBRs. This methodology provides an assessment of the amount of biomass available for a particular site based on drive times. The key assets considered in the analysis are as follows:

- Nodes – specific sites in the supply chain where processing occurs (e.g., solid depot where slash is densified into chips, liquid depot where slash or chips are converted into sugar rich syrups, or integrated biorefineries where slash, chips or sugar rich syrups are converted into alcohol).
- Linkages – road, rail, barge and pipeline infrastructure
- Areas – biomass density, forest mask, land ownership

Combining the three supply chain assets creates the drive time polygons. Figure E-3.1 indicates that 880,000 BDT of biomass are available for an IBR at Cosmo Specialty Fibers in Cosmopolis, WA. This scenario shows the IBR receiving feedstock by direct haul as well as remote solid depots.

The Supply Chain Scenario Development Steps document outlines the step-by-step process used to conduct the analysis and is available for viewing here: https://docs.google.com/a/nararenewables.org/file/d/0B0GFmLDildnoSkZVNUp4VnpNNmc/edit

SITE SELECTION ANALYSIS

The site selection analysis in the MC2P region focused on three facility types:

1. Integrated Bio-refinery (IBR): a high-capacity plant that takes biomass from raw slash or other woody residuals all the way to biojet fuel. The target was set at 770,000 BDT biomass input.
2. Liquids Depot: a facility that receives raw and mechanically processed woody residuals directly from nearby forests, or chips or pellets from a solids depot. Sugar-rich syrup from a liquids depot would go to an IBR for further refining into biojet fuel or other chemical conversion facilities. The target was set at 250,000 BDT of biomass input.
3. Solids Depot: a facility that receives raw slash, forest thinnings, and/or construction and demolition (C&D) waste biomass. Mechanically processed materials would be shipped by rail or highway truck to a receiving liquids depot, IBR or other potential end user. The target was set at 100,000 BDT of biomass input.

The site selection analysis started by identifying assets and site characteristics necessary for facility types (e.g., proximity to harvested forests, site acreage, transportation access, etc.). The assets and characteristics were weighted according to their rela-

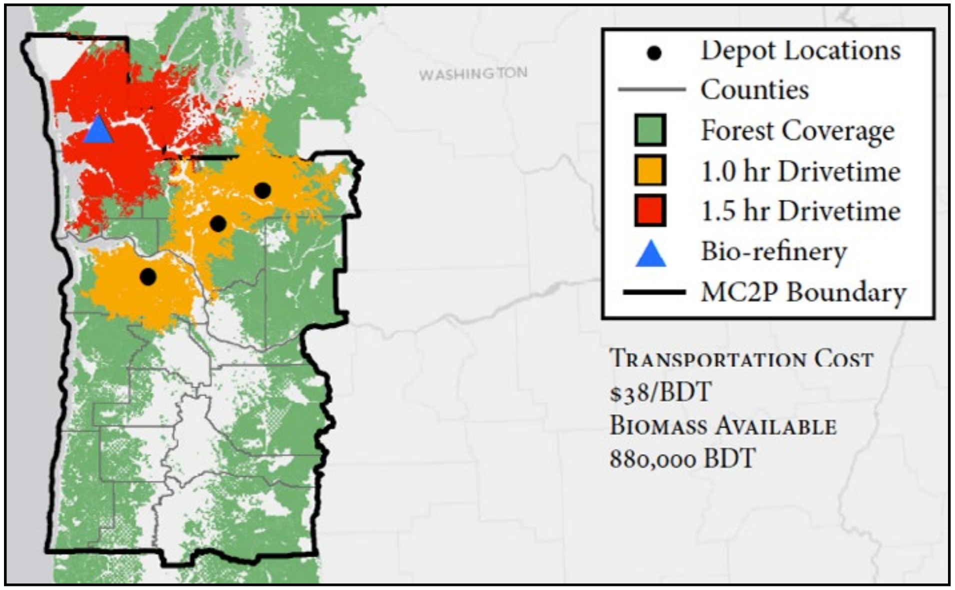

Figure E-3.1. Feedstock available to an Integrated Biorefinery in Cosmopolis, WA, supported by three remote depots

Table E-3.1. Site Typologies

Integrated Biorefinery (15 candidate sites)	Liquid Depot (15 candidate sites)	Solid Depot (24 candidate sites)
Full Integration	Kraft and/or bisulfite pulp & paper mills	Sawmills & Chip Mills
Distillation/Distribution only	Active Sawmills	Decommissioned Sites/ Surface Mines
	Inactive Mills	

Table E-3.2. Identified Facilities for Supply Chain Activities in the MC2P Region

Integrated Biorefinery	Liquid Depot	Solid Depot
Cosmo Specialty Fibers, Cosmopolis, WA *Option 1*: Co-located IBR with existing operations	Kapstone Pulp & Packaging, Longview, WA Co-located Liquid Depot	Sierra Pacific Industries, Aberdeen, WA Co-located Solid Depot
Cosmo Specialty Fibers, Cosmopolis, WA *Option 2:* Transition of existing operations to IBR	Weyerhaeuser Bay City Log Yard, Aberdeen, WA Liquid Depot on grayfield	Former Bradley-Woodward Lumber Company Bradwood, OR Solid Depot on grayfield

tive importance for each facility type. Sites were compared using a matrix, and an overall score for each facility was calculated based on the individual weights assigned to each facility's assets or characteristics. For example, close proximity to regularly harvested forest areas is a higher priority for a solids depot than for an IBR, while an industrial site with large acreage is likely critical for an integrated bio-refinery or a liquids depot, and less important for a solids depot. Sites were then organized into typologies based on regional assets and site characteristics expected to affect the value of the location for the operation in question. Table E-3.1 shows the total number of sites identified in the MC2P by facility type, and typology categories.

Based on the typology criteria and weighting scheme, candidate sites were ranked and vetted with local stakeholder input. One or two locations were selected from among the top candidates for more intensive site analysis and design. Sites with the highest number of assets and potential for expansion or redevelopment were selected for further study. The full discussion of site selection analysis for each of the facility types and the ranking of the candidate sites is available in the NARA Facility Site Selection: Mid-Cascade to Pacific Region factsheet, available for viewing here: https://docs.google.com/a/nararenewables.org/file/d/0B0GFmLDildnoSmFsSHM0RjNOaHM/edit.

The sites selected for intensive site analysis and design are listed in Table E-3.2. On February 20-21, 2014, IDX teams toured each of the facilities. The onsite tours gave teams a feel for the properties and the existing assets the teams had to work with for designing their conceptual plans. The onsite managers have been extremely helpful in providing GIS and other data for the teams to use in their proposals. For each site the following documentation has been developed: 1) a programming table showing needed facility types and sizes; 2) a facility resource flow diagram; 3) physical, environmental and cultural site inventories; 4) schematic and master plans illustrating programming on the site analysis and design documentation for these sites will be available in by July 2014.

Recommendations | Conclusions

The MC2P region has abundant biomass resources (e.g., forest residuals and C&D waste). It would be possible to have an IBR located in the MC2P region that relies on direct haul of biomass to the facility. This is in contrast to the Western Montana Corridor (WMC), where a centrally located conversion facility in either Libby or Frenchtown, MT required feedstock inputs from remote depots. The forests in the WMC region are less dense than those found in the MC2P region. However, in the MC2P region we did examine the use of remote solid depots to supply chips to a centrally located IBR and found that this type of arrangement can help to ensure steady supplies for the IBR, where feedstock can be pre-processed and stored off-site and supplied when needed. This reduces the on-site pre-processing and storage needs on the IBR site.

In the MC2P region we also considered an intermediate depot, termed a liquid depot that produces a wood-derived sugar-rich syrup that can be sent to an IBR for fermentation and distillation, or sent to other markets. Analysis was conducted with respect to the facilities and sizing required for a liquid depot. This information is being used to supply the techno-economic analysis team with information needed for future TEA's on specific sites.

This year the site selection analysis used in the WMC was refined and applied to the MC2P. Critical assets were examined to identify potential solid depots, liquid depots and IBRs. A number of assets were the same for the three site types, which included: availability of Forest Residuals, transportation infrastructure (rail, road, barge, pipeline), facility size, and utility costs. Other assets considered for the IBR included: cost of living, labor force, pretreatment capability, boiler/energy plant on site, and wastewater treatment onsite. Additional assets considered for the Liquid Depot included facility type (saw mill/pulp mill), operational status (decommissioned, active), natural gas, and Unemployment. Each asset was evaluated and ranked on a scale of -5 to +5. The assets at each facility were combined using an asset factor, which weighted each asset depending on the relative importance of the factor. The asset factors applied to the assets were made based on information in the NARA techno-economic analysis. However, some of the factors were assigned based on assumptions for the assets' importance. The algorithm of assets and asset factors produced a final score for each facility, providing a ranking of all candidate sites. Rankings for candidate sites were then vetted with local stakeholders in the region.

In the coming year, we plan to refine the site selection analysis, analyze NARA's four state region (WA, OR, ID, MT) for other potential supply chain regions, and provide a comparison of the supply chain regions analyzed in the four state region. To refine the site selection analysis we plan to fully substantiate the critical assets and the asset factors for the site selection analysis. GIS analysis will be provided for the entire four state region, normalizing data across state boundaries, and providing full view of the region's potential. This data will then be used to compare various supply chain scenarios in different areas of the NARA region.

RESEARCH PRESENTATIONS

Austin, G. and T. Laninga. 2014. "Jet Bio-Fuel: Environmental Implications of Woody Biomass Harvest." 56th Annual Idaho Academy of Science Meeting and Symposium. Moscow, ID. March 21.

Laninga, T. "Wood-based Biofuels Supply Chains in the Pacific Northwest." Washington Contract Loggers Association Annual Meeting. Spokane, WA. March 14, 2014.

Gray, P. 2013. "Supply Chain Research." Poster presentation at the NARA Annual Meeting, Corvallis, OR, September 10, 2013.

IDX 2012/2013 Class. 2013. "Western Montana Corridor Summary" Poster presentation at the NARA Annual Meeting, Corvallis, OR, September 10, 2013.

Laninga, T. and M. Wolcott. 2013. "Western Montana Corridor—Pilot Supply Chain Case Study." NARA Annual Meeting. Corvallis, OR.

Laninga, T., M. Vachon and M. Payne. 2013. "Asset-based Assessment of Regional Wood-based Biofuels Industry Potential." Idaho Chapter, American Planning Association. Idaho Falls, ID, October 10, 2013.

Martinkus, N. , M. Wolcott and J. Potter. "GIS-Based Conversion Facility Site Selection Process in the Western Montana Corridor" Poster presentation at the NARA Annual Meeting, Corvallis, OR, September 10, 2013.

NARA Outreach and Education Teams. "NARA Outreach and Education – An Integrated Approach." NARA Annual Meeting. Corvallis, OR, September 10, 2013.

Potter, J. 2013. "Supply Chain – Libby Scenario" Poster presentation at the NARA Annual Meeting, Corvallis, OR, September 10, 2013.

Potter, Jon. 2013. "Feedstock Availability" Poster presentation at the NARA Annual Meeting, Corvallis, OR, September 10, 2013.

OTHER PUBLICATIONS

IDX. 2014. "MC2P Supply Chain Analysis Methodology. Washington State University and University of Idaho. Pullman, WA. February. Available Online: https://docs.google.com/a/nararenewables.org/file/d/0B5bWXFlHEGdxMFJKcFNrbjNzbVU/edit

IDX. 2014. "Biomass Availability by Drive time for Cosmo Specialty Fibers." Washington State University and University of Idaho. Pullman, WA. February.

Available Online:
https://docs.google.com/a/nararenewables.org/file/d/0B0GFmLDildnoZ19NXzJIZ3ZxWHM/edit

IDX. 2014. "MC2P Site Selection Factsheet." Washington State University and University of Idaho. Pullman, WA. January. Available Online:
https://docs.google.com/a/nararenewables.org/file/d/0B0GFmLDildnoSmFsSHM0RjNOaHM/edit

IDX. 2013. "MC2P Profile." Washington State University and University of Idaho. Pullman, WA. August. Available Online: https://docs.google.com/a/nararenewables.org/file/d/0B5bWXFlHEGdxamZsSUFULXlMMTA/edit

VIDEOS AND WEBINARS

IDX. 2014. Site Analysis Presentations. Washington State University, Pullman, WA. March 12, 2014.

IDX Presentation - Integrated Biorefinery - Cosmo

IDX Presentation - Liquid Depot - Weyerhaeuser (Bay City)

IDX Presentation - Liquid Depot - Kapstone

IDX Presentation - Solids Depot - Sierra Pacific Industries

IDX Presentation - Solids Depot - Bradwood

IDX. 2013. Supply Chain Site Selection Final presentations. Washington State University, Pullman, WA. December 4. Available online: https://www.youtube.com/watch?v=8q-usW6AVq0

TRAININGS, EDUCATION AND OUTREACH MATERIALS

Workshops, seminars, conferences held, field days, demonstrations, course/teacher packages, etc.

Laninga, T. "Wood-based Biofuels Supply Chains in the Pacific Northwest." MaCall Outdoor Science School Teacher Professional Development Webinar. February 13, 2014.

Laninga, T. "Cascade to Pacific: Wood-based Biofuels Supply Chain Analysis." Washington Forest Biomass Coordination Group. Olympia, WA. December 10, 2013.

Laninga, T. and C. Rawlins. 2013. Western Montana Corridor Supply Chain Region Lessons Learned. MC2P Stakeholder Meeting. Vancouver, WA. May 21.

Martinkus, N. 2013. GIS-Based Supply Chain Analysis in the Mid Coast and Cascade Range Region (MC2R2). MC2P Stakeholder Meeting. Vancouver, WA. May 21.

Olsen, K, and T. Laninga. 2013. IDX Structure, Collaboration, Deliverables and Data Needs. MC2P Stakeholder Meeting. Vancouver, WA. May 21.

Laninga, T. 2013. Pilot Supply Chain Analysis and Overview. MC2P Stakeholder Meeting. Vancouver, WA. April 12.

TASK E-8: DISTRIBUTED SUGAR MODEL

Key Personnel	Affiliation
Jinwu Wang	Washington State University
Michael Wolcott	Washington State University

Task Description

This subtask aims to scope, develop and enable distributed production scenarios that can be cost-effectively operated for conversion of biomass to standardized feedstock or sugars. The primary aim of distributed production is to maintain small facility scales and decrease the complexity compared to an integrated biorefinery. Achieving these goals could potentially decrease biomass and labor costs while extending utilization of existing facilities. A techno-economic analysis (TEA) by the NARA systems metrics group in project years one and two projected that the cost of biomass feedstock contributes substantially to the overall production of biofuels. It is envisioned that decentralized sugar depots that locally transforms bulky biomass into cellulosic sugars provides potential for reducing the biomass transportation cost, which contributes substantially to the overall feedstock cost. If successful, a web of distributed sugar depots could become a key component in a forest residue supply chain for producing fuels. Such cellulosic sugars are versatile intermediate precursors, not only for producing fuels, but also developing valuable platform chemicals and polymers. They can be a “drop in” feedstock for existing and emerging ethanol plants worldwide in solid or syrup. Exploring opportunities to diversify NARA product portfolio to include cellulosic sugar intermediates can insulate from current uncertainties in advancing cellulosic biofuel markets.

Distributed sugar depots located in remote rural areas require a simple conversion process with low capital costs, decreased need for specialized workforce, and low environmental impact. In Years three to five, the feedstock and product characteristics and process performance necessary for analysis of technical feasibility and economical viability of a distributed sugar depot will be investigated in the context of realizing a cost-competitive cellulosic sugar production. We will use a pilot facility at WSU Composite Materials and Engineering Center (CMEC) to simulate the process and generate the necessary data to evaluate performance. A simulated sugar depot in the lab consists of a mechanical size reduction system, dispersive enzyme mixing with milled wood by a conical twin-screw extruder and subsequent enzymatic hydrolysis in a digester, and sugar stream separation and characterization. Specifically, woody biomass from a stakeholder mill in the east Washington and from one of municipal recycling facilities is hammer-milled into a targeted fineness and then pulverized for an optimal period of time. The mechanically activated wood meal is mixed with enzymes using a twin-screw extruder and digested in a reactor. The sugar stream is then separated and characterized.

Biomass comminution holds an analogy to ore comminution in the mining industry, in which about 50%-70% energy used for mineral extraction is consumed on ore comminution (Walkiewicz et al., 1989). Mining engineering has developed algorithms and methodologies to design and scale-up comminution processes based on the lab-scale experimental data (Herbst and Fuerstenau, 1980; Herbst et al., 1982; Man, 2001; Morrell and Man, 1997; Morrell, 2009). For ore, primary size reduction is crushing, while for woody biomass, it is chipping or grinding, but late stages of comminution to the micro-scale level are quite similar to the tumbling mills used with ore. The cases, practices, designs, and process economic analysis in the mature mine comminution will be analyzed and tailored for biomass comminution. The algorithms will be developed linking small systems up to larger ones and used to project scale up production. Specifically, the relationships between comminution energy and product size is predicated on the assumption that the required energy for a differential decrease in size is proportional to the size change (dx) and inversely proportional to the size to some power n (Jankovic et al., 2010). One of explicit solutions describing size reduction follows a particular relationship as delineated by the well known “third theory” equation (Bond, 1952), where W is the specific energy expenditure at an industrial scale, Wi is the work index from the standardized laboratory grinding tests, P is the 80% passing size for the product, and F is the 80% passing size for the feed (Morrell, 2008, 2004). The total power for a commminution system in a sugar depot can then be projected according to the designed capacity (Schlanz, 1987). The potential industrial scale comminution systems will be identified based on the required comminution power.

A sugar depot that prepares biomass into readily fermentable sugars, and ships them to conversion facilities draws various categories of biomass from a smaller fibershed including forest residuals and construction and demolition (C & D) wood waste from municipal solid waste streams. Diversifying the biomass sources could be a way to mitigate supply risks and reduce the supply radius. The viability of sugar depots will be enhanced if they can process multiple feedstocks. The tolerance to feedstock variability and feedstock purity is thus evaluated. Methods and barriers of measuring purity levels are investigated.

This technology is selected because 1) preliminary tests by Weyerhaeuser in Year two demonstrated that pulverizing alone can be an effective means of pretreating wood for enzyme hydrolysis, 2) such an approach would eliminate the need for chemicals thereby decreasing environmental permitting, labor cost without a need for chemical engineers, and environmental burdens; 3) mechanical activation can be accomplished at low temperatures and generate fewer inhibitors compared to thermochemical pretreatments under combined action of chemicals, temperature, and pressure; and 4) twin-screw extrusion is a mature “plug and play” technology adaptable for all scales, for mixing, shearing, and processing of high solids concentration reducing water usage in a continuous process mode. The limitation is that this biomass-to-sugar conversion consumes a large quantity of electrical energy for milling. However, it may be a good choice in the Pacific Northwest, where electricity is relatively low cost and large quantities are generated from relatively clean hydro and wind powers. Relevant unit processes will be specifically investigated for energy requirements, evolution of carbohydrate content, digestibility, and sugar specifications. Other unit process alternatives will be identified and integrated to create a novel sugar production line appropriate for a sugar depot. Mechanical pretreatment in combination with moderate chemical treatment may be an alternative to generate synergistic effect to enhance digestibility and lower energy consumption.

EXPECTED TASK OUTPUTS

1) *Design milling systems to achieve desired fineness and sugar recovery rate and yield*

Douglas-fir wood chips from a lumber mill and the C & D wood from one of the municipal recycling facilities in the NARA region are shipped to the CMEC, which are then screened to remove impurities. The accepts are subjected to a two-stage milling: coarse and fine milling. Specifically, wood chips are comminuted to a specific size with a combining milling system, then to activated states with different types of pulverizing machines including ball mill and ring and puck mill in dry or wet modes, or in combination with moderate chemical loading. For the coarse milling, different types of milling circuit processes (closed- vs. open-circuit grinding) are designed and evaluated utilizing a pilot plant comprising two hammermills, one knife mill, and one screener in order to obtain the desired fineness for next stage pulverization. Design and operating variables are related to classification, circulating load, and circuit efficiencies. Energy requirements for milling Douglas-fir wood chips to an optimal fineness at a full-scale sugar depot are projected through a developed algorithm.

2) *Develop metrics to assess milling systems and define specifications of the ground materials*

Process metrics include specific electrical energy consumption, specific surface area increase, comminution ratio and efficiency. Product metrics include digestibility, size and size distribution, bulky density, aspect ratio, powder flow behavior, and slurry rheology. Principal breakup mechanisms (compression, tension, shear, and impact) and biomass breakage modes are investigated to provide an insight in designing innovative grinding and milling processes. Grinding performance parameters and modeling are to be learned from the comminution of the mineral ore.

3) *Design hydrolysis system and evaluate hydrolysis efficiency*

Milled wood meal and enzymes are extruded with a Cincinnati Milacron 55-mm conical twin-screw extruder; the extrudates are then enzymatic hydrolyzed in a digester. The process performance is evaluated in terms of energy requirement and sugar recovery.

4) *Separate and condense sugar stream, and define sugar specifications*

Sugar stream is processed into various product forms (granulate, powder, syrup, or separation of C5 and C6 sugars, crystalline, or amorphous) and characterized in terms of physical and chemical properties (chemical compositions, mixed sugar profile, inhibitors, fermentability etc.).

5) *Analyze sugar depot process economics*

Process economics from wood chips to sugars with respect to depot sizing and unit operations will be analyzed in a low lever techno-economical analysis. Information about comminution capital and operational costs will be collected from pulping and mining industries, literature, and through simulation based on lab experimental data.

6) *Summarize and report the findings*

The results are summarized and disseminated to the NARA leadership team and at the annual conference.

Activities and Results

A network of pre-processing facilities (known as depots) near the biomass sources that upgrade the physical and/or chemical characteristics of bulky forest residues into a uniform formatted and energy-rich feedstock would be a key unit in the softwood biomass to aviation fuel logistics infrastructure. The possibility of transforming forest residues to the forms of pellets, panels, and cellulosic sugars was explored in the laboratory. The wood chips (moisture content (MC) 104%) were acquired in November 2012 from Vaagen Brothers Lumber Inc. at Colville, Washington, screened to the fraction of -25.4 to +4.75 mm, air dried to be MC 15%, and stored in 12% equilibrium moisture content room until use. The chips were then ground with a hammer mill (Prater, 14.9kw, 1750 rpm) at five screen sizes of 7/16, 1/4, 1/8, 1/16 and 1/32 inches and a knife mill (Nelmor, 3.73kw, 1745 rpm) at four screen sizes of 3/8, 1/4, 3/16 and 1/8 inches. Under optimal feeding rates, hammer mill consumed less energy and produced finer wood particles than knife mill fitted with same screen size, and in both cases the geometric mean diameter (GMA) of the particles is significantly smaller than the screen aperture size (Table E-8.1).

The effect of four factors (particles retained on 10, 20 and 35 meshes; moisture content 12, 20 and 28%; temperature 90, 120, 150°C; and dextrin content 0, 3 & 6%) on the densification process and pellet characteristics was investigated (Figure E-8.1). Analysis of variance indicated that optimal densification conditions was 12% MC, 150°C, 10 mesh, and 3% dextrin content, under which the energy consumption was minimized and the pellet strength was the largest. We further explored the effect of chemically pre-conversion using alkaline hydrothermal treatments on densification and pellet characteristics and found that chemically pre-conversion enhanced bonding between particles, made binder addition unnecessary and reduced pellet dusting during handling (Figure E-8.2). NARA SURE summer intern Andrea Laguna demonstrated that the densification of bisulfite-pretreated softwood at the low pressing temperatures did not decrease sugar yields. She found that consolidated pretreated solids contained high carbohydrates and could be used as a more efficient way of transporting forest residues (Figure E-8.3).

Size reduction effect of extrusion process was studied using a torque rheometer as a model operation simulating an extrusion process. Douglas-fir particles between 10~20 mesh were kneaded under different moisture content, temperature, rotation speed, and residence time. Size reduction response was evaluated with cumulative particle size distribution, geometric mean diameter, and scanning electronic microscopy. Specific mechanical energy consumption was also quantified and correlated with characteristics of reduced particles (Figures E-8.4, E-8.5, E-8.6). Experiment results demonstrated that most particles were reduced to microns under different process conditions; moisture content, temperature, rotation speed, and residence time have significant effect on particle size reduction and energy consumption.

Preliminary test showed that the mechanical pretreatment was very promising in preparing softwood for digestion. Douglas-fir wood chips (12% MC) were hammer milled to pass through 1/16-inch screen, then Wiley milled to pass through the 40-mesh sieve, and further milled for various time periods using a planetary ball mill under ambient or cryogenic temperature. The micronized wood flours were then enzymatically hydrolyzed. Images of scanning electron microscopy showed that fiber cell walls were fragmented and the hierarchical structure of wood disappeared in the extensive milled samples (Figure E-8.7). Cellulose crystallinity of the ball-milled samples measured with a powder x-ray diffractometer did not change with milling time until 45 min and then decreased with milling time down to amorphous state at 240 min (Figure E-8.8). Chemical composition of the ball-milled samples did not change with milling time. Enzymatic digestibility increased with milling time and correlated with the changes of cellulose crystallinity (Figures E-8.8 and E-8.9) and reached around 85% theoretical sugar yields at 120-min millings (Figure E-8.9). The results indicated there was little difference in cellulose crystallinity change and enzymatic digestibility between ambient and cryogenic ball millings. No inhibitory compounds have been detected in the hydrolyzates with the high performance liquid chromatography.

The high electrical energy consumption of milling is the major concern to the economic feasibility of mechanical pretreatment. Lowering the energy consumption of micronizing wood is a key to make this method commercially viable. Grinding chemical-impregnated wood particles so-called mechanochemcial pretreatment and a ring and puck mill were investigated to reduce energy consumption. The results indicated that alkaline hydrogen peroxide impregnated wood samples at room temperature reduced energy consumption for the same duration of grinding as much as 20%-50% as compared with the untreated. Energy consumptions were inversely proportional to the size of starting materials (Figure E-8.10). Scanning electronic microscopic image revealed that the cell wall was aggressively deconstructed with disappearing of hierarchical microstructure. Subsequent enzymatic hydrolysis results suggested that mechanochemcial pretreatment could result in effective polysaccharide digestion (Figures E-8.11 and E-8.12). Grinding time significantly contributed to the increase of saccharification of carbohydrate and total sugar yield (Figure E-8.12). Both glucan conversion rate and total sugar yield depended on the size of starting material for grinding. The highest values of 81% theoretic glucan conversion rate and 460 mg /g wood of total sugar yield were achieved at 10-minute grinding of the material passed through 1/32 inch screen size with the ring and puck mill, in contrast, it took 120-minute grinding with the planetary mill. This preliminary tests implied that the ring and puck mill is more efficient than the planetary ball mill in disrupting wood recalcitrance for saccharification.

Figures E-8.13 and E-8.14 shows additional analysis results of particle sizes for a ball milled sample, an extruded particles and two ring and puck milled samples. Their corresponding sugar yields are shown in Figure E-8.9, Figure E-8.11, and Figure E-8.12. Generally, the sugar yield was proportional to the particle size. The extruded sample is highly acicular (with aspect ratio >5:1), bimodal distribution was observed during the analysis. Mode 105μm could be indicating fiber width whereas mode 626 μm could be indicating fiber length. The tail that extends down to 1μm may be showing dust fibers attached to larger particles. This tests demonstrated the utility of the laser particle size analyzer in characterizing wood particles and correlating particle size distribution with enzymatic digestibility.

Figure E-8.1. Pellets consolidated with 12% MC, 150°C, 10 mesh, and 3% dextrin content

Figure E-8.2. Pellets densified with sodium sulfite treated particles under 160 oC for 10 min

Figure E-8.3. Panel pressed with the bisulfite and sulfuric acid treated chips under 180 oC for 10 min

Table E-3.1. Characteristics of the ground materials and energy consumptions using the hammer mill and the knife mill

Mill type	Hammer mill					Knife mill			
Screen size (mm/ inch)	11.1 (7/16)	6.35 (1/4)	3.18 (1/8)	1.59 (1/16)	0.79 (1/32)	9.53 (3/8)	6.35 (1/4)	4.76 (3/16)	3.18 (1/8)
Moisture content (%, db)	12.7	12.2	12.4	11.3	8.1	12.3	11.6	10.9	9.0
Geometric mean diameter Xgm(mm)	2.25	1.49	1.02	0.84	0.65	4.66	2.66	1.94	1.54
Standard deviation Sgm (mm)	1.88	1.81	1.78	1.75	1.83	1.77	1.83	1.76	1.86
Bulk density (kg/m3) (SD)	189 (1.1)	204 (0.8)	218 (0.9)	240 (1.8)	267 (2.2)	214 (0.7)	246 (2.3)	263 (2.8)	283 (3.1)
Optimal feeding rate (kg/min)	8.72	7.07	3.92	3.33	2.28	5.72	3.00	2.26	1.05
Total specific energy (SD), (kJ/kg)	113 (3.1)	194 (3.5)	310 (1.2)	524 (1.1)	734 (16.5)	138 (0.9)	303 (38)	370 (9.7)	1050 (28)
Net specific energy (SD), (kJ/kg)	59 (0.7)	95 (2.0)	141 (1.0)	223 (7.7)	328 (8.4)	70 (2.0)	153 (14)	205 (12)	345 (12)

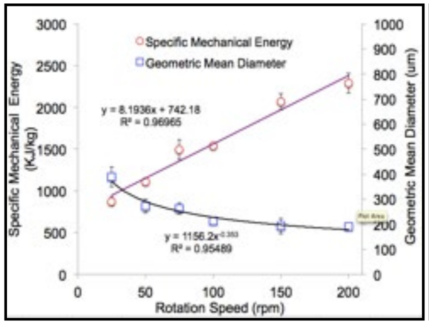

Figure E-8.4. Specific mechanical energy and geometric mean diameter during model extrusion process under different rotation speed. Other conditions: 90 oC, MC 20%, and 10min.

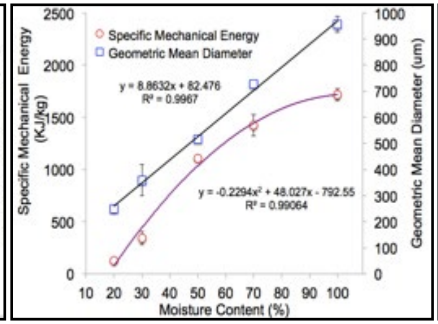

Figure E-8.5. Specific mechanical energy and geometric mean diameter during model extrusion process from biomass with different moisture content.
Other conditions: 90 oC, 50rpm, and 10min.

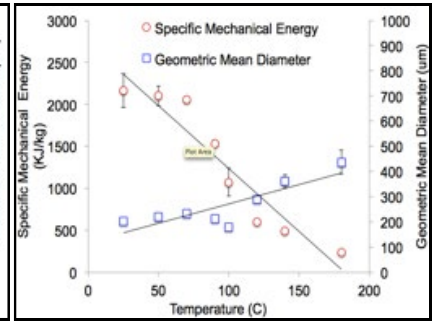

Figure E-8.6. Specific mechanical energy and geometric mean diameter during model extrusion process under different temperature. Other conditions: MC 20%, 50 rpm and 10min

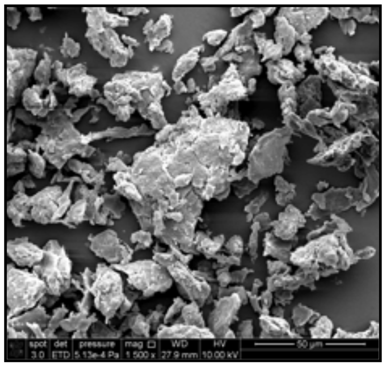

Figure E-8.7. Ball milling for 120min under ambient temperature led to the almost complete disappearance of discernible tissue structures (cell walls, lumens, pits and spiral thickenings).

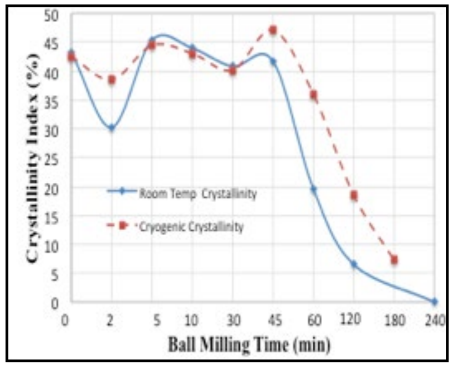

Figure E-8.8. Cellulose crystallinity index changed with ball milling time. Initial ball milling did not affect cellulose crystallinity, but it decreased after 45-minute milling with a slower rate for cryogenic ball milling.

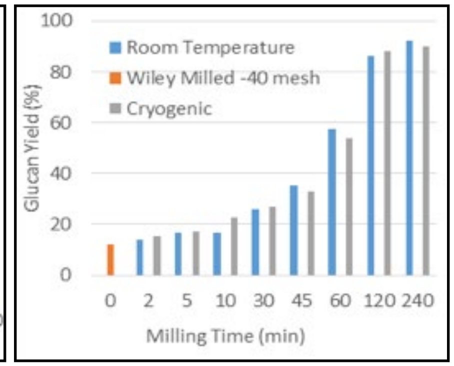

Figure E-8.9. Glucan yields of 72-hour enzymatic saccharification increased with milling time under different milling conditions (Wiley knife milled, ball milled without controlling chamber temperature, and cryogenic milling)

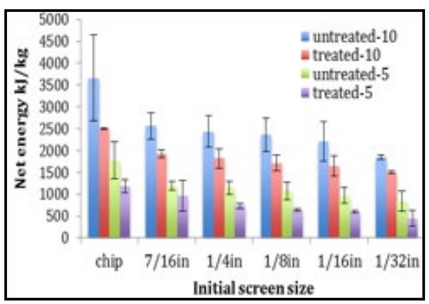

Figure E-8.10. Grinding energy consumption of mechanochemical pretreatment of Douglas-fir (Treated: alkaline hydrogen peroxide impregnation before ring & puck mill grinding; untreated: non-chemical treated; 5 & 10: grinding time, minutes)

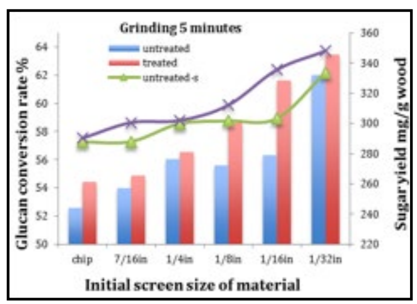

Figure E-8.11. Enzymatic hydrolysis of mechanochemical pretreated softwood after 5 min grinding

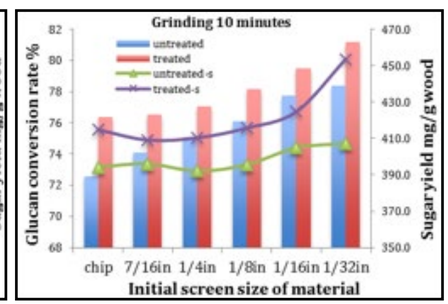

Figure E-8.12. Enzymatic hydrolysis of mechanochemical pretreated softwood after 10 min grinding

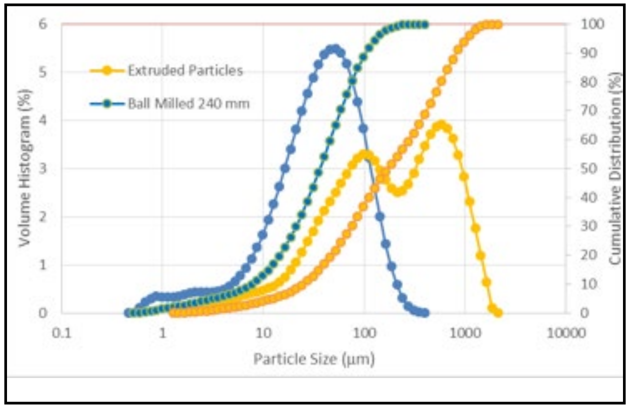

Figure E-8.13. Particle size distribution by a laser particle size analyzer. Extruded Particles: feeding 10~20 mesh, process condition: 50 °C, 100 rpm, 10 min, 20% MC. D_{10}=28, D_{50} =195, and D_{90}=934 um. Ball milled 240 min: feeding 40 mesh particles, D_{10}=9, D_{50}=41, and D_{90} =117 um. (D_{90} means diameter at 90 percentiles)

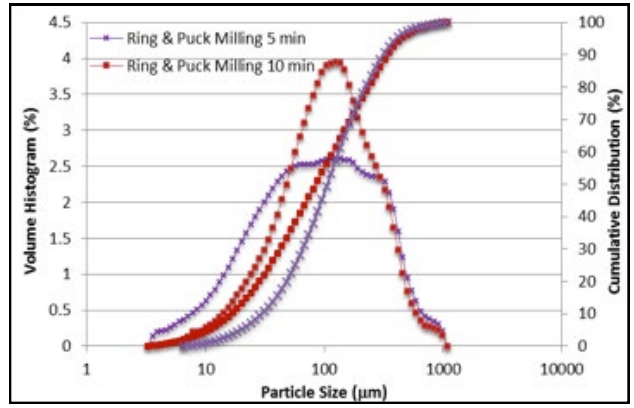

Figure E-8.14. Ring and Puck Milling 5 min: feeding particles passed through 7/16" screen, milling 5 min, D_{10}= 17, D_{50}=85, and D_{90}=342 mm. Ring and Puck Milling 10 min: started from 7/16" particles, milling 10 min, D_{10}= 30, D_{50}=106, and D_{90}=314mm

Recommendations | Conclusions

Cellulosic sugars are potential feedstocks for existing corn-based ethanol plants, emerging advanced biomass-to-biofuel plants, or other chemical upgrading plants, which are currently utilizing other sources of sugars and would benefit by reducing their ecological footprint. It seems resonable that mechanical pretreatment followed by an extrusion-assisted enzymatic hydrolysis will lead to a simple and clean biomass-to-sugars conversion process while appling less demand on human capital. This type of processing may be ideal rural areas.

Bearing on this assumption, the distributed sugar team will: 1) characterize the suitability of available biomass within a small fiberline supply radius including waste wood streams; 2) characterize the fine milling in terms of energy consumption, conversion performance conversion, and process intensification. A NARA SURE summer undergraduate intern will be recruited to provide additional research assistance. A planetary ball mill has been purchased and a laser scattering size analyzer will be aquired shortly to support this investigation.

Physical and Intellectual Outputs

RESEARCH PRESENTATIONS

Oral, Posters or Display Presentations

Norton, K., Wolcott, M., Wang, J.W., Flores, O.M., and Ha, S. 2013. Physical methods for breakdown of cellulose Crystallinity. Poster presentation at the NARA Summer Undergraduate Research Symposium, Pullman, WA, August 2, 2013.

Norton, K., Wang, J.W., Flores, O.M., Liu, H.N., Liu, Y.L., Ha, S. and Wolcott, M.P. 2013. Transform Forest Residues into Activated Feedstock by Ball Milling, Poster at the Annual Meeting of Northwest Advanced Renewables Alliance, Corvallis, Oregon, Sep. 11-13, 2013

Wang, J.W., Liu, Y.L., Jiang, J.X., Liu, H.N. and Wolcott, M.P. 2013. Identify Technologies for a Depot-Based Feedstock Development, Poster at the Annual Meeting of Northwest Advanced Renewables Alliance, Corvallis, Oregon, Sep. 11-13, 2013

Liu, H.N., Wang, J.W. and Wolcott, M.P. 2013. Size Reduction for MechanoChemical Processes Using Extrusion Technology, Poster at the Annual Meeting of Northwest Advanced Renewables Alliance, Corvallis, Oregon, Sep. 11-13, 2013

Jiang, J.X., Wang, J.W. and Wolcott, M.P. 2013. Chemical Preconversion of Softwood with Alkaline Hydrogen Peroxide (AHP) Method for Denser Carbohydrate Feedstock Supply in Biorefinery System, poster at the Annual Meeting of Northwest Advanced Renewables Alliance, Corvallis, Oregon, Sep. 11-13, 2013

Liu, Y.L., Wang, J.W. and Wolcott, M.P. 2013. Specific Energy Consumptions of Comminuting Douglas-fir Wood Chips, poster at the Annual Meeting of Northwest Advanced Renewables Alliance, Corvallis, Oregon, Sep. 11-13, 2013

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Morrell, S., 2008. A method for predicting the specific energy requirement of comminution circuits and assessing their energy utilisation efficiency. Miner. Eng. 21, 224–233.

Morrell, S., 2009. Predicting the overall specific energy requirement of crushing, high pressure grinding roll and tumbling mill circuits. Miner. Eng. 22, 544–549.

Morrell, S., Man, Y., 1997. Using modeling and simulation for the design of full scale ball mill circuits. Miner. Eng. 10, 1311–1327.

Schlanz, J.W., 1987. Grinding: An overview of operation and design (No. 87-31-P). North Carolina State University Minerals Research Laboratory.

Walkiewicz, J.W., Raddatz, A.E., McGill, S.L., 1989. Microwave-assisted grinding, in: Industry Applications Society Annual Meeting, 1989., Conference Record of the 1989 IEEE. IEEE, pp. 1528–1532.

TASK E-7: FEEDSTOCK SUPPLY CHAIN ANALYSIS - MSW

Key Personnel	Affiliation
Karl Englund	Washington State University

Task Description

This task will inventory and assess the biomass within the municipal solid waste (MSW) and construction and demolition (C&D) supply chain throughout the NARA region. Research focus will be placed upon developing an overall and accessible inventory of the woody biomass in the Northwest (especially NARA communities), developing strategies to increase the recovery this material, establishing quality control/product specifications, and identifying where these materials fit within the wood utilization supply chain.

Activities and Results

We have developed GIS databases and provided them to the Integrated Design Experience (IDX) team at WSU that provide the volumes and locations of all the current municipal recycling facilities (MRFs) in the four-state NARA region. At this time, MRFs are the primary source of C&D recovered wood. These databases will be updated as MRFs are opened or closed in the region. Being in contact with stakeholders in the C&D supply chain will allow us to stay up to date on the status of the regional MRFs. The “wasteshed” for the biofuel supply chain is outlined in Figure E-7.1, where most of the wood volumes from C&D are within the Portand, OR metropolitan area.

The database for MRF’s is complete at this time for the NARA four-state region. We will continue to monitor the changes with MRF’s in the region and update them as needed. With the onset of a new study region we will assist the IDX and NARA Education teams to create new wasteshed volumes for assigned regions.

The next tasks are to include an evaluation of selected MRF wood waste streams as a viable feedstock for biojet and related co-products. Identifiying potential conversion process inhibitors and classifying non-renewable contents for potential RINS credits will be addressed in the upcoming year. We have started collecting representative wood waste from MRFs at this time and will continue to characterize the materials.

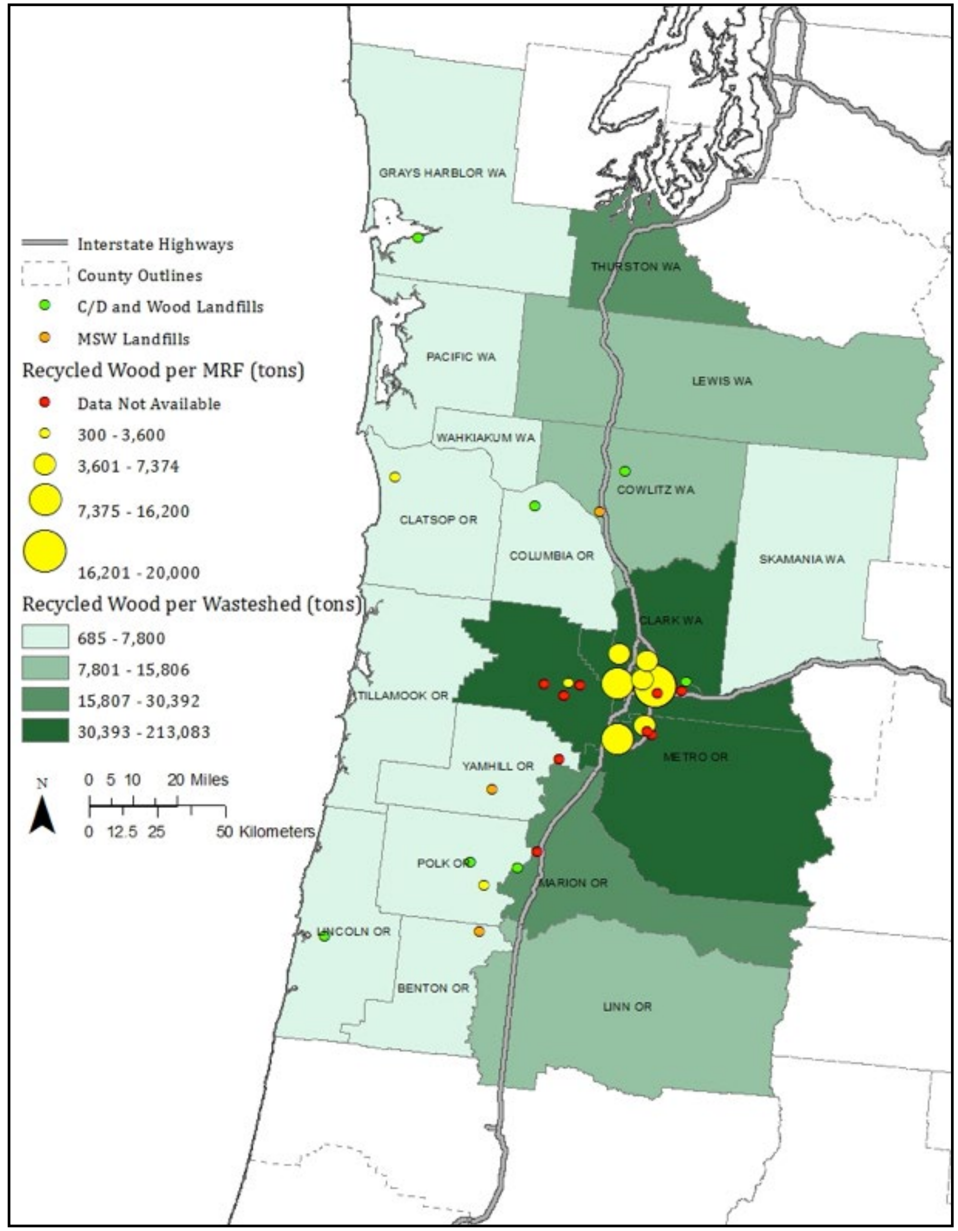

Figure E-7.1. Wasteshed of wood volumes derived from MRFs in the MC2P NARA supply chain

Recommendations | Conclusions

The primary concern of using wood wastes from C&D is the presence of contaminants that may inhibit the fermentation or pretreatment process involved in biojet production, alter the wood's chemical structure, and negatively affect qualification for RINS credits. We will evaluate the waste wood streams based upon the tests and methods shown in Table E-7.1.

To identify the non-renewables in the wood waste materials, the guidelines specified in the Renewable Fuel Standards 2 (RFS2) on carbon 14 analysis will be followed. A suitable facility will need to be identified to conduct these tests. The protocol established through our efforts will provide a framework for MRF operations to follow while obtaining their non-renewable content for future biofuel markets.

Table E-7.1.

Property	Standard or Method and possible place
Ash content	ASTM D1755 or NREL/TP-510-42622
Bulk density	ASTM E873.
Particle size and shape	No defined until receiving samples and after visual inspection on materials.
Moisture content	ASTM D4442
Chemical composition (cellulose, hemicellulose, lignin, extractives)	Method NREL (Sluiter et al., 2011) or ASTM E1758
Chorine	Method of Bartelt et al. (1998), method of Zapala et al. (2013), or micro-XRF (energy-dispersive micro X-ray fluorescence spectrometry)
Identification of metals (Pb, S, Cd, others)	ICP-MS (Inductively coupled plasma mass spectrometry) and/or Method of Euro Chlor (2009).
Elemental composition (C, N, H, O, S)	Pelaez-Samaniego et al. (2014), using a LECO CHN module and a LECO S module for elemental analysis.
Crystallinity (of cellulose)	X-ray powder diffractometer (XRD)
Surface area of ground materials	Brunauer, Emmett and Teller (BET) method (Tristar Micromeritics, USA) Dasgupta et al. (2009).
Phenolic compounds	UV-Visible Spectroscopy

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Ximenesa, E., Kim, Y., Mosiera, N., Dien, B., Ladisch, M., Enzyme and Inhibition of cellulases by phenols, Microbial Technology 46 (2010) 170–176.

Zapala, E., Kuklis, I., Fabjańska-Swieca, G., Tarnowska, J., Application of ion chromatography for determination of chlorine content in solid biomass for power sector, CHEMIK 2013, 67, 12, 1217–1226.

Physical and Intellectual Outputs

RESEARCH PRESENTATIONS

Schneider, G.A., and K. Englund. Wood Waste Assessment within the Construction and Demolition Industry. Poster presentation at the NARA Annual Meeting, Corvallis, OR, September 10, 2013.

THESIS AND DISSERTATIONS

Gerald Schneider, M.S., Construction and Demolition Recycled Wood Waste Assessment within the Northwest United States. August 2013. Masters Thesis. Washington State University, Pullman, WA

Outreach_Yadama_Englund

NARA

	Task Name	2011–2016
1	O-1. Washington State University NARA Extension Initiative	63%
2	Task O-1.1. Bioenergy Literacy	60%
3	Task O-1.1.1. Develop an energy literacy platform for ease of communication	65%
4	Establish technology transfer mechanisms	100%
5	Coordinate and compile information from each of the NARA Research Teams	55%
6	Network with Outreach Team Partners	59%
7	Forest Business Network (FBN)	58%
8	Link NARA on FBN	100%
9	Integrate NARA into FBN newsletters	55%
10	Assist NARA with MT Pilot Community	100%
11	Assist NARA with other PSC study regions	15%
12	Coordinate NARA's Role in Small Log Conf	100%
13	USDA FS PNW	55%
14	State Extension Personnel (OR, ID, MT)	55%
15	Ruckelshaus Center	55%
16	GreenWood Resources	100%
17	Task O-1.1.2. Outreach Activities for Disseminating Knowledge and Receiving Feedback	61%
18	Assess and determine dissemination mechanism	100%
19	Design and draft agenda for the outreach activity in coordination with corresponding team	55%
20	Disseminate NARA findings (Conferences, Fact Sheets, Knowledge Base, etc.)	55%
21	Managing Woody Biomass Supply Chain Symposium	100%
22	Compile and catalog activity outcomes	100%
23	Program development and coordinate NARA related sessions for NW Bioenergy Research Symposium	100%
24	Small Log Conference with FBN	100%
25	Compile and catalog activity outcomes	100%
26	Develop program, coordinate, and organize NARA Conference 1	75%
27	Compile and catalog conference proceedings	0%
28	Develop program, coordinate, and organize NARA Conference 2	0%
29	Compile and catalog conference proceedings	0%
30	Task O-1.1.3. Catalog Activity Outcomes and Benchmark Reports and Studies	55%
31	Catalog benchmark reports and studies related to biofuels, bioenergy, and co-products	55%
32	Develop and conduct applied research on pre-conversion of woody biomass and alternative value-added options	55%
33	Task O-1.2. Build Pilot Supply Chain Coalitions	66%
34	Task O-1.2.1. Define Stakeholders and Articulate Communication Mechanisms	100%

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	Task Name	% Complete
35	Stakeholder (SH) Development	100%
36	Identify potential SH groups	100%
37	SH Interaction model	100%
38	SH engagement	100%
39	Plan and develop communication mechanism	100%
40	Implement communication mechanism	100%
41	Task O-1.2.2 NARA Pilot Supply Chain Study Region Establishment and Development	37%
42	1st Pilot Supply Chain Study(PSC) Region	87%
43	Coordinate with and assist Education team in the 1st PSC (WMC)	100%
44	Compile pilot community resources and assets	100%
45	Identify and engage key SHs	100%
46	Determine/develop community Leadership Team	100%
47	Leadership Team formed/identified	100%
48	Form regional coalitions and assist Education and EPP teams 1st PSC region with data collection and SH engagement	75%
49	Compile a list of regional SHs	100%
50	Coordinate with Education and EPP teams in working with SHs in region to develop their short, medium, and long-range goals and outcomes	40%
51	Coordinate planning and designing strategies with coalitions in PSC and review	80%
52	Disseminate PSC research findings	80%
53	Document PSC study findings Region 1	90%
54	2nd Pilot Supply Chain Study(PSC) Region	59%
55	Coordinate with and assist Education team in the 2nd PSC	75%
56	Compile pilot community resources and assets	70%
57	Identify and engage key SHs	70%
58	Determine/develop community Leadership Team	100%
59	Leadership Team formed/identified	100%
60	Form regional coalitions and assist Education and EPP teams 2nd PSC region with data collection and SH engagement	45%
61	Compile a list of regional SHs	70%
62	Coordinate with Education and EPP teams in working with SHs in region to develop their short, medium, and long-range goals and outcomes	40%
63	Coordinate planning and designing strategies with coalitions in PSC and review	15%
64	Disseminate PSC research findings	40%
65	Document PSC study findings Region 2	0%
66	3rd Pilot Supply Chain Study(PSC) Region	0%
67	Coordinate with and assist Education team in the 3rd PSC	0%
68	Compile pilot community resources and assets	0%
69	Identify and engage key SHs	0%
70	Determine/develop community Leadership Team	0%

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	Task Name	% Complete
71	Leadership Team formed/identified	0%
72	Form regional coalitions and assist Education and EPP teams 3rd PSC region with data collection and SH engagement	0%
73	Compile a list of regional SHs	0%
74	Coordinate with Education and EPP teams in working with SHs in region to develop their short, medium, and long-range goals and outcomes	0%
75	Coordinate planning and designing strategies with coalitions in PSC and review	0%
76	Disseminate PSC research findings	0%
77	Document PSC study findings Region 3	0%
78	4th Pilot Supply Chain Study(PSC) Region	0%
79	Coordinate with and assist Education team in the 4th PSC	0%
80	Compile pilot community resources and assets	0%
81	Identify and engage key SHs	0%
82	Determine/develop community Leadership Team	0%
83	Leadership Team formed/identified	0%
84	Form regional coalitions and assist Education and EPP teams 4th PSC region with data collection and SH engagement	0%
85	Compile a list of regional SHs	0%
86	Coordinate with Education and EPP teams in working with SHs in region to develop their short, medium, and long-range goals and outcomes	0%
87	Coordinate planning and designing strategies with coalitions in PSC and review	0%
88	Disseminate PSC research findings	0%
89	Document PSC study findings Region 4	0%
90	Task O-1.2.3. Assist EPP with PSC Selection Process and Support Index Study	84%
91	Coordinate with EPP in PSC Selection	84%
92	Develop criteria for selection	100%
93	Develop PSC selection process	100%
94	Assist compiling community resources and assets for GIS development	65%
95	Develop long-list of potential PSC regions in the region	100%
96	Develop and survey NARA Outreach members to nominate PSC regions	100%
97	Conduct and analyze the survey results	100%
98	Compile long list of PSC regions	100%
99	Assist EPP with surveys in potential PSC regions	100%
100	Assist EPP to synthesize and analyze assets of PSC regions	100%
101	Identify potential PSC regions	100%

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Outreach_Kolb

NARA

	Task Name	%
1	O-2. Montana State University NARA Extension Initiative	66%
2	Attend kick-off meeting	0%
3	Introduce NARA to Montana Biomass Working Group and use to develop Montana NARA advisory group	100%
4	Introduce NARA to Montana Forest Council	100%
5	Introduce NARA to Montana Logging Association	100%
6	Develop article about NARA and publish on Montana Tree Farm and forest landowner newsletter, as well as send out to all Montana State county Extension Agents	100%
7	Develop NARA web site on MSU Extension web page	100%
8	Develop database and periodically update of potential feedstock suppliers	66%
9	Work with entire NARA program and MT Biomass working group to develop test bed site criteria and rubric	100%
10	Work with Montana Biomass working group to solicit and collect data and applications from landowners, industry and extension stakeholders with regard to potential test bed sites for Montana	100%
11	Review data and rank sites for potential NARA Communities	100%
12	Organize and conduct meetings and field trip with Montana NARA working group and potential NARA Communities	50%
13	Summarize results from MT NARA working group and present finding to NARA regional alliance	100%
14	Communicate updates on biomass specifications to stakeholders via web page, newsletter updates and working group updates	66%
15	Organize meetings with selected NARA community and stakeholders to update on feedstock developments	50%
16	Organize and conduct field trips to potential feedstock sites and harvesting practices within selected NARA community(s)	66%
17	Write final NARA program summary and impacts for Montana Stakeholders and publish in landowner newsletter and web page	0%

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Outreach_Leavengood

NARA

	Task Name	% Complete
1	O-4. Oregon State University NARA Extension Initiative	34%
2	Introduce project to OR Forest Biomass Wrkg Grp – solicit group's involvement as advisory committee (AC)	100%
3	Task O-4.1. NARA Regional Alliances	41%
4	Review existing data & reports on potential test sites	75%
5	Convene 1-day meeting of AC to review NARA community criteria & identify 2 test sites	85%
6	Convene focus grp meeting at test site 1 – discuss feedstock specs & logistics, tech. adoptions w/existing infra., etc.	0%
7	Convene focus grp meeting at test site 2 – (same as above)	0%
8	Meet with suppliers for site 1	0%
9	Meet with industrial stakeholders for site 1	0%
10	Host community forum for site 1	0%
11	Meet with suppliers for site 2	0%
12	Meet with industrial stakeholders for site 2	0%
13	Host community forum for site 2	0%
14	Task O-4.2. NARA Extension Engine	28%
15	Develop NARA page on OSU Forestry Extension website	100%
16	Develop newsletter article on NARA project; send to OSU Extension Foresters for newsletters	100%
17	Develop briefing paper on NARA community criteria and post to project website	50%
18	Develop detailed report on each test site; post to project website	0%
19	Meet with policymakers re: project results	0%
20	Organize field trips to key supply sites & ind. facilities for site 1	0%
21	Organize field trips to key supply sites & ind. facilities for site 2	0%
22	Organize and deliver statewide conference (OR) on NARA research findings	0%
23	Develop NARA update newsletter article; send to OSU Extension Foresters for newsletters	0%

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Outreach_Brooks

NARA

	Task Name	% Complete
1	O-5. University of Idaho NARA Extension Initiative	30%
2	Network with NARA research and industry partners	75%
3	Initiate relationships with stakeholders	87%
4	Establish working relationship w/ regional cooperators	20%
5	Help identify test-bed sites	100%
6	Help develop survey w/ EPP group	50%
7	Help survey potential test-bed sites	50%
8	Help establish working relationship w/ test-bed sites	0%
9	Communicate NARA goals to test-bed sites	0%
10	Establish focus groups w/in test-bed sites	20%
11	Help plan, organize, and coordinate workshops	25%
12	Help plan, organize, and coordinate stakeholder mtgs	20%
13	Help distribute newsletters/articles/briefs to communities	20%
14	Evaluate impact of workshops	15%
15	Assist with synthesis of survey results	5%
16	Help publish impact of program	5%
17	Help organize/conduct field trips for stakeholders	20%

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Outreach_Lowell

NARA

	Task Name	% Complete
1	O-6. Forest Service - Pacific NW Research Station	47%
2	Task O-6.1. NARA Regional Alliances	54%
3	Opening meeting	100%
4	Network with other NARA teams	45%
5	Initiate relationships with regional stakeholders and partnerships	50%
6	Assist in development of decision criteria for test bed selection	85%
7	Identify candidate test bed sites near timber dependent communities	65%
8	Participate in screening of test bed communities	55%
9	Meet with clients and stakeholders at test bed communities	55%
10	Convene Focus Group at each test bed site	50%
11	Facilitate Focus Group meetings	50%
12	Identify and/or organize potential field visits and demonstrations	35%
13	Task O-6.2. NARA Extension	39%
14	Assist in organization of workshops	40%
15	Produce newsletter/one-page briefing papers	35%
16	Serve on Planning Committee for NARA First Conference	95%
17	Publish Proceedings as PNW-GTR	0%
18	Serve on Planning Committee for NARA Second Conference	0%
19	Publish Proceedings as PNW-GTR	0%

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Outreach_RuckelshausCtr

NARA

#	Task Name	Progress
1	O-7. William D. Ruckelshaus Center	53%
2	Task O-7.1. Develop Leadership Team & Stakeholder Advisory Board	100%
3	Work with the Leadership Team and the SAFN group to propose an 8-12-member "Stakeholder Advisory Board" to advise the Leadership Team over the course of the project	100%
4	Solicit input from Stakeholder Advisory Board members to assess the situation and facilitate identification of issues, opportunities and recommendations for the project	100%
5	Provide formal recommendations based on that assessment for the Leadership Team	100%
6	Task O-7.2. Meeting Facilitation and Informing Policy Makers	47%
7	Monthly meetings of the Leadership Team	47%
8	Quarterly meetings of the Stakeholder Advisory Committee	47%
9	Quarterly newsletters, web updates and legislative liaison packages from information provided by Project Directors and Leadership Team	47%
10	Annual Project Assessment Meetings to include Stakeholders	47%
11	Task O-7.3. Assessment & Survey	52%
12	Participate in assessment of public perceptions to "connect social and technical aspects" of the project	75%
13	Quantitative surveys	50%
14	Focus groups	80%
15	Inventory and assess applicability of existing DGSS survey data sets for use in the ground-truthing process	100%
16	Complete data extraction, formatting and consolidation to support ground-truthing using DGSS survey data sets	25%
17	DGSS will work with the EPP team to analyze DGSS and National Data Sets to accomplish the ground-truthing	20%
18	Final report	0%

Timeline: 2011–2016 (Q1–Q4 each year)

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Education_Wolcott_Laninga

NARA

	Task Name	% Complete
1	E-3. Bioregional Integrated Design Experience (IDX)	58%
2	Task E-3.1. NARA Community Design #1	100%
21	Task E-3.2. NARA Pilot Supply Chain #2	100%
40	Task E-3.3. NARA Pilot Supply Chain #3	96%
41	Recruit and Select Community Partners	100%
42	Community Profile for Design Team	100%
43	Task E-3.3.1. Community Resource Atlas Development	100%
44	Assess Community Resources and Assets	100%
45	Develop analysis tool skills	100%
46	Analyzing resource and asset data	100%
47	Compile MC2P Analysis Document	80%
48	Task E-3.3.2 Community Plans and Design	89%
49	Collect Site Attributes	100%
50	Optimized Supply Chain Analysis	90%
51	Supply chain site location selection	100%
52	Resource flows and site analysis for supply chain site	100%
53	Site case studies and design interventions	75%
54	Design Documentation	75%
55	MC2P Summary Document	0%
56	Task E-3.4. NARA Pilot Supply Chain #4	0%
75	Task E-3.5. NARA Pilot Supply Chain #5	0%

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Education_Wang_Wolcott

NARA

	Task Name	% Complete
1	E-8. Distributed Sugar Depot	4%
2	Task E-8.1. Milling, System Metrics, and Modeling	16%
3	Task E-8.1.1. Size reduction using pilot scale hammer mill and knife mill	70%
4	Factors affecting size reduction	100%
5	Specific energy consumption	100%
6	Ground materials characterization	70%
7	Effects of feedstock sizes on pretreatment severity	40%
8	Task E-8.1.2. Fine milling (pulverizing)	16%
9	Milling characteristics using plantary ball mill	20%
10	Milling characteristics using ring mill	20%
11	Milling characteristics in wet mode	0%
12	Characteristics of chemical enhanced milling	20%
13	Task E-8.1.3. Particle characterization	6%
14	Particle size analyzer identification, consulting, order, and installation	80%
15	Particle size measurement	0%
16	Crystallinity by X-ray diffractometry	10%
17	Particle morphology	0%
18	Task E-8.1.4. Particles performance	2%
19	Slurry formation and characteristics	0%
20	The effects of size distribution on sugar recovery rate and yield	0%
21	Models correlating input, process, and output variables	5%
22	The mechanical pretreated materials are characterized. The desired specifications are identified and methods to measure these properties are developed	0%
23	Task E-8.2. Sugar Depot Feedstock Flexibility	0%
24	Tolerance to feedstock contamination	0%
25	Chemical compostion of construction and demolition wood waste	0%

Timeline: 2013 (Q1–Q4), 2014 (Q1–Q4), 2015 (Q1–Q4), 2016 (Q1–Q4)

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#	Task Name	% Complete
26	Contamination level	0%
27	The effect of contamination on pretreatment and digestibility	0%
28	Task E-8.3. Hydrolysis Design, Process, Metrics Development, and Sugar Specification	2%
29	Task E-8.3.1. Hydrolysis kinetics using a toque rheometer	6%
30	Effect of solid contents on rheology	5%
31	Rheology change with enzymatic hydrolysis time	5%
32	Particle size changes with enzymatic hydrolysis time	5%
33	Energy consumption	5%
34	Sugar hydrolysis rates and yield	10%
35	Task E-8.3.2. Hydrolysis with an extruder	0%
36	Pre-extrusion treatments enhanceing extrusion process	0%
37	Extrusion variables optimization	0%
38	Post-extrusion treatments	0%
39	Extrudates sacharification	0%
40	Pretreated materials are enzymatic hydrolyzed via an extrusion system. Process performance such as viscosity, flowability, and energy consumption relating to handling of the mechanical pretreated materials is assessed. Conditions of enzymatic hydrolysis are optimized	0%
41	Task E-8.3.3. Sugar Specification	0%
42	Sugar streams separation and condense	0%
43	Sugar formats optimization and characterization	0%
44	Task E-8.4. Sugar Depot Process Economics	0%
45	Task E-8.4.1. Milling technology in wood and pulping industry review	0%
46	Potential industrial scale milling systems are identified	0%
47	Task E-8.4.2. Milling technologies in the mining engineering review	0%
48	Research, development, and design methodology	0%
49	Modeling, simulation, and design	0%
50	Milling equipment and case study	0%
51	Identify methods and modeling for wood milling research	0%

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	Task Name	
52	Pilot milling trials are carried out and optimal milling schemes and parameters are found. Required energy consumptions at optimum milling conditions are measured	0%
53	Task E-8.4.3. Development of algorithms correlating comminution features of starting materials, products, energy consumption and power requirements	0%
54	Modeling with lab data	0%
55	Scale modeling to large scales	0%
56	The performance of the pretreated materials for cellulosic sugars is experimentally investigated at the bench scale. The correlation between physical chracteristics and performance of the pretreated materials is established	0%
57	Task E-8.4.4. Low level Sugar depot techno-economic analysis	0%
58	Sugar depot sizing and design	0%
59	Sugar depot unit process and potential industrial equipment	0%
60	Ccapital and operational cost estimations	0%
61	Compile a low level TEA report	0%
62	Enough information about a sugar depot is collected and a low-level technoeconomic analysis of sugar depot is finished	0%
63	Task E-8.5. Analysis & Report (periodic & final reports)	0%
64	Process energy requirements, costs, savings potentials, chemical composition, the presence of inhibitors, and the saccharification rate and degree are investigated to evaluate the performance of comminution. An algorithm linking data from lab tests and pilot trials and design of an industrial-scale sugar depot facility is developed	0%

Education_Englund

	Task Name	% Complete
1	E-7. Feedstock Supply Chain Analysis - MSW	41%
2	Task E-7.1. Develop MSW/C&D woody biomass inventory in NARA region	82%
3	Task E-7.1.1. Identify and collect exisiting MSW and C&D data - by states	100%
4	Establish contacts for inventory info	100%
5	Collect all existing inventory data	100%
6	Normalize data to collate and compare	100%
7	Create inventory of existing data	100%
8	Task E-7.1.2. Establish model for woody biomass inventory in NARA regions	100%
9	Identify potential models for inventory assessment	100%
10	Identify model communities for wood inventory	100%
11	Establish modeling procedure for NARA region	100%
12	Inventory model completed	100%
13	Task E-7.1.3. Validate model with surveys and on-site inventories	57%
14	Identify applicable test sites for inventory	100%
15	Collect data via on-site or compiled info	95%
16	Validate model from data collection	0%
17	Develop inventory of wood waste in MSW throughout NARA region based on existing data and model results	0%
18	Task E-7.2. Inventory of NARA Communities (NC)	47%
19	Work with Extension team to develop NC criteria	100%
20	Task E-7.2.1. Develop extensive inventory for 1st NC	100%
21	Identify geographical range	100%
22	Identify all sources of MSW and C&D	100%
23	Collect data and normalize for summation	100%
24	Finalized data entered into GIS database	100%
25	Task E-7.2.2. Inventory analysis of remaining NCs	11%
26	Identify all sources of MSW and C&D	5%
27	Collect data and normalize for summation	0%
28	Finalized data entered into GIS database	20%
29	Final Inventory assessment of NCs	0%
30	Task E-7.3. Develop strategies to utilize woody biomass from C&D for biofuel feedstocks	5%
31	Task E-7.3.1 Categorize incoming wood materials to select NARA-based MRFs	4%
32	Identify and categorize major contaminants for fuel production	10%
33	Determine contaminant levels in wood wastes	0%
34	Task E-7.3.2. Develop specifications for "allowable materials" for biofuel usage	5%
35	Identify procedure for providing MRF RINS credits	5%
36	Provide pathway for MRF EPA recongnized renewable woody biomass feedstock for biofuels	0%

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	Task Name	2011–2016 (Q1–Q4)
37	Task E-7.4. Develop wood composition model	1%
38	Collect initial data/info on wood materials in MSW	5%
39	Address historical data on wood materials in building construction	0%
40	Model wood material types in the C&D stream	0%
41	Final report on quality control and specifications for using MSW and C&D wood as biofuel	0%

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