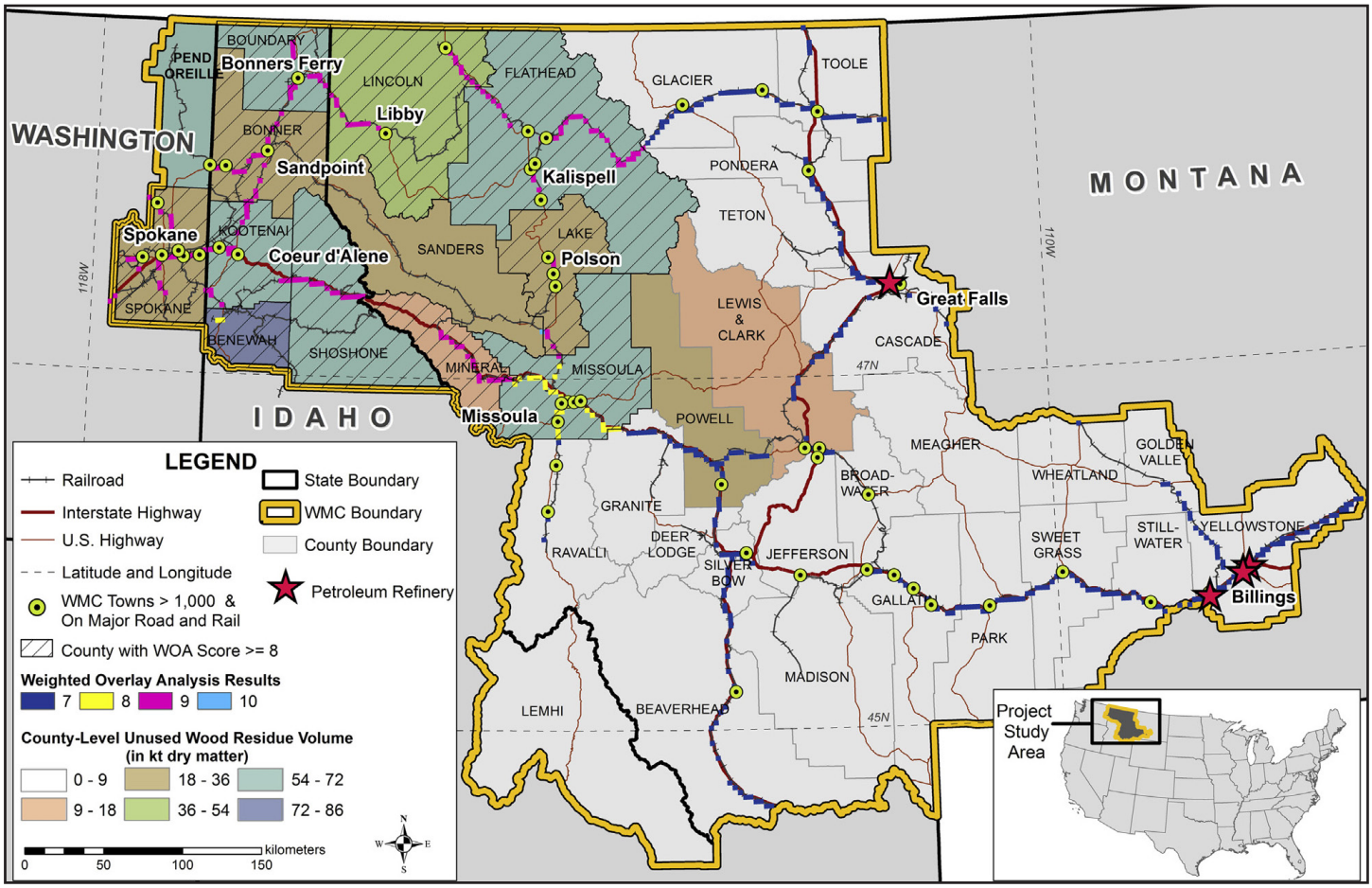
NARA
Northwest Advanced Renewables Alliance

Newsletter | **May 2014**
Volume 3.5




WMC region with select biogeophysical assets and weighted overlay analysis (WOA) results. Figure from Martinkus N, et al., Integrating biogeophysical and social assets into biomass-to-biofuel supply chain siting decisions, Biomass and Bioenergy (2014), http://dx.doi.org/10.1016/j.biombioe.2014.04.014

# Locating Wood-Based Biofuel Refineries and Depots in the Pacific Northwest

NARA is tasked with helping stakeholders identify depot and biorefinery site locations suitable for a developing industry that uses forest residuals to produce bio-jet fuel and valued co-products. To provide impartial, science-based recommendations, NARA researchers devise ways to quantify and score important factors that impact a production facility's economic sustainability, and then rank locations according to their combined scores.

In a recently published paper funded by NARA and titled "Integrating biogeophysical and social assets into biomass-to-biofuel supply chain siting decisions", the authors describe NARA's approach used to rank counties for their suitability as depot or biorefinery locations. The measures used to rank these counties look at biogeophysical capacity and social assets. The authors then demonstrate their methodology to rank counties within the NARA pilot supply region, the western Montana corridor (WMC), for both biogeophysical capacity and social assets.

View the article *Integrating biogeophysical and social assets into biomass-to-biofuel supply chain siting decisions*

Information regarding the Western Montana Corridor supply chain study

## Scoring Biogeophysical Capabilities

To measure a county's biogeophysical capabilities, the authors recorded for each county, and county cluster, the amount of unused forest residuals available within a given distance and the approximate distance to a petroleum refinery that would process the isobutanol produced. Additional considerations were given for rail and road access. Combining all of these factors produced a single score termed "Weighted Overlay Score" (WOS) that ranged from 1-10, with 10 representing the most favorable score for a facility location.

Eleven counties within the WMC received WOS scores of eight or greater. Of the 11 counties, eight had population centers greater than 1000 citizens and road and

rail access close by. These eight counties are Bonner, Kootenai, and Boundary Counties in Idaho; Spokane County in Washington; and Lincoln, Lake, Flathead and Missoula Counties in Montana.

## Determining a Social Asset Factor

Ranking refinery site locations based on biogeophysical capabilities satisfies logistical considerations but neglects a community's willingness or cultural ability to positively engage with a new industry. The authors point out case studies that describe collaborative efforts occurring within the NARA region that succeed in one community yet fail in others. The conclusion made to explain success and failure in these cases is that communities differ in their "social assets".

Measures used in this study to characterize a community's social assets are 1) presence of rent-seeking groups, 2) presence of an arts related workforce, and 3) the health status construct. The presence of rent seeking-groups is a good indicator of a community that values networking between individuals and groups and reflects a willingness to collaborate. The presence of an arts related or creative workforce is indicative of a community that would show innovative approaches to handling change and overcoming challenges. The physical and mental health of a community will impact a workforce's commitment and ability to run a facility. All of the datasets used to score these measures are available at the county level. The authors combine these three measurements into a single score designated as a Social Asset Factor (SAF). The higher the SAF score, the greater likelihood that a community will be socially inclined to embrace a new bio-facility. The authors in this study describe a high SAF as,

"… indicative of healthy communities that have trust of their government and each other, support for new ideas, and strong leadership to turn ideas into reality."

The authors go on to say that,

"…a low SAF score may point toward additional investor challenges when trying to mobilize communities to support biomass-to-biofuel economic development opportunities."

## WMC county rankings combining biogeophysical and social asset scoring

A social asset factor was generated for the eight counties identified with high biogeophysical capabilities, and the five counties with the highest SAF score are Missoula, MT (1.69 SAF), Spokane, WA (0.79), Flathead, MT (0.75), Bonner, ID (0.32) and Kootenai, ID (0.13). Based on these results, it is anticipated that engaging with stakeholders in Missoula, Spokane and Flathead Counties will provide a positive collaborative experience.

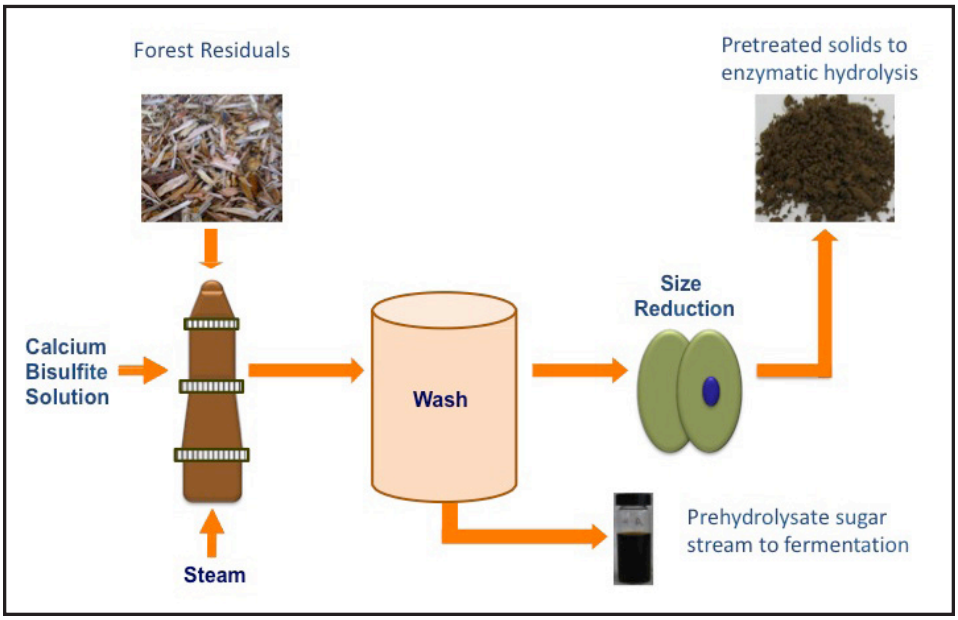
## Additional Refinements to be Done

The authors intend to apply the SAF scoring method to other arenas (natural resources, health and human services) where a new policy or facility was introduced to communities and experienced success in some and failure in others. Their intent is to see if SAF scoring could have predicted the outcome. This retroactive analysis will test the method's predictive capability to determining social acceptance. Meanwhile, the two-tiered scoring system described in this paper will be applied to other sub-regions within NARA's four-state region (ID, MT, WA and OR) in order to provide facility recommendations for those sub-regions.

Currently locations are being evaluated in western Oregon and Washington in a NARA pilot supply region called the Mid-Cascade to Pacific (MC2P) region.

Watch a presentation to learn more about work done in the MC2P region

# NARA Selects a Single Pretreatment Method




Simplified cartoon of the mild bisulfite pretreatment process

When NARA was initiated in the Fall 2011, it was tasked to evaluate available pretreatment methods and ultimately select one as a NARA-preferred method to incorporate into a wood to biojet fuel conversion process. Pretreatment is the process that breaks up the wood fibers so that enzymes can access and release the simple sugars in wood. The simple sugars are used to make isobutanol, which is further processed to make a number of products including biojet fuel.

Initially, NARA considered the below pretreatment processes:

1. SPORL (sulfite pretreatment to overcome recalcitrance of lignocellulose): This pretreatment method was developed at the USDA Forest Service, Forest Products

Laboratory, a NARA affiliate. The process relies on heat, chemicals (sodium bisulfite) and mechanical grinding.

2. Mild bisulfite (MBS): This process was developed at Catchlight Energy and USDA Forest Service, Forest Products Laboratory. The process is similar to SPORL.

3. Wet Oxidation (WO): Developed at Washington State University's Bioproducts, Sciences and Engineering Laboratory (WSU-BSEL), this process relies on pressure and oxygen.

4. Dilute Acid (DA): This method uses sulfuric acid and heat and has been widely studied and used to pretreat crop residues like wheat straw and corn stover.

> View a review of the pretreatment process

A comparative analysis between DA and SPORL pretreatment methods on wood samples determined that SPORL pretreatment delivered higher sugar and ethanol yields and facilitates lignin removal better than DA pretreatment. NARA researcher Xiao Zhang uses the DA protocol to rapidly screen Douglas-fir seedlings for susceptibility to pretreatment; but as an industrial pretreatment protocol, SPORL was a superior choice.

Over the last two years, researchers at the USDA Forest Service Forest Products Laboratory and Catchlight Energy made modifications to the SPORL protocol to create a hybrid protocol termed the mild bisulfite (MBS) pretreatment. MBS differs from SPORL by employing calcium bisulfite instead of sodium bisulfite and a lower cook temperature, which were instrumental to improved conditions for downstream isobutanol production and for adoption into existing biorefinery infrastructure.

These developments left two pretreatment protocols under consideration, MBS and wet oxidation. Last September, after NARA's annual meeting, the NARA Advisory Board recommended that NARA select a single pretreatment protocol. This action would establish a single wood to sugar conversion protocol and allow NARA teams investigating environmental and economic impacts, plus teams optimizing protocols to convert the sugars and lignin residues into products, to focus their analyses on a single wood to sugars conversion pathway. A single pretreatment protocol would also allow NARA's feedstock sourcing team to specify feedstock moisture content and particle size that best accommodate the selected protocol.

## A Phase Gate Analysis on MBS and Wet Oxidation

The Phase and Gate process is a well-known project management and decision support tool that improves project execution and promotes fact-based decision-making. Phase and Gate processes typically include "Phases", where the project work is completed, and "Gates", where decisions for continuation and next Phase objectives are set. NARA employs the Phase and Gate model, and the phase of optimizing and evaluating pretreatment protocols was wrapping up.

> Learn more about NARA's Phase and Gate model

In order to evaluate whether the MLB or wet oxidation pretreatment protocol are best suited for wood residual to bio-jet fuel and co-product industrial production, data and observations were collected and organized from multiple NARA teams. The pretreatment team evaluated both protocols for saccharification efficiency (the ability for enzymes to release simple sugars). The Gevo conversion team considered how well their specialized yeast converted the hydrolysate (sugar solution) into isobutanol. The co-products team compared activated carbon products developed from the lignin-rich residuals generated from both protocols. The techno-economics team compared the costs associated with each protocol while the life cycle assessment team considered the environmental impacts.

Linda Beltz, NARA executive committee member, summarized the detailed information from these teams into a Gate 1/2 Feasibility Analysis and Validation Packet along with conclusions and a summary. The data was reviewed by NARA team leaders and sent to the NARA Advisory Board. A conference call was held on March 28th, with NARA's Executive Committee and Advisory Board, to discuss the details and provided a single pretreatment recommendation.

## The mild bisulfite (MBS) pretreatment protocol was selected as the "preferred method"

Based on feedback from NARA's Project Director Ralph Cavalieri and review facilitator Jim Reed, the NARA Advisory Board was impressed with the report's quality and credibility and the decision to approve the MBS choice was unanimous.

The mild bisulfite protocol is still being optimized and work to scale the process and produce 1000 gallons of bio-jet fuel within the next two years is underway.

> Read TASK C-P-4 in the "Sustainable Biojet" section in the second NARA Cumulative Report for a detailed description of the mild bisulfite pretreatment process.


Keynote speaker Peter Goldmark (pictured left), Washington State Commissioner of Public Lands, is introduced by NARA's Co-Project Director Michael Wolcott at the Northwest Wood-Based Biofuels and Co-Products Conference.

# Forest residues, machines and soil: how do they mix?

The Northwest Wood-Based Biofuels + Co-Products Conference wrapped up earlier this month in Seattle WA. NARA played a lead role in developing this conference, and based on the 200 + attendance and enthusiasm displayed by the attendees, this first time event was a success.

The meeting rooms were full as the agenda matched the diversity of the audience. Students, scientists, surveyors, business owners and managers, engineers, extension agents, tribal members, educators, foresters, economic development specialists and environmental activists all came to share their interest in a developing wood to biofuel industry.

Figure 1 partitions the conference attendees according to their area of interest.

The conference provided a mix of industry and academic representatives followed by a large student and government presence. This mix fits well with NARA's mission to provide multiple stakeholders with analysis and data that facilitates a wood to biofuels and co-product industry. In addition, the sizable student presence complements NARA's goal to enhance bioenergy literacy for a sustainable work force.

A closer look at industries represented (Figure 2) reveals that interests throughout the NARA supply chain were represented. Companies, consultants and associations involved with forestry (mills, trucking, forest landowners, equipment manufactures) had 36 persons attending. Twenty-six participants were involved with conversion technology companies (Gevo, BacGen Technologies, Sundrop Fuels, BASF SE) while eight representatives were affiliated with end users (airlines, utility companies).

A breakdown of academic interests (Figure 3) also shows a diversified mix. A relative large number of "outreach" personnel were present. Outreach defined in this case primarily includes university employees involved in communications, extension services or fostering industry/university partnerships.

Various government levels were represented (Figure 4). The US Department of Agriculture and federal government laboratories had representatives present at the federal level. Representatives from state departments of ecology, commerce, natural resources and energy were present as well as a number of county economic development representatives.

This level of diversity illustrated at this conference mirrors the diversity associated with all aspects of the NARA project. Student demographics involved in NARA's educational efforts, engaged stakeholders on the NARA mailing list, and members within the NARA team bring a broad array of talents and interest to the effort of facilitating the development of a Pacific Northwest Industry that uses sustainable wood resources to supplement the use of fossil fuels.

The Seattle NPR radio station interviewed NARA Co-Director Michael Wolcott at the conference. You can read or hear their

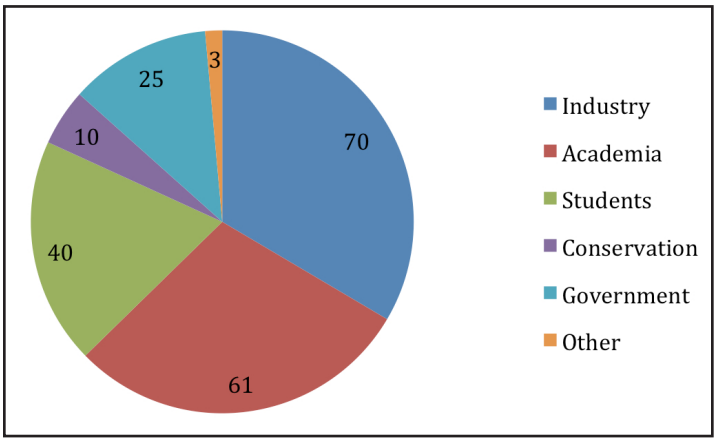



Figure 1. Number of participants attending the 2014 Northwest Wood-Based Biofuels + Co-Products Conference based on their professional category

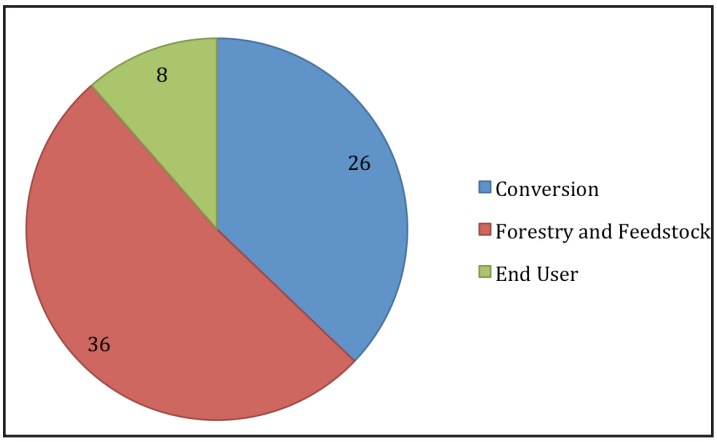



Figure 2. Number of industry participants attending the 2014 Northwest Wood-Based Biofuels + Co-Products Conference with interest in various stages in the NARA supply chain

report here. For those who missed the conference, NARA presentations can be viewed here and the proceedings can be obtained here.

NARA will help coordinate another conference similar to this one in 2016. By that time, this project will be finishing up and many new developments will be ready to share.

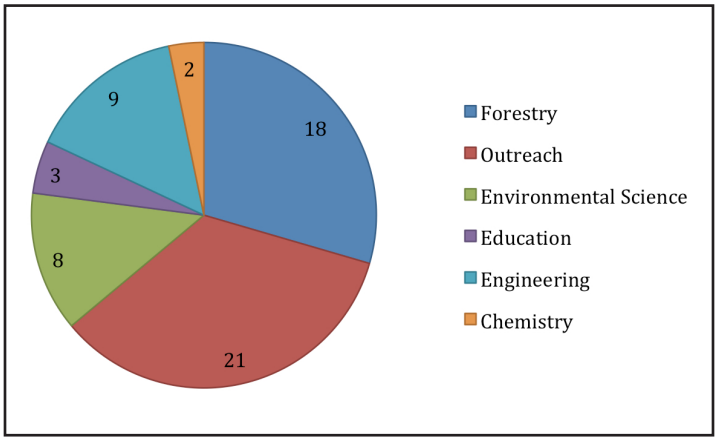



Figure 3. Number of academia participants attending the 2014 Northwest Wood-Based Biofuels + Co-Products Conference with interest in various fields of study and roles

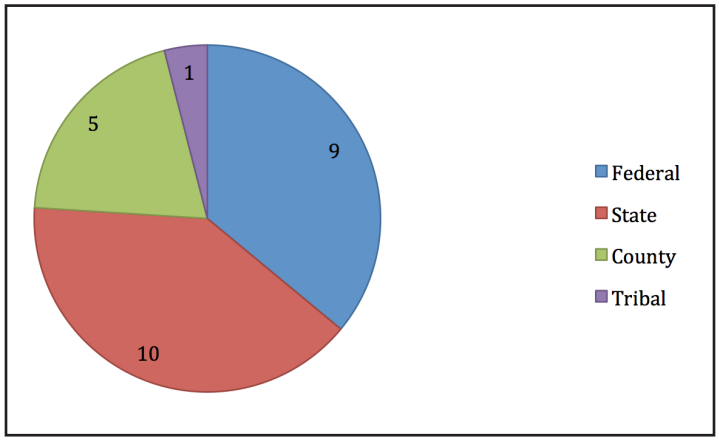



Figure 4. Number of government employed participants attending the 2014 Northwest Wood-Based Biofuels + Co-Products Conference grouped within various levels of government.

NARA is led by Washington State University and supported by the Agriculture and Food Research Initiative Competitive Grant no. 2011-68005-30416 from the USDA National Institute of Food and Agriculture.

nararenewables.org BY-NC-ND