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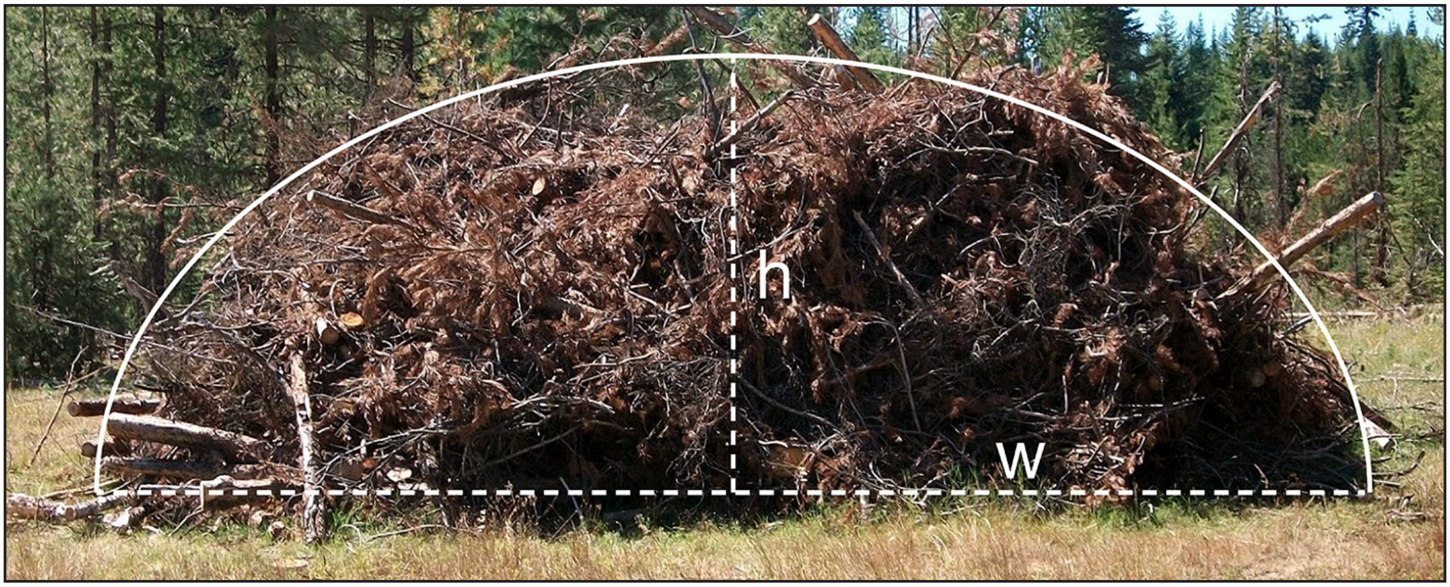


IDX students and mentors touring Weyerhaeuser's Longview facility

Smart tools to measure slash pile volumes

A woodland owner has a choice of time tested measuring techniques to predict how much lumber can be produced from trees. Accurate volume estimates can help forest managers plan for the number and type of trees to harvest and the appropriate workforce and equipment needed.

NARA provides technical assistance to an emerging industry that, instead of using the bole wood (trunk) for lumber, uses the wood residuals (limbs, tops, stumps and low grade-wood) left over after timber harvest or forest thinning to produce chemical products like biojet fuel. Here as with harvesting trees for lumber production, knowing how much feedstock, in this case forest residuals in slash piles, is available on site is helpful to plan processing and transport options.

Methods are available to estimate the amount of wood residuals attached to a standing tree, however, this volume does not necessarily represent the volume available in slash piles. First, a percentage of those residuals are left on the forest floor and second, some of those residuals may be removed to produce higher value products like pulp. With a new use for the forest residuals that normally would be burned, methods to determine the amount available need to be evaluated.

Terrestrial LiDAR to Establish Baseline
To evaluate methods used to estimate the volume of forest residuals in slash piles, NARA researchers Justin Long and Kevin Boston at Oregon State University tested two methods for 1) ease of use and 2) accuracy: one method relies on a geometric base and the other relies on a laser rangefinder. The results from their analysis are published in the journal Forest Science.

> Read *An Evaluation of Alternative Measurement Techniques for Estimating the Volume of Logging Residues*

To test the accuracy of these two methods, volume baselines were determined on 33 slash piles of different shapes and sizes using terrestrial LiDAR analysis. Terrestrial LiDAR is considered a very accurate tool to measure 3-dimentional shapes with sub-centimeter precision and is recognized as the best option to measure slash pile volumes; however, the hardware and software costs, plus the technical skill required for data analysis, make this method an unlikely choice for harvest operators due to high costs.

The Geometric Method

To use the "geometric method", the operator first visually classifies the slash pile as having one of seven geometric shapes and then calculates the volume based on the shape. For instance, if the slash pile shape is similar to a half-sphere, then the parameters measured for the volume would be the height and width. Slash piles with complex shapes may require multiple geometric shapes to be applied and added together. This method is fast and can be performed without specialized equipment; however, as the slash piles get bigger and more irregular in shape, the volume measurements stray further from the terrestrial LiDAR measurements. In addition, the operator determines which geometric shape(s) to use, so measurement variability can be increased when multiple people are taking measurements.

The Laser Rangefinder

The laser rangefinder measures distance by bouncing a laser beam off an object and calculating the distance based on time of flight. In this study, an average of 173 measurement points were determined by laser rangefinder for each slash pile, and the total surface volume was then calculated via specialized software. According to the study, "the laser rangefinder produced results that were closer to the LiDAR-generated estimates in more than two-thirds of the samples measured in this study". In addition, measurements are reproducible when using multiple users. However, since this technique requires "at least three instrument setups to ensure adequate coverage of the entire pile", it is more time consuming than using the geometric method.

Measuring the volume of raw materials such as coal, sand and gravel piles is not new. What is unique about slash piles is their irregular shape. Comparing the accuracy and ease of use between the geometric method and a laser rangefinder, the authors of this study recommend the use of a laser rangefinder.

MOSS graduate students with Dr. Karl Englund. From left to right: Hanna Ridgeway, Karl Englund, Luke Smith, Michael Wang-Belt and Ben Seipel.

Webinars highlight NARA's environmental sustainability research

NARA is tasked with enhancing the bioenergy literacy of students, educators, professionals and the general public. A critical challenge that faces NARA, and all complex enterprises, is how do you describe the work, technology, results and issues to those who are non-members of the discipline (i.e. the layperson). The effort requires communicators who are familiar with the discipline's language (jargon), methods and history and can translate that knowledge effectively to the learning audience.

NARA's task to describe its findings and challenges to K-12 students and their teachers relies on these specialized communicators and efforts are underway to train them. The University of Idaho (a NARA member) is conducting a course entitled Advanced Field Ecology Course Design that trains graduate students how to distill complex technological subjects to K-12 students.

The course is located at the McCall Outdoor Science School (MOSS) and has NARA members Jenny Schon and Karla Eitel on the instructor team. Graduate students are assigned to work on three topics important to the Pacific Northwest: 1) managing Idaho's landscapes for ecosystem services 2) using remote sensing in forestry and agricultural applications and 3) developing an industry that uses forest residuals to create biofuels and co-products.

Students Hit the Road

In the first week of March, graduate students funded by NARA hit the road throughout Washington state to learn from key individuals and organizations involved with developing fuels from woody biomass. To learn about woody biomass feedstock, they met with Washington State University extension specialist Karl Englund; Keith Thompson at WSU Tri-Cities described the technologies involved with converting wood into fuel; Carol Sim with Alaska Airlines provided a major biofuel purchaser's perspective; Carter Fox and Ian Dallmeyer from Weyerhaeuser outlined their efforts to produce products from the leftover wood material after the carbohydrates have been used to produce fuel; and finally Indroneil Ganguly and Tait Bowers of the University of Washington described how to measure and compare the carbon footprint of biofuel production to fossil fuels. A separate team visited with classroom teachers to learn how to effectively bring new science to K12 classrooms.

Translate Knowledge to K-12 Students

Learning about the topic was only one part of the course, the graduate students are also challenged to communicate their findings to K-12 students and educators using a variety of media outlets including social media and video production. In addition, they will design curricula for K-12 students highlighting wood-to-biofuel production and logistics. This work will be assisted by NARA member Facing the Future, who through NARA funding, has already published biofuels curricula.

> To read their blog posts, visit Teaching AL@MOSS

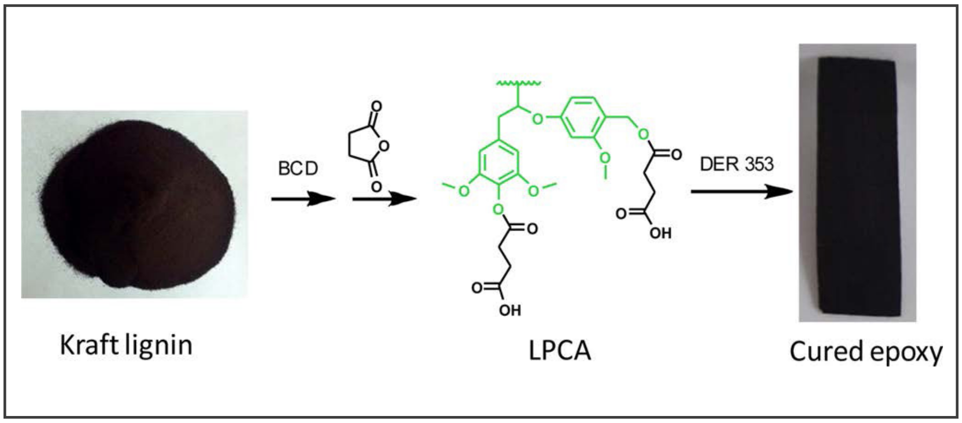
> Review and order biofuel curricula developed by Facing the Future

"Getting graduate students out to meet with the people directing this emerging industry has been an incredibly valuable and exciting part of this course", says Karla Eitel, director of education at MOSS. "In addition, those interviewed by the graduate students get the benefit of viewing their efforts from a K-12 student's perspective and contributing to bioenergy literacy improvement."

Luke Smith, a graduate student from the University of Idaho, participated in the tour. He is working towards a Master of Science in natural resources with an emphasis in environmental education. "I really enjoyed meeting with Dr. Carter Fox and Dr. Ian Dallmeyer at Weyerhaeuser to talk about lignin and lignin co-products", said Luke when asked which meeting he found most interesting. " The potential broad-reaching impacts of using the stuff left over (a mixture of lignin, polysaccharides [sugar], and other chemicals)after the biofuel conversion process is both impressive and inspiring".

In addition to this course, NARA funds multiple programs that impact a wide range of students from the elementary level through to high school and the graduate school level.

[More information that highlights the various programs funded by NARA.]



Breaking Lignin into New Biomaterials

For wood tissue, lignin plays an essential role. It is a complex molecule located in the cell walls that provides mechanical strength and allows for efficient water transport. It is also quite plentiful. Depending on the species, the lignin in wood can represent between 25 to 30% of the dry weight.

Typically, the lignin produced from the pulp and paper industry (known as kraft lignin) is considered a byproduct and burned to power electrical generators or provide heat. A number of commercial products have been produced from kraft lignin including cement dispersants, dust suppressant for roads and a variety of chemical products.

As with the pulp and paper industry, the process to convert wood residuals into simple sugars used to make biojet fuel leaves a lignin-rich byproduct. Creating products from the lignin byproduct with high economic value is one of NARA's five goals. Success in this area will help drive the economic viability of a wood residual to biojet and co-product industry.

NARA funds research to develop commercial products from a range of lignin sources. Research at the University of Minnesota under Simo Sarkanen, explores commercial use from purified unaltered lignin; work done at Weyerhaeuser uses an impure lignin source or "lignin rich" material, left over after the simple sugars in wood residuals are removed for biofuel production, as a raw material for product formation; and kraft lignin is the material investigated in a recent publication by Washington State University researchers Jianglei Qin, Michael Wolcott and Jinwen Zhang.

Obtain a copy of *Use of Polycarboxylic Acid Derived from Partially Depolymerized Lignin As a Curing Agent for Epoxy Application*

Breaking Lignin into Smaller Parts

In this paper, two important steps were accomplished. First, Jianglei Qin and his colleagues developed a process in which they "depolymerized" or broke the kraft lignin structure into smaller pieces. In doing so, they changed the properties of the kraft lignin so that it could dissolve into organic solutions. Now the "partially depolymerized lignin" (PDL) is a biomaterial that is more compatible with other materials. "This paper introduces the concept that PDLs can be used as a feedstock for the preparation of new polymer materials", says co author Jinwin Zhang, associate professor in the Composite Materials and Engineering Center at Washington State University.

Using PDLs as a Curing Agent for Epoxies

To prove his point, they next modified the PDL and used it as a curing agent to cure a commercial epoxy called DER353. Epoxy resins have excellent bonding properties and are used in a wide range of commercial applications. Curing agents can modify the epoxy characteristics for mechanical strength, chemical resistance and electrical capacity. As a curing agent, the modified PDL worked as well as commercially available curing agents.

PDL's From "NARA Lignin"

Using the PDL as a curing agent is just one of many possibilities for the new raw material and new techniques are being evaluated to create alternative forms of the PDLs. In a separate paper published recently in Bioresource Technology, Dr.

Zhang and this team created high yields of PDLs from a different lignin source derived from wood residuals after the simple sugars were removed by enzyme hydrolysis. The lignin in this case best resembles the lignin left after the conversion of wood residuals into isobutanol and therefor resembles the lignin material anticipated in the conversion from wood to biojet fuel. Here again, the PDLs from this lignin were highly soluble in organic solvents.

Having a new biomaterial like PDLs to work with opens new opportunities to create commercial products. These opportunities are not only important for creating an economically sustainable wood residual to biojet industry, but also another avenue to reduce the use of fossil fuels as a feedstock for commercially valued chemicals.

Obtain a copy of *Partial depolymerization of enzymolysis lignin via mild hydrogenolysis over Raney Nickel*

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