



Delivering Education Materials to the Classroom

One of five major goals for the NARA project is to elevate the level of bioenergy literacy, particularly as it relates to biofuels and the [NARA supply chain](#). The intent is to help the public make informed decisions and opinions about energy choices, provide the industry with timely information, and educate and prepare a future workforce for the new jobs created.

The path to develop biofuels involves several different disciplines in both the physical and social sciences. K-12 educational materials are available for these disciplines through courses, books and web-based sites, but it can be difficult to understand how the information is connected and contributes to biofuel development. In addition, new educational resources designed for K-12 classrooms that address biofuel development are being produced, and an efficient way to disseminate the content to educators is needed.

A New and Powerful Resource: the Energy Literacy Principle Matrix (ELPM)

Work led by NARA researcher [Justin](#)

[Hougham](#), a post doctoral fellow affiliated with the McCall Outdoor Science School ([MOSS](#)), created a web-based “Energy Literacy Principle Matrix” (ELPM), designed to house and effectively organize educational materials covering a broad spectrum of subjects related to biofuels. Its design is flexible and adapts well to NARA activities while providing a single site where teachers or community members can effectively find information about biofuels.

[Energy Literacy Principle Matrix](#)

For K-12 educators, this web-based resource is unique in that it cross-referenc-

es written, image and video materials to both fundamental science concepts and to the energy literacy concepts outlined by the [Department of Energy](#). If a teacher requires materials such as lesson plans, data sets, videos, images, activities software and modules to support specific science standards or topics, they can easily discover and retrieve it through the ELPM. Additionally, content can be screened for those tailored to specific grade levels.

“The matrix has already been a great help to middle and high school teachers developing projects for the upcoming [Imagine Tomorrow competition](#)”, says Justin. “I anticipate that the Energy Literacy Principles Matrix will grow and become more useful as more people use and contribute information and recommendations. It is infinitely scalable, and I think, based on the way it is organized and built, it can be used for other science-based projects as well.”

NARA

Educational Resources

The NARA Matrix is a vast collection of educational resources related to biofuel solutions that are economically viable, socially acceptable, and meet the high environmental standards of the Pacific Northwest. You can use the Matrix to find teaching materials such as lesson plans, datasets, videos, images, activities, software and modules.

[Click Here to Learn More](#)

- SEARCH** Find what the matrix has to offer.
- LEARN** Learn from the matrix's information.
- PREPARE** Prepare from the resources in the matrix.
- TEACH** Easily teach what the matrix has provided.



Douglas-fir core samples

Softwoods get a new look

Genetic selection and testing has been applied to softwood timber species for over 50 years. As a result of those efforts, commercial foresters can now plant softwood seedlings that possess desired characteristics affecting disease resistance, stress tolerance, growth rate, and wood traits such as specific gravity and stiffness: traits pre-selected to benefit a timber industry interested in healthy fast-growing trees to produce lumber, veneer and pulp.

The NARA project is helping create a new industry based on converting softwood residues, left over after commercial harvest, into biojet fuel and lignin-based co-products. Softwood characteristics important for this purpose would include a favorable ratio of carbohydrates to lignin, good carbohydrate and lignin quality during processing, and wood that releases its simple sugars well when undergoing [enzyme hydrolysis](#).

In order to help sustain this emerging industry, NARA has implemented a long-term goal to identify genetic markers in softwood lines that correlate to the downstream chemical needs for biojet and co-product production. Identifying these genetic markers should allow breeding new softwood trees lines that satisfy traditional and future use.

Sampling the population

As a first step to discover genetic mark-

ers linked to desired softwood chemical traits, [Keith Jaywickrama](#), NARA researcher and Director of the [Northwest Tree Improvement Cooperative](#) at Oregon State University, and his team obtained core samples from Douglas-fir trees possessing good industry traits and representing distinct families grown on several plantation sites. Information connected to each core sample includes the site-location, family and individual tree identification number. These core samples provide a snapshot of the wood chemistry from trees of various families and their genetic material.

Analyze Douglas-fir chemical content and susceptibility to hydrolysis

The next step is to determine whether these Douglas-fir individuals differ in traits desirable to a biofuel and bio-products industry. This job went to NARA researcher [Xiao Zhang](#), assistant professor at Washington State University, and his team. First, they analyzed a sub-set of the core samples and determined the amount of carbohydrates, lignin and extractives (resins) in each core sample before and after [pretreatment](#). The results show that the extractives, lignin and carbohydrate content varies significantly among Douglas-fir families. Some of the Douglas-fir individuals have a higher ratio of carbohydrate to lignin than others. The molecules used to make biojet fuel are

derived from carbohydrates in the wood, so individuals with higher carbohydrate content may provide an advantage in generating higher biojet fuel yield per ton of biomass.

Higher carbohydrate content, however, does not directly translate into higher yield if the simple sugars cannot be released from the wood tissue. Therefore, Dr. Zhang's team subjected these core samples to two pretreatment strategies; introduced [enzymes](#) that remove the simple sugars from the carbohydrate polymers in the wood tissue, a process known as enzymatic hydrolysis; and measured the amount of simple sugars released. What they discovered is that pretreated wood tissue from some core samples responded better to enzymatic hydrolysis, and released more simple sugars, than other samples. Pretreating the wood so that the carbohydrate polymers are accessible to enzymes used to remove the simple sugars is an expensive part of the conversion process. Processing softwood materials that release their simple sugars more readily should provide a significant impact and help lower conversion costs and improve yields.

Together, these initial experiments suggest that Douglas-fir trees vary significantly in terms of chemical content and susceptibility to enzyme hydrolysis.

Matching physical characteristics to genes

So, with evidence suggesting that some Douglas-fir trees possess traits more suitable to biofuel processing than others, the next step is to identify regions in the DNA (deoxyribonucleic acid) that contribute to these favorable traits. Generating the tools used to link the chemical characteristics of the wood tissue to the DNA sequence is a challenge taken up by [Callum Bell](#), NARA researcher and Vice President for Research at [NCGR](#) (National Center for Genomic Resources). His team is currently aligning existing DNA sequence data from many Douglas-fir lines and using this data to identify regions in the genome where nucleotide variations exist.

DNA, which supplies the code an or-

ganism uses to produce proteins and enzymes, is a linear chain of four distinct molecules called nucleotides: adenine (A), thymine (T), guanine (G) and cytosine (C). How these nucleotides arrange in sequence will affect the physical characteristics of the organism. Most of the DNA sequence between individuals within a species is identical. There are, however, regions on the DNA sequence that vary. For instance, a Douglas-fir individual from one line may have the DNA sequence AAGCTA whereas another individual from a different line contains AACCTA in the same DNA region. In some cases, this single nucleotide difference can be responsible for a physical distinction between the two individuals. Dr. Bell's team will identify DNA sequence regions where a single nucleotide in the same DNA

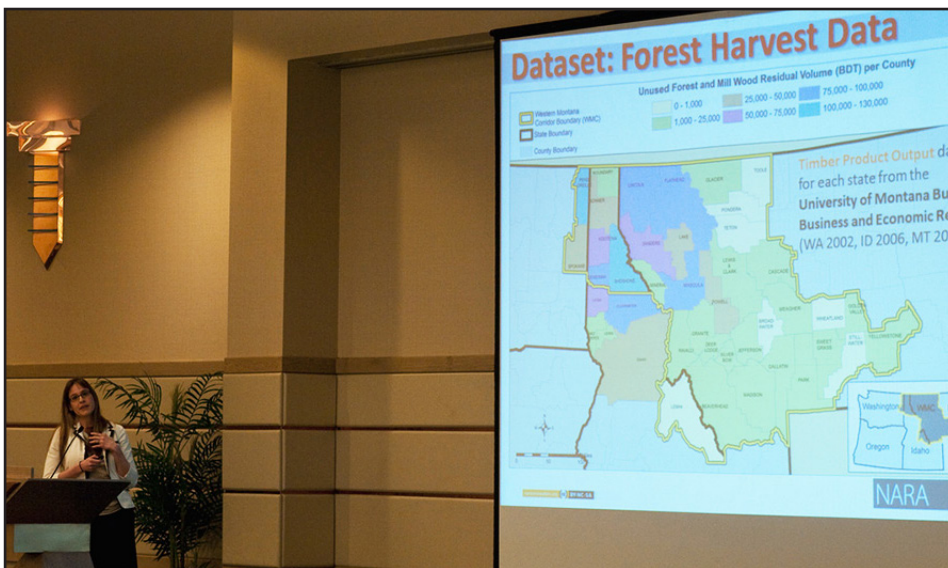
region is variable between many individuals. These variable regions are called SNPs ([Single Nucleotide Polymorphisms](#)).

Once a large number of Douglas-fir SNP sites have been identified, those DNA regions containing the SNP can be permanently attached to a solid surface resulting in a powerful resource called an [SNP array](#). The SNP array can be used to rapidly screen DNA isolated from any Douglas-fir individual in order to determine the variable nucleotide present in each SNP site.

"A single nucleotide variation by itself doesn't tell you much, but if you look at thousands of SNPs from the genomes of various individual trees, then you can develop a genotype for each one," says

Dr. Bell. "From there you can develop correlations between favorable or unfavorable traits in the trees and their genotype."

Once the SNP array is completed, DNA isolated from the core samples analyzed in Dr. Zhang's lab will be screened to determine their genotype. In addition, sequencing a softwood species like Douglas-fir will have benefits to work applied to other softwood species like ponderosa pine. With that information, softwood tree breeders, like Dr. Jay-wickrama, can begin to assign the SNP variations to traits and use these SNPs as genetic markers to breed trees that still benefit traditional users as well as a wood residue to biojet fuel and co-product industry.



NARA graduate student Natalie Martinkus speaking at the 2013 Small Log Conference - photo by Thomas Waddell, Forest Business Network

NARA participates in the 2013 Small Log Conference

NARA representatives participated at the Small Log Conference held in Coeur d'Alene, Idaho March 13th -15th, 2013. This was the sixth year for the biannual event organized by the [Forest Business Network](#). The theme for this event was titled "An Integrated Approach: Challenges, Opportunities, and Growth for a Small Log Industry", and the topics discussed certainly delivered as advertised.

The conference kicked off with keynote speaker [Evan Smith](#), Vice President of

Conservation Ventures at the [Conservation Fund](#). Yep, that's right, a conservation organization opened a conference populated with mill owners and loggers. Evan's message was that the fund's motto "Saving America's Favorite Places" and timber harvest are both important and not mutually exclusive. He articulated a position that forests represent a valuable infrastructure to American business providing clean water, quality of life, fresh air and sustainable jobs.

Starting this conference with Evan's message may seem out of place, but as the conference progressed, it was clear from the comments made by speakers and the over 200 delegates that some old systems were not working well and that new approaches to forest management and the industry were needed. In this context, NARA's message of providing a new industry based on wood residues was timely.

NARA Updates and Opportunities

NARA hosted a panel at this event moderated by NARA Co-project Director [Michael Wolcott](#) and populated by NARA members [Tom Spink](#), [Gevan Marris](#), [Natalie Martinkus](#) and [Todd Beyreuther](#). Tom described each conversion step from forest residue through to biojet fuel and provided the most current yield estimates. Gevan's presentation outlined the various feedstocks available and their chemical properties. Natalie highlighted the use of GIS to support facility site recommendations and indicate biomass availability; whereas Todd gave an analysis of how conversion and depot site selection relates to residue biomass availability. In all, the panel provided the delegates with updated information relating to NARA's goals to supply biojet fuel and co-products from wood residuals and establish supply chain coalitions.

[Tom Spink presentation](#)[Gevan Marrs presentation](#)[Natalie Martinkus presentation](#)[Todd Beyreuther presentation](#)

In addition to panel speakers, [Ivan Eastin](#), Indroneil Ganguly and Tim Bowers presented a poster describing the LCA (Life Cycle Analysis) work and used the occasion to meet with [Tim Smith](#) and Michael Wolcott and coordinate further LCA efforts. NARA outreach members [Vikram Yadama](#), [Peter Kolb](#), [Martin Twer](#),

and [Charles Burke](#) were present meeting with conference delegates and manning the NARA booth.

Community Impact

Gauging the level of impact from an event like this is a challenge. Evidently delegates were curious about NARA with new visitor [website](#) visits up 59.22 % from the previous week, 164% from the previous month, and 177% from the same week the previous year. In addition, eight signed up as stakeholders and 18 signed on to this newsletter. One of the activities featured from the NARA booth was the [NARA SURE program](#): an opportunity for

undergraduate students to conduct NARA related research and receive a generous stipend. A week after the conference, a surprising 14 applications were submitted!

According to Vikram Yadama, NARA Outreach Team leader, numerous delegates shared with him their hope that a value can be placed on the wood waste so they can afford to transport it out of the woods.

To review the Small Log Conference agenda and read testimonials, visit the [conference page](#) on the Forest Business Network website.

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