US FOREST SERVICE NORTHERN RESEARCH STATION

Research *Review*

NO. 19 | WINTER 2013

Fast-Growing Poplars Provide Solutions for Both Energy and Pollution Problems

Foresters have always sought to find trees that grow faster and bigger. But now, a targeted breeding and testing program by the Northern Research Station (NRS) of the U.S. Forest Service is producing varieties of fast-growing poplars that can meet energy needs and restore water and soil quality, as well as deliver the traditional wood products of pulp and lumber.

Forest Service Research and Development (R&D) has a long tradition of studying and improving short-rotation woody crops, with the first research projects starting in the late 1960s in the Midwest. Since then, the Northern Research Station's program has been a leader in the region, as well as nationally and internationally. Ron Zalesny, forest geneticist at the NRS Institute for Applied Ecosystem Studies (IAES) in Rhinelander, WI, continues this legacy by testing new poplar varieties that are appropriate for many different site conditions and are tailored to specific end-uses, such as producing biomass for energy and for phytoremediation.

Poplars are able to hybridize naturally among certain taxonomic groups, as well as from planned breeding efforts. Most of the variability of poplars is at the species level, and both intra- and inter-specific hybridization have been vital tools for producing progeny that outperform either or both parents for biologically and economically important traits. Zalesny is working to refine breeding, testing, and selection protocols and is providing new poplar genotypes that are matched not only to the specific conditions where they will be planted but also to their ultimate end-uses.

Intensively managed poplars in Minnesota at mid-rotation.
Photo by Ron Zalesny, U.S. Forest Service

continued on page two

continued from page one

BIOENERGY

The continually increasing costs of petroleum supplies and concerns about energy security have fostered interest in growing biomass feedstocks for bioenergy and biofuels. In addition to farm crops such as corn and sugar cane, another important source of biomass for energy portfolios is wood cellulose obtained from more efficient use of logging and mill residues or from purpose-grown short-rotation woody crops. Woody biomass can be used either directly for burning to produce electricity or indirectly as a basis for alcohol production as liquid fuels. The Energy Independence and Security Act of 2007 (EISA, Public Law 110-140) mandates that by 2022, the United States will replace 36 billion gallons per year (bg/yr) of transportation fuels with biofuels, with at least 16 bg/yr of that coming from cellulosic feedstocks.

TREE FARMING FOR BIOMASS PRODUCTION

Creation of sustainable bioenergy and biofuels industries on a significant scale is critically dependent on having an adequate supply of biomass at a reasonable cost for the long term. Success at this industrial scale will require that some trees be raised as crops. In the Southeast, this has already happened; over half of the area of southern pine resources is in intensively-managed loblolly and slash pine plantations. These species can be said to have been "domesticated." Tree form and growth rate, seedling quality, and site preparation, planting, and silvicultural techniques have been optimized through research and development, much of it by the U.S. Forest Service and its research partners. However, most of the timber output of these tree cropping systems is used for lumber and paper pulp.

Purpose-grown poplar energy crop in the Pacific Northwest.
Photo by Ron Zalesny, U.S. Forest Service.

Now, with our needs for energy crops, the horizons in tree farming are expanding. In the Midwest, members of the genus *Populus*—poplars, aspens, cottonwoods, and their hybrids—are already being grown, but mostly for producing paper pulp and materials for manufacturing particleboard. **What is particularly helpful is that poplars can be "farmed," that is, grown on marginal croplands, and thus reduce the pressure to harvest trees in naturally growing forests.**

NRS Laboratories Part of USDA Network of Regional Biomass Research Centers

In 2010, USDA Secretary Tom Vilsack created a network of regional biomass research centers to help make the most of departmental research by coordinating the various agencies that are currently working on biomass production and use. Along with NRS Assistant Director Tom Schmidt; Charles Michler of the NRS Hardwood Tree Improvement and Regeneration Center in West Lafayette, IN; and Alan Rudie and Ted Wegner from the U.S. Forest Service's Forest Products Laboratory in Madison, WI, Ron Zalesny is on the leadership team of the Northeast Regional Biomass Center. The five USDA Regional Biomass Research Centers are networks of existing USDA Agricultural Research Service and FS R&D facilities and scientists across the country with research expertise in the development and sustainable production and management of biomass.

"Domestic production of renewable energy, including biofuels, is a national imperative and that's why USDA is working to assist in developing a biofuels industry in every corner of the nation."

USDA Secretary Thomas Vilsack

PHYTOREMEDIATION

Some of Zalesny's most exciting work results from developing poplars for environmental remediation methods such as phytoremediation—the direct use of living plants alone or plants and their associated soil microorganisms—to destroy, remove, and stabilize contaminated soils, sludges, sediments, and water. Just as he does with traditional biomass trials, Zalesny tests and identifies favorable genotypes within two groups: (1) generalists that perform well over a broad range of contaminants, and (2) specialists that perform well when subjected to specific pollutants. Consequently, he studies a broad variety of contaminants. Many pollutants are industrial byproducts—heavy metals such as lead, arsenic, mercury, cadmium, etc., as well as toxic hydrocarbons such as perchloroethylene, polycarbonated biphenyls, and petroleum hydrocarbons. These are found in U.S. Environmental Protection Agency Superfund sites, mine spoils, brownfields, landfills, and other liability sites. Other pollutants result from agricultural practices such as excessive pesticide applications and other nitrate runoff from large feedlots and dairies.

Saline conditions are a problem in many areas of the world, especially arid and semi-arid regions that have been irrigated heavily with saline sources (e.g., the U.S. Southwest and the Middle East). In these areas, salt build-up over time contributes to soil conditions that inhibit plant growth. Although Midwestern soils are not inherently saline, runoff from deicing road salts is a major concern, as are municipal and industrial wastewaters.

Along with partners from the U.S. Forest Service (Chris Soriano, International Programs; John Stanturf, Southern Research Station) and USDA Agricultural Research Service (Steve Evett), Zalesny was recently part of an USAID project in Egypt addressing such issues, whereby poplars were among the tree species that were tested for afforestation in the Nile River Valley.

The major advantage of using poplars for phytotechnologies is that these natural systems typically cost one-third to one-half of traditional methods. However, proper plant selection is necessary for system success as uptake into roots, wood, and leaves depends on matching pollutants with favorable poplar varieties ("active remediation"). In addition, certain genotypes are associated with soil microorganisms that break down contaminants in the root zone ("passive remediation"). Zalesny has developed "phytorecurrent selection," a method that consists of revising and combining crop and tree improvement protocols to meet the objective of utilizing superior poplar genotypes for broad-ranging phytotechnologies. The ultimate goal is to deploy a combination of genotypes with improved phytoremediation potential over the original set of clones, with adequate genetic variation to guard against insect/disease outbreaks, changes in soil conditions, and unfavorable genotype-environment interactions.

Poplar tree being irrigated with high-salinity landfill leachate in northern Wisconsin. Photo by Ron Zalesny, U.S. Forest Service.

Mature poplar stand in southwestern Wisconsin.
Photo by Ron Zalesny, U.S. Forest Service.

From World's Largest Landfill to New York City's Newest Park: NRS Scientists Help Restore Freshkills Salt Marsh, Staten Island

Located at the southwestern corner of Staten Island, New York City, the Freshkills salt marsh became the world's largest landfill during the latter half of the 20th century (*kill* is Middle Dutch for "stream, creek, or arm of the sea"). Since the landfill was closed in the 1990s, the NYC Department of Parks and Recreation has been working to convert the landfill into a park and citywide cultural destination through extensive ecological restoration and landscape planning efforts. At 2,200 acres, Freshkills Park will be the largest park developed in New York City in over 100 years.

View from atop North Mound of Freshkills with the Manhattan skyline in the background. Photo by Ron Zalesny, U.S. Forest Service.

Northern Research Station scientists are at the forefront of social science and biological research at Freshkills, working in partnership with the City of New York. In particular, NRS research social scientists Lindsay Campbell and Erika Svendsen from the Forest Service's New York City Urban Field Station, along with partners at Purdue University, have been documenting the development process and studying Staten Island residents' memories of the landfill and their fears and interests in using the future park.

From the biological side, Ron Zalesny has teamed with Rich Hallett (Center for Research on Ecosystem Change/New York City Urban Field Station), Nancy Falxa-Raymond (New York City Urban Field Station), and Mary Beth Adams (Ecological and Economic Sustainability of the Appalachian Forest) to assess the feasibility of using trees and grasses to improve ecosystem health and functioning at Freshkills Park—a long-term, deliberate forest succession project with two major research areas: tree genetics and physiology, and soil ecology. They are currently propagating over 100 unique native poplar and willow genotypes collected from Staten Island to be used in early phytorecurrent selection and will outplant the most successful genotypes at Freshkills Park.

Propagation of native Staten Island poplar during initial stages of Freshkills study. Photo by Ron Zalesny, U.S. Forest Service.

Ron Zalesny is a team leader and research plant geneticist at the Northern Research Station's Institute for Applied Ecosystem Studies at Rhinelander, WI; a member of the leadership team of the USDA Northeast Regional Biomass Center; and the program manager for USFS Northwoods Environmental Scholars Program and an advisor to the University of Wisconsin (Stevens Point) LEAF K-12 Forestry Education Program. He studies genetic and physiological mechanisms regulating biomass production of short-rotation woody crops (poplars and willows) grown for bioenergy, fiber, and phytotechnologies. He provides policy-relevant input on bioenergy opportunities for the Northern Research Station and U.S. Forest Service. Ron received his PhD from Iowa State University (McNabb Excellence Fellow) in forest biology (2003) and his BS from the University of Minnesota (1999). He joined the Forest Service in 1995.

RESOURCES AND REFERENCES

Websites:

Northern Research Station Websites:

NRS Center for Research on Ecosystem Change:
www.nrs.fs.fed.us/units/crec
NRS Institute for Applied Ecosystem Studies:
www.nrs.fs.fed.us/units/iaes/focus/energy_climate_genetics
NRS Hardwood Tree Improvement and Regeneration Center:
www.nrs.fs.fed.us/units/htirc
NRS New York City Urban Field Station: www.nrs.fs.fed.us/nyc
NRS Renewable Energy in the Appalachians:
www.nrs.fs.fed.us/units/appalachian

U.S. Government Websites:

USDA Biomass Research Network:
www.csrees.usda.gov/nea/technology/pdfs/11_bioenergy.pdf
U.S. Forest Service, Research and Development:
www.fs.fed.us/research/biomass-bioenergy
U.S. Forest Service, National Woody Biomass Program:
www.forestsandrangelands.gov/woody_biomass
U.S. Environmental Protection Agency:
www.epa.gov/superfund
U.S. Geological Survey:
www.usgs.gov/science/science.php?term=769

Technical Information Websites:

International Phytotechnology Society: www.phytosociety.org
Interstate Technology and Regulatory Council: www.itrcweb.org
Poplar Council of Canada: www.poplar.ca
Short Rotation *Populus*: A Database of North American Literature:
www.poplardatabase.com
Short Rotation Woody Crops Operations Working Group:
www.woodycrops.org

Books:

Dickmann DI, Isebrands JG, Eckenwalder JG, Richardson J, eds. 2001. **Poplar Culture in North America.** Ottawa: NRC Research Press.

Stettler RF, Bradshaw HD Jr, Heilman PE, Hinckley TM, eds. 1996. **Biology of *Populus* and Its Implications for Management and Conservation.** Ottawa: NRC Research Press.

References:

Vance ED, Maguire DA, Zalesny RS. Jr. 2010. **Research strategies for increasing productivity of intensively managed forest plantations.** Journal of Forestry 108: 183-192.

Zalesny JA, Zalesny RS Jr, Wiese AH, Sexton B, Hall RB. 2008. **Sodium and chloride accumulation in leaf, woody, and root tissue of *Populus* after irrigation with landfill leachate.** Environmental Pollution 155: 72-80.

Zalesny JA, Zalesny RS Jr, Wiese AH, Hall RB. 2007. **Choosing tree genotypes for phytoremediation of landfill leachate using phyto-recurrent selection.** International Journal of Phytoremediation 9: 513-530.

Zalesny RS Jr, Donner DM, Coyle DR, Headlee WL. 2012. **An approach for siting poplar energy production systems to increase productivity and associated ecosystem services.** Forest Ecology and Management 284: 45-58.

Zalesny RS Jr, Stanturf JA, Evett SR, Kandil NF, Soriano C. 2011. **Opportunities for woody crop production using treated wastewater in Egypt. I. Afforestation strategies.** International Journal of Phytoremediation 13(S1): 102-121.

Zalesny RS Jr, Cunningham MW, Hall RB, Mirck J, Rockwood DL, Stanturf JA, Volk TA. 2011. **Woody biomass from short rotation energy crops.** In: Sustainable Production of Fuels, Chemicals, and Fibers from Forest Biomass. Zhu JY, Zhang X, Pan X, eds. Washington, DC: American Chemical Society: 27-63.

Zalesny RS Jr, Hall RB, Zalesny JA, McMahon BG, Berguson WE, Stanosz GR. 2009. **Biomass and genotype × environment interactions of *Populus* energy crops in the midwestern United States.** BioEnergy Research 2: 106-122.

Zalesny RS Jr, Bauer EO. 2007. **Selecting and utilizing *Populus* and *Salix* for landfill covers: implications for leachate irrigation.** International Journal of Phytoremediation 9: 497-511.

US Forest Service
Northern Research Station
359 Main Road
Delaware, OH 43015

Contact the Northern Research Station
www.nrs.fs.fed.us

Michael T. Rains
Station Director
11 Campus Boulevard #200
Newtown Square, PA 19073

610-577-4017
mrains@fs.fed.us

Rebecca G. Nisley
Writer and Editor

203-230-4338
rnisley@fs.fed.us

For additional copies or to be put on the mailing list, email nrspubs@fs.fed.us or call 740-368-0123.

NRS Research Review is published quarterly by the Communications and Science Delivery Group of the Northern Research Station (NRS), U.S. Forest Service. As part of the nation's largest forestry research organization, NRS serves the Northeast and Midwest and beyond, providing the latest research on current problems and issues affecting forests and the people who depend on them.

Our research themes are (1) Forest Disturbance Processes, (2) Urban Natural Resources Stewardship, (3) Sustaining Forests, (4) Providing Clean Air and Water, and (5) Natural Resources Inventory and Monitoring.

There are 135 NRS scientists working at 20 field offices, 24 experimental forests, and universities located across 20 states, from Maine to Maryland, Missouri to Minnesota.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternate means for communication of program information (braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, S.W., Washington, DC 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.