

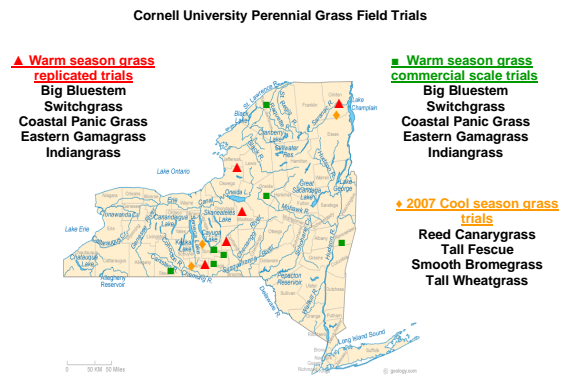
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Introduction

New York State and the Northeast (NE) Region stakeholders' interests in the evolving bioenergy and bioproducts economy are driven by a number of diverse issues including rural economic development, regional energy security and climate change mitigation. There are a number of federal policies that have been put into place to respond to these drivers, such the Renewable Fuels Standard that mandates the production of 16 billion gallons for cellulosic biofuel use by 2022. Such a rapid expansion in biofuels production will require large increases in feedstock production. It will necessarily be transformational as we in the NE seek to do our part in securing our national energy security. In addition, vibrant feedstock acquisitions and feedstock conversion industries must be developed based on the NE resource base and infrastructure and these industries will generate greatly needed green jobs. Cornell researchers and educators are doing their part to catalyze the development of sustainable agriculturally-based bio-industries through innovative research programs, and by educating the next generation of young innovators, entrepreneurs and leaders. This document provides brief snapshots of some selective Cornell biofuels research, education and outreach programs.

Feedstock Development

Perennial Grasses Breeding: Research and Extension. Dr. Donald Viands, Professor of Plant Breeding and Genetics at Cornell University, is leading a multi-disciplinary (plant breeding, plant pathology, seed science, soil and crop science, agricultural economics, agricultural education, weed science, plant biology, biological and environmental engineering) renewable energy research effort focused on the production of perennial grasses for use as bioenergy feedstock for conversion to liquid fuels, gases and combustible products. Starting in 2007, his program began establishing warm and cool season perennial grass trials (~95 acres) in small and large plot experiments in diverse regions of NY. Through these on-going trials the project has been able to collect data on grass yield in monoculture and polyculture systems, nutrient use efficiency, occurrence and severity of pests and pathogens, and chemical compositional characteristics related to downstream energy conversion. The Cornell project is also a participant in a Regional Herbaceous Feedstock Production Trial, sponsored by the Sun Grant Initiative and the US Department of Energy, and has recently received a USDA/NIFA award "Carbon sequestration and gaseous emissions in perennial grass bioenergy cropping systems in the Northeastern US" to quantify



carbon and greenhouse gas flux in perennial grass systems. In addition, Viands is leading a grass breeding program (approximately 16,000 individual plants transplanted from germinated seed collected from the Northeast) to develop switchgrass and big bluestem varieties for dedicated use as bioenergy feedstocks in the region. With support from the New York Farm Viability Institute, Dr. Gary Bergstrom, Professor of Plant Pathology, is leading an investigation of methods for managing switchgrass smut to prevent pathogen spread and significant biomass losses in this fledgling crop.

Woody Feedstock Breeding and Genomics: Research and Extension. Previous regional assessments have concluded that the deployment of dedicated short-rotation shrub willow bioenergy crops can contribute significantly to the sustainable production of bioenergy and bioproducts in the Northeast. Recent breeding and commercialization of shrub willow has been sufficient to demonstrate their suitability as dedicated energy crops, but there is tremendous potential to optimize yields and reduce inputs through advanced genomics, breeding, and integration with production and conversion systems. The primary focus of research in Professor Larry Smart's lab is on breeding and identification of new shrub willow varieties with the potential to produce high yields across a wide range of climatic zones and on marginal sites, also displaying improved pest and disease resistance so as not to demand any inputs of pesticides. Willow breeding is advancing in the age of genomics, as we are working with the USDOE Joint Genome Institute to sequence the *Salix purpurea* genome in collaboration with Oak Ridge National Lab and the J. Craig Venter Institute. While recent breeding selection trials indicate that new varieties may produce as high as 15-20% improvement in growth over existing commercial varieties bred and patented in this program, the prospects for continued improvement will be strengthened by the use of genomics-assisted discovery of the genes controlling key traits for biomass production and stress tolerance. To further encourage commercialization, we have established business relationships with a large production nursery (Double A Willow) to support the deployment of superior varieties. We also partner with Cornell Cooperative Extension in developing programming for the delivery of science-based information to growers, aggregators, and conversion facility managers. This past year we launched the Willowpedia web site (<http://willow.cals.cornell.edu>) to serve as a clearinghouse for technical information and a focal point for extension and outreach.



Biofuels Research Laboratory

Cornell's Biofuels Research Laboratory (BRL) is an 11,500 square ft facility designed and built to address biological barriers to the development of cellulosic biofuels such as ethanol, butanol, hydrogen, and methane. Funding for the BRL was provided by Empire State Development Corporation (ESDC) through a grant entitled "Enabling Cornell's Research Capacity for Developing New York State Biofuels/Industrial Biotechnology Sector." This facility is currently under the directorship of Professor Larry P. Walker. Within the walls of this state-of-the-art facility Cornell has built major research capacity to address scientific and technical barriers to liberating sugars from energy crops, such as switchgrass and woody biomass, and to biologically convert these sugars into biofuels. The BRL houses laboratories for the following activities: 1) feedstock size reduction and handling, 2) feedstock pretreatment, 3) biochemical conversion, 4) submerged and solid-state fermentation, 5) state-of-the-art analytical systems, and 6) office space designed to accommodate



researchers from different disciplines that are participating in multidisciplinary research projects. Some of the technological breakthroughs that have been achieved in the BRL are: 1) the development of a greener and robust biomass pretreatment process that reduces the number and amount of chemicals needed to make feedstock more biodegradable (Professors Larry Walker and Jeff Tester, Cornell); 2) the development of novel enzymatic processes for lignin utilization based on nano-magnetic particles technology (Dr. Stephane Corgie and Professors Emmanuel Giannelis and Larry Walker, Cornell); 3) identification of novel plant cell-wall degrading enzymes from the world of plant pathogenic fungi (Dr. Donna Gibson, USDA, Dr. Marshall Hayes, and Professors Gary Bergstrom and Larry P. Walker, Cornell); and 4) the development of improved yeast strains that exhibit higher ethanol tolerance or yield higher lipid content for biodiesel development (Dr. Manual Villa and Professor Susan Henry and Larry P. Walker, Cornell). An important objective for the BRL is the development of integrated intellectual property that improves the overall performance of the conversion system.

State and Regional Collaborations

As the land-grant institution for the State of New York, Cornell has had a tradition of helping New York and Regional stakeholders tackle major economic, environmental and social challenges. Thus it should come as no surprise that Cornell researchers and educators are very active in several state and regional efforts to enable a green economy. Through these initiatives Cornell can leverage its innovative research, education and outreach programs to build strategic partnerships and consensus to enable the emerging green economy. The following are examples of how Cornell researchers and educators are continuing the land-grant tradition of community engagement.

New York Renewable Fuels Roadmap. Several Cornell researchers and educators were active participants in drafting of the “New York Renewable Fuels Roadmap and Sustainable Feedstock Supply Assessment.” In drafting this report the expertise of over 40 scientists, engineers, economists, government and industry experts was tapped to provide the “best” estimates for the sustainable production of biomass feedstocks. Dr. Corinne Rutzke served as Co-project manager and Editor in the effort led by Pace University Energy and Climate Center, performed on behalf of the New York State Energy Research and Development Authority, The New York Department of Agriculture and Markets, and the New York Department of Environmental Conservation. Professor Larry Walker served as an “Expert Advisor” to the NY Roadmap project. A major conclusion of this report is that New York State could produce and process sufficient biomass to replace 5.6 to 16% of liquid transportation fuels projected to be used in the State by the year 2020. The Roadmap was a report to Governor David Patterson and the Governor’s Renewable Energy Task Force. The first detailed public reporting of the NY Renewable Fuels Roadmap and Sustainable Feedstock Supply Assessment was through the Northeast Sun Grant Initiative (NESGI) Annual Conference, held in Syracuse, NY, in May 2010.

Northeast Sun Grant Initiative. The Northeast Sun Grant Initiative (NESGI) is a Federally Authorized regional competitive grants program with National coordination between the five Sun Grant Regions, focusing on biobased energy and products (<http://www.nesungrant.cornell.edu>). The Northeast Sun Grant region includes the States of Connecticut, Delaware, Massachusetts, Maryland, Maine, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Vermont, and West Virginia, and the District of Columbia. The Northeast Sun Grant is led by Director Larry Walker at Cornell University and an 11-member regional Steering Committee. Funding for the NESGI is provided by the United States Department of Transportation (USDOT), United States Department of Agriculture (USDA), and United States Department of Energy (USDOE). The majority of federal appropriations are from the USDOT Highway Bill. The NESGI research grants portfolio includes 40 biofuels and bioproducts research, outreach and education projects in the strategic areas of biomass feedstock development, conversion technologies, harvest, storage and transportation logistics, economics, social, and environmental factors, and policy analysis. The first funded

studies (2007) have recently concluded and have made significant contributions to our understanding in plant genomics for selecting plants with higher energy value (Prof. Jocelyn Rose, Cornell Univ.) discovering a new microbe from oceanic geothermal-vents that is more efficient at breaking down cellulose than any other reported microbe (Prof. James Holden, Univ. of Massachusetts); identifying, testing and breeding novel crops, such as Hazelnuts, that can out-produce soybeans in the Northeast in oil production per acre per year (Prof. Thomas Molnar, Rutgers Univ.). In addition to funding research and education projects, the NESGI is also making a difference by hosting annual conferences that serve as major networking opportunities for regional researchers, educators and stakeholders to reach a consensus on a regional vision for the Northeast bioeconomy.

Northeast Bioenergy and Bioproducts Faculty Development Programs. Several NESGI researchers and educators are actively developing major regional initiatives focused on green jobs education and development in New York and the NE. USDA National Institute for Food and Agriculture just recently announced the selection of Cornell to lead a “Northeast Bioenergy and BioProducts Faculty Development Program.” This summer program provides opportunities for teachers (grades 6-16) interested in expanding their basic understanding of biobased energy and biobased products and incorporating these topics in their classroom through hands-on activities. The program is directed by Dr. Corinne Rutzke at Cornell University and operates through five Mirror Training sites in the Northeast Region: Main site: Cornell University and Boyce Thompson Institute in Ithaca, NY; Ohio Bioproducts Innovation Center at The Ohio State University in Columbus, Ohio; University of Maryland Eastern Shore in Princess Anne, Maryland; Delaware State University in Dover, Delaware; and Pace University Energy and Climate Center in White Plains, NY. Professor Larry P. Walker is playing an advisory role for this program



The summer program offers 66 teacher training positions annually (10 Certified Master Teacher Trainers, 50 Master Teachers and 6 Summer Internship positions). Master Teachers will be trained on a suite of bioenergy and bioproducts teaching tools including bioenergy and bioproducts interactive white board lessons, and will be qualified to train other teachers on use of the same kits and materials at their home-schools. The program provides bioenergy and bioproducts workbooks, lab-kits and engagement activities for classrooms (with school-year follow up support from each mirror site) that have been developed by the Main and Mirror site partners. Interns work with a specific research laboratory or industry partner.

Why Cornell?

Cornell is in a unique position to serve as a catalyst for the development of the New York State bioenergy and bioproducts sector. It is the only institution in the Ivy League that has a land grant mission that includes improving economic opportunities for rural communities and developing sustainable agriculturally-based systems. **New York State has traditionally looked to Cornell to be an objective and progressive resource on issues bearing on the economic well-being of New York State residents.** In the past Cornell has helped the State maintain its productivity for several major production agriculture and agribusiness sectors, addressed issues of rural development, and played an important role in responding to environmental quality issues. This long tradition of being involved in rural development has its foundation in the thinking and leadership of Liberty Hyde Bailey, the first Dean of the College of Agriculture. Our biofuels and bioproducts researchers and educators are keeping this tradition alive!