Northeast Sun Grant Initiative Feedstock Summit November 12, 2007

Review of the Northeast Sun Grant Initiative Competitive Grants Program

2007 and 2008

Sun Grant Legislative Authority

- Authorized by Congress in 2004
- Build a network of regional land grant universities partnering to build a bio-based economy that will benefit America's farmers, rural communities and the public at-large
- 5 regional centers – Cornell U., U. Tennessee, South Dakota State U., Oklahoma State U., and Oregon State U.

Northeast Sun Grant Initiative Competitive Grants Program

The regional Sun Grant mission is to focus the intellectual capacity of the region's land grant universities in partnership with the private sector to enhance national energy security through the development, distribution and implementation of bio-based energy technologies, promote bio-based diversification and environmental sustainability of the region's agriculture, and promote opportunities for bio-based economic diversification in rural communities in assisting the region and the nation move toward greater energy independence.

Sun Grant Strategic Area Descriptions

- BioFuels – Biomass resources that are used to replace fossil fuels for transportation, etc.
- BioPower – Use of renewable biomass as a fuel to produce heat and electricity. Biopower production utilizes similar equipment and conversion technology, such as thermal gasification, as is used for petroleum based fuels.
- BioProducts – Chemicals and materials made from biomass resources that may traditionally come from petroleum resources, e.g., biodegradable plastics and biobased industrial chemicals.

Sun Grant Enabling Activities

- Feedstock Development
  - Plant breeding and selection
  - Agronomic practices for optimal sustainable yields
  - Equipment technologies for sustainable harvests
  - Multiple land use issues, e.g., agronomic production, wildlife habitat, soil and water conservation

Sun Grant Enabling Activities

- Conversion Processes
  - Conversion efficiency
  - Cost of production
  - Enzymatic conversion
  - Thermo-chemical conversion

Sun Grant Enabling Activities

- Systems Integration
  - Feedstock transport, delivery and storage
  - Biofuel transport
  - Environmental Impact
    - Greenhouse gas emissions
    - NOX emissions
    - Carbon flow models
    - Systems modeling analysis to assist and evaluate scale alternatives for biorefineries
    - Transportation infrastructure and logistics analysis modeling

Sun Grant Enabling Activities

- Marketing, Economic and Policy Issues
  - Economics and policy analyses
  - Impact on food, feed and fiber markets
- Education and Outreach
  - e-Extension activities
  - Rural development outreach

Sun Grant Program Priorities

Proposals should demonstrate value to the region and to stakeholders, by:

- Addressing the potential quantity of fossil fuels replaced
- Number of NE states to be impacted
- Number of farms or rural communities impacted, and how
- Number of acres of land involved
- Potential for commercialization of a technology

Northeast Sun Grant Initiative Competitive Grants Program FY 2007

- Awarded $985,000
  - 1 Lead proposal
  - 7 Seed proposals
- Preproposals submitted
  - 37
- Proposals submitted
  - 38: 30 Seed proposals; 8 Lead proposals

Northeast Sun Grant Initiative Competitive Grants Program FY 2007

- Lead proposals – Multi-investigator, multi-institutional, multi-disciplinary and/or multi-year proposals that address the priorities of the NESGI while integrating research, education and outreach objectives. Up to 600K
- Seed proposals – Grants to individual PI's and small teams for up to 100K

Northeast Sun Grant Initiative Competitive Grants Program FY 2007

- Analysis by proposal
  - Economics and policy - 8
  - Biomass production - 13
  - Systems integration - 2
  - Conversion technologies - 8
  - Education and outreach - 3
  - Environmental impact - 1
  - Land use - 2

Northeast Sun Grant Initiative Competitive Grants Program FY 2007

- Submissions by state

Maine - 4
Ohio - 3
Michigan - 3
Maryland - 5
Mass - 1
DC - 1
Connecticut (New Haven) - 1
NJ Rutgers - 2
NY Cornell - 6
Penn State - 7
West Va. - 2
Rhode Island - 1
Connecticut (Storrs) - 1

2007 Northeast Sun Grant Funded Projects

Overview of Funded Projects' Objectives

A Biofuel Screening Program for Grass Feedstocks: Diversity, Physiological Traits and Compositional Characteristics for Optimal Yield.

PI: Jocelyn Rose, Cornell University. $100,000, 2 years

OBJECTIVES

Collection and performance evaluation of a broad range of monocultures and mixed stands of grass species and cultivars grown at multiple locations, on a range of soil types and under different fertilizer regimes, incorporating a variety of harvesting dates.

(1) Biomass yield analysis

Data related to biomass yield of the various grasses under evaluation will be derived from: ***(a)*** replicated small research plots seeded in Ithaca on Cornell land and at 4 other locations across the state; ***(b)*** a demonstration nursery and existing replicated trials at the USDA-NRCS Big Flats Plant Materials Center (PMC) NY and the National PMC in Beltsville MD and other selected PMCs; ***(c)*** species mixtures, to compare with the monoculture plots. The test plots will be planted and harvested by Cornell researchers and collaborators; ***(d)*** ecotypes of eastern North American grass species provided by Ernst Conservation Seeds

(2) Predicted ethanol yield analysis

Samples for lab analyses will be collected from the Cornell test plots will be assayed by bomb calorimetry.

(3) Stand establishment and pests

Plots will be observed for weeds, diseases, and insects.

Developing the Potential of Hazelnuts as a Feedstock for Biodiesel and other Oleochemicals in the Northeast.
PI: Thomas Molnar, Rutgers University. $58,062, 2 years

- Investigating Hazelnuts as a high yielding feedstock for biodiesel and other oleochemicals. Calculated yield of 0.89 tonnes oil/hectare in NW. (Compare to US avg for soybean, 0.5 tonnes oil/hectare).
- Primary limiting factor for northeastern US production is Eastern Filbert Blight (EFB)
- Have 5000 controlled hybridizations, 200 genotypes with resistance to EFB, later flowering.

OBJECTIVES

- Evaluate kernel percentage and crude kernel oil content of top 200 genotypes.
- Top 25 performers: evaluate fatty acid profiles (gc-looking for high oleic,linoleic, low saturated)
- Top 10 performers from objective 2: clonally propagate and establish replicated yield trial
- Initiate a genetic improvement program to examine inheritance of oil traits in hazelnut.

Project timeline

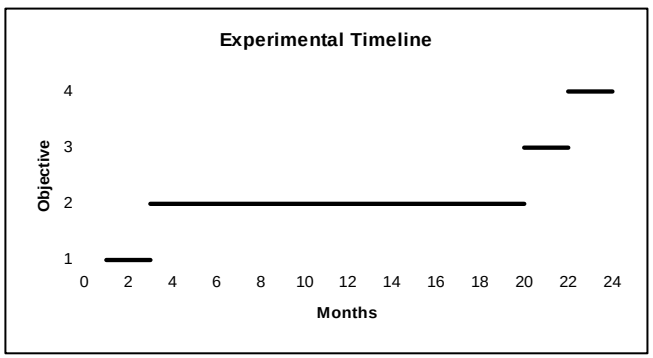
Objective	2007	2008	2009
1	-------	---	
2	-------	---	
3	----------	----------	----------
4			----------

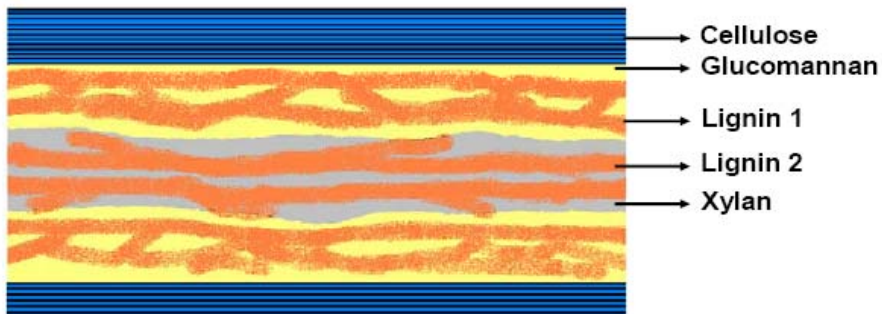
Improving Woody Biomass Separation by Enzymatic Means, PI: Nancy Kravit, University of Maine in collaboration with Tethys Research $90,581, 2 years

- Exploring enzymatic fractionation of wood (as alternative to chemical fractionation).
- Have used an artificial substrate (hemicellulose ether-bonded to lignin, fluoresces when broken) to search for novel enzymes (existing collections and Maine forest sources)
- Have 3 organisms with putative hemicellulose:lignin etherase (HLE) activity, appear to have HLE activity specific for galactomannan-lignin ether bonds.

OBJECTIVES

- to determine the best starting material for the isolation, i. e. whether to use culture supernatant or a subcellular fraction,
- to devise an isolation scheme,
- to confirm its activity on natural lignin-hemicellulose complexes (in natural wood extracts) as opposed to synthetic model compounds, and
- to microsequence the activity and determine its identity or reveal similarities to known protein families.





Enhanced Microbial Cellulose Degradation and H_2 Production above 80C. PI: James Holden, University of Massachusetts. $22,346, 1 year

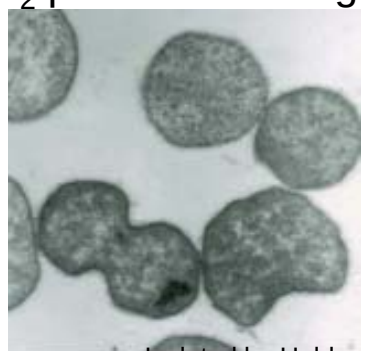
- Microbial growth rates on cellulose increases with temperature, but previous studies do not extend beyond 74 °C.
- Cellulose hydrolysis is generally the rate limiting step for growth, it is hypothesized that the rate of cellulytic enzyme activity (i.e., b(1->4) endoglucanases) and cellulose degradation also increases with temperature.
- Study focuses on hyperthermophiles *Pyrococcus* and *Thermococcus* (85 and 95 °C)

OBJECTIVES

- Screen the PI's culture collection (>25) of *Pyrococcus* and *Thernococcus* strains from deep-sea geothermal hydrothermal vents for ability to grow on Avicel (microcrystalline cellulose).
- Determine microbial growth rates and compare to other known cellulose degraders below 80°C.
- Bioreactor (20L) studies on most promising lines: Determine whether these organisms can degrade cellulose with H_2 as the primary waste product and quantify H_2 per cell doubling.

Table 1. Time table of research activities for this study

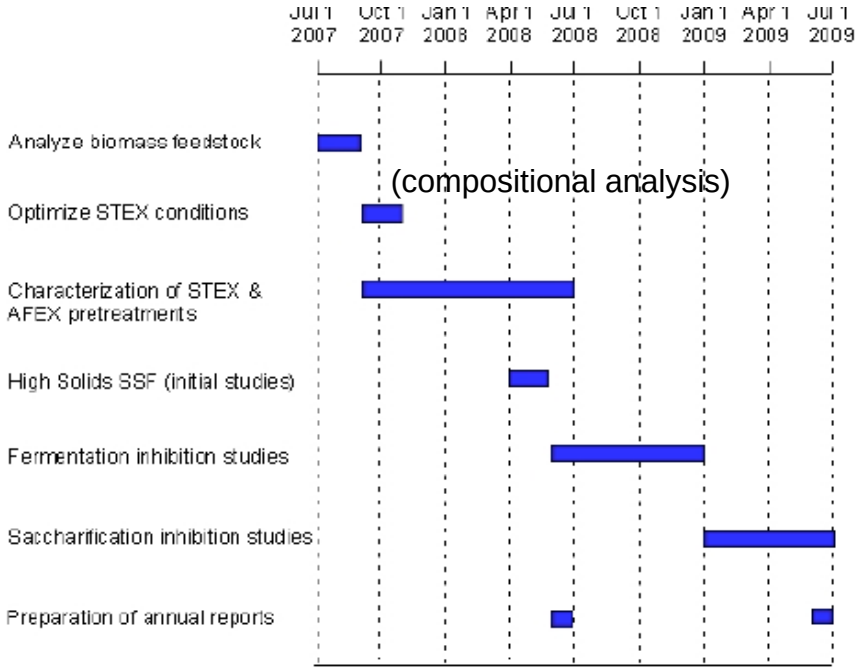
Research Step	Month											
	J	A	S	O	N	D	J	F	M	A	M	J
Organism screening	•	•	•	•	•	•						
Growth kinetic study				•	•	•	•	•	•			
Bioreactor study							•	•	•	•	•	•
Poster presentation of results												•



Thermococcus, sp. Isolated by Holden et al., 1998

Influence of Alternative Pretreatment Strategies on Cellulosic Ethanol Production using Simultaneous Saccharification and Fermentation at High Solids Concentrations.
PI: James Gossett, Cornell University. $99,999 2 years

- Conversion of lignocellulosic biomass to ethanol
  - – Preferred process is a thermochemical pretreatment followed by enzymatic hydrolysis to fermentable sugars and fermentation.
  - - Simultaneous saccharification-fermentation (SSF) allows both processes at once.
    - Advantages: Results in higher ethanol concentration, lowering distillation costs
    - Disadvantages: with high solids, challenges in pumping & mixing, inhibitory by-products



- Fundamental research on two classes of SSF pretreatment 1) (acidic – steam explosion (STEX) and 2) alkaline –ammonia fiber explosion (AFEX)) of switchgrass at high solids concentration (20-40 % w/v)

- Addressing high-solids conc. issues of:
  - Interference with saccharification
  - Interference with fermentation
  - Direct inhibition of enzymes & yeast
  - Substrate masking through re-deposition of solubilized lignin products

Development of a Temperature-phased Anaerobic Digestion Process for Enhanced Conversion of Solids in Livestock Manure and Food Wastes to Methane.

PI: Dr. Zhongtang Yu, Ohio State University. $100,000, 2 years

- Methane production by anaerobic digestion is considered on the best methods to generate methane bioenergy, especially from livestock manures and food-processing wastes, however up to 50% of the lignocellulosic solids pass through AD undigested.

OBJECTIVES

- Develop a temperature-phased anaerobic digester (TPAD) process with enhanced digestion of solids by increasing hydrolysis of lignocellulose in these wastes. Implement an integrated research platform consisting of *rrs* gene sequencing and metagenomics to identify key microbes/their metabolisms underpinning biomethanation.
  - Phylogenetic identification of microbes from 3 communities (thermophilic, mesophilic and control) (rrs genes - which microbes are present and which are missing)
  - Metatranscriptomics analysis of gene expression (eukaryotic & prokaryotic). (environmental mRNA reversed transcribed to complementary DNA, cDNA - which microbes are active)
  - cDNA clones will serve as sources for full-length genes for functional screening. (how well are they degrading fiber – polysaccharide-specific stain)
  - Compliment the functional screening – will screen cDDNA and metagenomic libraries for genes encoding potentially interesting enzymes identified in the metatranscriptomics analysis

Milestone	2007	2008	2009
1) TPAD Development	----------	----------	
2) *rrs* sequencing	----------	---	
3) Metatranscriptomics		----------	
4) Metagenomics		----------	

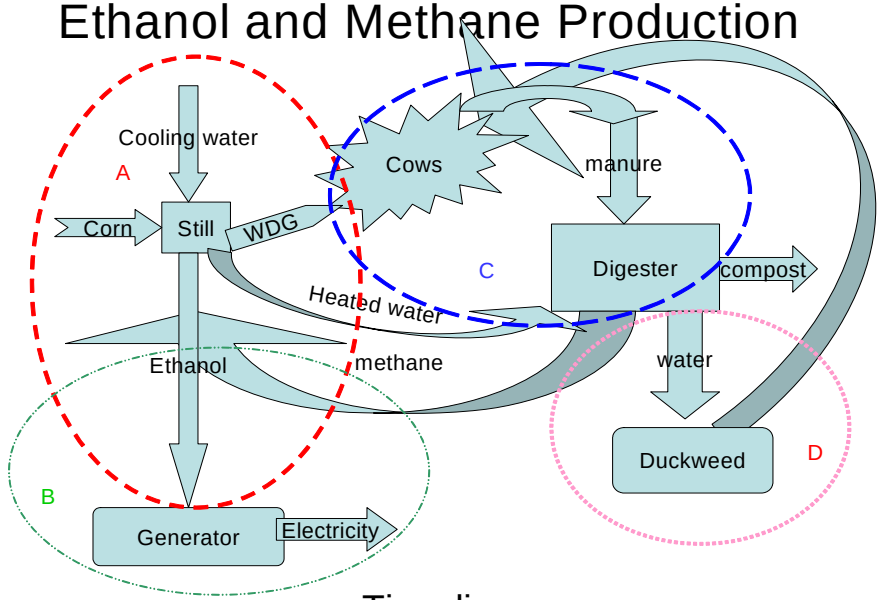
Small Farm Integrated Energy System.
PI: Norm Scott, Cornell University in partnership with local Ficken family farm. $75,010, 1 year

OBJECTIVES

- Design an anaerobic digester for dairy farm with less than 100 cows (representing 75% of NY diary farms).
- Use off-the-shelf materials for construction;
- Requiring 15- 30 minutes farm operator time per day;
- System will not exceed the normal management skills of a small farm operator.

INEXPENSIVE
SIMPLE DESIGN
EASY TO OPERATE
DEMONSTRATION

Ethanol and Methane Production



Milestone		Time line 2007	2008
1)	Design still & grain storage	---	
2)	Construction/trouble shooting	--------	
3)	Production of ethanol		----------
4)	Digester design & placement	-------	
5)	Digester operational		----------
6)	Produce methane		----------
7)	Integrate systems		---------
8)	Develop educational tools		-----

Biomass Feedstock Production in the Northeast: Economic and Environmental Implications.
PI: Tom Richard, Penn State University Collaborating Institutions: Michigan State, Cornell, USDA-ARS, Univ. Maryland - Eastern Shore $439,000, 2 years

OBJECTIVES

The goal of this project is to assist landowners and land managers, their technical advisors, and policy developers in evaluating options for dramatically increasing the biomass productivity of landscapes in the Northeast Sun Grant region. The project will examine the economic and environmental impacts and opportunities from a range of feedstock production systems relevant to the Northeastern US.

Scale	Biophysical Indicators	Socioeconomic Indicators	Key Personnel
Field and Farm	Crop yield Soil erosion Soil quality Carbon and nutrient flows Greenhouse gases	Farm income Labor requirements Government payments Asset turnover ratio Crop vs. livestock intensity	Tom Richard Greg Hanson Bruce Dale Paul Adler Al Rotz Marianne Sarrantonio Kat Harting
Biorefinery and Watershed	Carbon flow models Nutrient recycling Wildlife habitat Water quality Byproduct integration with livestock and crop production	Land values Community development Feasibility of regional feedstock processing Profitability of refinery value chains	Bruce Dale Satish Joshi Richard Reddy Peter Woodbury Paul Adler Gary Feyereisen Pat Norris
NE Region	Nutrient balances Regional GHG emissions Resource sufficiency	Environmental policy Economic policy	Peter Woodbury Richard Reddy Pat Norris

Biomass Feedstock Production in the Northeast: Economic and Environmental Implications (continued)

1) Predict feedstock production potential and effects at farm scale.
   - DAYCENT (field scale-biophysical model – carbon, nitrogen fluxes, energy bal)
     COMPARE DAYCENT PREDICTIONS WITH data-base driven tools:
   - IFSM (whole-farm scale mechanistic model -growth, harvest, handling, storage)
   - I-FARM – (whole-farm scale – biophysical & economic model)) to simulate feedstock production.
2) Predict financial gains and losses at farm scale.
   - Develop biomass farm profit optimization report by state
   - Biomass production roadblocks report by state
   - Guidelines for biofuels investment at farm level by state
   - Identify incentives that promote profitable production of biofuels in Northeast.
3) Develop scenarios of regional biomass supply chains and processing facilities
   - Analyze technical/economic feasibility of regional biomass processing facilities RBMPF
   - Develop 3 test location/scenarios for northeast RBMPF, identify factors for success
4) Geospatial - SWOT analysis on regional level (near term 5-10 y, and 20-30 y)
   - Biomass feedstock production capacity
   - Analyze potential effects of northeast region fuel production on:
     - food, feed, fiber production capacity
     - Regional variation in energy inputs/outputs including transportation fuels
     - Net GHG emissions, water and air quality impacts (regional scale and 3-5 distinct case studies)
       - Different physiographic regions (Interior plains, Atlantic plain, Appalachian highlands)
   - Identify most sustainable technology options for different portions of the region
5) Outreach to land managers, extension agents, legislators and others

Northeast Sun Grant 2007 Funded Projects

	BIOFUELS	Investment $
FEEDSTOCK PRODUCTION	GRASSCREEN HAZEL	100,000 58,062
CONVERSION PROCESSES	WOODENZ PYROTHERM SSF TEMPAD	90,581 22,346 99,999 100,000
SYSTEMS INTEGRATION	FARMDEMO	75,010
POLICY, ECONOMICS	NEEEMODEL	439,000

Northeast Sun Grant initiative Competitive Grants Program 2008 RFA

- $1.053M in funding
  - Integrated Lead Proposals – up to $450K
  - Seed Proposals – up to $100K (1-3 years in duration)
- Letters of Intent – Required
  - December 15, 2007
- Full Proposals – February 15, 2008

Northeast Sun Grant initiative Competitive Grants Program 2008 RFA

- Will seek proposals with an emphasis on Biofuels that show the potential for displacement of imported petroleum
- Proposals with emphasis areas of BioPower and BioProducts are also appropriate if they show a strong potential for displacement of imported transportation-petroleum fuels or support a part of the industrial ecology to make production of a biofuel more economically feasible.

Northeast Sun Grant initiative Competitive Grants Program 2008 RFA

- Matching – Successful applicants must demonstrate a 20% match (auditable)
- Preference will be given to grants demonstrating commercialization efforts and matching funds originating from business or industry