Regional Feedstock Partnership: Woody Crops
(Award # GO85041; WBS 7.6.2.5)

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Terrestrial Feedstocks

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Quad Chart Overview

Timeline

- Start date – 1/15/2007
- End date – 12/31/2015
- 90% complete

Barriers

- Ft-A: Resource availability & cost
- Ft-B: Sustainable production
- Ft-C: Crop Genetics

Partners

- Collaborations: ArborGen, Inc., Cornell Univ., GreenWood Resources, Michigan State Univ., Middlebury College, Mississippi State Univ., ORNL, Sun Grant Initiative, SUNY-ESF, Univ. of Connecticut, Univ. of Minnesota-NRRI, USDA-Forest Service

<table>
<thead>
<tr>
<th></th>
<th>Total Costs FY07-FY12</th>
<th>FY 13 Costs</th>
<th>FY 14 Costs</th>
<th>Total Planned Funding</th>
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<tbody>
<tr>
<td>DOE Funded</td>
<td>$1,804,279</td>
<td>$558,829</td>
<td>$457,929</td>
<td>$435,274</td>
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<tr>
<td>Cost Share (Comp.)*</td>
<td>$380,229</td>
<td>$251,594</td>
<td>$194,533</td>
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</table>
DOE and the Sun Grant Initiative formed the **Regional Biomass Feedstock Partnership** in 2007
- Regional Biomass Feedstock Workshops
- Conduct a literature review to establish the current state of technology for major woody crop candidates
- Establish field trials to evaluate new varieties on representative sites around the country
- Produce new, elite genotypes for improved process performance
- Assess yield data, including long-term production patterns
- Provide data to the KDF for public consumption
Approach

1. Advance genetics & breeding program
2. Establish replicated field trials for new varieties (poplar & willow)
3. Incorporate existing field trials for current baseline yields
4. Populate the KDF with current yield data
Woody crops (poplar & willow) offer significant genetic variation to draw on for advancement.

Presents the prospect of tailoring crops for optimal conversion.

Woody crops fulfill the need for a portfolio of feedstock sources to:
1) Address varied landowner interests
2) Maximize ecological and environmental benefits

Woody crops provide an important approach to address annual supply issues.

The supply chain infrastructure is in place due to FPI.

Woody crops provide material for diverse markets.

Flex management targets the range of landowner interests and objectives.
The Woody Crops Field Trial Network

68 Total Sites

- Genetics tests
- Yield trials
- Nurseries
Age 4 measurement summaries:

- Clone Test
  - ID: ArCW335
  - Mean height: 20.3 ft (range: 13-30 ft)
  - Mean DBH: 2.4 in (range: 1.4-3.6 in)

- Clone Screening Test
  - ID: ArCW568
  - Mean height: 21.5 (range: 13-32 ft)
  - Mean DBH: 2.1 in (range: 1-3.3 in)
Advances In Biomass Yield

- Avg. for 5 clone trials, MN
- 71 clones/site planted, 2008
- Top 10 clones: NM6 = 1.98

- Large yield trials, MN
- Schultz site planted in 2007
- Top 8 clones: NM6 = 1.6
Breeding and Genetic Improvement

- Created one of the largest collections of new clonal material in the world adapted to northern climates
- Expanding breeding for southern regions using the best parents with proven performance in the South
- Large-scale "family field tests” in Minnesota have developed unique understanding of underlying genetic mechanisms in poplar
- Largest network of field tests including clone test and biomass yield studies in US
- Support of breeding has led to opportunities for distribution of new clones to support cooperative tests at locations in the US and strategic areas of Europe
Willow Biomass Production Cycle

1. **Site Preparation**

2. **PLANTING**

3. **First Year Growth**

4. **COPPICE**

5. **Early Spring after Coppice**

6. **Harvest**

7. **Three-year old after Coppice**

8. **One-year old after Coppice**
Essential to monitor trials over multiple rotations for a system that is designed to function for 20-25 years and include 5 to seven harvests.

Long-term yield data impacts economic analysis, environmental assessments, and selection of improved cultivars.
Relative growth rate of willow cultivar SV1 over 6 rotations. First rotation yield is baseline for relative growth calculations.

- Only one of 19 cultivars in this trial still being sold commercially for biomass production
- Over 6 rotations growth has consistently been greater than 1st rotation
- Supports assumption of long term productivity of systems
Improvements in Yield

- Yield increased by 13 – 35% for the top cultivars.
- Much smaller yield decrease in top five cultivars for post 2005 trials (6%) versus pre 2005 (21%).
- Survival for the best producing cultivars increased by 16%.

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<thead>
<tr>
<th></th>
<th>Pre-2005 Yield Trials (n=11)</th>
<th>Post-2005 Yield Trials (n=5)</th>
<th>One-way ANOVA</th>
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<tbody>
<tr>
<td></td>
<td>Yield (dry Mg ha⁻¹ yr⁻¹)</td>
<td>Yield (dry Mg ha⁻¹ yr⁻¹)</td>
<td>Percent Change in Yield</td>
</tr>
<tr>
<td>Top cultivar</td>
<td>10.5 ± 0.7</td>
<td>11.9 ± 0.6</td>
<td>13.3%</td>
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<tr>
<td>Top 3 cultivars</td>
<td>9.3 ± 0.4</td>
<td>11.5 ± 0.4</td>
<td>23.7%</td>
</tr>
<tr>
<td>Top 5 cultivars</td>
<td>8.3 ± 0.3</td>
<td>11.2 ± 0.3</td>
<td>34.9%</td>
</tr>
<tr>
<td>All cultivars</td>
<td>5.6 ± 0.2</td>
<td>8.8 ± 0.1</td>
<td>57.1%</td>
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(Liu 2014)
Data from network of yield trials was the basis for regional yield modeling efforts.
Broader Impacts

- Woody crops team data and expertise supported PRISM modeling
- Material (willow and poplar) provided to INL Biomass Library
- Chemical composition data provided to INL database
- Continued populating KDF Data
- Trail data used for willow LCA (net energy balance and GHG emissions)
- EcoWillow model updated with RFP trial data
- Best cultivars from trials have been licensed to a commercial nursery in NY (Double A Willow) for large scale production and sale
- Data from yield trials was instrumental in USDA BCAP project approval and helping landowners make selections for expansion of willow biomass crops in northern NY
- Yield trials network used for related studies (pests and diseases, nutrient management and changes in soil characteristics)
Woody Team – Future Work

- Measure and maintain existing trial network
- Collect and submit yield data to KDF
- Complete yield modeling (PRISM) manuscript and several others

**Poplar Specific**

- Distribute *P. nigra* parents Breed new *deltoides* clones and distribute for field testing
  - DxN to improve *P. deltoides* rooting

**Willow Specific**

- 1st rotation data from 14 RFP trials
- Compile data from related trials outside RFP
- Develop long-term productivity projections (old and new varieties).
Summary Remarks

• The RFP’s Woody Crops Team is defining today’s state-of-the-art with an eye on tomorrow’s targets.
• From the Billion Ton Report to BCAP and the KDF, the team is informing policy and science with data created through its innovative protocol.
• The coordinated national structure offers one-of-a-kind data, information, and knowledge on woody crop genetics.
• The RFP’s Woody Crops Team continues to develop new germplasm for deployment while monitoring and maintaining existing trials.
Questions
Publications (34)


Publications (34), cont’d.

- Kenaley, S.C., Smart, L.B., and Hauller, G.W. In revision. Genetic evidence for three discrete taxa of Melampsora (Pucciniales) affecting willows (Salix spp.) in New York State. Fungal Biology.
Presentations (50)

• Rials, T. and T.A. Volk. 2011. Sun Grant/DOE Feedstock Development Partnership – Woody Crops. DOE Feedstock Peer Review meeting, April 7-8, 2011, Annapolis, MD.