A Protocol for Identifying Suitable Testing & Deployment Sites of Poplar Energy Production Systems in the Midwest, USA

Ronald S. Zalesny Jr.¹, Deahn M. Donner¹, David R. Coyle², William L. Headlee³, Richard B. Hall³

¹Forest Service, United States Dept. of Agriculture
Northern Research Station
Institute for Applied Ecosystem Studies
Rhineland, WI 54501

²University of Wisconsin, Dept. of Entomology

³Iowa State University, Dept. of Natural Resource Ecology & Management
Energy

Forest bioenergy & bioproducts supply chain
Energy

- Biofuels
- Bioenergy
- Bioproducts
Renewable Fuel Standard

- Annual production of 36 billion gallons of biofuels by 2022
- Ethanol production from corn capped at 15 billion gal yr$^{-1}$
- Remaining 21 billion gallons from advanced biofuels
- 16 billion gallons from cellulosic biofuels
- Seven-fold increase in current biomass production from 190 million dry tons to 1.36 billion dry tons
- DOE / USDA goal of replacing 30% petroleum consumption with biofuels by 2030


Poplar Genetics Research

- **Northeastern - 1920’s**
  - 1924 to 1939: 13,000 hybrids

- **Lake States**
  - 1950’s (IL), 1960’s (MN), 1980’s (IA & WI)

- **Pacific Northwest - 1960’s**

- **USFS**
  - 1950: LSFES rejected Schreiner’s idea for collaborative study
  - 1983: Poplar genetics research began
North Central Poplar Breeding

Duluth, MN (UMN NRRI) (B. McMahon)
St. Paul, MN (UMN TC) (C. Mohn)
Ames, IA (ISU) (R. Hall)
Urbana-Champaign, IL (UI UC) (J. Jokela)

~40,000 + ~48,000 + Previous
~88,000 Genotypes + Previous
>100,000 Genotypes
Why Poplars?

<table>
<thead>
<tr>
<th></th>
<th>Realized Productivity</th>
<th>Potential Productivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switchgrass</td>
<td>20 Mg ha(^{-1}) yr(^{-1})</td>
<td>&gt;22 Mg ha(^{-1}) yr(^{-1})</td>
</tr>
<tr>
<td>Willow</td>
<td>18 Mg ha(^{-1}) yr(^{-1})</td>
<td></td>
</tr>
<tr>
<td>Poplar</td>
<td>16 Mg ha(^{-1}) yr(^{-1})</td>
<td></td>
</tr>
</tbody>
</table>

Depends on genotype environment interactions
Additional Advantages

- Energy per biomass unit:
  \[1.9 \times 10^{10} \text{ to } 2.0 \times 10^{10} \text{ J Mg}^{-1} (16.5 \text{ to } 17.2 \text{ MBtu dt}^{-1})\]

- Energy returned on energy invested (EROEI)

- Can be stored on the stump until harvest

- Harvest throughout the year

- Minimal fertilization

- Extended haul distances

- Used in crop rotations to improve soil tilth

- Elevated rates of soil carbon storage

- Superior genotypes replace existing clones

Sustainability

Short rotation woody crops are one of the most sustainable sources of biomass, provided we strategically place them in the landscape & use cultural practices that…

- Conserve soil & water
- Recycle nutrients
- Maintain genetic diversity

*Uniformity within
*Diversity among
*4 ha clone⁻¹

Potential Limitations to Success

- Intensive management & high costs during establishment
- Elevated water usage
- Failure to match clones with sites
- History of land use (i.e., social resistance to monocultures)
- Competition for land & price of land
- Competition among end uses
- Harvest efficiencies
- Difficulties in drying the wood
- Loss of research funding
Potential Limitations to Success

- Intensive management & high costs during establishment
- Elevated water usage
- Failure to match clones with sites
- History of land use (i.e., social resistance to monocultures)
- Competition for land & price of land
- Competition among end uses
- Harvest efficiencies
- Difficulties in drying the wood
- Loss of research funding
Long-Range Goal

Develop a protocol for identifying suitable testing & deployment sites of poplar energy production systems in the Midwest, USA (& beyond...)
Objectives

1. Develop coarse & fine resolution digital maps of environmental & sociopolitical constraints to identify candidate core areas

2. Construct database of poplar growth & development, apply information within areas

3. Evaluate land-use, soil health, & water quality changes within areas

4. Synthesize results to assess potential impacts of deploying poplars across region

Map Development

Constraints Considered

- Land cover class
- Land ownership
- Available water storage capacity
- Water deficit (P – PET)
- Soil texture
- Precipitation / Temperature
- Flood frequency
- Depth to bedrock
- Patch size
## Map Development
### Final Constraints

<table>
<thead>
<tr>
<th>CONSTRAINTS</th>
<th>DEFINITION OF CONSTRAINTS USED</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Land Cover Dataset (NLCD 2001)</td>
<td>Grassland/Herbaceous, Pasture Hay, Cultivated Crops</td>
</tr>
<tr>
<td>GAP Stewardship 2008 (Land Ownership)</td>
<td>Federal, Tribal, State, County (excluded)</td>
</tr>
<tr>
<td>Available Water Storage Capacity (SSURGO)</td>
<td>≥7 cm (assuming 0 to 50 cm depth, 0.15 fraction available water)</td>
</tr>
<tr>
<td>Precipitation – Potential Evapotranspiration (PPET)</td>
<td>PPET for the months of April and May combined</td>
</tr>
<tr>
<td>Soil Texture (SSURGO)</td>
<td>Clay Loam, Coarse Sandy Loam, Coarse Silty, Fine Sandy Loam, Gravelly Loam, Gravelly Sandy Loam, Loam, Loamy Coarse Sand, Loamy Sand, Mixed, Sandy Clay Loam, Sandy Loam, Sandy Over Loam, Silt Loam, Silty, Silty Clay Loam, Very Fine Sandy Loam</td>
</tr>
</tbody>
</table>
## Potential Land Base

<table>
<thead>
<tr>
<th>County</th>
<th>Hectares</th>
<th>County</th>
<th>Hectares</th>
<th>County</th>
<th>Hectares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aitkin</td>
<td>12,729</td>
<td>Itasca</td>
<td>14,859</td>
<td>Pope</td>
<td>123,517</td>
</tr>
<tr>
<td>Anoka</td>
<td>2,334</td>
<td>Jackson</td>
<td>109,339</td>
<td>Ramsey</td>
<td>154</td>
</tr>
<tr>
<td>Becker</td>
<td>44,401</td>
<td>Kanabec</td>
<td>17,868</td>
<td>Red Lake</td>
<td>30,955</td>
</tr>
<tr>
<td>Beltrami</td>
<td>18,239</td>
<td>Kandiyohi</td>
<td>78,256</td>
<td>Redwood</td>
<td>171,551</td>
</tr>
<tr>
<td>Benton</td>
<td>51,440</td>
<td>Kittson</td>
<td>35,451</td>
<td>Renville</td>
<td>119,623</td>
</tr>
<tr>
<td>Big Stone</td>
<td>48,260</td>
<td>Koochiching</td>
<td>1</td>
<td>Rice</td>
<td>84,282</td>
</tr>
<tr>
<td>Blue Earth</td>
<td>116,734</td>
<td>Lac Qui Parle</td>
<td>93,685</td>
<td>Rock</td>
<td>98,246</td>
</tr>
<tr>
<td>Brown</td>
<td>116,441</td>
<td>Lake</td>
<td>0</td>
<td>Roseau</td>
<td>135,899</td>
</tr>
<tr>
<td>Carlton</td>
<td>13,192</td>
<td>Lake of the Woods</td>
<td>12,874</td>
<td>Scott</td>
<td>44,109</td>
</tr>
<tr>
<td>Carver</td>
<td>35,800</td>
<td>Le Sueur</td>
<td>73,775</td>
<td>Sherburne</td>
<td>3,557</td>
</tr>
<tr>
<td>Cass</td>
<td>9,874</td>
<td>Lincoln</td>
<td>40,919</td>
<td>Sibley</td>
<td>83,110</td>
</tr>
<tr>
<td>Chippewa</td>
<td>107,409</td>
<td>Lyon</td>
<td>79,170</td>
<td>St. Louis</td>
<td>1,452</td>
</tr>
<tr>
<td>Chisago</td>
<td>34,413</td>
<td>Mahnomen</td>
<td>21,395</td>
<td>Stearns</td>
<td>189,848</td>
</tr>
<tr>
<td>Clay</td>
<td>139,035</td>
<td>Marshall</td>
<td>91,743</td>
<td>Steele</td>
<td>85,142</td>
</tr>
<tr>
<td>Clearwater</td>
<td>31,547</td>
<td>Martin</td>
<td>92,834</td>
<td>Stevens</td>
<td>96,274</td>
</tr>
<tr>
<td>Cook</td>
<td>0</td>
<td>McLeod</td>
<td>51,791</td>
<td>Swift</td>
<td>64,287</td>
</tr>
<tr>
<td>Cottonwood</td>
<td>141,032</td>
<td>Meeker</td>
<td>61,087</td>
<td>Todd</td>
<td>102,704</td>
</tr>
<tr>
<td>Crow Wing</td>
<td>0</td>
<td>Mille Lacs</td>
<td>19,812</td>
<td>Traverse</td>
<td>94,004</td>
</tr>
<tr>
<td>Dakota</td>
<td>72,864</td>
<td>Morrison</td>
<td>87,040</td>
<td>Wabasha</td>
<td>35,109</td>
</tr>
<tr>
<td>Dodge</td>
<td>77,200</td>
<td>Mower</td>
<td>157,995</td>
<td>Wadena</td>
<td>19,232</td>
</tr>
<tr>
<td>Douglas</td>
<td>84,348</td>
<td>Murray</td>
<td>104,565</td>
<td>Waseca</td>
<td>59,345</td>
</tr>
<tr>
<td>Faribault</td>
<td>109,180</td>
<td>Nicollet</td>
<td>60,925</td>
<td>Washington</td>
<td>29,702</td>
</tr>
<tr>
<td>Fillmore</td>
<td>140,009</td>
<td>Nobles</td>
<td>137,910</td>
<td>Watonwan</td>
<td>82,385</td>
</tr>
<tr>
<td>Freeborn</td>
<td>136,488</td>
<td>Norman</td>
<td>98,855</td>
<td>Wilkin</td>
<td>127,100</td>
</tr>
<tr>
<td>Goodhue</td>
<td>79,882</td>
<td>Olmsted</td>
<td>120,324</td>
<td>Winona</td>
<td>82,848</td>
</tr>
<tr>
<td>Grant</td>
<td>76,913</td>
<td>Otter Tail</td>
<td>133,597</td>
<td>Wright</td>
<td>62,238</td>
</tr>
<tr>
<td>Hennepin</td>
<td>20,908</td>
<td>Pennington</td>
<td>45,871</td>
<td>Yellow Medicine</td>
<td>145,608</td>
</tr>
<tr>
<td>Houston</td>
<td>69,599</td>
<td>Pine</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hubbard</td>
<td>8,778</td>
<td>Pipestone</td>
<td>72,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isanti</td>
<td>47</td>
<td>Polk</td>
<td>112,798</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>5,998,612</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Field Sites

- Agronomic
- Old US DOE poplar trials
- Production plantings
48 agronomic sites
alfalfa, corn, grass, oats, sod, soybean, sugar beet, sunflower, tillage radish, tilled fallow field, & wheat)

4 cover types = 80%
corn (31%)
soybean (23%)
alalfa (13%)
grass (13%)
Detailed Site Analysis and Mapping of Agroforestry Potential in the Northern Agricultural Zone of Saskatchewan

W. Schroeder, S. Silim, J. Fradette, J. Patterson and H. de Gooijer
Agriculture and Agri-Food Canada, PFRA Shelterbelt centre
Indian Head, Saskatchewan
2003

Prepared for the Saskatchewan Forest Centre - Forest Development Fund
Agronomic Site Characterization

- **Slope Class**
  - 0 to 2%: 11%
  - 2 to 5%: 58%
  - 5 to 9%: 27%
  - 9 to 15%: 4%
  - >15%: 4%

- **Surface Stoniness**
  - Non-Stony: 98%
  - Slightly Stony: 2%
  - Moderately Stony: 2%
  - Very Stony: 15%
  - Exceedingly Stony: 15%
  - Excessively Stony: 37%

- **Erosion Risk**
  - Very Low: 15%
  - Low: 23%
  - Medium: 15%
  - High: 37%
  - Very High: 10%

- **Soil Drainage**
  - Rapidly Drained: 23%
  - Well Drained: 40%
  - Moderately Well Drained: 33%
  - Imperfectly Drained: 4%
  - Poorly Drained: 40%
Soil Textures

Compare soil from individual sites with GIS data

- Sandy Loam: 32%
- Loam: 25%
- Loamy Sand: 4%
- Sandy Clay Loam: 10%
- Silt Loam: 8%
- Clay Loam: 17%
- Sandy Clay Loam: 3%
- Sand: 1%
Predict location of land-use change in addition to estimating quantity of land-use change
Integrated Studies

Enterprise Budgets

Landowner Preferences

Productivity Modeling

Carbon Sequestration
Future Directions

Wisconsin (2010/2011)

Iowa (2012)

Evaluate Changes

Regional Synthesis

Poplar Suitability

Low                                  High
Thank you!

Contact Information

Dr. Ronald S. Zalesny Jr.
Team Leader, Genetics and Energy Crop Production
Research Plant Geneticist
U.S. Forest Service
Northern Research Station
Institute for Applied Ecosystem Studies
5985 Highway K
Rhineland, WI 54501

Phone: +1 715 362 1132
Cell: +1 715 490 1997
Fax: +1 715 362 1166

rzalesny@fs.fed.us
http://www.nrs.fs.fed.us/people/Zalesny

populusdatabase@gmail.com