An Approach for Siting Poplar Energy Production Systems to Increase Productivity & Associated Ecosystem Services

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Multiple Uses of Poplars

- **Traditional products**

  Pulpwood, chips (oriented strand board), engineered lumber products, etc.

- **Energy**

  Biofuels, bioenergy, bioproducts

- **Phytotechnologies**

  Phytoremediation, phytovolatization, rhizodegradation, etc.



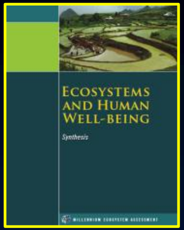



Ecosystem Services

The benefits people obtain from ecosystems

(Source: http://www.greenfacts.org/glossary/def/ecosystem-services.htm)

Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington. 155pp.



Provisioning Services

The goods or products obtained from ecosystems

Biomass

Freshwater

Regulating Services

The benefits obtained from an ecosystem’s control of natural processes

Erosion Control

Soil Quality

Cultural Services

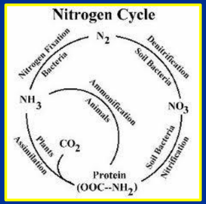
The nonmaterial benefits obtained from ecosystems (e.g., values)

Spiritual

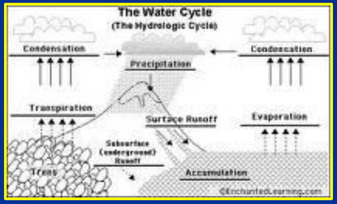
Educational

Supporting Services

The natural processes that maintain the other ecosystem services



Nitrogen



Water

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**

1990

1994

1996

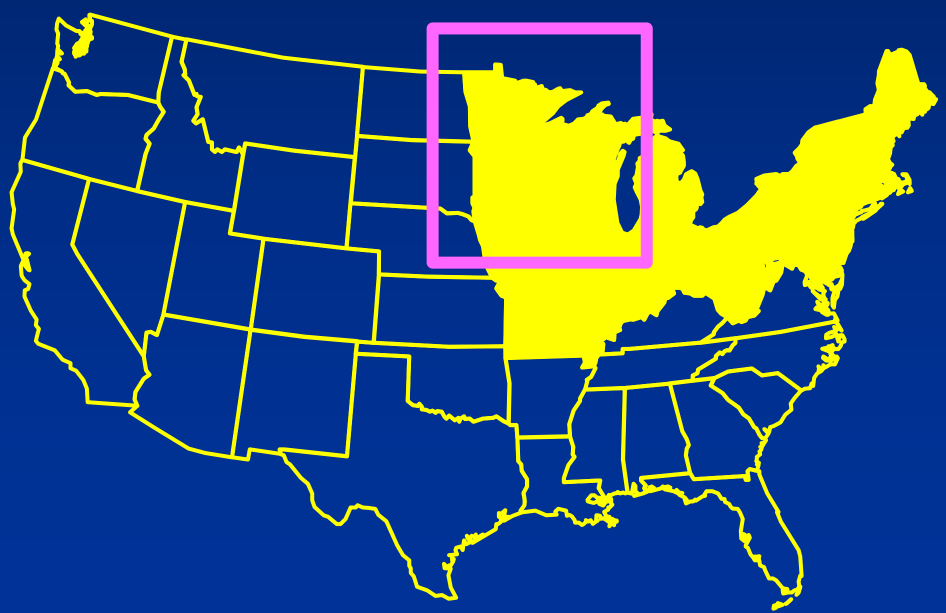
***Uniformity within**
***Diversity among**
***4 ha clone^{-1}**

Hall, R.B. 2008. Woody bioenergy systems in the United States. NRS-GTR-P-31.

Ecosystem Services
&
Pillars of Sustainability

Long-Range Goal

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



Northern
RESEARCH STATION
USDA Forest Service

Objectives

1. Identify eligible lands suitable for poplar deployment based on current land use, land ownership, & local soil characteristics
2. Determine temperature-precipitation gradients important to poplar growth
3. Establish sites for field reconnaissance within the suitable lands
4. Assess the validity of the outcomes from 1) & 2) by comparing available databases with field soils data (i.e., QA/QC)
5. Apply a process-based growth model (3-PG) to predict & map poplar productivity within the identified suitable lands
6. Assess the regional sustainability of potential poplar deployment within the eligible lands (current studies)
7. Develop a database of information to guide protocol development & sustainability assessment

Zalesny, R.S. Jr., et al. 2012. An approach for siting poplar energy production systems to increase productivity and associated ecosystem services. For Ecol Manage 284:45-58.

Objectives

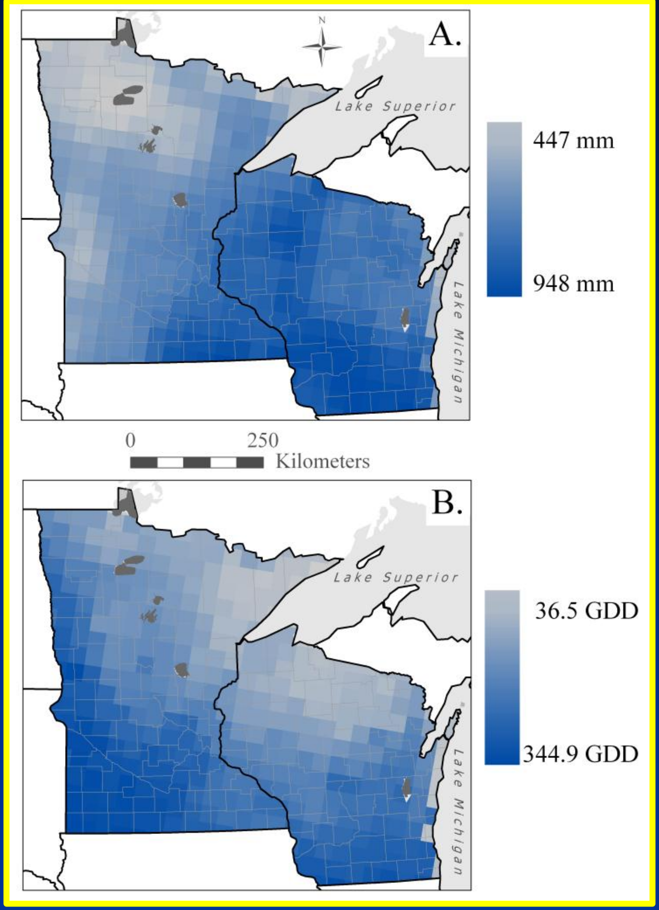
1. Identify eligible lands suitable for poplar deployment
2. Determine temperature-precipitation gradients
3. Conduct field reconnaissance
4. Assess the validity of the outcomes from 1) & 2)
5. Predict & map poplar productivity
6. Assess the regional sustainability of poplar deployment
7. Develop a database of information

Zalesny, R.S. Jr., et al. 2012. An approach for siting poplar energy production systems to increase productivity and associated ecosystem services. For Ecol Manage 284:45-58.

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



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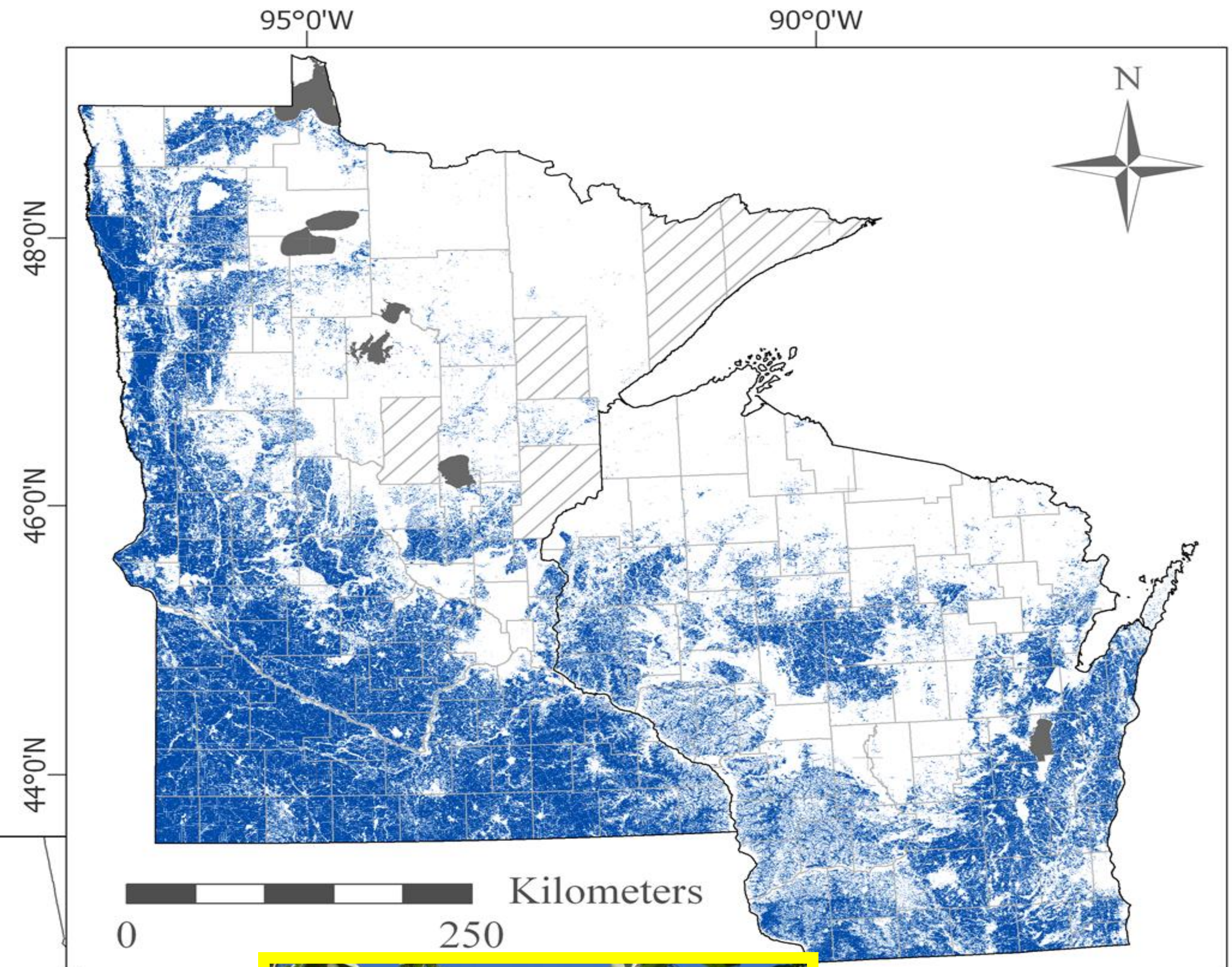
Map Development

Primary Constraints

CONSTRAINTS	DEFINITION OF CONSTRAINTS USED
National Land Cover Dataset (NLCD 2001)	Grassland/Herbaceous, Pasture Hay, Cultivated Crops
GAP Stewardship 2008 (Land Ownership)	Federal, Tribal, State, County (excluded)
Available Water Storage Capacity (SSURGO)	≥7 cm (assuming 0 to 50 cm depth, 0.15 fraction available water)
Soil Texture (SSURGO)	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

Obj. 1: Eligible Lands

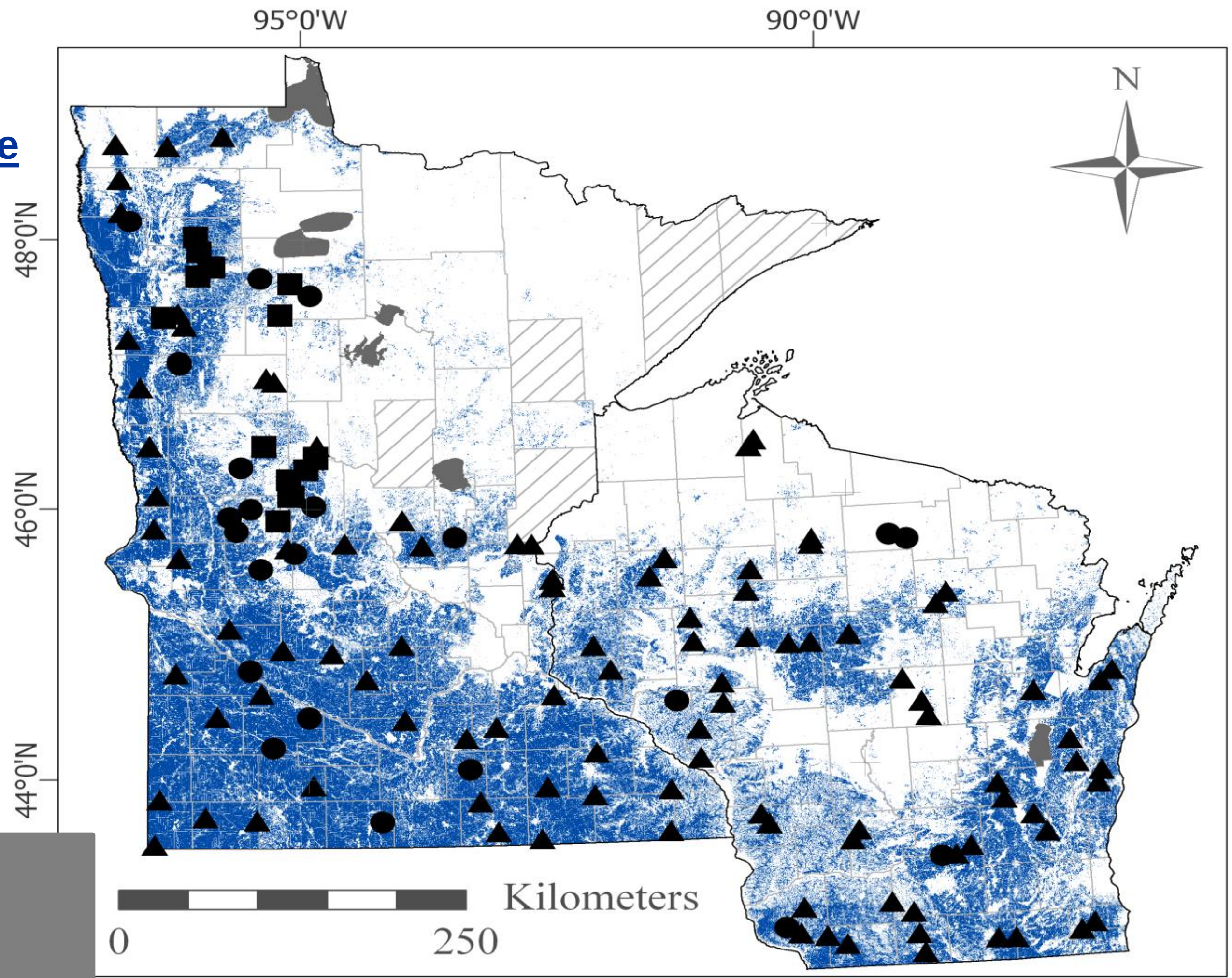
- **11.2 million ha**
  - MN = 7.5 million ha
  - WI = 3.7 million ha
- **30.8% of study area**
- **Land cover**
  - 79.1% cultivated crops
  - 17.8% pasture/hay
  - 3.1% grassland



Obj. 3: Field Reconnaissance

- **143 sites**
  MN = 84
  WI = 59
- **Most slopes 5% or less**
- **Acceptable drainage**
  MN = 70%
  WI = 98%
- **Acceptable erosion**
  MN = 81%
  WI = 85%
- **Negligible stoniness**

	MN	WI
Corn	19%	49%
Alfalfa	8%	17%
Soybean	13%	19%
Poplar	40%	8%
Other	20%	7%








Soil Evaluations

Field

- Soil structure
- Presence of horizons / gleying

Laboratory

- Soil texture*
- pH*
- Nitrogen, Carbon
- Base Cations (Ca, Mg, K, Na)
- CEC*, ECEC

*Used for comparison with SSURGO data (QA/QC)

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3-PG Productivity Modeling

SSURGO Soils Data *(Headlee et al. 2012 – STATSGO)*

- **Soil texture**
- **Available soil water in top 100 cm**
- **Minimum depth to water table**

NARR Climate Data *(Headlee et al. 2012 – Weather Station)*

- **Surface precipitation**
- **Temperature (2-m; surface)**
- **Downward shortwave radiation**

Headlee, W.L., et al. 2012. Using a process-based model (3-PG) to predict & map hybrid poplar biomass productivity in Minnesota & Wisconsin, USA. BioEnergy Research (in press)
Zalesny, R.S. Jr., et al. 2012. An approach for siting poplar energy production systems to increase productivity and associated ecosystem services. For Ecol Manage 284:45-58.

3-PG Productivity Scenarios

1. Generalist clones
   - Default settings from Headlee et al. (2012)
   - SSURGO soils data
2. Specialist clones (SITE)
   - Default settings from Headlee et al. (2012)
   - Optimum temperature for growth set equal to each site's mean maximum growing season temperature (June – August)
   - Field soils data
3. Specialist clones (SSURGO)
   - Default settings from Headlee et al. (2012)
   - Optimum temperature for growth set equal to each site's mean maximum growing season temperature (June – August)
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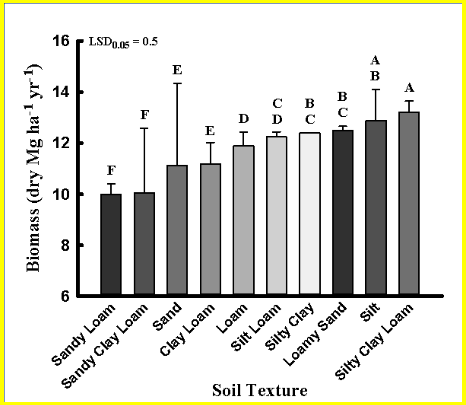
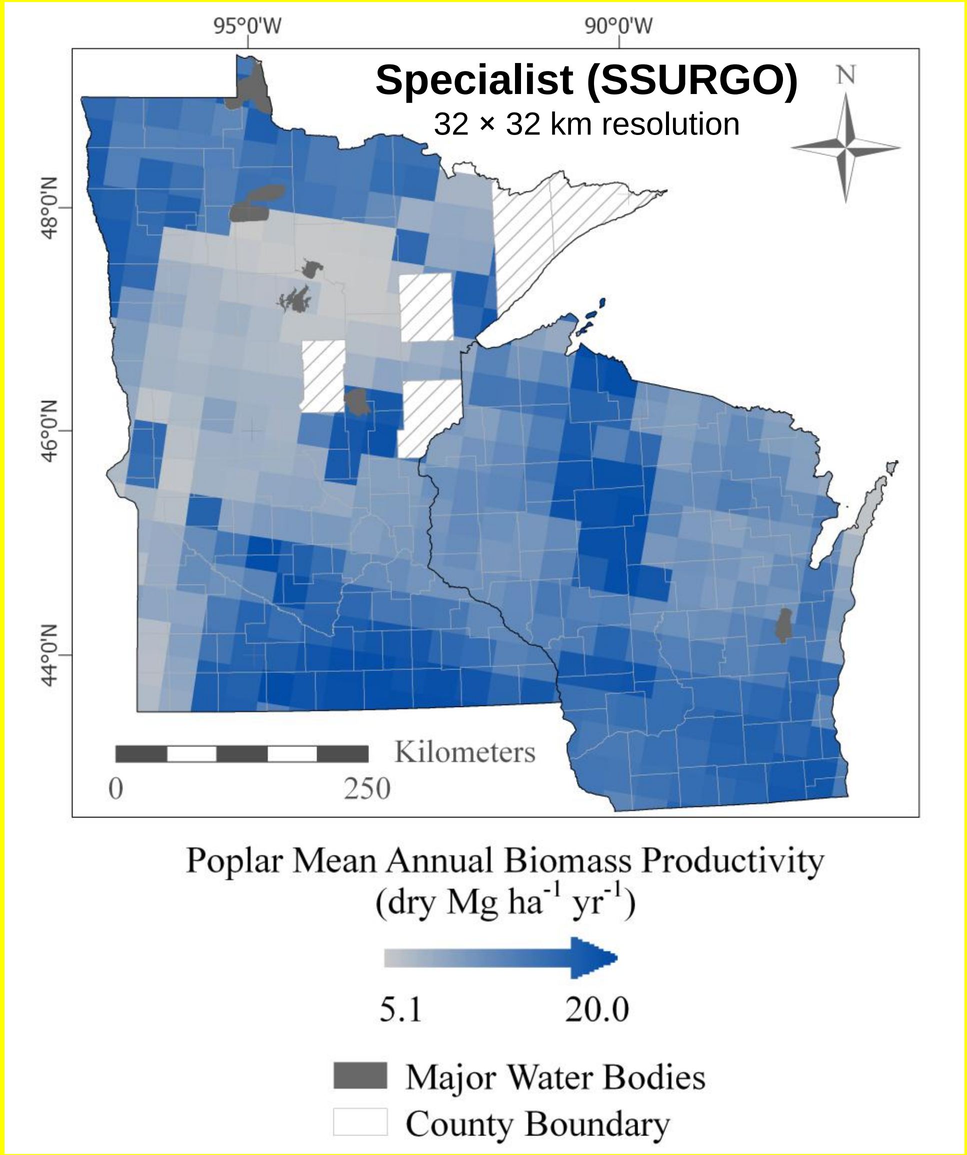
Poplar Productivity Across Study Area

Across states & scenarios
- Range: 9.5 – 11.9 dry Mg ha^{-1} yr^{-1}
- Mean: 10 dry Mg ha^{-1} yr^{-1}

Within states
- WI: 11.2 dry Mg ha^{-1} yr^{-1}
- MN: 10.6 dry Mg ha^{-1} yr^{-1}

Within scenarios
- Specialist (SITE): 11.6 dry Mg ha^{-1} yr^{-1}
- Specialist (SSURGO): 11.4 dry Mg ha^{-1} yr^{-1}
- Generalist: 9.7 dry Mg ha^{-1} yr^{-1}





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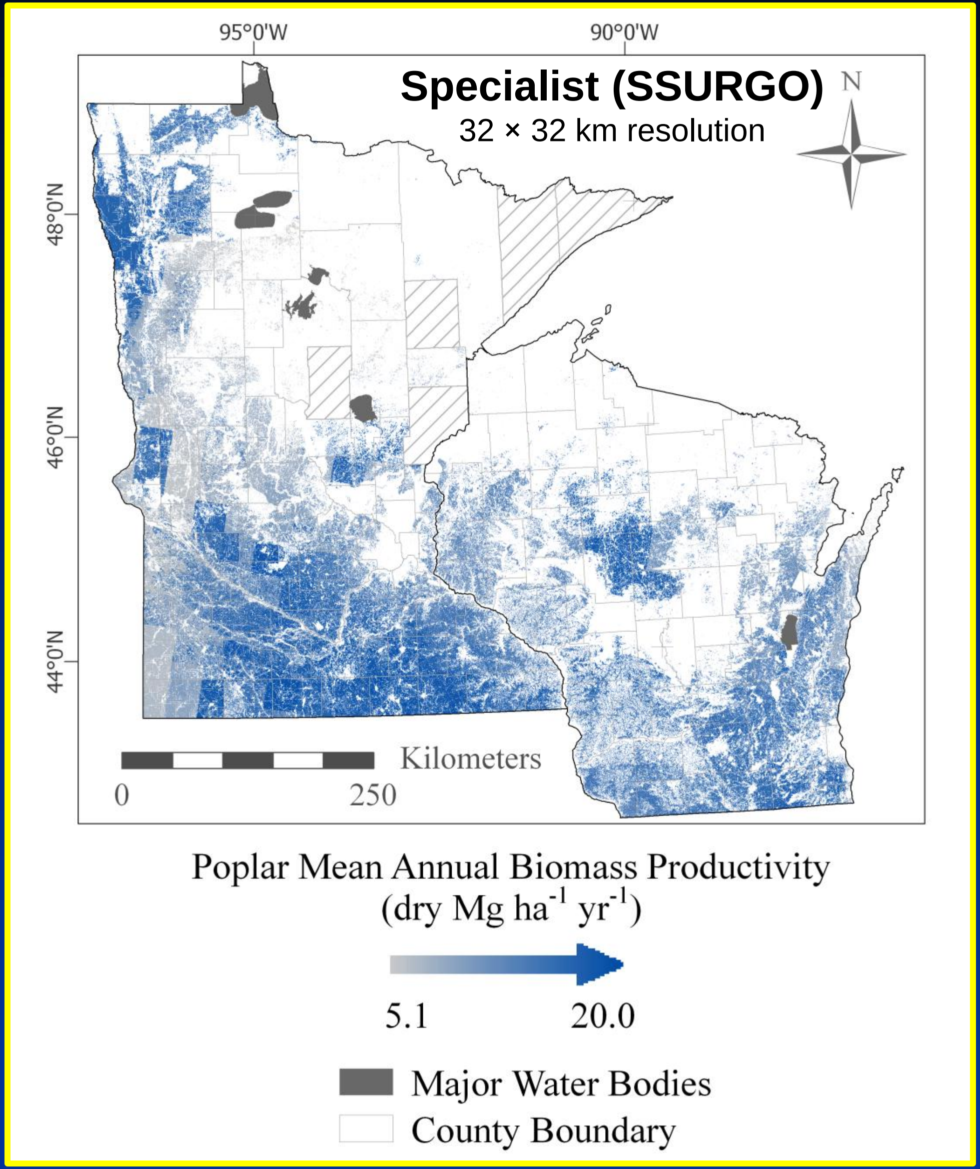
Poplar Productivity Within Eligible Lands



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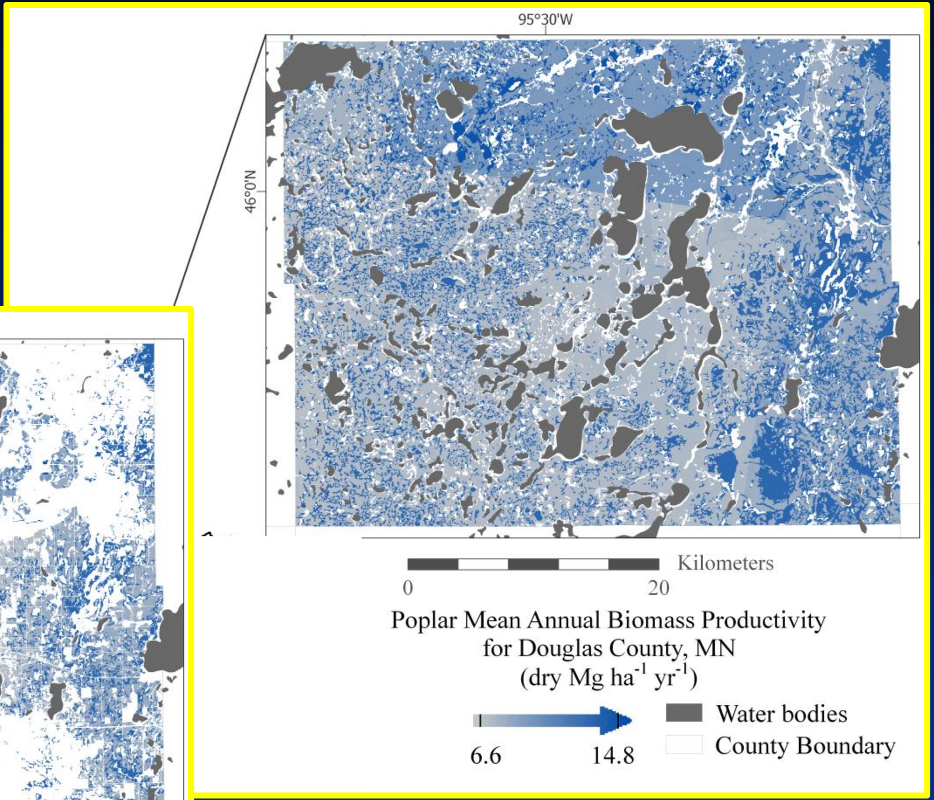
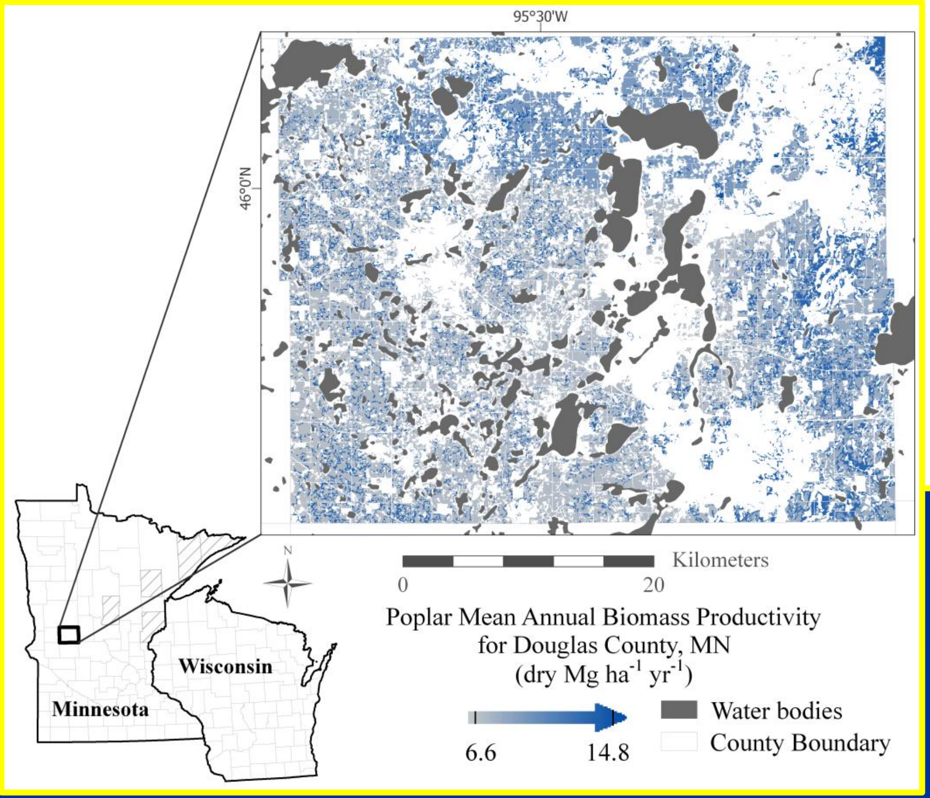
Poplar Productivity Within Eligible Lands

Specialist (SSURGO)
30 × 30 m resolution





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Contribution of Poplar Biomass?

2× Total Standing Biomass **16× Cottonwood/Aspen Biomass**

Table 5
Total standing aboveground dry biomass (Tg) of natural forests on private lands in Minnesota and Wisconsin, USA (2007 to 2011; DBH > 2.54 cm) (data from Woudenberg et al., 2011) (A.) and potential of poplar on suitable lands at the end of a 10-year rotation as predicted using three yield scenarios with 3-PG (B.).

(A.)

Tree Species Group	Minnesota	Wisconsin	Minnesota + Wisconsin
Cottonwood and Aspen	44.0	33.4	77.5
Noncommercial Hardwoods	3.0	4.8	7.9
Commercial Hardwoods[a]	130.7	295.5	426.2
Softwoods[b]	34.4	68.1	102.5
Total	212.2	401.8	614.0

(B.)

Yield Scenario[c]	Minnesota	Wisconsin	Minnesota + Wisconsin
Generalist (SSURGO)	712.5	363.5	1,087.3
Specialist (Site)	847.5	441.4	1,300.2
Specialist (SSURGO)	825.0	441.4	1,277.8

[a]Commercial hardwood species include: ash, basswood, beech, black walnut, hard maple, hickory, red oaks, soft maple, white oaks, and yellow birch (Woudenberg et al., 2011).
[b]Softwood species include: balsam fir, eastern hemlock, eastern white and red pines, jack pine, and spruces (Woudenberg et al., 2011).
[c]See Materials and Methods for details about the three yield scenarios tested with 3-PG.

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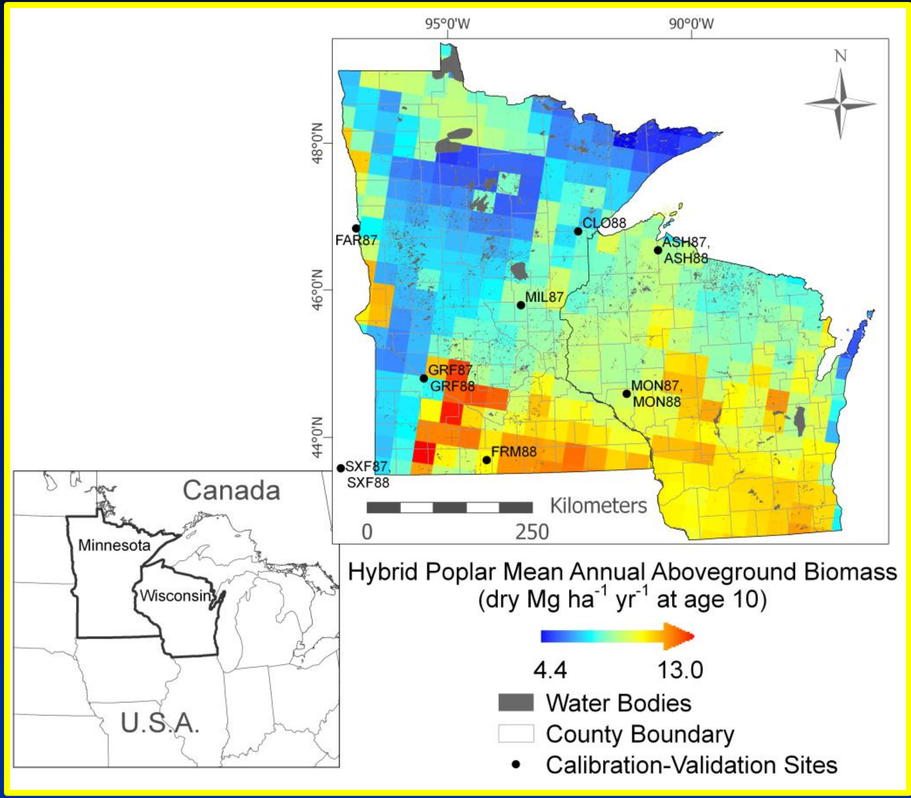
Integrated Studies: Regional Sustainability



Productivity Modeling

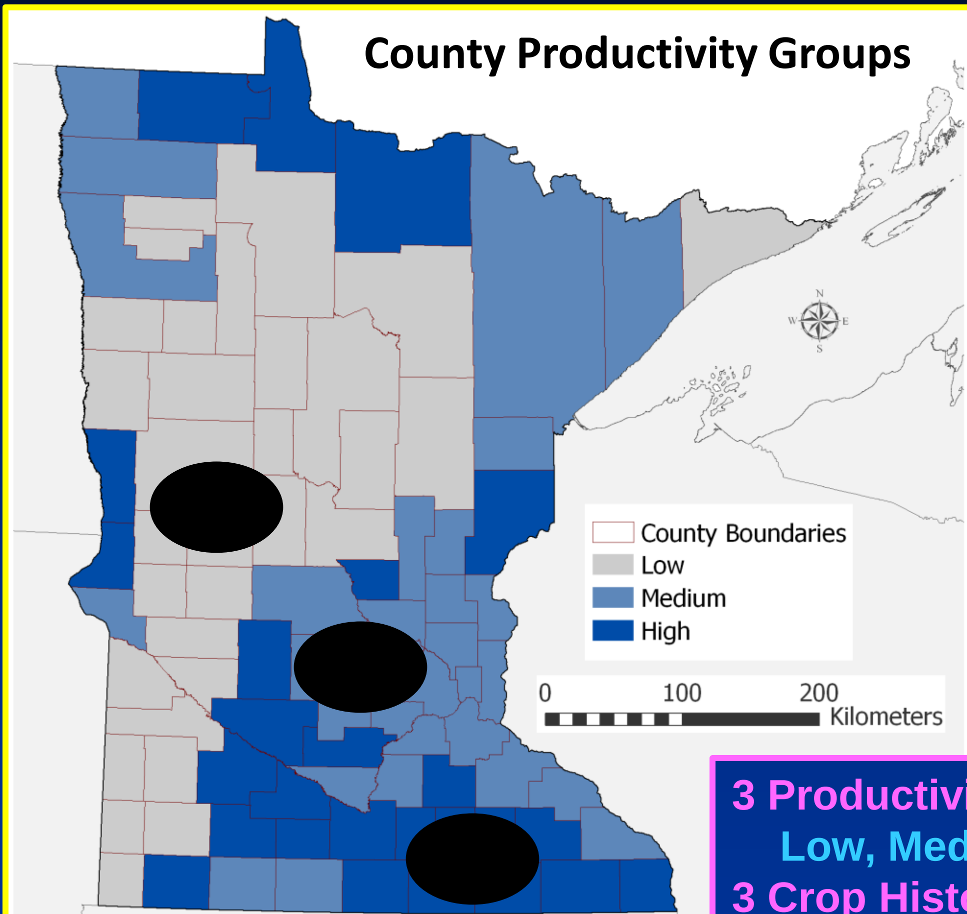
Enterprise Budgets

Landowner Preferences

Carbon Implications

Headlee, W.L., Zalesny, R.S. Jr., Donner, D.M., Hall, R.B. 2012. Using a process-based model (3-PG) to predict & map hybrid poplar biomass productivity in Minnesota & Wisconsin, USA. BioEnergy Research (in press)

Integrated Studies: Regional Sustainability



Productivity Modeling

Enterprise Budgets

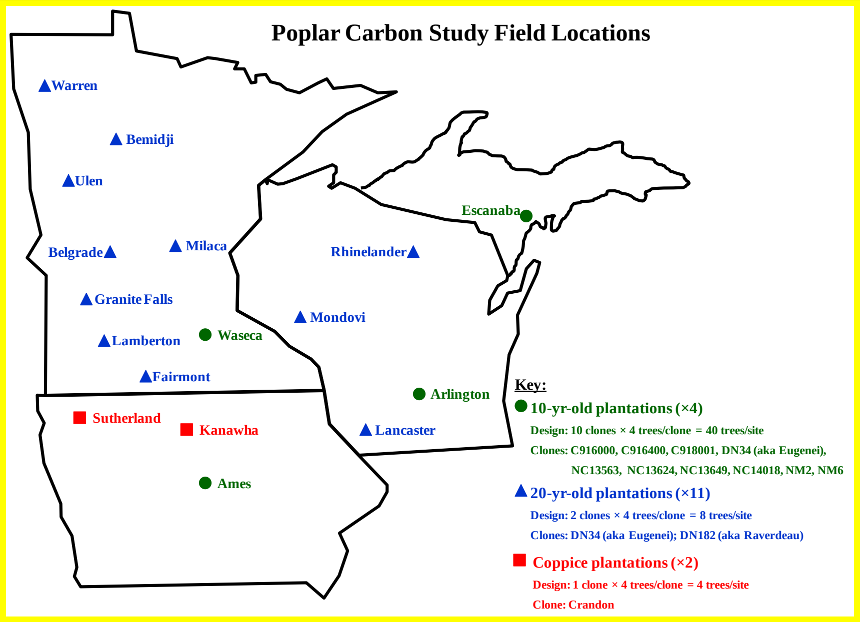
Landowner Preferences

Carbon Implications

3 Productivity Levels
Low, Medium, High
3 Crop Histories
Corn, CRP, Poplar
2 Genotype Groups
Specialist, Generalist

12 Counties
Low, Medium, High
2 Genotype Groups
Specialist, Generalist

Integrated Studies: Regional Sustainability



Productivity Modeling

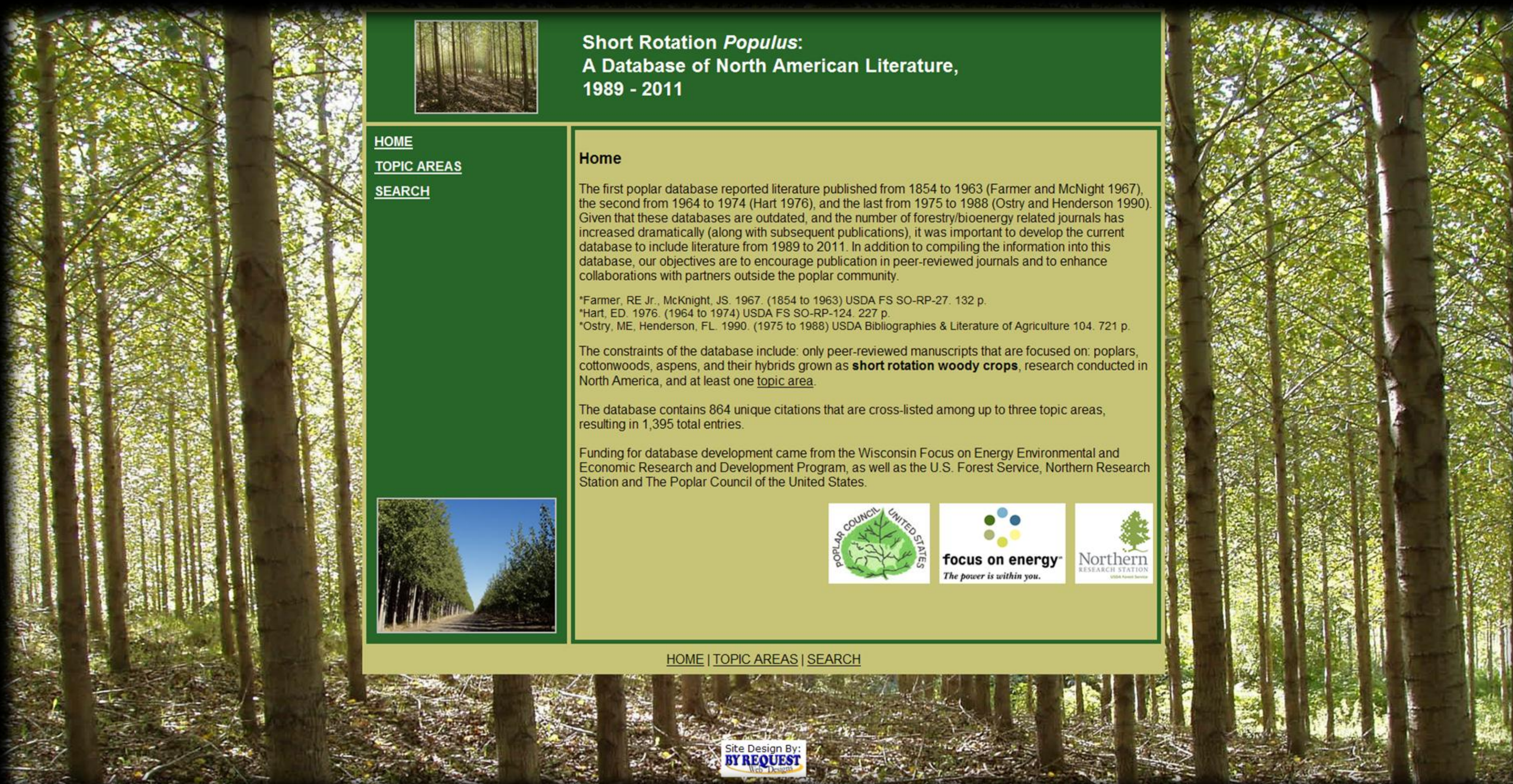
Enterprise Budgets

Landowner Preferences

Carbon Implications

- Soil carbon sequestration & greenhouse gas emissions
- Aboveground carbon stocks
- Biochemical conversion to liquid fuels

Poplar Database: Home



Short Rotation *Populus*:
A Database of North American Literature,
1989 - 2011

HOME
TOPIC AREAS
SEARCH

Home

The first poplar database reported literature published from 1854 to 1963 (Farmer and McNight 1967), the second from 1964 to 1974 (Hart 1976), and the last from 1975 to 1988 (Ostry and Henderson 1990). Given that these databases are outdated, and the number of forestry/bioenergy related journals has increased dramatically (along with subsequent publications), it was important to develop the current database to include literature from 1989 to 2011. In addition to compiling the information into this database, our objectives are to encourage publication in peer-reviewed journals and to enhance collaborations with partners outside the poplar community.

*Farmer, RE Jr., McKnight, JS. 1967. (1854 to 1963) USDA FS SO-RP-27. 132 p.
*Hart, ED. 1976. (1964 to 1974) USDA FS SO-RP-124. 227 p.
*Ostry, ME, Henderson, FL. 1990. (1975 to 1988) USDA Bibliographies & Literature of Agriculture 104. 721 p.

The constraints of the database include: only peer-reviewed manuscripts that are focused on: poplars, cottonwoods, aspens, and their hybrids grown as **short rotation woody crops**, research conducted in North America, and at least one topic area.

The database contains 864 unique citations that are cross-listed among up to three topic areas, resulting in 1,395 total entries.

Funding for database development came from the Wisconsin Focus on Energy Environmental and Economic Research and Development Program, as well as the U.S. Forest Service, Northern Research Station and The Poplar Council of the United States.

HOME | TOPIC AREAS | SEARCH

www.poplardatabase.com

Poplar Database: Topic Areas

Short Rotation *Populus*:
A Database of North American Literature,
1989 - 2011

HOME

TOPIC AREAS

- Cell & Tissue Culture
- Conservation
- Diseases
- Economics & Social Science
- General
- Genetics
- Global Change
- Growth & Productivity
- Insects & Mites
- Physiology
- Phytotechnologies
- Silviculture
- Wood Science & Wood Products

SEARCH

Printer-Friendly Page

Topic Area Descriptions

Cell & Tissue Culture
Proliferation of tissues from callus, ovules, nodules, buds, etc.

Conservation
Sustainability of water, soil, and wildlife resources.

Diseases
Major stem and leaf diseases impacting health and productivity.

Economics & Social Science
Financial feasibility of growing and harvesting poplars; public perception.

General
Advantages and disadvantages of short rotation poplar crops; technological innovations.

Genetics
Quantitative, molecular, and population genetics of pure species and hybrids.

Global Change
Climate change effects on tree establishment and growth.

Growth & Productivity
Below- and above-ground growth of individual trees and plantations, including yield predictions.

Insects & Mites
Major insects and mites impacting health and productivity.

Physiology
Internal processes regulating plant growth and development.

Phytotechnologies
Use of the trees for remediation of contaminated soil, water, and sediment.

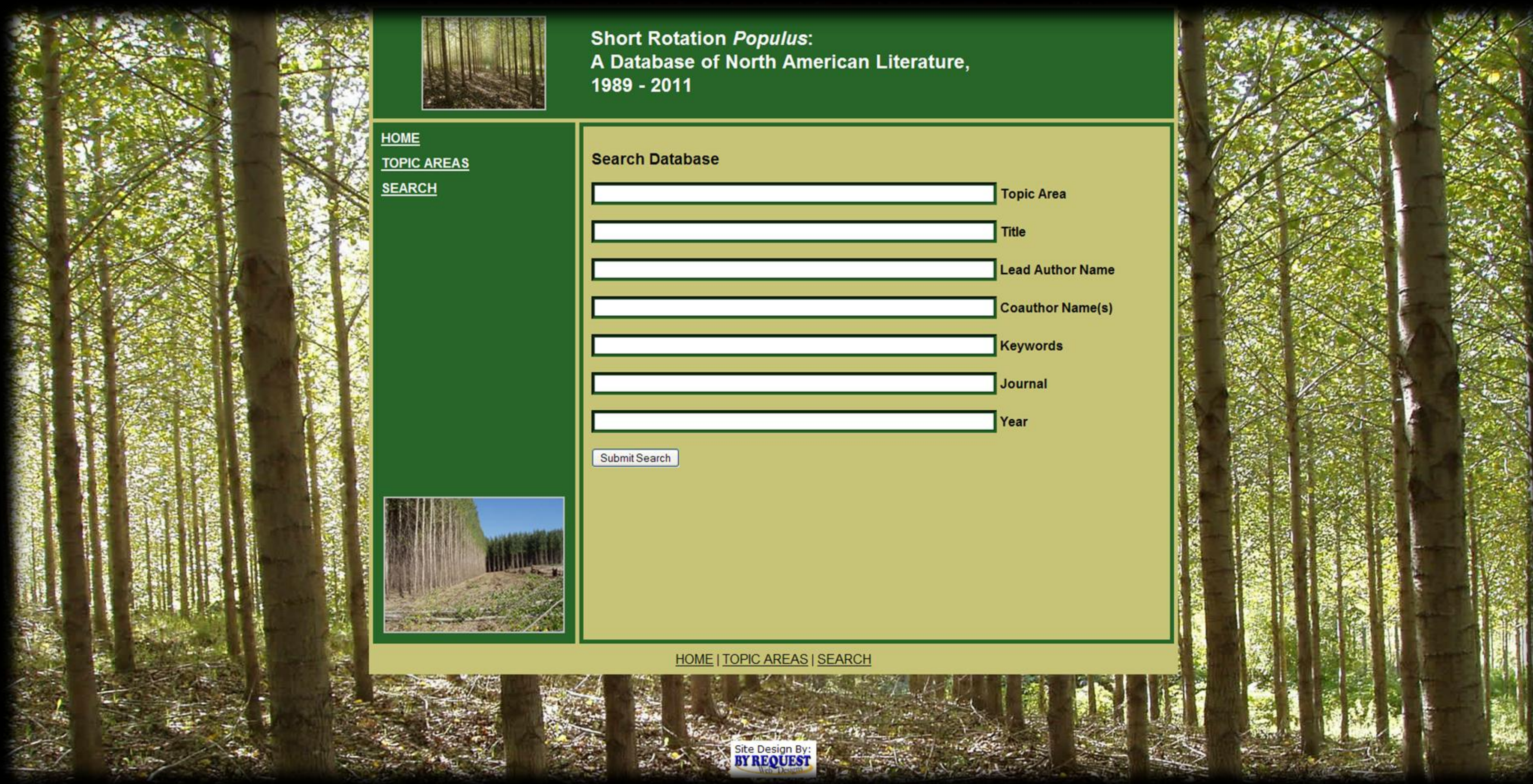
Silviculture
Production management systems, including irrigation and fertilization.

Wood Science & Wood Products
Wood properties and conversion technologies; consumer products.

HOME | TOPIC AREAS | SEARCH

www.poplardatabase.com

Poplar Database: Search



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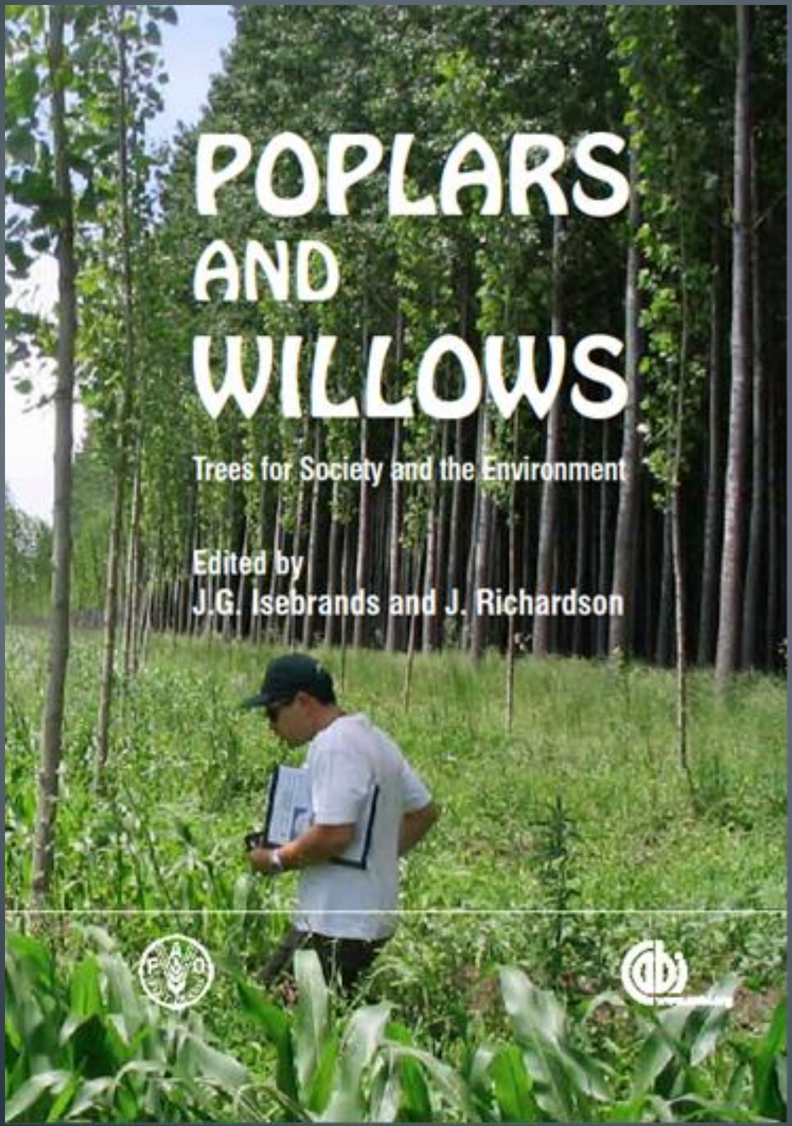
New publication in press



- Worldwide overview
- Latest knowledge and technology
- Research and implementation
- Characteristics, cultivation & use
- Issues, problems and trends
- 13 chapters
- 70 contributing authors
  - from 15 countries in 5 continents
- >500 pages
- Nearly 2500 references
- Fully illustrated (b/w & color)
- Co-publication of CABI & FAO
- Available early 2013

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Contents

Thank you!

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Acknowledgements

I thank the conference organizing committee for the opportunity to speak.

Table 1
Classification scheme for assigning soils to default 3-PG soil classes. The SSURGO soil textures were used for base map development, while the site textures were those sampled from the 143 field plots and used for QA/QC analyses.

3-PG Soil Class	SSURGO Texture	Site Texture	Approximate Composition
Clay[a] (C)	None	Silty clay	>40% clay
Clay Loam (CL)	Clay loam, fine loam, sandy clay loam, silty clay loam	Clay loam, sandy clay loam, silty clay loam	20-40% clay
Sandy Loam (SL)	Coarse loam, coarse sandy loam, coarse silt, fine sandy loam, fine silt, gravelly loam, gravelly sandy loam, gravelly coarse sandy loam, gravelly fine sandy loam, gravelly silt loam, loam, sandy loam, sandy over loam, silt loam, silt, very fine sandy loam, very gravelly loam, very gravelly sandy loam	Loam, sandy loam, silt, silt loam	<20% clay, <80% sand
Sand (S)	Loamy coarse sand, loamy fine sand, loamy very fine sand, loamy sand	Loamy sand, sand	<20% clay, >80% sand

[a]Suitable soil textures for base map development were based on those deemed highly suitable and suitable by Schroeder et al. (2003); those classified as marginally suitable (e.g., with >40% clay content) were not considered in the current study.

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Table 2
Descriptions of soil drainage and erosion risk classes (from Schroeder et al., 2003).

Drainage Class	Description
Rapidly drained	The soil moisture content seldom exceeds field capacity in any horizon except immediately after water additions (soils are free from gleying throughout the profile)
Well drained	The soil moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a significant part of the year (soils are free from mottling in the upper 1 m)
Moderately well drained	The soil moisture in excess of field capacity remains for a small but significant period of the year (soils are mottled in the bottom of the B and C horizons)
Imperfectly drained	The soil moisture in excess of field capacity remains in subsurface layers for moderately long periods of the year (soils are mottled in the B and C horizons)
Poorly drained	The soil moisture in excess of field capacity remains in all horizons for a large part of the year (soils are usually very strongly gleyed)
Erosion Class	
Very low	Good soil management and average growing conditions will produce a crop with sufficient residue to protect these soils from erosion
Low	Good soil management and average growing conditions may produce a crop with sufficient residue to protect these soils against erosion
Medium	Average growing conditions may not supply adequate residue to protect these soils against wind erosion, and enhanced soil management practices are necessary to control erosion
High	Average growing conditions will not provide sufficient residue to protect these soils against erosion
Very high	These soils should not be used for annual cropping, but rather for pasture and forage crops which will protect the surface from severe degradation

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