Commercial Application of Biomass Energy
Laurentian Energy Authority

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Technology Area Review: Feedstock Supply & Logistics

Principal Investigators:

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Organizations:

Laurentian Energy Authority – prime contractor

University of Minnesota, Duluth – subcontract for biomass source research

Commercial Application of Biomass Energy
Laurentian Energy Authority, Virginia, MN

- CHP systems – Virginia and Hibbing, MN in response to renewable portfolio mandate of MN Legislature
- 250,000 green tons needed annually
- Came on-line in early 2008
- DOE project to identify potential biomass sources and costs

Project Goal

Develop Best Management Practices and Logistical and Cost Information for Biomass Energy Sources in Minnesota

- Best Management Practices for Forest Harvest Residues and Brushlands
- Harvest Equipment Development for Brushland Harvesting
- Brushland Resource Assessment
- Forest Harvest Residue Analysis
- Rights-of-Way Biomass
- Poplar Plantations – Breeding and Yield/Clone Tests (modification to 2014)
- Aspen Thinning
- Red Pine Thinning Response
- Repowering – engineering at LEA sites

Quad Chart

Timeline

- Start Date - 7/2007
- End Date - 12/2014
- 75% complete

Barriers

- Lack of information and agreement on acceptable residue removal rates
- Better information needed for management of stands through thinning, impacts, volumes, economics
- Lack of a diverse set of hybrid poplar clonal material in the United States

Budget

Funded through two CDPs – 2006, 2009 for total of 2,221,550 matched by 25% of direct DOE funds in the amount of $555,375 – State, LEA, University

Funding for FY11 - $195,389 total, 148,180 DOE, 47,209 Cost-Share

Funding for FY12 - 34,000 (cost share funds – pending modification)

Funding for FY13 – 350,000 primarily DOE-direct, match has been met

Average annual funding - $383,000 including DOE and matches, approximately 1/3 is University overhead charges on UM portion.

Quad Chart (cont.)
Project Partners

ArborGen – Poplar Breeding and Genetic Development
Aspen Plantations LLC – Poplar Research Acreage
Auburn University– Dr. Tom Gallagher, Harvest Logistics
GreenWood Resources LLC – Poplar Breeding and Genetics
Michigan State University – Cooperative Regional Clone Tests
Minnesota Department of Natural Resources – Harvest Guidelines and Brushland Biomass Assessment, Land for Thinning Trials
Minnesota Power – Land for Aspen Thinning Trials, Funding
Mississippi State – Cooperative Breeding for South/Mid-South
Molpus Land Management Group – Land for Pine Trials, Funding
St. Louis County Land Department – Land for Pine and Aspen Trials
Verso Paper Company – Land for Poplar Genetics and Yield Tests, Funding

Technical Approach

- Multi-Topic Project
  - Ranged from field research with milestones for study establishment and breeding timelines to completion of multi-agency projects with set timelines for public input
- In cooperation with project partners, arranged for materials and land for establishment of field studies and all studies completed according to schedule.
- Breeding activities are done according to biological timeframe and success measured by live plant production
- Biomass studies used on-site visits with loggers, existing databases and information from equipment suppliers to evaluate logistics and costs associated with biomass procurement

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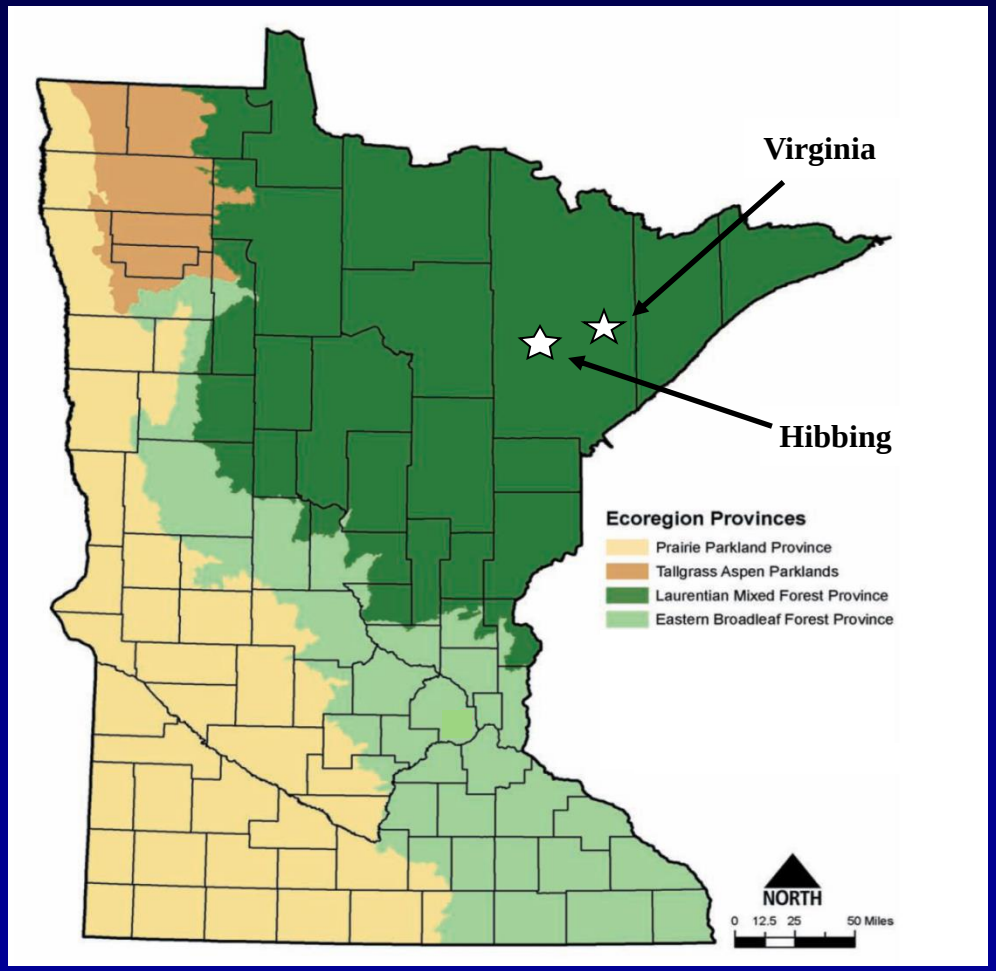
Two locations



Located in the forested zone

Primarily forest biomass but some plantation poplars

New/Underutilized Biomass Sources

Potential Biomass Sources

- Tops and Limbs (small diameter) of trees harvested by the pulp-and-paper or building products industry
- Thinnings – small diameter portion of stand removed to improve growth rate and quality of remaining trees
- Brushland Biomass – low lying, wet areas dominated by naturally occuring willow and alder brush species
- Dedicated Energy Crops – grown primarily on agricultural sites with emphasis on poplar on upland sites in MN

Relevance to DOE Biomass Program Goals

Relates to DOE's stated feedstock goals to:

- Identify sustainable, high-quality feedstock supply
- Develop logistics systems to meet physical and quality specifications
- Develop commercial-scale supply systems

Project done in a commercial context with project partners with attention to develop high-quality woody biomass supply leading to enhanced use in power production (this project) and greater opportunity for biomass-to-liquids conversion

Partnership with DOE

Minnesota Forest Productivity Research Cooperative

- Consortium of industry and public land agencies
- Hybrid poplar breeding and productivity
- Red Pine thinning and productivity
- Aspen thinning potential
- State funds eliminated – DOE funds leveraged

Minnesota Department of Natural Resources - Cooperation

- Biomass Harvesting Guideline Development
- Brushland remote sensing project
- Brushland data collection

SunGrant Regional Feedstocks Partnership

- UM staff lead on Poplar Team

Development of Best Management Practices for Biomass Harvesting on Forested and Brushland Sites

- Statewide effort funded by LEA-DOE project
- First of its type in the country
- Coordinated by the MN DNR – Forestry Division

- Team of twelve people from various disciplines met repeatedly to discuss and develop guidelines

- Bill Berguson was on the team, LEA reviewed documents

- Strong environmental component – nutrient retention, productivity impacts, wildlife concerns and soil compaction

- Produced two chapters as addendum to existing Forest Management Guidelines (one Forest Sites, one Brushlands) – project complete

Biomass Harvesting on Forest Management Sites

CONTENTS

Evaluation of Brushland Biomass

- Potential to harvest biomass from brushland sites

    - potential for significant biomass if:
        - biomass density is sufficiently high and,
        - biomass can be harvested cost-effectively

- Previous tests demonstrated the need for modification of forwarding equipment to collect biomass in windrows produced after shearing

- Interest by the DNR in habitat improvement for Sharptail Grouse – prefers open habitats

Shearing of Brushland Biomass for Wildlife Habitat Improvement

Modification and Site-Testing of Modified Forestry Forwarder

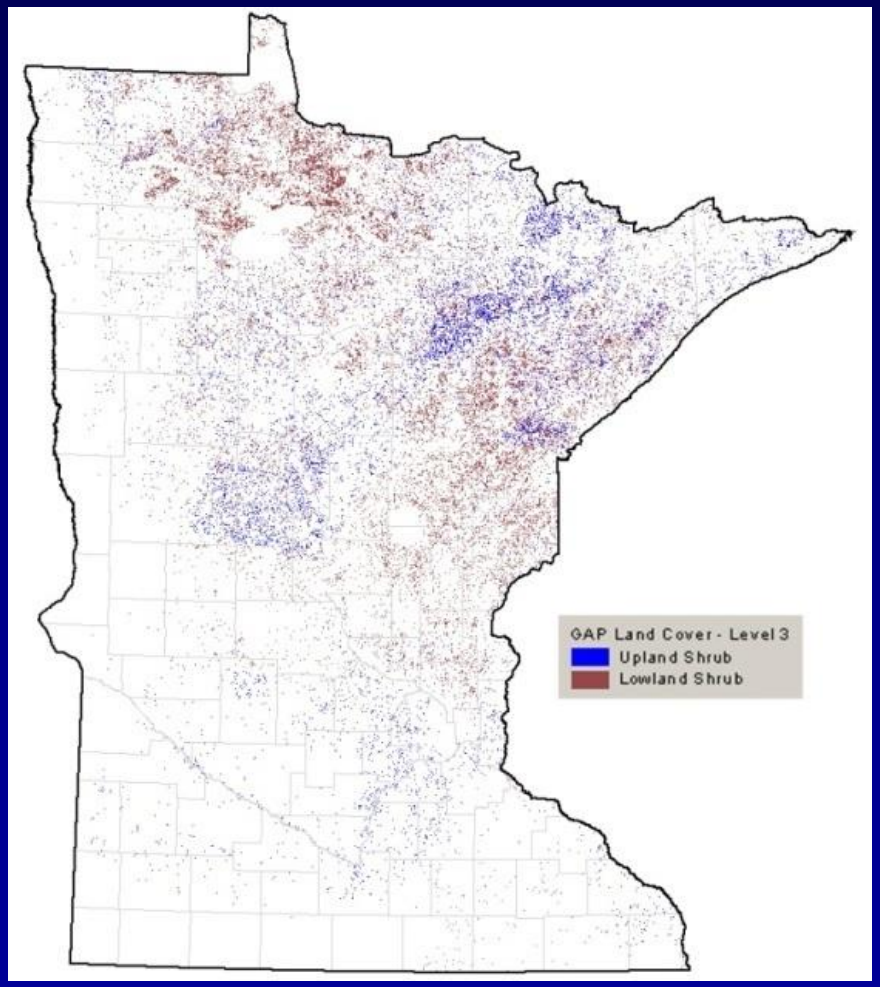
Fabtek 546C Forwarder

- Previous tests on brushlands showed low productivity
- Need to increase handling and carrying capacity
- Testing on high-residue forested sites

Forest Harvest Residue and Brushland Biomass Processing

- Gathered chipping and grinding equipment data including costs and productivity
- Consulted with logging community on integration of energy biomass production into current roundwood production systems
- Produced estimates of processing costs of top-and-limb biomass

Brushland Biomass Resource Assessment



- Relevant question: How much biomass is available?
- Developed sampling plan with the MN DNR
- MN DNR crews sampled biomass
- NRRI/DOE input data, developed biomass equations and estimated biomass on 30 sites

Photo Interpretation by NRRI

- Brushland polygons identified (H, M, L)
- On-site sampling done
- Tested correlation of photo interpretation with on-site biomass estimates
- Average biomass is 4.3 tons/acre
- High average is 8.3 tons, medium 5.3

- Statewide estimated biomass is 10 million tons
- Economic availability affected by biomass density
- 700,000 dry tons potentially available annually
- Results published in DNR/UM report with recognition of DOE
- Result: tool to assess biomass density and feasibility remotely

Forest Harvest Residues

- Top and limb material, not easily debarked
- Easily integrated into current harvesting systems
- Largest, most immediate source of biomass
- Use has increased recently

Thanks to Chuck Baxter for photo

NRRI Forest Harvest Residues

- Analysis of logging infrastructure – costs and logistics
- Developed estimates of biomass availability - residue and low-value hardwoods
- Contacted loggers to determine realized amounts of biomass in current logging operations

NRRI Residue Analysis

- Questions about operational yields in aspen, particularly in winter
- Sampling aspen and hybrid poplar trees from sites in winter
- Average of 15% top and limb biomass – aspen, 25% poplar
- Including nonmerchantable trees (species, form, diameter), 18% a reasonable estimated value for aspen

NRRI Residue Analysis – Red Pine

- Intermediate treatments (thinning) is common with potential to produce significant biomass
- How much biomass in top- and limb material?
- In cooperation with St. Louis County, collected and analyzed data
- 40% top and limb biomass
- Much higher than thought, confirms suspicions of land managers
- Information used in timber sales – practical implications

Poplar Energy Crop Development

- Established test sites to evaluate new genetics and potential yields in Minnesota

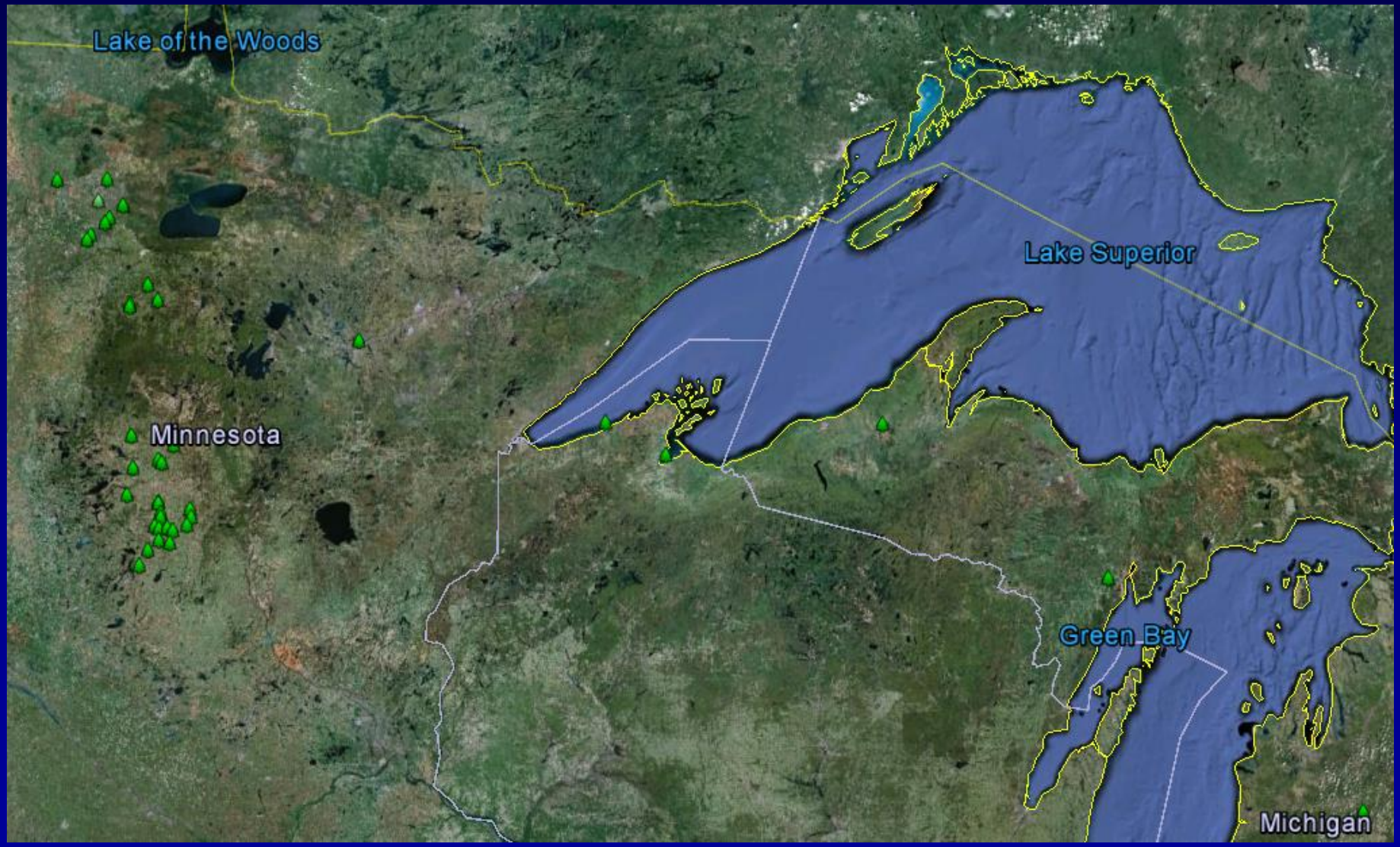
Poplar Culture in Minnesota

- University's research led to genetic selection for commercial use
- Commercial production in Minnesota – 20,000 acres (8,000 ha)
- Energy demand is very high if economically feasible

Minnesota Poplar Field Trial Network

Year Est.	Sites	Clone Trials	Yield Blocks	Family Field Trials	Spacing Trials
1996	1		1		
1998	1	1			
1999	2	4		2	1
2001	1		1	1	
2002	1			1	
2003	1			1	1
2004	1			1	
2005	1			1	
2006	2	2	2		
2007	2	2	2	2	
2008	8	7	6	1	
2009	3	6	3		
2010	1	2	1		
Total	25	24	16	10	2

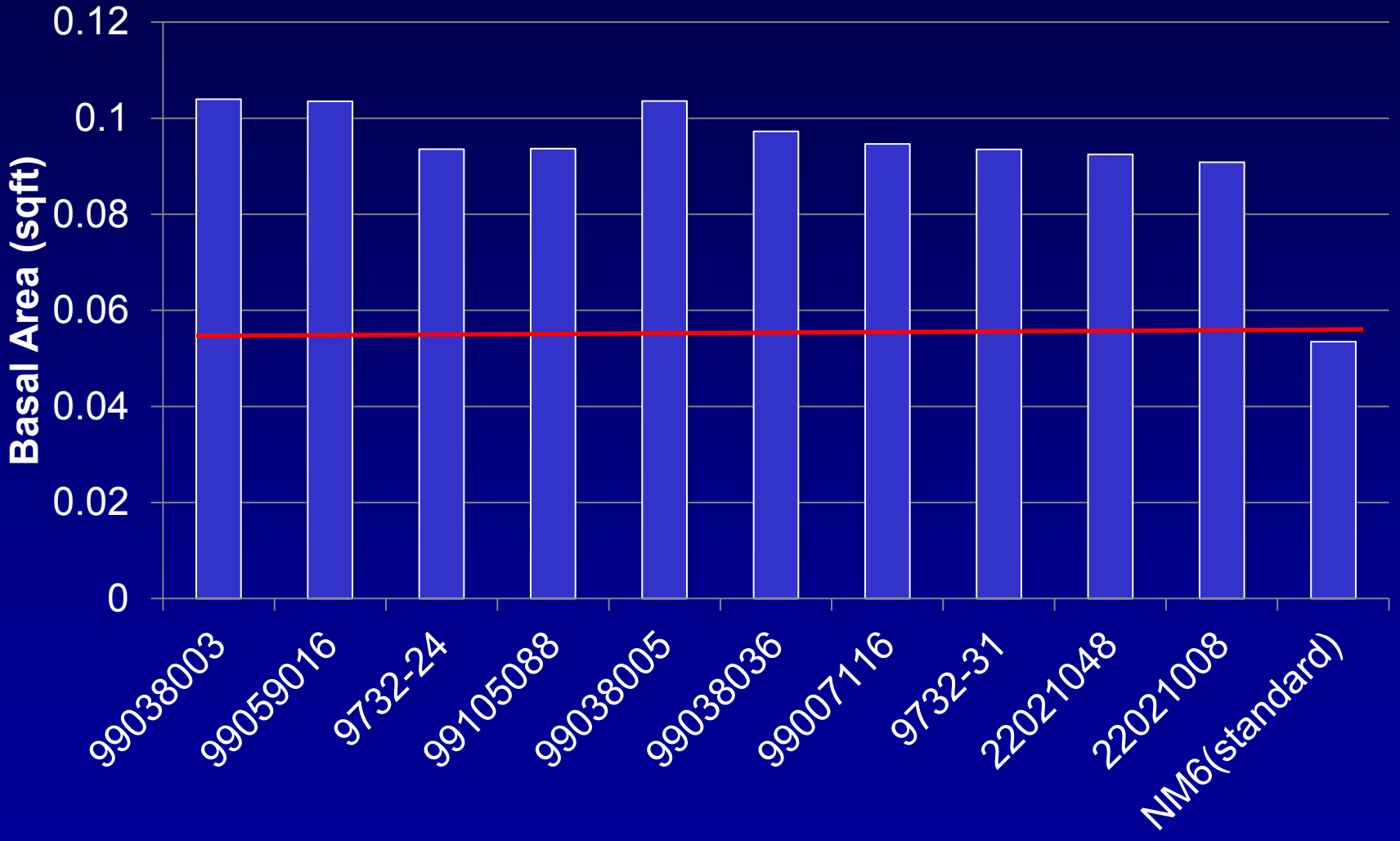
Poplar Field Trial Network – Lake States



Genetic Improvement of Poplars

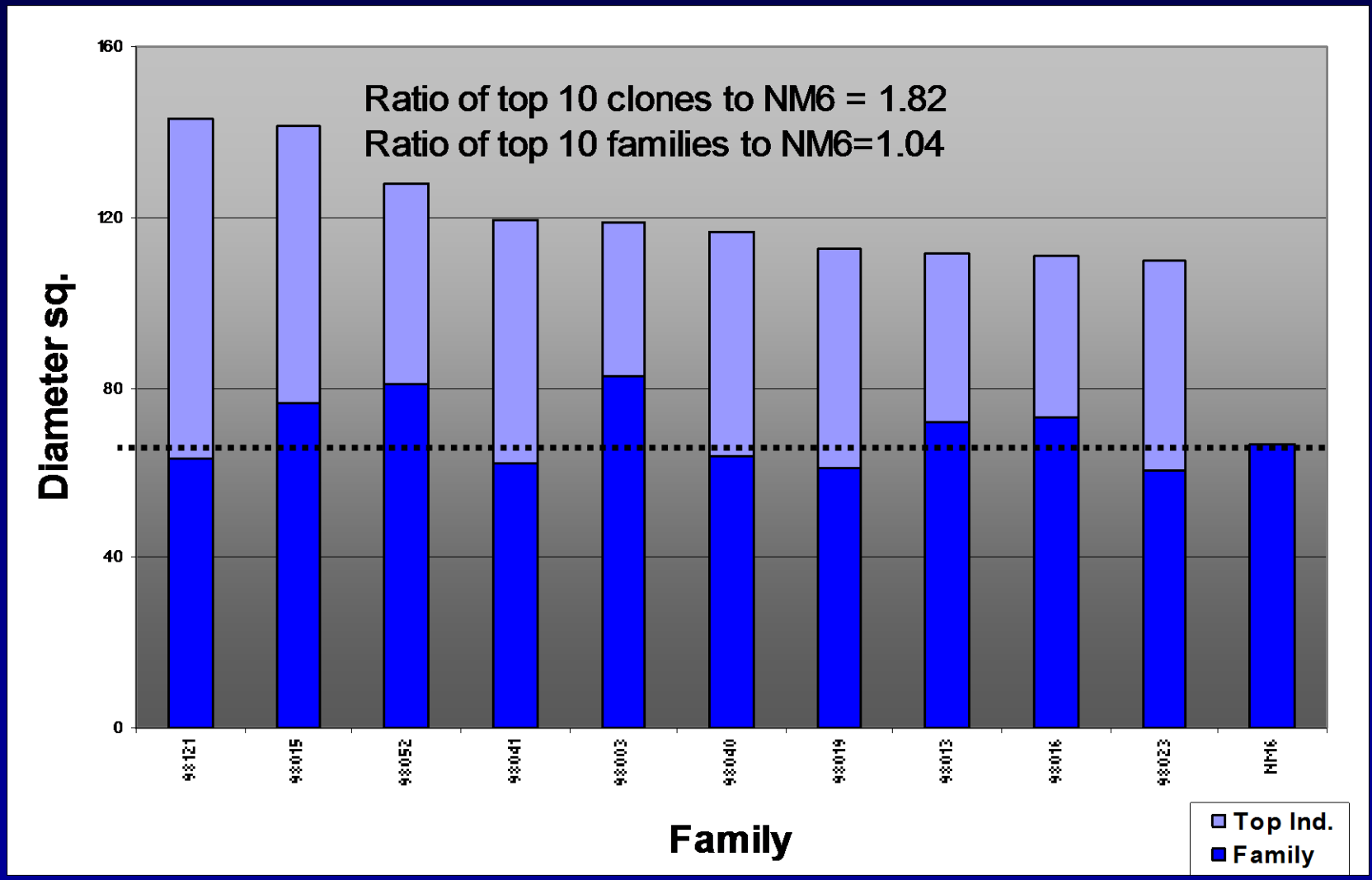
Age 5 Average BA of 6 Clone Trials in MN

71 clones/site planted in 2008



Ratio of top 10 clones : NM6 = 1.8

Central MN - Family Field Tests – Woelful site (after five years)



High potential for yield improvement through breeding

New Research

- Second appropriation allowed additional field research
- Consolidated with the first project as one project
- Large network of previously established Red Pine thinning trials
- Aspen thinning tests underway
- Data collection and analysis on Red Pine and Aspen sites

Red Pine Research

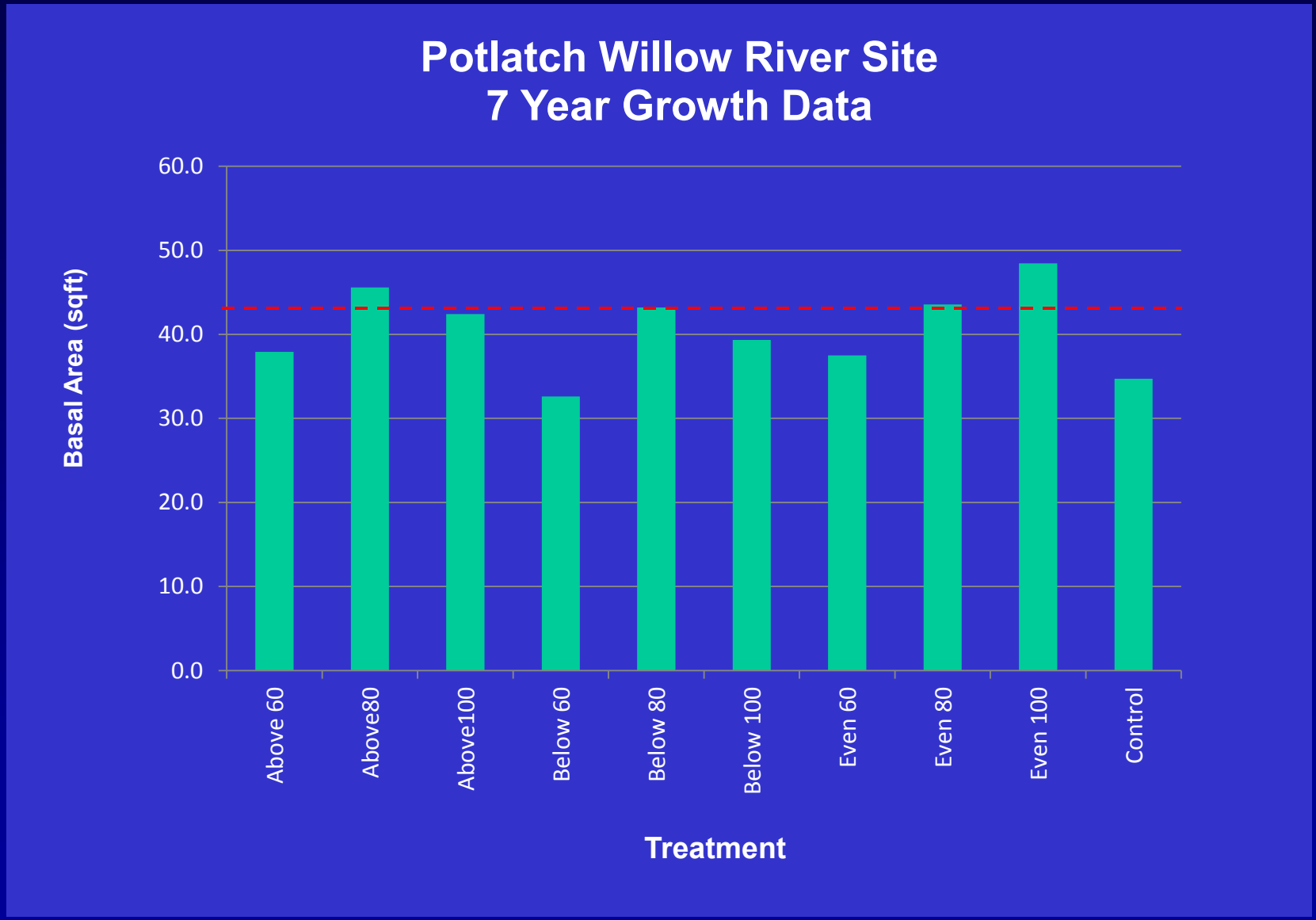
- Nine multi-treatment studies established on partners lands
- Questions remained on effect in young stands, mechanical thinning techniques

- Treatments include a 3x3 factorial combination of:
- stand basal area (how much volume removed)
- stem size distribution (which trees removed)

- This issue is particularly important at first thinning

- Will allow economical thinning at the proper time

Red Pine Research Results



Aspen Thinning Research

- Aspen is dominant in Minnesota – 4.5 million acres
- Three pre-existing multi-treatment trials - control, 300, 450
- ½ acre treatment plots, 1/10th acre measurement plots
- Question of biological response and economics
- What is the price paid in future growth?

Progress Summary

- BMPs for Biomass Harvesting completed
- Brushland resource analysis complete
- Initial harvest residue analysis complete but being updated to reflect changes in forest product industry
- Hybrid poplar test sites established and expanded
- Right of way analysis to be done – funding has delayed completion but pending

Progress Summary

- 13 Study sites completed in Red Pine thinning
- 4 new aspen thinning sites established
- Poplar breeding program being supported by new project modification and directly supports the DOE/SunGrant Regional Biomass Feedstocks Partnership (leadership in poplar team)
- Breeding has been very successful with over 15,000 new genotypes produced for nursery establishment and eventual field testing
- Significant genetics resources benefitting entire program nationally

Pending Modification

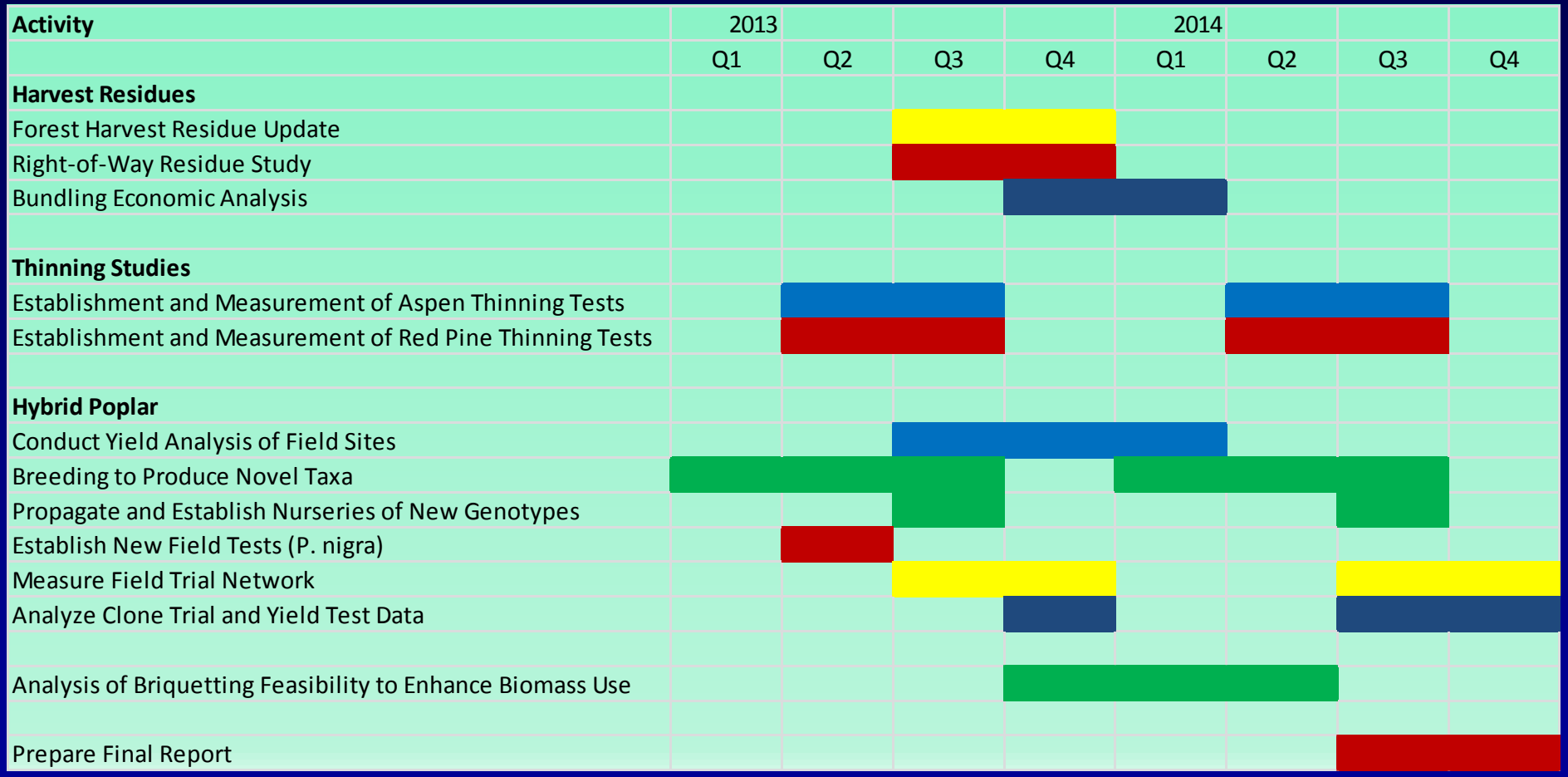
- SunGrant Partnership reduced funding in 2012, 2013

- Approximately $700K left in LEA account due to “no-go” recommendation on repowering from consultants

Added or Continued Modification Activities

- Completion and updating of residue analysis
- Investigation of bundling technology feasibility in cooperation with Tom Gallagher at Auburn
- Poplar breeding to complement DOE national goals
- Continuation of thinning trial measurement and analysis
- Investigation of briquetting feasibility to increase biomas utilization and address MACT rules

Schedule of Future Research Activities



Project Results to Date

- Developed first-of-their-kind recommendations for biomass removal in forested and brushland environments
- Developed method to assess brushland biomass density contributing to logistics of harvest
- Developed method to estimate economics and logistics of practical collection of forest harvest residues
- Established largest network of red pine thinning research
- Established one of the largest poplar breeding and field-testing programs in the U.S.
- Genetics resources important to national program
- Funding will allow continuation of national leadership in development of poplar as a dedicated energy crop

Success Factors/Challenges

- High degree of cooperation with LEA, land agencies, industrial cooperators and SunGrant leadership and within the team
- Interest in information is very high – gasification in industry (iron mines, paper mills, net technology), potential torrefaction in electric utilities – MN Power
- Challenges – lack of current demand and proven technology
- Economics of aspen thinning needs to be evaluated
- Growth response of red pine critical to acceptance
- Poplar research - on track and high payoff but long-term proposition
- Directly relates to DOE goals of delivery of cost-effective feedstock

Project Summary

- Completed Biomass Harvest Guidelines and Incorporated into Statewide Forest Harvesting BMPs
- Completed Joint MNDNR-UM Brushland Biomass Assessment
- Completed Analysis of Harvest Residue Collection Economics
- Completed Analysis of Forest Harvest Residue Availability (to be updated)
- Established Largest Network of Red Pine Thinning Trials in Midwest
- Established Network of Aspen Strip Thinning Trials
- Successful Poplar Breeding with National Cooperators