# Poplar Breeding in North America
# -
# What are we breeding for?

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September 8, 2017
Departmental Seminar
SLU, Uppsala

# Outline

- Commercial species
- Uses of poplars/aspens
- Who is working with them?
- Some program details in
  - Canada
  - USA
- Challenges
- Opportunities

# Backdrop

- Poplar/aspen breeding occurs under the backdrop of enormous natural resources



*Populus tremuloides,* Aw
nearly identical for *P. balsamifera,* Pb

Aw & Pb harvest:
35% - Alberta
40% - Saskatchewan
31% - Manitoba
21% - Ontario
~12% - Territories
(FPAC)

Lake States ( Minnesota, Wisconsin & Michigan) Aw represents ~ 44% of total harvest
(Dickmann et al. 2000)

WikiCommons

# Key Areas

- Pulp (native trembling aspen and HP)
- Oriented strand board (native aspen/poplar)
- Phytoremediation (HP, Pb & willow spp.)
- Reclamation (native aspen/poplar & HP)
- Bioenergy (HP & willow)
- Veneer (HP)
- Feedstock (HP)

# By Region/Organization - CA

- British Columbia:
  - University of BC (eg: (Douglas), Mansfield, Guy - PopCan)
  - BC Ministry (*P. trichocarpa* collection)
  - Dave Derbowka (Passive Remediation Systems Ltd.)
    - www.prsi.ca
- Alberta:
  - University of Alberta (eg: Thomas, Landhausser, Karst)
  - Canadian Forest Service (Krygier – willow)
  - Alberta-Pacific Forest Industries Inc., Western Boreal Aspen Corp.
- Saskatchewan:
  - Agric. & Agri-Food Canada (Raju Soolanayakanahally/Bill Schroeder)
    - willow, AgCanSalix, balsam poplar, AgCanBaP
- Quebec:
  - Pierre Perinet (Quebec Ministry of Forests)
  - Canadian Forest Service (eg: Nathalie Isabel)
  - UQAT (eg: Annie Desrochers)

# By Region/Organization - US

- Oregon:
  - GreenWood Resources (Brian Stanton)
  - Oregon State University (eg: Jared LeBoldus – pathologist)
- Minnesota:
  - UMD NRRI (University of Minnesota-Duluth, Natural Resources Research Institute), US DOE SunGrant Program (Bill Berguson/Bernie McMahon)
  - Aspen/larch coop (Andy David)
- New York:
  - Cornell (Larry Smart - willow)
  - SUNY ESF, Syracuse (Tim Volk)
- Mississippi:
  - Randy Rousseau (cottonwoods & black willow)
- Weyerhaeuser US
  - Hybrid aspen propagation development

Brian Stanton, Barb, Bill Schroeder, Pierre Perinet

# Phytoremediation/Reclamation

- Passive remediation systems – use existing clones (eg: DTAC 7 & TxD53-242):
  - Landfill projects
  - Biochar
  - Remediation options for Oil & Gas (BC primarily)
- Alberta-Pacific Forest Industries & Syncrude:
  - Using balsam poplar (*P. balsamifera*)
  - Taking advantage of a program designed for pulp with 200+ clones screened for salt tolerance

# Al-Pac/Syncrude


- Oil sands footprint = 89,592 ha (2013)
- 0.2% reclaimed to date (2013)
- Process of reclamation begins with reconstructed landscapes
  - Overburden dumps, tailings deposits, process water lakes

# Why use balsam poplar?

- Very flexible species
  - Native species to region (required)
  - Easy to propagate, rapid growth (common feature)
  - Natural role in phytoremediation (used globally)

- Access to appropriate genetic material from regional forest company (Alberta-Pacific) where energy company dispositions and the forest companies forest management agreement areas (FMAs) OVERLAP – partnerships..


Images courtesy Syncrude Canada Ltd.

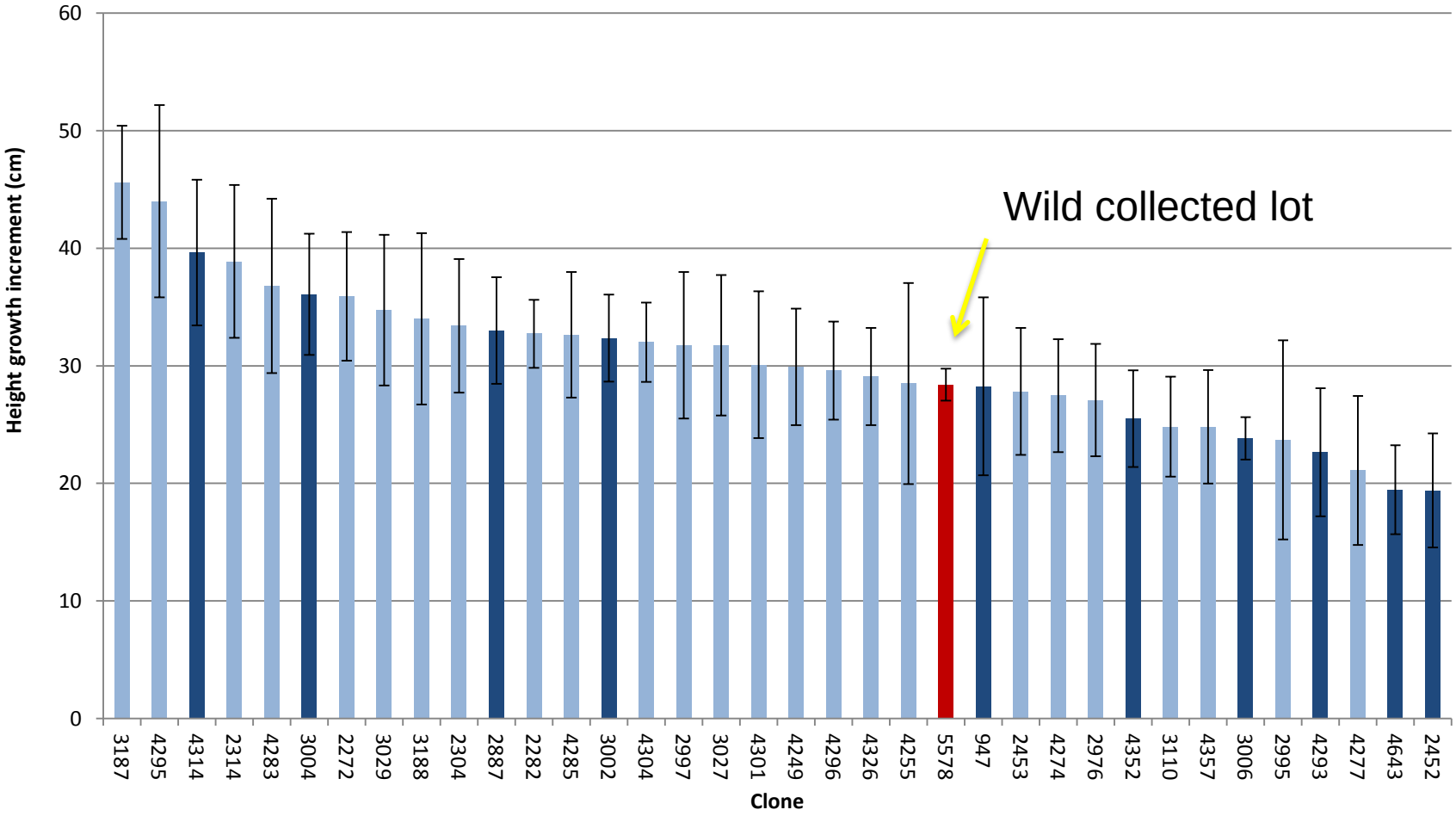
# BML – 2014 plant




- 4-ramets per TRT1 & 2, 60
- 5-tree rows– perpendicular to lake edge
- 40-trees long
- 1m within rows, 3m between rows
- 3 blocks, 200 trees per block

TRT1=salt tolerant; TRT2=not salt tolerant; TRT3=local lot

**Images courtesy Syncrude Canada Ltd.**




**Mean height growth increment (cm) (±SE) for Base Mine Lake by clone in 2015.**

**Light blue bars = high salt tolerant clones; dk blue bars = low salt tolerant clones.**

# Prairie Collections

- Alberta-Pacific Forest Industries Ltd.
  - HP and HA for pulp
  - 10,000ha planted, program closed 2012
  - New clones were about to be released for commercial use (bred and tested for Al-Pac)
- Two Canada wide collections of balsam poplar (AgCanBaP) and willows (AgCanSalix):
  - Some breeding with wide parentage
  - Multiple test sites
  - Available for research and other?

# Example of Al-Pac material

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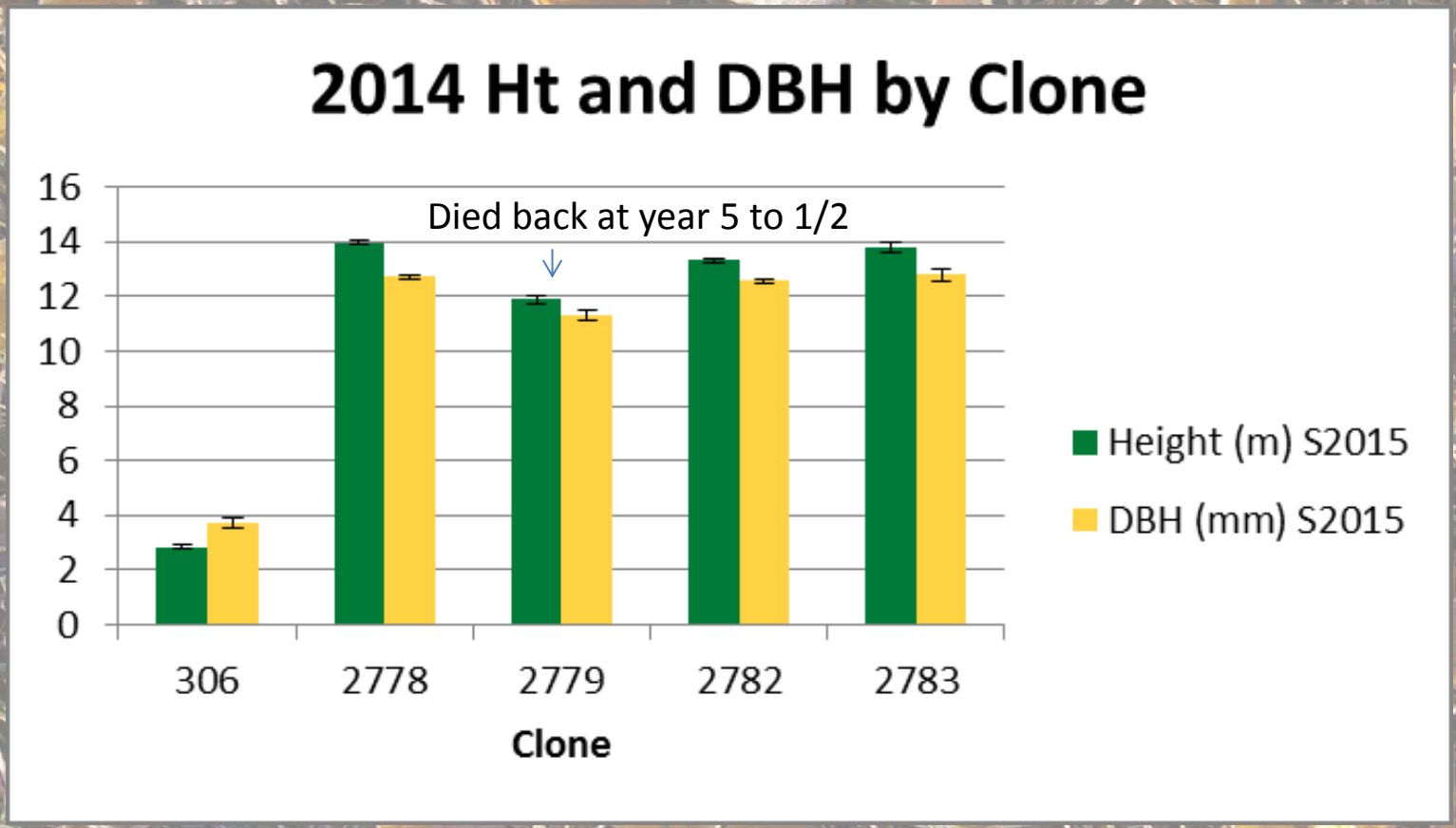



**Nine-year-old hybrid aspen (TxTa) vs native *P. tremuloides***

# Example of Al-Pac material

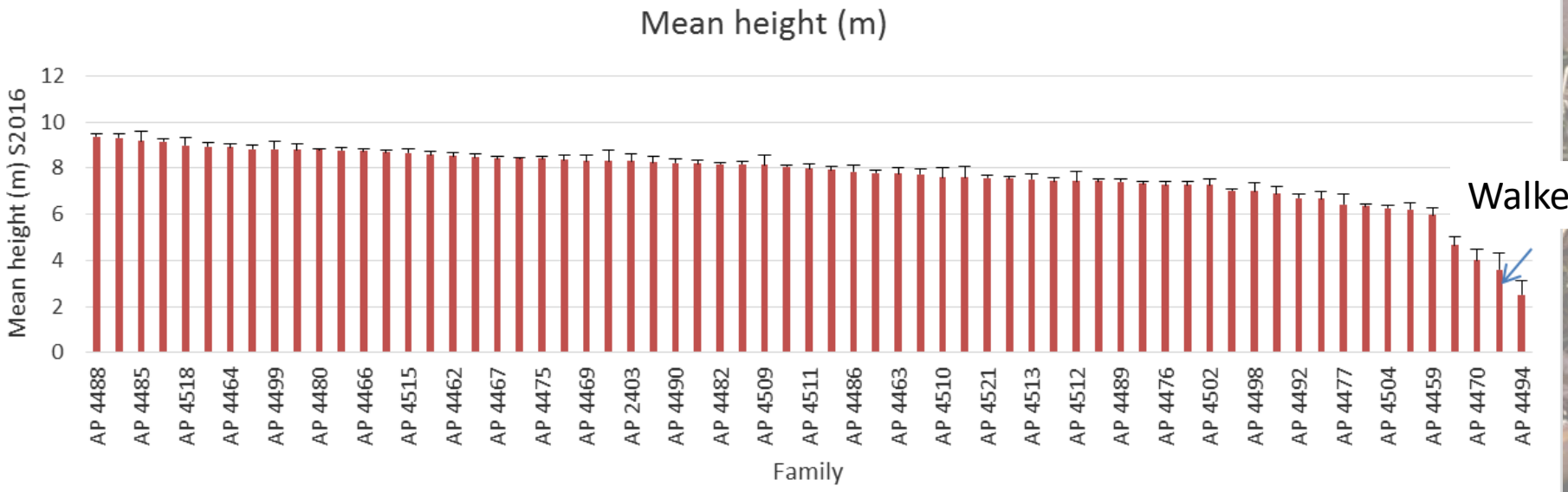
Key families (year 7 growth, Walker control):

AP 4488 = *P. maximowiczii* x *P. balsamifera* (tallest)

AP 4465 = *P. balsamifera* x *P. maximowiczii* (largest DBH, not shown)

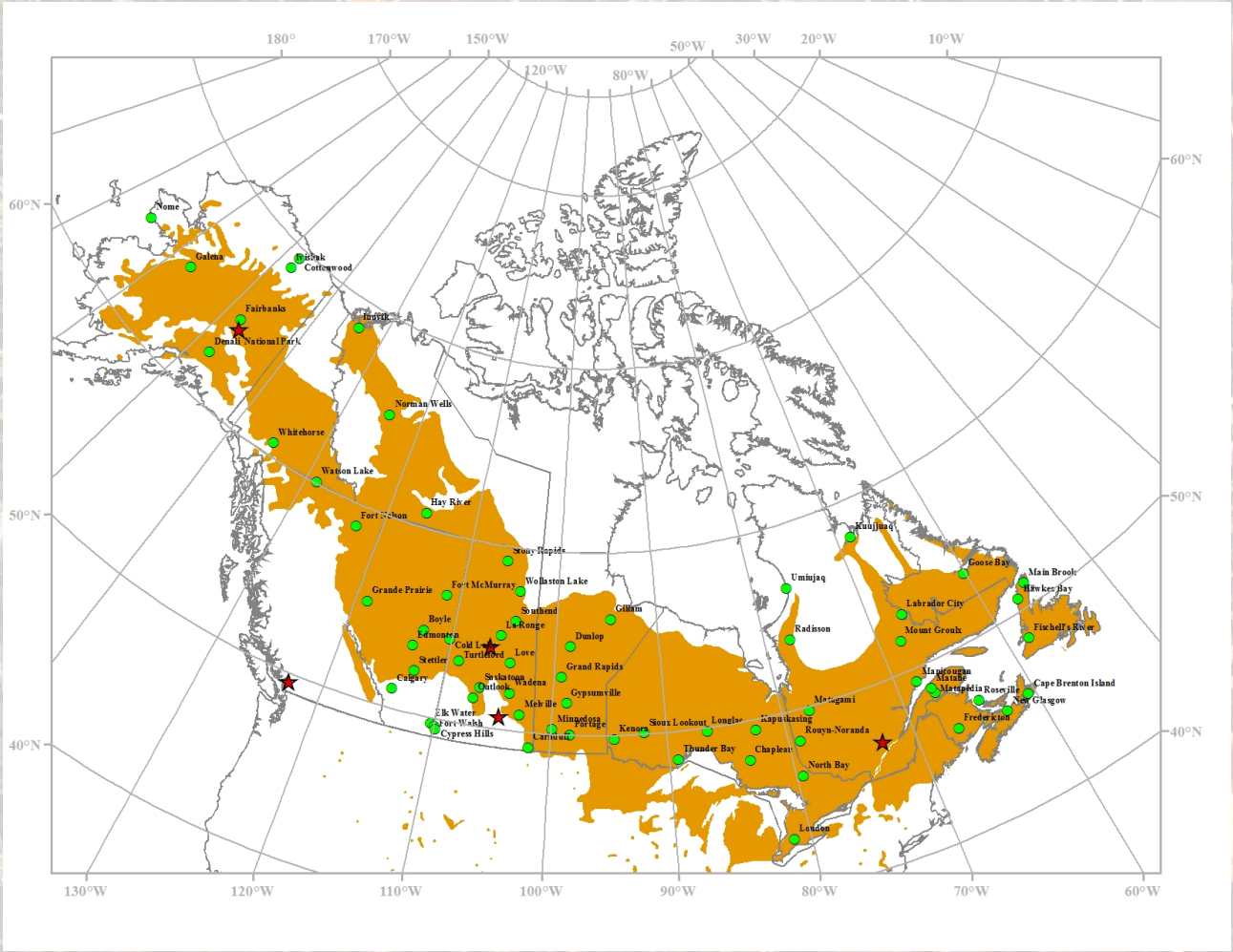
AP 4474 = *P. balsamifera* x *P. maximowiczii* (lowest Septoria score, not shown)

AP 4494 = *P. maximowiczii* x *P. balsamifera* (smallest & highest Septoria score)



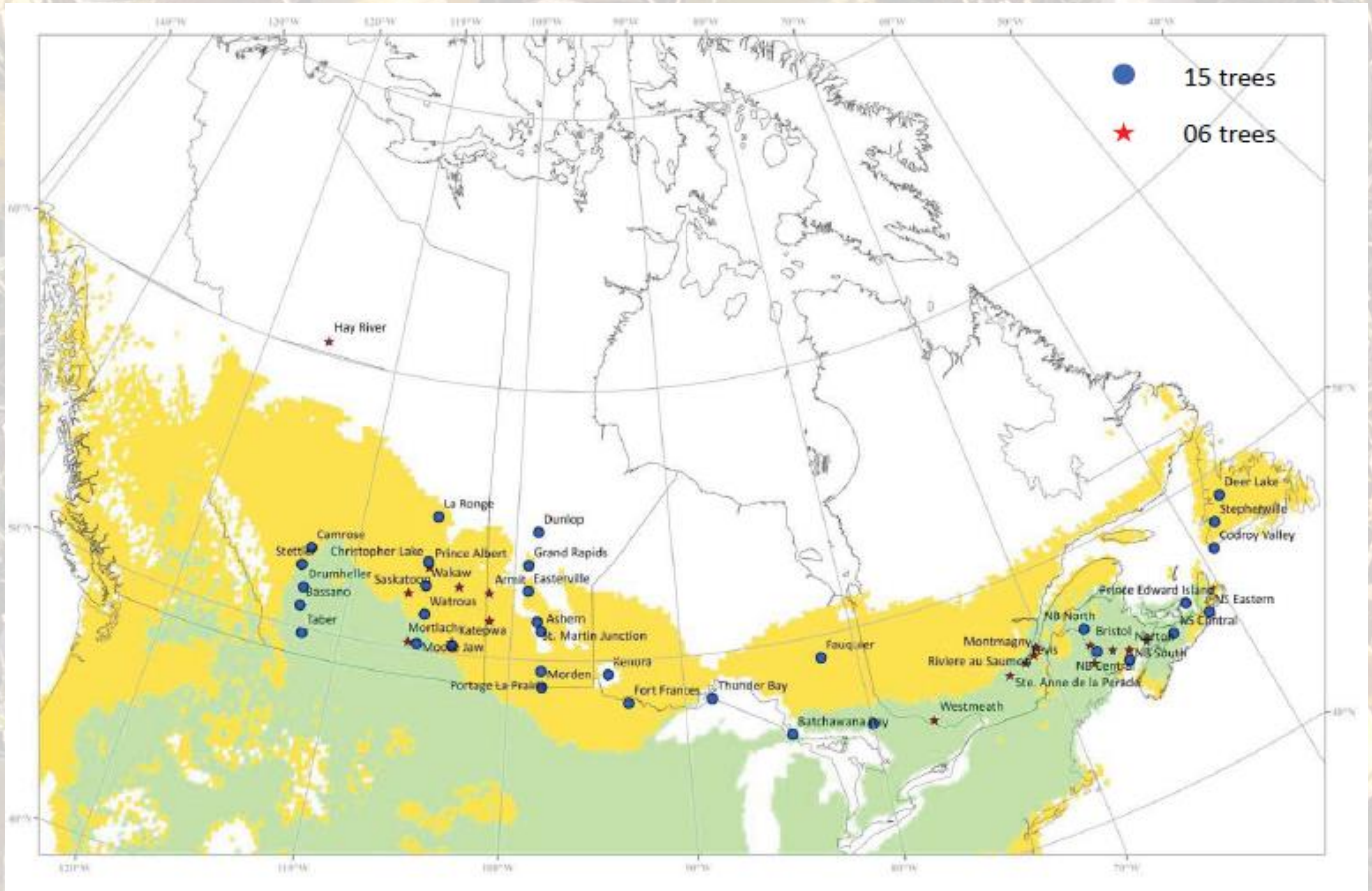
# AgCanBaP – 62 populations

*P. balsamifera* – Bioenergy, molecular markers (UBC)



# AgCanSalix – 53 populations

- 4 species (15 trees/population)
  - *S. eriocephala, S. bebbiana, S. interior, S. discolor*
  - Biomass, bioenergy & environmental applications



# Overview of willow improvement

The same approach was taken for the balsam poplars

**Genotyping**

**Genetic diversity**
SNP database

biomass growth
secondary cell wall genes

AgCan*Salix* collection

**Association mapping**

**Willow improvement program**

**Phenotyping**

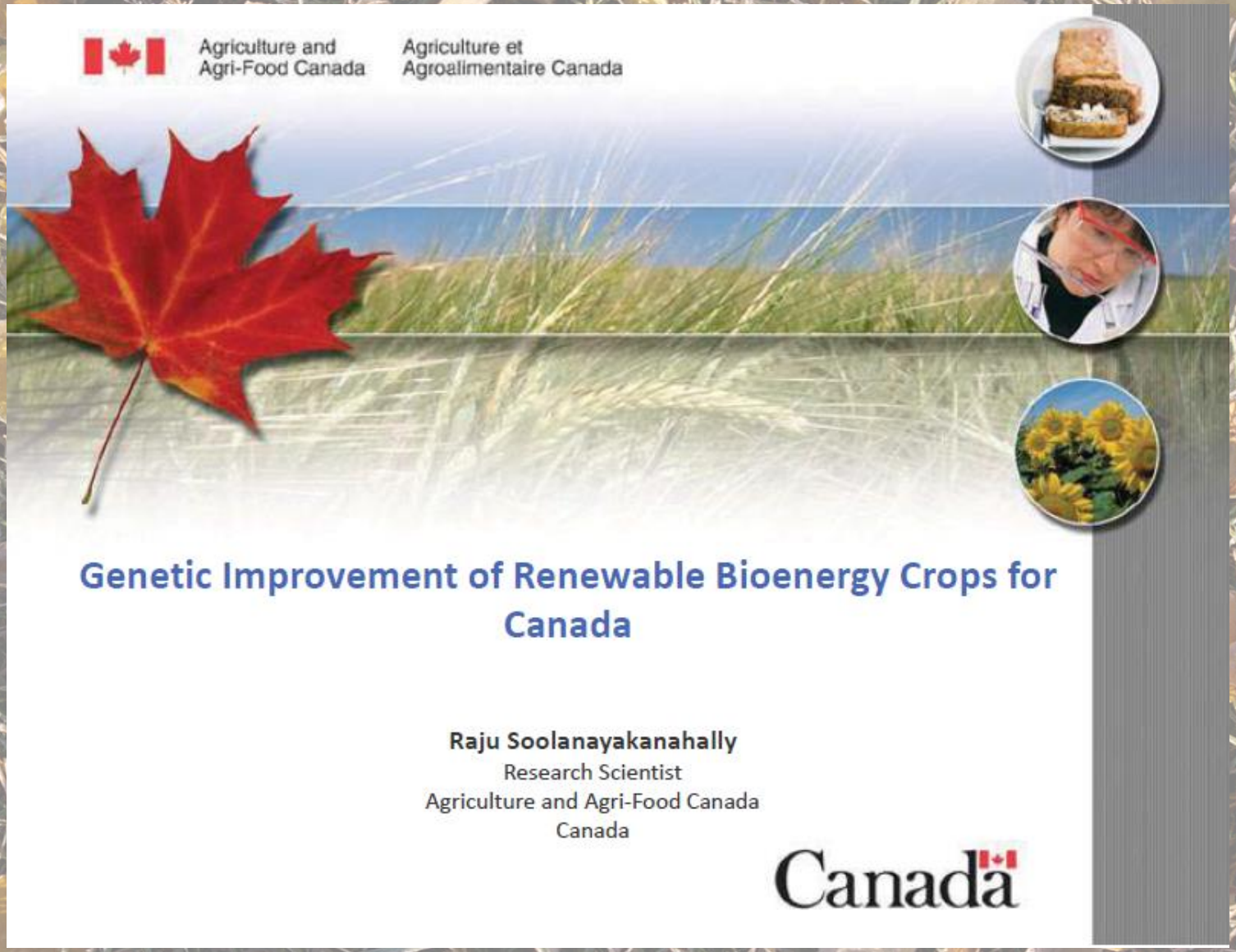
**Biomass traits**
photosynthesis
water- & nitrogen- use efficiencies
leaf morphological traits

**Adaptive traits**
phenology
cold tolerance
salinity tolerance

**Secondary cell wall traits**
wood density
cellulose, hemicellulose, lignin
sugar yields

**Disease susceptibility**
rust monitoring

# Details can be found in:



# Quebec Program
# Pierre Perinet

- Only on-going active breeding program for *Populus* currently in Canada
- 2004 – pure and hybrid breeding (some with Al-Pac)
  - BxB, MxB, BxM, MxD, MxDN, MxT, + parents M, D, DN, B
- 2012 – productive MxT, TxM, TxT hybrids
  - MxT for biomass
- 2016, 2017 & 2018
  - intraspecific *P. deltoides*
  - Hybrids *P. suaveolens* (China) x *P. maximowiczii* (Japan)

# *P. deltoides* breeding

# MxDN;
# Max parents

# Canker damage; MxT 3yrs-old

# Canadian Programs - Traits for Selection – Besides Volume

- Septoria canker (*Septoria musiva*)
  - BC, Alberta, Quebec
- *Melampsora* leaf rust
  - BC, not such a problem on the Prairies or east
- Jared LeBoldus –
  - Oregon State (plant:pathogen interactions)
- Richard Hamelin –
  - UBC (pathogen focus)

# GreenWood Resources (GWR)
# Brian Stanton – Oregon USA

- Manages 6,000 acres (Oregon)
  - Product: Veneer
  - Expectation: Could increase in demand
  - Excess sales to pulp mills in the area
- Other areas of operation/testing
  - Chile, Poland, China

# Species of interest for GWR

- Two taxa
  - *P. x generosa* (aka *P. x interamericana* = TxD or DxT)
    - Good stem form
    - *Melampsora* leaf rust and *Venturia* shoot blight resistance - challenging
  - *P. deltoides x P. maximowiczii*
    - Stem form poor with sweep & sinuosity
    - Resistance to pathogens excellent – no selection required
    - Growth rate 'phenomenal'
  - Both taxa produce superior genotypes acceptable for:
    - Gross & grade recovery from mill peeling and drying trials

# Breeding focus for GWR

- Breeding focus
  1. Parental generations of:
     - *P. maximowiczii* & *P. simonii*
       - Japanese, Chinese and Korean collections
     - P. *deltoides*, *P. trichocarpa* and *P. nigra*
       - North American and European collections
  2. Bioenergy
     - Not competitive with crude oil @ $50/barrel
     - Working with Oak Ridge National Lab & DOE 5-years $
       - Genome sequencing for implementing 'Genomic Selection' using genomic-estimated breeding values for bioenergy conversion traits from 49 *P. trichocarpa* families & 20 full-sib progeny

# Collaborations

- Additional work:
  - *P. trichocarpa x P. maximowiczii*
    - reciprocal hybridization efforts (TxM & MxT)
    - Alwin Janssen (Germany)
    - Targeting the Polish plantation program of GWR
  - MxT progenies to be shared with the Swedish Forest Research Institute
    - Lars-Gören Stener (spring 2018)

# Harvesting 3-year-old monoclonal demonstration block for bioenergy

# 2013 *P. maximowiczii* breeding orchard and greenhouse facilities in Oregon, WA

# Clonal Biomass Trial
# Larry Smart (Cornell)

- Clonal block trial replicated at Geneva and Tully NY
- 50 new hybrids from UMD NRRI (McMahon & Berguson)
  - DxN, TxD, TDxD, D & NM6 control + B from Al-Pac
- Also testing for:
  - *Septoria* canker
  - *Melampsora* leaf rust
  - *Marssonina* leaf spot

# Clonal Biomass Trial
# Larry Smart (Cornell)

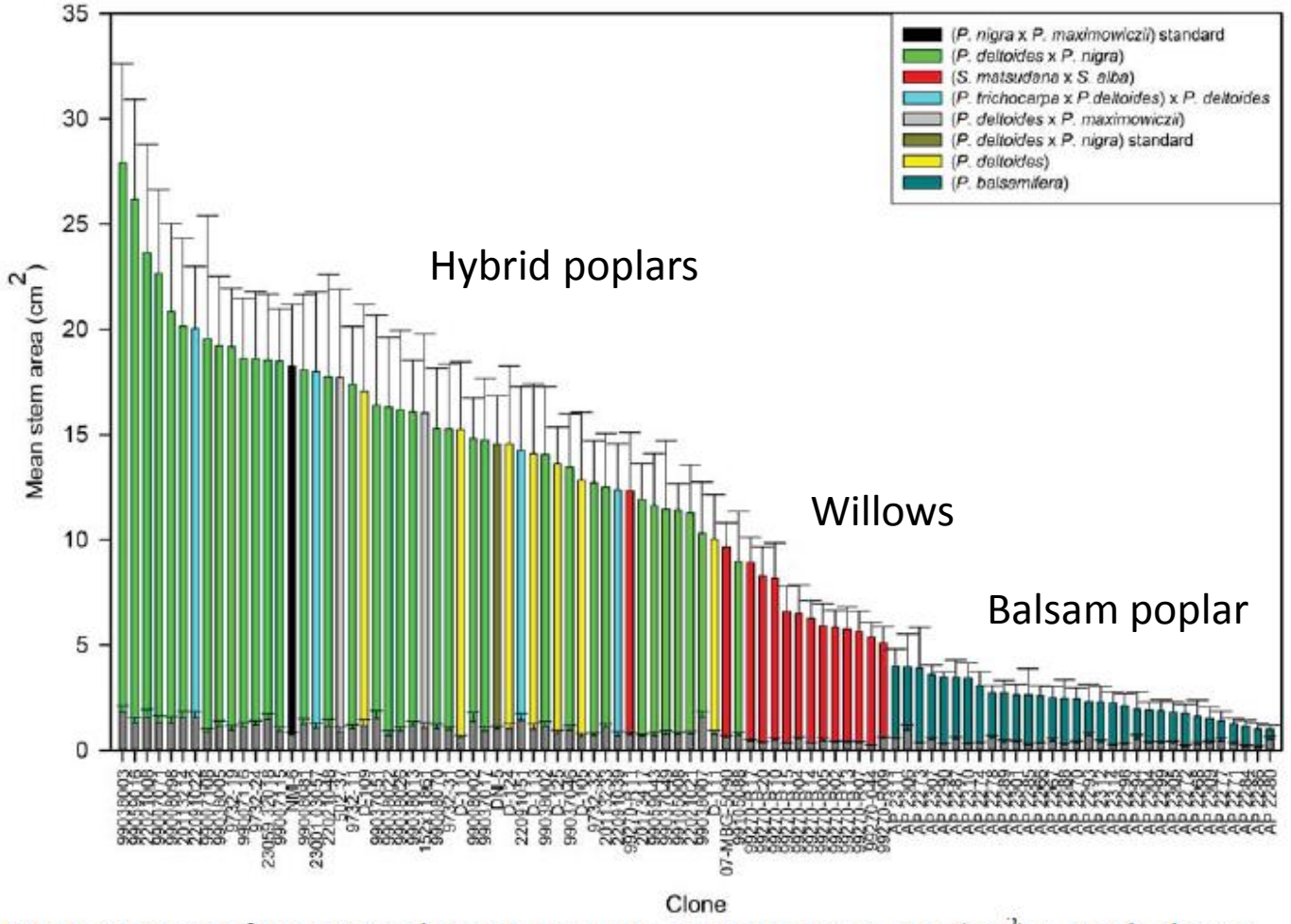



**Fig. 1.** Stem area for year 2 and year 1. Bars represent mean stem area ($cm^2$) ± standard error. Dark gray bars show first year growth.

**Fig.** 7 Poplar clone trial at Cornell's NYSAES Crittenden North Farm – 3rd year growth. Photo taken May 14, 2014.

**Septoria canker lesion on a DxN clone**

# Sun Grant Regional Biomass Feedstock Partnership

- University of Minnesota, Michigan State University, Mississippi State University, University of Tennessee, ArborGen (Southeast U.S.) and GreenWood Resources (Pacific Northwest).
- Allowed for consolidation of a wide array of field trials and genetic improvement research under one national framework.

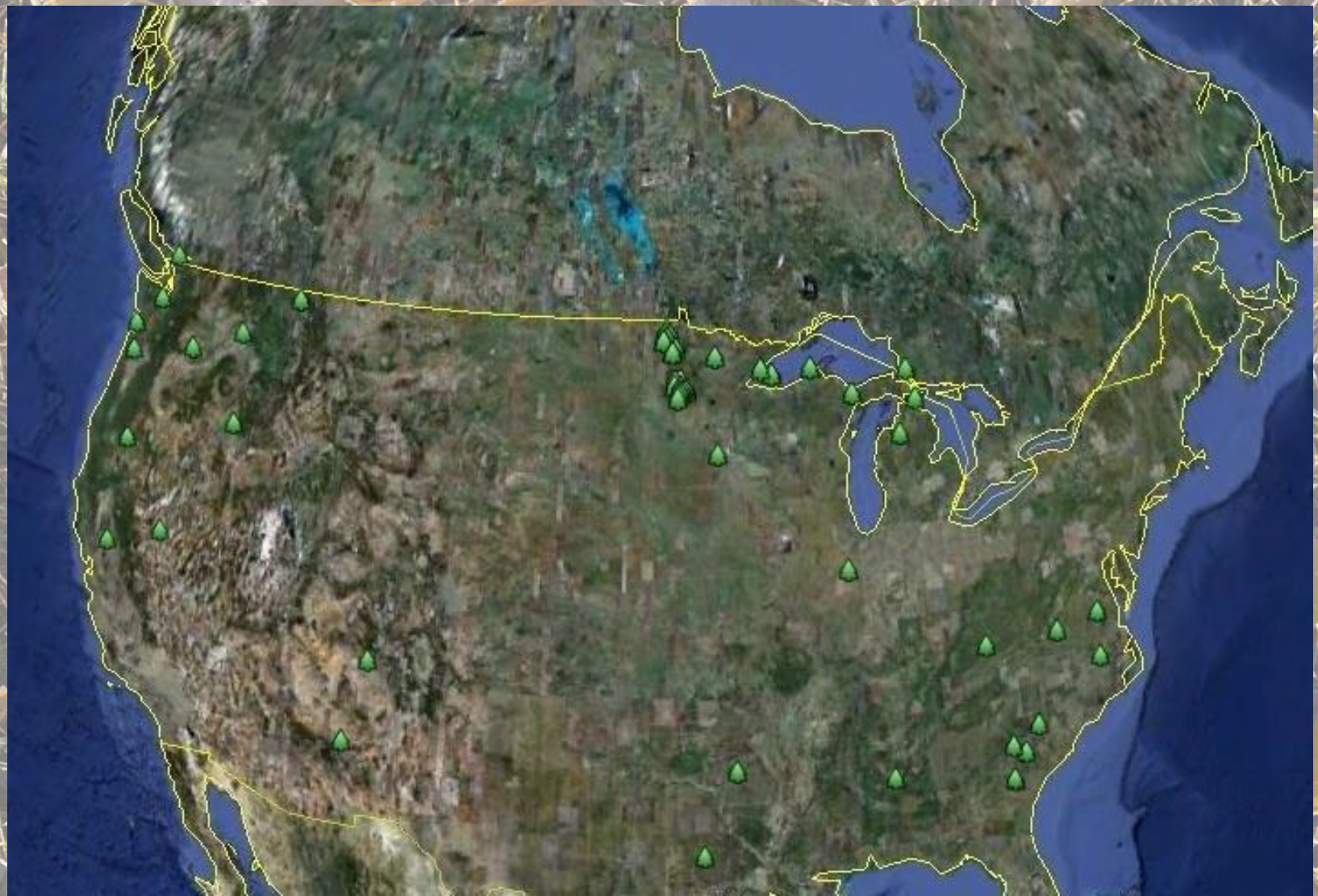
# Goal – DOE SunGrant Final Report (B. Berguson)

- The overall goal of the research is to improve growth and reduce production risk and costs of biomass produced in dedicated feedstock production systems. In the case of poplar, the need exists in all regions of the United States to develop a suite of genetically diverse clones with demonstrated high yield, disease resistance and growth stability on many sites within a region.

# Some Key Features

- Typically 50-80 clones in replicated trials
- Emphasis on improving and testing parental stock in:
  - *P. deltoides*
  - *P. nigra*
- Genetic variance components consistent among three key full-sib families: *P. deltoides* x *P. deltoides*, *P. deltoides* x *P. maximowiczii* and *P. deltoides* x *P. nigra.*

# Sun Grant Regional Feedstock Partnership Trial Network



# Key Outputs

- Tested clonal performance: selected superior genotypes for each region
- Identified canker-susceptible clones in the Southeast
- Produced large quantities of next-generation materials for testing and yield improvement through breeding
- Produced unprecedented infrastructure of parent collections to support further breeding through genetic improvement research
- Enhanced understanding of genetic effects and “bang for the buck” in expected yield gain per breeding cycle (20% gain expected each 10-year cycle)

# Key Outputs

- Developed cash flow models and gained a better understanding of production economics
- Developed a much more extensive dataset of yield estimates for all regions, with benefits to the national mapping effort
- Supported cooperative research in sustainability and carbon sequestration
- Facilitated international cooperation resulting in joint field tests in Europe.

# Challenge

- **<u>Retaining our genetic resources!</u>**
  - Eg: Al-Pac has > 25,000 genotypes of hybrids and pure species collections (eg: *P. davidiana, tremula, simonii, balsamifera, tremuloides*), program closed.
  - Agriculture and Agri-Food Canada – closed the doors at the Indian Head facility after 114 years of research and service to farmers.
    - Distributed seedlings and cuttings to more than 50,000 farmyards, protecting more than 1 million ha of land providing erosion control, snow fences, odor reduction, moisture retention, phytoremediation, shade and enjoyment. Housed international collections of 50 woody species.

# Opportunities?

- Remain significant
  - Volume
  - Flexibility in breeding objectives
    - Fibre
    - Energy
    - Phytoremediation (environmental services)
  - Climate change
    - Short rotations, quick turn around, easy to breed & propagate!
  - Poplar and Willow Council of Canada (www.poplar.ca)
    - clone directory of all (most) clones/seedlots of poplars, aspens and willows in Canada ($30/yr to join!)

# Thank-you!

In particular: Bernie McMahon: Brian Stanton: Pierre Perinet: Dave Derbowka

Poplar & Willow Council of Canada 2011 meeting – Al-Pac

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→ Recruiting for several grad students (MSc & PhDs) to work on trembling aspen in:

***ecophysiology, genetics, & climate change***