ecoETI Theme: Purpose-grown woody biomass production - 2010/11 Progress Report -

Short-Rotation Biomass Production in Native Willows

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*Objectives – **(eco-ETI, 2008-2011)**:*

1. Locate natural populations of promising native willows for field testing in common garden tests
2. Quantify variation in biomass yield and quality traits in native willows
3. Select and distribute superior clones of high-yielding willows & assist in further field-testing

*Objectives – **(Clean Energy Fund, 2010-2012)**:*

1. Test, select, and distribute superior willow clones adapted to mine site conditions
2. Assist in further field testing and mine site restoration

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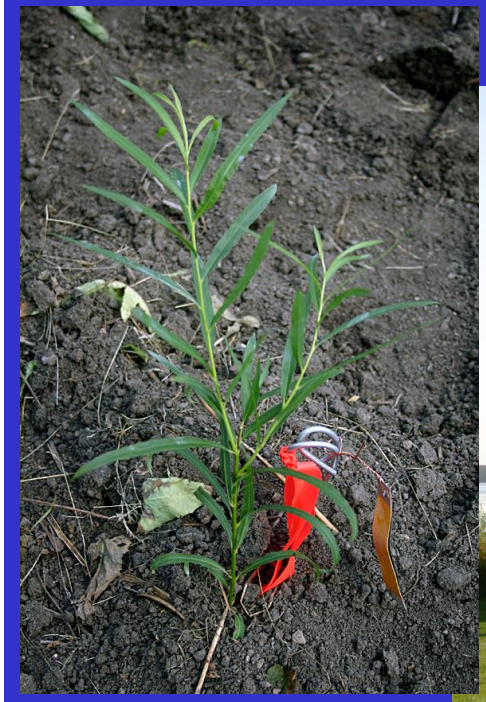
Canada

Some key questions in testing Canada's native willows:

- What are the biomass yields in native willows compared with selected exotic species/clones?
- How can genetic variation within and between species be exploited to select superior clones?
- What biomass yield and quality traits deserve special attention for selection/breeding?
- Can we develop a set of superior clones adapted over a wide range of site types?



Colony-forming
Salix interior

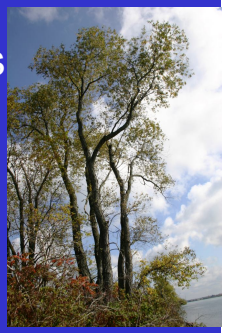
The genus *Salix* (willows) from a global perspective…

- **350** willow species worldwide – mostly in the northern hemisphere
- **76** willow species native to Canada
- Willows occupy a wide range of site types in Canada
- Only about **220** native woody perennial species in Canada

An exotic willow *Salix fragilis* on a floodplain in Chile

Native willow species of interest for biomass production

***Salix* species**	**Habit and height**	**Site type**
S. amygdaloides	8-15 m tree	edges of poorly-drained, standing wetlands
S. bebbiana	4-6 m shrub/small tree	seepage slopes, ditches, upland sites
S. discolor	4-10 m shrub/small tree	seepage slopes, wetlands, & ditches
S. eriocephala	4-6 m shrub	fast-flowing stream banks
S. interior	4-6 m shrub	river banks, sandbars, floodplains, & gravel pits
S. humilis	1-2 m shrub	well-drained upland sites & forest openings
S. nigra	10-12 m tree	riparian habitats (river banks & floodplains)



Salix humilis on a dry, rocky oak-pine ridge

Wetland population of Salix bebbiana, S. petiolaris and *S. discolor*

Progress on activities & deliverables in 2010/2011 for eco-ETI

- Established four new field tests in 2010 (waste management facility, blueberry fields, mine sites)
- Harvested 1 and 2-year-old coppice growth from selected clones from two tests at Montreal Botanical Gardens
- Assessed rooting ability in difficult-to-root *S. bebbiana* and *S. humilis,* and collected cuttings from selected clones
- Collected pollinator species from 7-species willow test at AFC for pollinator diversity studies
- Maintained field tests

Rooting test on mine site

Field tests established along shoreline with best clones from seven species

Oven-dry biomass weight (kg), moisture content & shoot specific gravity of 2-year-old and 1-year-old coppice stems of native willows at Montreal Botanical Gardens (harvested 2010)

Salix species	No. of clones	Percent moisture content	Oven-dry biomass	Shoot specific gravity
			mean (range)	mean
2-year-old coppice:				
S. viminalis	1	51.5	**6.66**	0.43
S. discolor	9	52.5	2.40 (1.55-**4.77**)	0.41
S. eriocephala	8	49.3	3.73 (2.23-**4.67**)	**0.45**
1-year-old coppice:				
S. amygdaloides	8	55.2	1.24 (0.95-1.58)	0.41
S. interior	9	54.2	**1.77** (1.60-**2.28**)	0.41
S. nigra	8	51.7	1.11 (0.76-1.79)	0.42

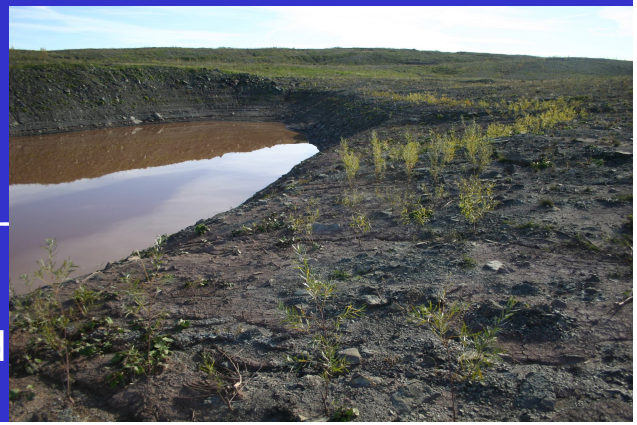
Montreal Botanical Gardens fieldtest

Survival of seven willow species on abandoned coal mine site

- 5 random genotypes from each of 4 natural populations
- rooting success correlated with habitat preferences

Species	No. of clones	No. of cuttings	Species mean % survival	Range in % survival among clones	% survival MBG select clones
S. amygdaloides	20	300	27	0 – 53	
*S. bebbiana***	19	260	5	0 – 40	
*S. discolor***	19	255	**13**	0 – 40	**68%** (12 clones)
*S. eriocephala**	16	235	**66**	0 – **100**	**97%** (24 clones)
*S. humilis***	19	285	11	0 – 60	
*S. interior**	20	295	46	0 – 93	
*S. nigra**	19	275	41	0 – 93	

*riparian species **non-riparian species



NB Coal Ltd mine site

Progress on activities & deliverables in 2010/2011 for CEF

- Collected cuttings from selected, superior clones from established field tests and from natural populations for further field testing on mine sites in 2011 and 2012 (Richard Krygier – NRCan)
- Presented possibilities for mine site restoration to representatives of mining industry in Sudbury, ON (Bryan Tisch – CANMET)
- Initiated collaborative study on ploidy levels in *Salix* spp. (Stewart Cameron – NRCan)
- Continued with identification of willow pollinator species collected in 2010 (Don Ostaff – NRCan)

Restoration of NB Coal Ltd. mine sites with native willows

Stream siltation on mine sites

Two-year-old plants of *S. amygdaloides* and *S. interior*

Five different willow species used along water courses

Stream bank stabilization with colony-forming *Salix interior*

Mature colony of natural *S. interior*

Salix interior spreading along stream banks via stem-suckering from lateral roots

Two-year-old plants from unrooted cuttings

Some conclusions based on preliminary studies of native *Salix*

- Most genetic variation (or differences) in traits resides among species and among clones within a population; relatively little variation among regions or populations (for most traits)
- Yields of 15-20 O.D.T./ha/a based on one-year-old coppice growth are possible
- Wood specific gravity is highly variable both among and within species & a potentially important trait for clonal selection and improvement
- Rooting ability is highly variable both within and among species, important to biomass yields, and clonal selection for improved rooting ability is an important breeding objective
- Riparian willow species root more quickly and more prolifically than non-riparian willows
- Herbivory by mice, voles, rabbits, deer & moose can cause serious growth losses on willows

Deer-browsed cuttings at NB Coal site

Activities and deliverables planned for 2011-2012 under the Clean Energy Fund (CEF) project

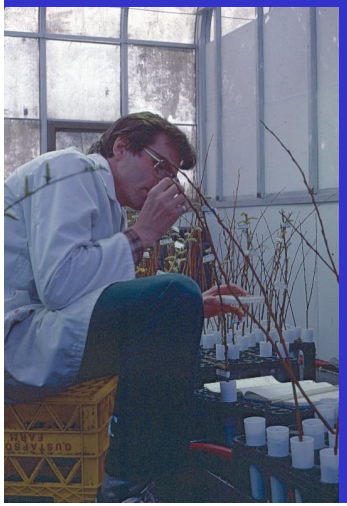
- Establish field tests on mine sites in Ontario in collaboration with CANMET (Bryan Tisch)
- Establish glasshouse tests in collaboration with NRCan-Edmonton (Richard Krygier) to assess selected willow species for oil sands restoration
- Establish a test of 8 selected clones of *S. interior* for bio-remediation of toxic landfill sites
- Identify pollinator species associated with seven willow species being tested
- Continuation of ploidy analysis for sterile hybrid breeding
- Continue maintaining field tests and assessing biomass production

Variations in water levels on mine sites

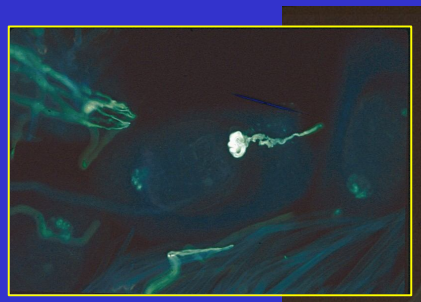
Objectives for 2011 and beyond…

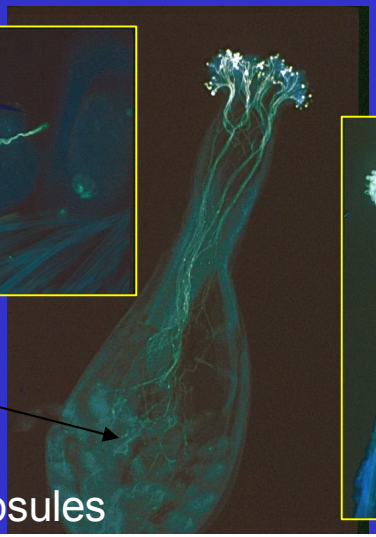
- Continuation of species testing & clonal selection aimed at expanding range of site types available for SRIC with willows (e.g., *S. bebbiana & S. humilis* for drier sites)
- Clonal selection and breeding for specific traits, chemicals, products, plant form, etc.
- Develop sterile hybrids for genetic engineering of traits
- Demonstrations of ecological restoration (habitat, water quality, erosion control, mine sites, etc.)
- Native willows as a foraging resource for pollinators
- Inter-specific hybridization to capture hybrid vigour & specific traits

9-tree plot of hybrid *S. interior x eriocephala*



Female flower capsules





Fluorescent micrographs


Pollen/Stigma Barrier
Normal Pollination
Fertilization