

Using short rotation willow crops: A win-win for the environment



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Short rotation willow crops: A win-win for the environment

Martin Labelle

- Forestry background
- British Columbia RFT
- 20 years managing plantations
- Conifers & some hardwoods
- Trees are initially grown in nurseries
- Then planted: in forests.
- Plugs have soil & roots



Short rotation willow crops: A win-win for the environment

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PREVIOUS WORK:

- Wildlife: Bears, cougars, wolves
- Complicated logistics: Floating camps, islands, inlets
- **Spring 2015:** Joined Bionera to establish willow plantations on marginal farm land in Alberta
- I thought this would be easier work
- With wind, drought, & hail: still challenging
- Now I'm working as a '***farmester***'



Short rotation willow crops: A win-win for the environment

This presentation will discuss:

- The evolution of willow biomass in western Canada
- Various applications for short rotation willow crops, including:



Biosolid use



Wastewater
uptake



Bioheat
feedstock



Land
reclamation

Short rotation willow crops: A win-win for the environment

Who is bionera?

Bionera is a subsidiary of [PRT Growing Services](#),

PRT:

- 30 years growing trees
- North America's largest producer of container-grown forest seedlings
- Network of 15 nurseries across Canada and the United States
- More than 4 billion seedlings planted



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Bionera's history:

- 2007 PRT diversifies operations: Woody Crops.
- 2008 -09 First plantation & biomass boiler in Red Rock.
- 2010 Plantations: Campbell River, BC and Oregon.
- 2011 Wastewater project at Beaver Lodge, AB.
- 2014-17 1000 acres: North Strathmore (6.7M cuttings).
- 2015 70 acres: Ryley, AB
- 2017 First wastewater project in SK: East of Regina.
- 2019-21 Exciting new mine reclamation project, Forestburg

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In 2006-2008: High energy prices

Initial premise for Bionera was to establish willow plantations to provide:

- purpose-grown woody biomass
- & stabilized energy supply and costs

In turn, this would:

- reduce greenhouse gas emissions
- shrink carbon footprint.



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Natural Gas prices have since been on steady decline.

- 2006-08: > \$7.00-\$10.50/GJ
- 2016-18: under \$3.00/GJ
- **Hard to compete**



Bionera needed to find new markets

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In 2013, we joined forces with Sylvis Environmental to **offer project management services and feedstock solutions to:**

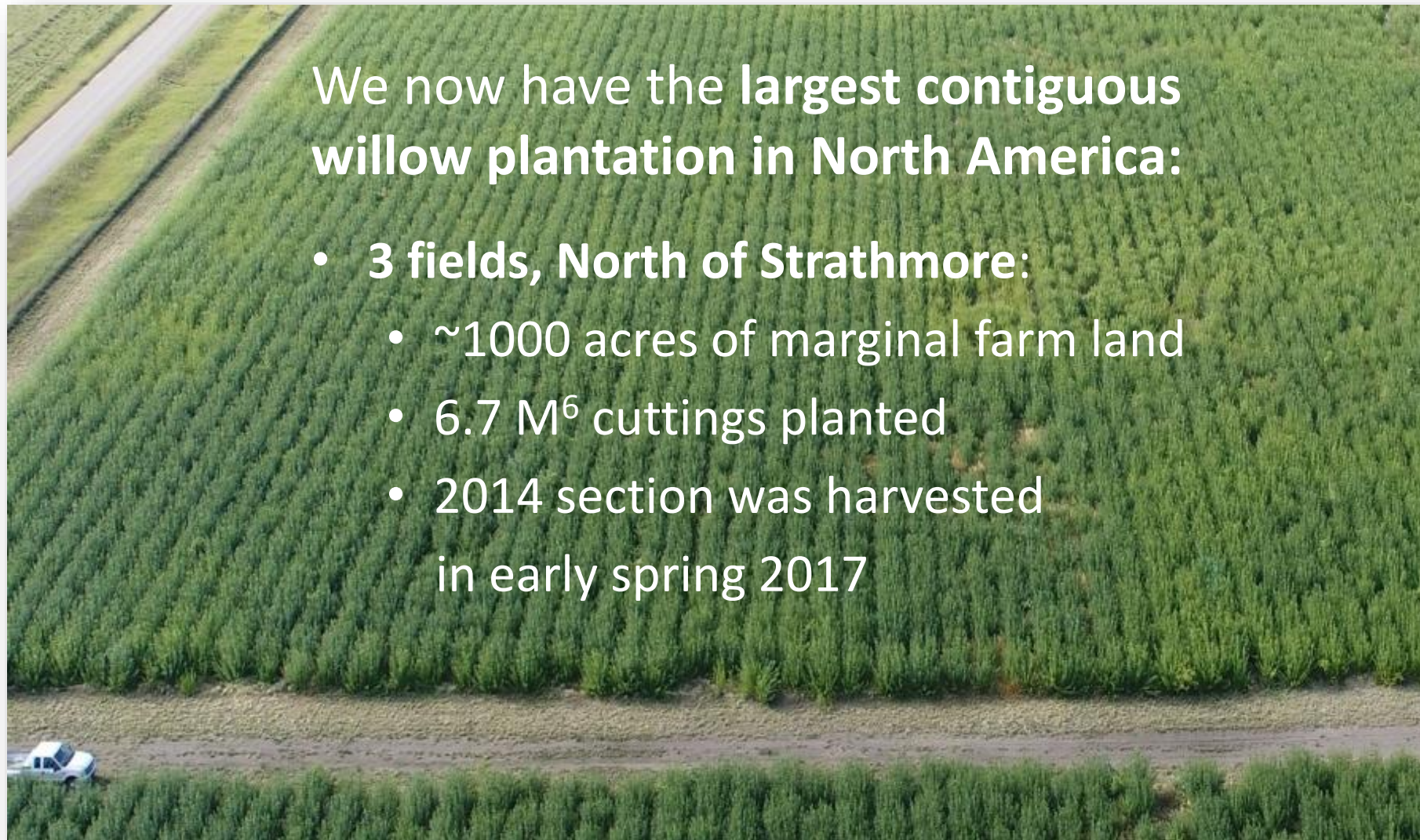
- **Municipalities and Industry:**
 - **Alternate solutions** to wastewater and biosolids management
 - **Phytoremediation options**
 - **Land reclamation choices**



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We now have the **largest contiguous willow plantation in North America:**

- **3 fields, North of Strathmore:**
 - ~1000 acres of marginal farm land
 - 6.7 M⁶ cuttings planted
 - 2014 section was harvested in early spring 2017



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Strathmore, AB project :

- Outlet for the biosolids of the City of Calgary
- > 150,000 bulk tonnes of biosolids applied so far
- > 4,000 truck loads
- > 32,700 dry tons so far
- Target of 8,000 dry tons / yr

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Biosolids utilization: How does it work?

- Biosolids are applied to marginal farmland
- Incorporation is done, using a disking implement.
- The site sits over the winter, until new willows are planted, in early spring.





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The light disking **incorporates the biosolids** and also provides a **smooth surface to plant**, with good soil aeration for cuttings' root development.



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Multiple winners:

- City of Calgary: Biosolid disposal on non-food crop
- City of Calgary: 'Bonus' biomass for multiple uses:
 - Composting, landscaping, zoo
- Land Owner: Soil improvement of marginal farm land: increased fertility and moisture retention



Environmental Monitoring

Critical to ensure:

Soil quality

- Spring sampling, year following biosolids application (fertility)
- Fall sampling, year following application (fertility and metals)

Water quality

- Spring meltwater
- Stormwater catchment, willow irrigation
- Voluntary well monitoring (spring & fall)



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Other Willow Applications:

**Community Wastewater
Treatment**



Bioheat & Bioenergy



Community Wastewater Treatment

- Throughout the prairies: there are more than **2,000 small communities that treat wastewater** with lagoon systems.
- **Excess wastewater** is often **discharged** overland or in adjacent streams during spring runoff
- This can be a **health and environmental hazard**



Community Wastewater Treatment

Irrigating an adjacent willow plantation with the excess wastewater is a great alternative that is:

- Environmentally-friendly
- Cost effective



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Wastewater Treatment: How does it work?

- Wastewater is pumped through the willow field via an irrigation system and provides moisture and **increased nutrients** for the willows, which in turn grow faster.



Wastewater Treatment: How does it work?

- Willows are like big filtering pumps, using their highly **effective evapotranspiration** to extract water & nutrients
- **1 hectare** of willows can treat **6-7 million litres** of wastewater effluents per year (40-60 people's waste)



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Numerous Benefits:

- **Reduction in environmental risk** to rivers and streams by eliminating spring runoff discharge.
- Meeting wastewater treatment standards, while **reducing capital expenditure** for future growth.



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Benefits (continued):

- Irrigating willow fields with wastewater helps **prolong existing infrastructure lifespan**. The system can remain viable for up to **twice the existing population**.
- The biomass produces a **valuable crop** for the municipality, which can result in project cost recovery.



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Benefits (continued): example of a real active project

- **Ohaton** is a hamlet located in **Camrose County**. This is a *Canadian Forest Service* Project where the willow fields are irrigated with municipal wastewater
- The biomass is used to heat buildings at the Camrose County regional facility



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Benefits (continued): **Environment**

- A large willow plantation development is a **wooded ecosystem**.
- It provides habitat, food, and foraging grounds for **songbirds, small mammals, and ungulates**.
- **It also acts as a wind barrier**, which can mitigate noise and smell around the lagoon installations.



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Bioheat

- The biomass from a willow plantation can help **offset energy expenses**, notably heating costs in colder climate portions of the country.



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Bioheat : How does it work?

- The biomass is collected from the plantation, every 3 years, with a specialized harvester.
- Willows grow back from the same root stock



Bioheat : How does it work?

- Biomass can be stored as **chips** or as **whips**, depending on the type and size of storage facility available.
- There are **available harvesters** for the different end uses.



Up to 40 t/hour



Up to 20 t/hour

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Bioheat : How does it work?

- Willow chips are burned in a boiler.
- Hot water circulates in pipes to heat buildings, like these greenhouses in Prince George, BC.



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Bioheat benefits

- Renewable 'green' resource
- Reduced dependency on fossil fuel
- Reliable, carbon-neutral feedstock

Willow Energy Value (conservative):

- 11.3 BDT per hectare / year
- 203 GJ generated in oven dry wood equivalent / year
- 56,388 kWh / hectare
- 4.7 ODT per acre / year
- 77.8 M⁶ BTU / acre
- 22,860 kWh / acre



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PRT Red Rock Nursery, Near Prince George, BC. *A real success*

- 100 burn cycles, starting early January.
- Replaces 80% of work done by 40 360,000 BTU furnaces.
- Offset is the equivalent of \$70,000 in natural gas costs.



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How do we establish a willow plantation?



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Willow Plantation Processes

INTEGRATED APPROACH

- *Suitable site selection*
- *Site preparation*
- *Plant willows*
- *Weed Control*
- *Final inventory
& decision making*
- *Coppicing*
- *Harvest willows*



Willow Plantation Processes

- **Suitable site selection**
 - Climate
 - Soils
 - Drainage
 - Irrigation available?
 - Water
 - Wastewater



Willow Plantation Processes

- **Site preparation** (August-October)
 - Initial weed control
 - Soil depth preparation
 - Biosolids application



Site preparation (August-October)

Initial weed control

- Key to success
- Site sanitation: start fresh
- Herbicide-resistant weeds?
- Pay now vs later



Site preparation (August-October)

Soil Depth Preparation

- Cuttings are 8"
- Compaction can be a problem for rooting
- Must also retain moisture
- Prevent soil erosion



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Site preparation (August-October)

Biosolids application

- Good incorporation is key
- Timing: before fall rains
- Alternative: all weather stock pile



Willow Plantation Processes

Plant Willows (May-June)

- Moisture Availability
- Warm soil temperatures
- Weed control: last chance
- Soil depth



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Bionera uses a mechanical planter

- 4 row unit
- average production of 18-25 acres per day
- Uses 4'-7' whips
- Cuts whips into 8" cuttings and plants them



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Advantages of a mechanical planter:

- Consistent, high quality planting
- Increased daily production
- Reduced breakdowns / maintenance
- Whips require less handling at nursery and in the field
- Better moisture retention



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Cuttings are key to success



- Well hydrated
- Buds tight and hard
- Straight and well nourished
- Robust hybrid varieties, well suited for your site

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How quickly do willows grow?



Within 2-5 weeks, roots
grow below ground
(4 weeks old on this photo)



Shoots emerge above
ground (5 weeks old on this
photo)

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How quickly do willows grow?



6 week old trees in sandy
soils, southern Alberta



12 week-old, 130cm tall
willows in southern Alberta
(near the end of August)

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How quickly do willows grow?



15 week old 170-200cm
willows, southern Alberta
(near the end of
September)



200-250cm at the start of
the second growing season,
southern Alberta (May)

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How quickly do willows grow?



End of the second growing
season: 300-400cm+
(September)



Start of third growing
season: 400-600cm (May)

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Willow Plantation Processes

- **Coppicing: Why do it?**



2 weeks later



4 weeks later



7 weeks later

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Willow Plantation Processes

- **Coppicing: Why do it?**



10 weeks after coppicing, willows occupy land
and start to shade out weeds

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Willow Plantation Processes - Summary

- **Based on sound agricultural practices**
 - Soil pH (6.5-7) and fertility correction, if needed
 - Weed management
- **Most cost incurred at establishment phase**
- **Long term costs are low**
 - Many harvests taken from the same planting
 - Weed control not needed after first two years
 - Fertilizer inputs are low /not required
 - Once established, crop requires little maintenance
- **Harvest cost is low due to mechanization and compatibility with agricultural harvest methods**

New Markets?

- **Industrial Land Reclamation & Phytoremediation**
- **Value added products**
- **District Heat for remote communities**
- **Small scale Bioenergy**
- **Cogen firing with coal**



Agrium- Fort Saskatchewan, AB



Biochar



Portable Gasifier

Acknowledgements

- **Sylvis Environmental:** Pioneer of land reclamation with biosolids
- **City of Calgary:** for endorsing the first large scale plantation
- **Mountain View Hutterite Colony:** for their ongoing support
- **Canadian Wood Fibre Centre at Natural Resources Canada:** for their ongoing support and promotion
- **Camrose County:** for promoting the benefits of wastewater treatment & bioheat with willows
- **You:** for attending this presentation



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Questions?



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