Bringing Short-Rotation Woody Crops Full Circle:
Exploring the Development of Ways and Means to Effectively Establish, Manage and Recover Value from Plantations under Short-Rotation Woody Crop Management Regimes in Canada

CIF e-Lecture
February 24, 2021

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Tim Keddy: Wood Fibre Development Specialist
Canadian Wood Fibre Centre, Edmonton, AB
Overview

Introduction
  • Who are We

Short Rotation Woody Crops
  • Why, What and How

Ellerslie SRWC Technical Development Site
  • History
  • Harvesting Story
  • Carbon Story
  • Economic Analysis

Other SRWC Technical Development Sites
Growing Canada's Forests Program (2Bt)

Questions
Who Are We?

Combined 75 Years of Forest Operations Experience
Combined 40 Years of Biomass - SRWC Experience
Who Are We?

Short-Rotation Woody Crops (SRWC)

Fast-growing, High-Yield Short-Rotation Plantations of Hybrid Poplar, Selected Aspen and Willow Clones with yields of 8-10 times that of natural forest averages.

High Yield Afforestation Rotation: 14-20yrs

Concentrated Woody Biomass Rotation: 3-4yrs
Why is SRWC an Option?

“...contribute to an evolving bio-economy...”

“...new source of wood fibre for the forest industry in close proximity to existing mill facilities...”

“...renewable energy supply...”

“...production of solid, liquid and gas fuels, such as pellets, bio-char, ethanol, diesel, jet fuels, renewable natural gas (RNG)...”

“...reduction in land required to produce wood fibre...”

“...contribute to C reduction...”
Why is SRWC an Option?

Multiple Benefits and Uses!

1) Visual/Noise Buffers
2) Riparian Zone Protection
3) Reducing Erosion
4) Revegetation of Disturbed Sites
5) Enhanced Wildlife Habitat
6) Ecosystem Restoration
7) Sequestering Carbon
8) Generating Biomass
Bio-Product Options for SRWC

Afforestation

Larger (>15cm)

Conventional Forest Product Options

Pulp OSB Veneer Dimensional Lumber

Concentrated

Smaller Diameter

Secondary Forest Product Options

Power Bio-Char Mulch Heat Pellets

Silviculture and BioEnergy Solutions
So How Did We Get Here?

- Intelligence Gathering
- Site Suitability Classification
- Development of Growth Trajectories
- National Network of Sites
- Development and Deployment of Protocols / Practices
- Development and Testing of Harvesting Options
- Validation and Refinement of Growth Trajectories
- Development of Mid-Supply Chain Options
- Industrial Revegetation Testing and Deployment
- Full Rotation Harvesting

- Canada Wide
- Canada / USA
- Maritimes
- Ontario / Quebec
- British Columbia
- Prairies
High-Yield Afforestation

Species: hybrid poplar, aspen  
Densities: 1,100-1,600 stems/ha  
Spacing: 3 X 3 or 2.5 X 2.5 metres  
Rotation Age: 12-20 yrs  
Stem Yields: 13.6-20 m³/ha/yr  
Biomass Yields: (7-10.3 ODT/ha/yr),
High Yield Afforestation

- Grid style plantations
- Consisting of hybrid poplar or aspen
- 11-1600 stems ha
- 1 x 16-20 yr rotation
- 13.6-20 m³ ha⁻¹ yr⁻¹
- 25cm+ DBH at harvest
- 20m+ HT at harvest
- 19-29 t CO₂ e ha⁻¹ yr⁻¹
Concentrated Woody Biomass Plantation: 3-row Bed

Species: willow and hybrid poplar
Density: 15,625 stems/ha
Spacing: 60cm X 60cm between Trees and rows and 2 metres between beds
Rotation Age: 3-4 yrs, 4-6 cycles
Biomass Yields: 6-10 ODT/ha/yr

60 cm between trees

200 cm

200 cm

60 cm between trees
Concentrated Biomass

- Hedge style plantations
- Consisting of hybrid poplar or willow
- 9000-16,000 stems ha\(^{-1}\)
- 7 x 3 yr rotations
- 6-10 ODT ha\(^{-1}\) yr\(^{-1}\)
- Small diameter (<10cm)
- High bark to white wood ratio
Concentrated Woody Biomass Establishment Practices

Site Preparation to create mixed soil to a depth of 30cm

Conditioning (soaking) and planting of Hardwood Cuttings (15,625 stems/ha)

Mechanical Marking to identify planting locations

Vegetation Management to control competition

2nd Year Plantation
Mixedwood Afforestation

Species: hybrid poplar/aspen & spruce
Densities: 1,100-1,600 stems/ha/species
Spacing: 3 x 3 or 2.5 x 2.5 metre/species
Rotation Age: 12-20 / 60-70 yrs (spruce)
Stem Yields: 13.6-20.0 m³/ha/yr
   4.0-5.0 m³/ha/yr
Biomass Yields: 7.3-10.8 ODT/ha/yr
   1.9-2.3 ODT/ha/yr

Spruce planted between hardwoods

2.5 - 3 metre spacing
Mixedwood Afforestation

- 11-1600 st ha\(^{-1}\) Hybrid poplar or aspen
- 8-1200 st ha\(^{-1}\) White spruce (allowing for multiple harvest entries)
- Flexible design and management
- Long term carbon sequestration option
- Fast growing overstory harvested at year 20
- 644 – 820 t CO\(_2\) e ha potentially sequestered over 20 + 50 yr rotation
Planting Design Options

High-Yield Afforestation

- 1,600 Stems/ha
  - 2.5 metres

- 1,157 Stems/ha
  - 2.4 metres

- 1,111 Stems/ha
  - 3.0 metres

Concentrated Woody Biomass

- 15,625 Stems/ha
  - 2.0 metres
  - 60 cm

- 14,815 Stems/ha
  - 1.5 metres
  - 75 cm

- 9,260 Stems/ha
  - 1.8 metres
  - 60 cm
Site Suitability

- a fuzzy-logic modeling approach
- expert knowledge used to determine the selection and magnitudes of environmental variables
- environmental variables selected included growing season precipitation, climate moisture index, growing degree days, the Canada Land Inventory capability for agriculture and elevation
- defined as the fitness of edaphic, climatic and topographic conditions to establish and grow SRWC species at rates 8 times those of native species.

### Site Suitability

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Figures in km²
## Site Suitability

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Figures in km²
## Land Eligible & Suitable for Afforestation Near Mills

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<td>145,706</td>
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Figures in km²
**Short Rotation Woody Crops**
- Purpose: grown woody crops of willow and poplar established as a means of rapidly producing lignocellulosic fiber for use in the wood products industry and for energy.
- Require appropriate site selection and preparation, suitable clonal planting stock and intensive site management to achieve high yields (6x native yields) over short rotations (3-20 years).
- The 3 most common types of SRWC plantations are: High Yield Afforestation, Concentrated Woody Biomass and Mixedwood Afforestation.

**High Yield Afforestation**
- Stand oriented design (1,100 - 1,600 stems/ha).
- Designed to meet yields of 13.6 - 20.0 gross cubic metres MAF or 7.3 - 10.8 CDT/ha/yr of woody biomass.
- Uses biogeoclimatically suitable hybrid poplar cultivars and superior aspen clones under intensive management regimes.
- Established on moderate to high quality agriculture land.
- 15 - 20 year rotations.
- Values: energy, forest products, carbon credits.

**Concentrated Woody Biomass**
- Short rotation (3-5 yr), high-yield biomass plantations that use high density designs (15,000 to 20,000 stems per hectare).
- Designed to meet yields of 6.0-12.0 CDT/ha/yr of biomass.
- High intensity, coppice management regimes with 5-7 generations from one root system.
- Established to develop feedstock for energy conversion and carbon credits (offsets).
- Various cultivars of hybrid willow and hybrid poplar are used.

**Mixedwood Afforestation**
- Designed to mimic the dynamics that exist within mixedwood forests in western Canada - the hardwood (hybrid poplar) provides the protection required by the spruce understory.
- Hybrid poplar (1,800 stems/ha) are inter-planted with white spruce (1,200 stems/ha) to meet yields of 13.8-20.0 m³/ha/yr and 4.0-5.0 m³/ha/yr respectively.
- A dual-crop strategy that maximizes the biomass, fibre and carbon values available from a given land base.
3 Key Factors for Success

**Site Suitability**

**Clone Selection**

All Equally Important!

**Management Systems**
Site Preparation Operations

Proper site preparation is vital to the success of growing any type of agricultural crop. This is also true for the establishment of trees or shrubs on agricultural land. The three key components of any afforestation site preparation plan are:
1. Creating a suitable rooting environment
2. Leveling the site to facilitate future treatments
3. Initiation of the site vegetation management program

Vegetation Management

“The importance of vegetation management of concentrated biomass for energy plantations cannot be overstated.”

This statement is paramount to the success of any plantation. A lot of time, effort and money can be used to establish an afforestation plantation. But if the competing vegetation is not managed correctly, all those initial resources will be wasted. Vegetation management treatments can take the form of chemical, mechanical or manual treatments. Experience shows that a successful vegetation management program requires a combination of two and sometimes all three of these options.

In other parts of the world, a post-planting pre-emergent chemical application is recommended. In Canada, very few, if any, of the suitable pre-emergent herbicides have included afforestation plantations in their label specifications. Again, experience has shown that the selective nature of the chemical applications have resulted in an increase of other species of competing vegetation which require additional mechanical and manual treatments. Therefore it is recommended that vegetation management programs be designed to deal with the competing vegetation post-emergence.

To manage competing vegetation requires close monitoring and timely action. It is vital that the vegetation be controlled at an early stage so that these seedlings are not able to develop a sustainable rooting base. It must be realized that the competing vegetation has the ability to go from the 3-4 leaf stage to the 30 centimetre stage in a relatively short time. It must also be remembered that once the competing vegetation reaches or exceed the height of the planted material it becomes very difficult to differentiate between the two. Once this occurs, the risk of damaging the planted material increases and the cost of vegetation management has the ability to skyrocket as the productivity decreases and the resources required increases.

Planting Operations

Establishing afforestation plantations is an expensive endeavor. The largest portion of these costs is the planting stock and the planting itself. Due to this high cost, it is paramount the planting operations be well-designed and carefully implemented. The implementation process can be divided into 3 separate operations:

1) Planting Design and Site Marking
2) Stock Preparation
3) Planting Methodology

Planting Design

Many groups from all over the world have been establishing afforestation plantations. And there has yet to be a consistent design incorporated by everyone. The single consistency between the designs is that all designs equate to 1,100 to 1,600 stems per hectare. The goal for any plantation design is to ensure an even distribution of stems over the entire area so that each tree can take advantage of the sites resources equally. The design must also take operational factors into consideration. For example, the design must incorporate access to equipment for operations and harvesting.

The Canadian Wood Fibre Centre has incorporated the 2.5 meter X 2.5 metre, 1,600 stems/ha design into their plantations. The uniform spacing between rows and between trees within rows allows for multi-directional management operations while enabling the trees to share site’s resources equally.

“Operator’s Guide to Operations” for the Establishment and Maintenance of Afforestation Plantations

T. J. Keddy and D. M. Sidders
Ellerslie SRWC Technical Development Site

20 ha of SRWC Plantations
Establishment Initiated in 2002
Intensive Monitoring Protocols
100+ Individual Operational Research Trials
Growth & Yield
Carbon Sequestration
Full Rotation Analysis
Test Ground for Afforestation Management Regimes

Harvest and Recovery Winter 2018/19

Pre 2002

2017
The ultimate goal of afforestation with SRWC (3-20 year rotation) is to maximize volume and value to land owners and industry. The fast-growing resource is a predictable and sustainable fuelstock for use in the production of conventional forest products and for bioenergy and other bio-products to grow the Canadian Bioeconomy.

The mature SRWC plantation, established and managed as a demonstration site by Natural Resource Canada’s Canadian Wood Fibre Centre (CWFC) in Edmonton was harvested in 2019-20 with a focus on evaluating a variety on-site mid-supply chain options to process harvested SRWC crops to the desired size and characteristics required by end users. The harvesting of the 18-hectare Edmonton SRWC plantation offered a unique research and development opportunity for CWFC to intensively measure, monitor and verify various harvesting, pre-processing, and transportation systems consistent with a commercial supply chain.

Detailed time and motion studies for all the equipment and weight measurements were completed to determine recovered volumes for all harvested materials. Full tree permanent samples were destructively sampled to validate growth trajectories, partition the tree components and determine carbon values.

To reduce transportation costs and enhance storability of woody biomass, a locally designed and manufactured woody biomass compaction unit prototype was demonstrated to compact and package woody biomass into dense, easily transported round bales. The compaction prototype created woody biomass bales that resulted in an increased bulk density of the piled material from 84.9 CGSD/m² to an average of 242.89 CGSD/m³, ranging from 216.96 (5″ Screens) to 265.79 CGSD/m³ (12″ Screens).

For additional information, contact Derek Sidders at derek.sidders@canada.ca or 825-510-1287 or Tim Keedry at tim.keedry@Canada.ca or 825-510-1193. Canadian Wood Fibre Centre, Edmonton, Alberta.
Short-Rotation Wood Crop Recovery, Pre-Processing and Transportation Options Explored

Produced by Derek Sidders, Tim Keddy and Brent Joss, Canadian Wood Fibre Centre, Edmonton

Primary Products from Large Stems

Secondary Products from Residues and Small Stems

Chips
Compressed Bales
Mulch
High-Yield Afforestation
17 Growing Seasons
## 2002 - 2018 High-Yield Afforestation Story

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**17 Growing Seasons**

- 12.25 Tonnes/ha/yr
- 11.35 m³/ha/yr
- 15.46 m³/ha/yr
High-Yield Afforestation
15 Growing Seasons
Ellerslie SRWC Research Site

**Forest 2020 Demonstration Trial**

Established 2004

Grid Style Plantation

1600 Stems/ha

3 Hybrid Poplar Clones

Intensively Managed till Crown Closure (Year 4)

Harvested December 2018

Full Tree Harvesting (Feller-Buncher)

Tree Length Processing (Dangle-Head)

Tree Length Delivered to Al-Pac for Pulp

15 Growing Seasons
### 2004 - 2018 High-Yield Afforestation Story

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<td>166.211</td>
<td>208.784</td>
</tr>
<tr>
<td>M³/ha (Full Tree)</td>
<td>287.985</td>
<td>253.503</td>
<td>211.736</td>
<td>250.935</td>
</tr>
<tr>
<td>Feller Buncher Tonnes/Hr (Productive)</td>
<td>56.936</td>
<td>54.319</td>
<td>50.835</td>
<td>54.215</td>
</tr>
<tr>
<td>Feller Buncher Cost/Tonne (Productive)</td>
<td>$4.99</td>
<td>$5.23</td>
<td>$5.58</td>
<td>$5.27</td>
</tr>
</tbody>
</table>

- **15 Growing Seasons**
- **13.10 Tonnes/ha/yr**
- **13.92 m³/ha/yr**
- **16.73 m³/ha/yr**
Clones With Crown Shyness

**Above Ground**

- Merchantable Stem (7.5cm top) = 94.93%
- Top Stem = 5.07%
- Limbs = + 5.77% of Merch. & Top Stem

**Below Ground**

- Stump + Roots = + 24.92% of Merch. & Top Stem

Clones Without Crown Shyness

**Above Ground**

- Merchantable Stem (7.5cm top) = 93.09%
- Top Stem = 6.91%
- Limbs = + 13.75% of Merch. & Top Stem

**Below Ground**

- Stump + Roots = + 28.69% of Merch. & Top Stem
2004 -2018 Carbon Story

2004 -18 Carbon Impacts

<table>
<thead>
<tr>
<th></th>
<th>Carbon (Tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hill</td>
<td>72.72 t</td>
</tr>
<tr>
<td>Assiniboine</td>
<td>91.05 t</td>
</tr>
<tr>
<td>Walker</td>
<td>99.41 t</td>
</tr>
<tr>
<td>Site Avg</td>
<td>87.73 t</td>
</tr>
</tbody>
</table>

Pre-Harvest/ha: 78.08 Tonnes C (286.30 Tonnes CO₂ eq)

Average Increase Pre-Harvest/ha: 87.73 Tonnes C (321.66 Tonnes CO₂ eq)

Average Increase Post-Harvest/ha: 37.21 Tonnes C (136.44 Tonnes CO₂ eq)
2004 - 2018 Carbon Story

2004 - 18 CO₂ eq Impacts

Pre-Harvest/ha: 286.30 Tonnes CO₂e (78.08 Tonnes C)

Average Increase Pre-Harvest/ha: 321.66 Tonnes CO₂ eq (21.44 Tonnes CO₂ eq yr⁻¹)

Average Increase Post-Harvest/ha: 136.44 Tonnes CO₂ eq (9.10 Tonnes CO₂ eq yr⁻¹)
2005 - 2018 Concentrated Biomass Story
2005 - 2018 Concentrated Biomass Story
2005 - 2018 Concentrated Biomass Story

Establishment Design is Less of an Issue!

Hybrid Poplar and Willow Show Consistent Growth Potential!

Clonal Selection / Suitability is Key!

Economical Harvesting Options are Limited!
### 2006 - 2018 State University of New York (SUNY) Clonal Trial

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Clone</th>
<th>Average Green Tonnes/ha/yr Rotation 1</th>
<th>Average Green Tonnes/ha/yr Rotation 2</th>
<th>Average Green Tonnes/ha/yr Rotation 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-4</td>
<td>94001</td>
<td>6.24</td>
<td>12.66</td>
<td>15.47</td>
</tr>
<tr>
<td></td>
<td>Saratoga</td>
<td></td>
<td></td>
<td>9.28 ODT</td>
</tr>
<tr>
<td></td>
<td>Tully Champion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sherburne</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-8</td>
<td>Fish Creek</td>
<td>4.82</td>
<td>9.73</td>
<td>11.90</td>
</tr>
<tr>
<td></td>
<td>Millbrook</td>
<td></td>
<td></td>
<td>7.14 ODT</td>
</tr>
<tr>
<td></td>
<td>Owasco</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Otisco</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9-12</td>
<td>SX-64</td>
<td>3.28</td>
<td>8.09</td>
<td>9.88</td>
</tr>
<tr>
<td></td>
<td>Wolcott</td>
<td></td>
<td></td>
<td>5.93 ODT</td>
</tr>
<tr>
<td></td>
<td>Allegany</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Canastota</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13-16</td>
<td>Oneida</td>
<td>2.72</td>
<td>6.20</td>
<td>7.58</td>
</tr>
<tr>
<td></td>
<td>Onondaga</td>
<td></td>
<td></td>
<td>4.55 ODT</td>
</tr>
<tr>
<td></td>
<td>5X-61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cicero</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17-20</td>
<td>SV1</td>
<td>1.99</td>
<td>5.07</td>
<td>6.20</td>
</tr>
<tr>
<td></td>
<td>Oneonta</td>
<td></td>
<td></td>
<td>3.72 ODT</td>
</tr>
<tr>
<td></td>
<td>Marcy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21-24</td>
<td>0OX-032-094</td>
<td>0.76</td>
<td>1.64</td>
<td>2.01</td>
</tr>
<tr>
<td></td>
<td>525</td>
<td></td>
<td></td>
<td>1.20 ODT</td>
</tr>
<tr>
<td></td>
<td>9837-77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0OX-026-082</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Clonal Varieties Resulted From Breeding Program Conducted by SUNY!

Top 8 Clones Show Potential for Use in Alberta!

A Lot of Clonal Variability!

Only 2 Clones Met or Exceeded the Growth of the CWFC Operational Clones!
### Full Rotation Biomass Economic Analysis Story

**SRWC Design**

<table>
<thead>
<tr>
<th>Species</th>
<th>High Yield Afforestation</th>
<th>Concentrated Biomass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid Poplar and Aspen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hybrid Poplar and Willow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Management Design

<table>
<thead>
<tr>
<th>Site Productivity</th>
<th>Low</th>
<th>Average</th>
<th>High</th>
<th>Maximum Estimated Yields</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rotation Age (Years)</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>22</td>
</tr>
<tr>
<td>Rotations</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Total Site Yield/ha Available at Harvest (ODT)</td>
<td>145.30</td>
<td>185.02</td>
<td>214.73</td>
<td>241.00</td>
</tr>
<tr>
<td>Total Aboveground (Full Tree) Yield/ha/yr (ODT)</td>
<td>5.90</td>
<td>7.52</td>
<td>8.69</td>
<td>10.95</td>
</tr>
</tbody>
</table>

#### SRWC Economic Data

| Establish and Management Costs/ha | $3,250.00 | $3,250.00 | $3,250.00 | $6,717.00 | $9,216.75 | $9,581.25 |
| Establishment and Management Costs /ODT | $27.54 | $21.60 | $18.70 | $27.87 | $38.24 | $39.76 |
| Harvest Cost/ODT | $25.90 | $25.90 | $25.90 | $52.36 | $52.36 | $52.36 |
| Transport Cost/ODT (50km Radius) | $16.79 | $16.79 | $16.79 | $16.79 | $16.79 | $16.79 |
| Harvest, Processing and Transport (50km) Costs/ODT | $61.88 | $59.14 | $57.08 | $100.81 | $100.81 | $100.81 |
| Total Delivered Cost/ODT | $89.42 | $80.74 | $75.79 | $128.68 | $139.05 | $140.56 |
| Delivered Biomass Value/ODT (@$50/Green Tonne + 50%MC) | $100.00 | $100.00 | $100.00 | $100.00 | $100.00 | $100.00 |

**Net Delivered Biomass Value/ODT (@$50/Green Tonne + 50%MC)**

- $10.58
- $19.26
- $24.21
- $28.68
- $39.05
- $40.56

---

**High Yield Afforestation Creates a Positive Return on Investment for the Production of Woody Biomass!**

**Even With Maximum Yields, Concentrated Biomass SRWC are not Financially Viable for Supplying Woody Biomass!**

**Other Tangible Benefits Needed for Concentrated Biomass SRWC to be Financially Viable!**

**Carbon Offsets are Usually Payable to the End User and May Not Trickle Down to the Landowners!**
St Albert SRWC Research Site

**High-Yield Afforestation Technical Development Site**

Established 2009
Grid Style Plantation
1600 and 6400 Stems/ha
4 Hybrid Poplar Clones and Clonal Aspen
Intensively Managed till Crown Closure
Harvested December 2020
Full Tree Harvesting (Feller-Buncher)
Full Tree Horizontal Grinder
Walking Floor Chip Trailers Delivered to Alberta-Pacific Forest Industries BioEnergy
Natural Resources Canada, St. Albert CHIP Pile Block Numbers

**3 Mix**

- **Green = 12 Yr-old Hybrid Poplar**
- **Red = 9 Yr-old Clonal Aspen**

Site Contact: Derek Sidders
780-951-6402

- **Sea Cans**
- **Toilet**
- **North**

- **27 Mix**

- **A**
- **B**
- **C**

**Demo Area**

- Hybrid WA
- Hybrid MW
- Concentrated (Collings) REP # 1
- Concentrated (Collings) REP # 2
- Afforestation (Chinese Basswood)
- Afforestation (Balsam Poplar)
- After - OK
- After - NW
- After - WA
- After - NW
- After - P-20
### 2009 - 2020 High Yield Afforestation Utilization Story

<table>
<thead>
<tr>
<th>Clone</th>
<th>Northwest</th>
<th>Okanese</th>
<th>Walker</th>
<th>Green Giant</th>
<th>Clonal Aspen</th>
<th>Total All</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planted</td>
<td>2009</td>
<td>2009</td>
<td>2009</td>
<td>2009</td>
<td>2010</td>
<td>N/A</td>
</tr>
<tr>
<td>Age at Harvest (Years)</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Area (ha)</td>
<td>3.25</td>
<td>2.05</td>
<td>1.75</td>
<td>1.75</td>
<td>7.2</td>
<td>16</td>
</tr>
<tr>
<td>Total Full Tree Biomass Recovered (Tonnes)</td>
<td>204.3</td>
<td>237.38</td>
<td>124.38</td>
<td>38.08</td>
<td>283.09</td>
<td>887.2</td>
</tr>
<tr>
<td>Full Tree Biomass Recovered (Tonnes/ha)</td>
<td><strong>62.86</strong></td>
<td><strong>115.8</strong></td>
<td><strong>71.07</strong></td>
<td><strong>21.76</strong></td>
<td><strong>39.32</strong></td>
<td><strong>62.16</strong></td>
</tr>
<tr>
<td>Biomass Recovered (m3)</td>
<td>291</td>
<td>347.14</td>
<td>187.57</td>
<td>58.48</td>
<td>447.4</td>
<td><strong>1332</strong></td>
</tr>
<tr>
<td>m3/ha Full Tree</td>
<td>89.54</td>
<td>169.33</td>
<td>107.18</td>
<td>33.42</td>
<td>62.13</td>
<td><strong>92.32</strong></td>
</tr>
<tr>
<td>m3/ha MAI (HP growth trajectory = 5.0 m3/ha) at 12 years</td>
<td><strong>7.5</strong></td>
<td><strong>14.1</strong></td>
<td><strong>8.9</strong></td>
<td><strong>2.8</strong></td>
<td><strong>5.6</strong></td>
<td><strong>7.78</strong></td>
</tr>
</tbody>
</table>
University of Guelph SRWC Research Site

Forest 2020 Field Demo
Established 2005 and 2009
Grid Style Plantation
1100/4400 Stems/ha
8 Hybrid Poplar Clones
Intensively Managed till Crown Closure (Year 3/4)
Harvested December 2020
Full Tree Harvesting (Feller-Buncher)
Grapple Skidder to Roadside Processing Site
Full Tree 1050 HP Horizontal Grinder
Loaded into Walking Floor Trailers and Delivered to a Mulch Supply Company
### Short-Rotation Woody Crops

#### Understand What You’re Getting In To!

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Challenges</th>
<th>End Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High-Yield Afforestation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple Product Options</td>
<td>Single Rotation</td>
<td>Conventional Forest Products</td>
</tr>
<tr>
<td>Reduced Establishment Costs</td>
<td></td>
<td>Woody Biomass</td>
</tr>
<tr>
<td>Longer Carbon Storage Potential</td>
<td>Long Wait Time to Harvest</td>
<td></td>
</tr>
<tr>
<td>Reduced Harvesting Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvesting Equipment Readily Available</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mixedwood Afforestation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same as High-Yield Afforestation</td>
<td>Increased Harvesting Costs</td>
<td>Conventional Forest Products</td>
</tr>
<tr>
<td>Longer Forest Cover Duration (&gt;70 Years)</td>
<td></td>
<td>Woody Biomass</td>
</tr>
<tr>
<td>Even More Product Options</td>
<td>Long Wait Time to Harvest</td>
<td></td>
</tr>
<tr>
<td>Extended Carbon Storage Potential</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Concentrated Biomass</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple Rotations</td>
<td>Increased Establishment Costs</td>
<td>Woody Biomass</td>
</tr>
<tr>
<td>Reduced Wait Time for Utilizing Biomass</td>
<td>Increased Harvesting Costs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lack of Available Harvesting Equipment</td>
<td></td>
</tr>
</tbody>
</table>
Lessons Learned!

Key Finding # 1 – Site Selection (“better quality lands grow more woody biomass for less costs when consistent and proven establishment and management protocols are utilized”)

Key Finding # 2 – Site Preparation (“create an environment in which trees love to grow”)

Key Finding # 3 – Clonal and Species Selection (“do your homework”)

Key Finding # 4 – SRWC System Selection (“select the system that best links to your management objectives”)

Key Finding # 5 – SRWC Economics (“make sure you understand where you will land before you jump”)

Key Finding # 6 – Adaptable to a National “Growing Canada’s Forest” Program
Supporting Natural Climate Solutions
Adapting Afforestation Scenarios to Address a Changing Climate

Canadian Wood Fibre Centre is actively involved in the operational research of innovative practices to establish, manage and utilize various afforestation scenarios. Establishing a “National Network of Sites” demonstrates the benefits of innovative afforestation systems to grow wood fibre and woody biomass at rates 8-10 times the growth of “native forests” on previously non-forested lands to create significant carbon sinks and produce feedstock for an evolving green or renewable energy industry, contributing to a low-carbon economy.

**High-Yield Afforestation**
- Grid style plantations
- Consisting of hybrid poplar or aspen
- 11-1600 stems ha⁻¹
- 1 x 16-20 yr rotation
- 13.6-20 m³ ha⁻¹ yr⁻¹
- 25cm+ DBH at harvest
- 20m+ HT at harvest
- 19-29 t CO₂ e ha⁻¹ yr⁻¹

**Concentrated Biomass**
- Hedge style plantations
- Consisting of hybrid poplar or willow
- 13-16,000 stems ha⁻¹
- 7 x 3 yr rotations
- 6-12 ODT ha⁻¹ yr⁻¹
- Small diameter (<10cm)
- High bark to white wood ratio

**Mixedwood Afforestation**
- 11-1600 st ha⁻¹ Hybrid poplar or aspen
- 8-1200 st ha⁻¹ White spruce
- Flexible design and management
- Long term carbon sequestration option
- Fast growing overstory harvested at year 20
- 644 – 820 t CO₂ e ha potentially sequestered over 20 + 50 yr rotation

For more information, please contact: Tim Keddy, Wood Fibre Development Specialist, CWFC and/or Derek Sidders, Regional Coordinator and Program Manager, CWFC
Growing Canada’s Forest program launches Expression of Interest and Request for Information!

Want to get involved? Are you:

- An organization with access to lands for tree planting or have trees to plant?
- An organization looking to invest in a tree planting initiative?
- A nursery operator looking to help meet the growing demand for seedlings?
- Seeking partnerships so that you can participate in this historic initiative?

Good news! Natural Resources Canada has launched an Expression of Interest (EOI) and a Request for Information (RFI). If you have proven experience in delivering large-scale tree planting projects or are interested in sharing your vision and your capacity for tree planting projects, we want to hear from you.
Where trees can be planted

https://www.canada.ca/en/campaign/2-billion-trees.html

Funded by the Government of Canada, the Growing Canada’s Forests program aims to motivate and support new tree planting projects. Supplementary activities (e.g. additional tree planting) to expand existing tree planting projects are included.

Trees can be planted:

- on public and private lands across the country
- in remote, rural, suburban and urban areas
- via afforestation, which is the creation of new forest cover on lands that currently do not have trees (e.g. abandoned fields)
- via reforestation, which is the regeneration of forests that have temporarily lost their tree cover through natural disturbances (e.g. after wildland fire) or in areas where commercial disturbances (e.g. forestry roads and landings, mining or seismic lines) have occurred, but for which there is no current legal requirement to plant trees
- to restore forest habitat, including under recovery strategies for species at risk, conservation agreements and related planning processes (e.g. range plans)

Tree planting projects must comply with provincial, territorial and federal laws that have authority over the management of most forested land in their jurisdictions.
Growing Canada’s Forests Program (2Bt)

https://www.fpac.ca/two-billion-trees-considerations-for-a-successful-federal-tree-planting-program/

CONSIDERATIONS FOR REFORESTATION ACTIVITIES

Although tree planting is generally a highly positive endeavor, large-scale reforestation programs can encounter predictable challenges which can be addressed bearing the following principles in mind:

1. AFFORESTATION AND REFORESTATION SHOULD BOTH BE PART OF A LARGE-SCALE TREE PLANTING PROGRAM

- The significant benefits of afforesting converted and degraded lands closer to communities in the southern parts of Canada are well known. However, there is also huge potential to reforest large areas in the north that have been severely impacted by natural disturbances. Therefore, a program should not simply focus on one or the other but ideally contribute to restore both, while considering the pros and cons of each situation.

<table>
<thead>
<tr>
<th>Afforestation</th>
<th>Reforestation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Converted and degraded lands (e.g., abandoned agricultural lands)</td>
<td>Forests severely impacted by natural disturbances not on a path to regeneration</td>
</tr>
<tr>
<td>Close to communities (more accessible)</td>
<td>Large areas (more cost effective)</td>
</tr>
<tr>
<td>Smaller and more dispersed areas</td>
<td>Significant proportion in non-accessible areas</td>
</tr>
</tbody>
</table>

- Although rural and northern regions offer a large opportunity for replanting, we also support the stated objective to help cities expand and diversify their urban forests. Urban forests provide tremendous benefits including cooling the air filtering pollutants, regulating water flow, and improving physical and mental health. They also have the potential to help a growing urban population reconnect with nature and remind urban Canadians about the importance of maintaining and managing healthy forests.

High Yield Afforestation and Mixedwood Afforestation Have the Greatest Potential for Sequestering Carbon!

Enhancing Natural Succession by Planting Tolerant Softwoods in Pure Deciduous Stands to Create Future Mixedwood Stands is the 2nd Best Option!
## Growing Canada’s Forests Program (2Bt)

<table>
<thead>
<tr>
<th>Hectares</th>
<th>Trees Planted</th>
<th>Potential CO₂ eq Sequestered Annually</th>
<th>Equivalent Cars Removed From The Road Annually</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,600</td>
<td>19 - 29</td>
<td>4 - 5</td>
</tr>
<tr>
<td>1,000</td>
<td>1,600,000</td>
<td>19,000 - 29,000</td>
<td>3,578 - 5,462</td>
</tr>
<tr>
<td>5,000</td>
<td>8,000,000</td>
<td>95,000 - 145,000</td>
<td>17,892 - 27,308</td>
</tr>
<tr>
<td>10,000</td>
<td>16,000,000</td>
<td>190,000 - 290,000</td>
<td>35,783 - 54,617</td>
</tr>
<tr>
<td>25,000</td>
<td>40,000,000</td>
<td>475,000 - 725,000</td>
<td>89,458 - 136,542</td>
</tr>
<tr>
<td>50,000</td>
<td>80,000,000</td>
<td>950,000 - 1,450,000</td>
<td>178,917 - 273,083</td>
</tr>
</tbody>
</table>

**THE BEST TIME TO PLANT**

A TREE WAS TWENTY YEARS AGO.
THE SECOND BEST TIME IS **NOW**.

*Chinese Proverb*
Growing Canada’s Forests Program (2Bt)

**Proven Operational Establishment and Management Protocols**

**Validated Site Suitability and G&Y Trajectories**

**Established Knowledge Transfer Products to Facilitate Program Delivery**
Growing Canada’s Forests Program (2Bt)

**Long History in Afforestation and Silviculture Operations on a National Basis Has Provided Information and Establishment of Key Networks to Identify Clonal / Species Suitability and Planting Material Availability Across Canada!**
CWFC fast-growing tree experience evident in national network of afforestation demonstration sites

BY TONY KRIZANOVIC

A forestation or establishing forests on non-forested land using short rotation woody crops (SRWC) is a national opportunity. A network of demonstration sites established by Natural Resources Canada’s Canadian Wood Fibre Centre (CWFC) shows which SRWC species grow well in various geodimorphic zones across Canada.

Today, nearly all of the primary technical development questions to successfully establish SRWC plantations in a variety of Canadian regions have been answered, and these sites are open to evaluation by anyone interested in this crop’s economic potential.

Thenetwork of well-advanced demonstration sites has been working for almost 20 years. Today’s primary national network of technical demonstration sites exists in Ontario, Manitoba, Saskatchewan, and Alberta, with hybrid poplar being the core species in a high-yield afforestation design.

“We have developed a map which identifies the site suitability and therefore the yield potential of various hybrid poplar clones, based on bio-geodimorphic conditions of all agriculture lands in Canada,” says Derek Sidders, Program Manager of the CWFC Technology Development and Transfer Group.

SRWC offer both a way for forest companies to enhance their fibre availability and the ability to grow more consistent and purpose-grown wood fibre with huge documented volume gains in a fraction of the time vs. a natural forest. These crops can also be planted in close proximity to final users.

SRWC plantations represent a new potential cash crop for farmers and landowners, and they can help mitigate the negative impacts of climate change, while having the potential to help Canada meet its international greenhouse gas (GHG) emission reduction targets because they are natural sowers in high quality land can produce 0.12 times more fibre than the average natural forest.

A second demonstration site near MacGregor, Manitoba, about 110 km west of Winnipeg and adjacent to the TransCanada Highway, features a number of locally adapted hybrid poplar clones and some custom designed for southern Manitoba. Some like Prairie Sky and CN-14 are achieving 10 centimetres in diameter and 15 metres in height after 10 or 14 years of growth, depending on the clone and planting, yielding between 120 and 140 cubic metres of fibre per hectare.

Sidders describes this as “extremely high productivity.”

A third demonstration site near the University of Guelph in southern Ontario was planted in 2005 and 2009 on a 25 hectare site. It features different management regimes and local site-adapted hybrid poplar with a long history in that region. After 10 years, the 2005 planted hybrid poplar on the Guelph site has achieved 15 to 16 centimetres in diameter, 15 to 16 metres in height, and volumes of 90 to 125 cubic metres per hectare. The nine-year-old plantings average 10 centimetres in diameter, 10.5 metres in height and 90 cubic metres per hectare.

“In a really extreme example, we have a site south of London, Ontario that was planted in 2012, and currently has the highest growth production that we have seen on any site,” says Sidders.

That SRWC plantation is in the Zone 8 hardiness area, featuring Class 5 agriculture land.

“The hybrid poplar has grown to 12 centimetres in diameter and 16 metres height after just six years of production, at 1,100 stems per hectare and three stems by three metres spacing,” says Sidders. “It is already yielding 60 cubic metres per hectare.”

A fifth demonstration site established in 2015 is on an eight-hectare location in Kemptville, Ontario, 60 km southwest of Ottawa. It has hybrid poplar at 10 centimetres in diameter and 9 metres in height after five growing seasons, and is on a trajectory similar to the London, Ontario site.

All these sites are being maintained and managed by CWFC’s partners to maturity.

For information about the location of CWFC short rotation woody crops demonstration sites and technical data related to these sites, contact Derek Sidders at derek.sidders@canada.ca or CWFC Wood Fibre Development Specialist Tim Waddy at tim.waddy@canada.ca.
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