



# **Production Economics of Short Rotation Plantation Forestry in Canada with Carbon Sequestration Values**

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**Presented by: Darren Allen**

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# Talk Overview

- **Context**
- **Models and relevant questions**
- **Some regional and national perspectives with and without carbon**
- **Concluding comments and future directions**



# Background - some policy context: FAACS, Forest 2020, CBIN & Kyoto



- **October 2000 announcement of “Government of Canada Action Plan 2000 on Climate Change”**
- **\$500 million investment over five years on specific measures that reduce greenhouse gases (GHG)**
- **Targeted key sectors, i.e., Transportation, Energy, Industry, Buildings, Agricultural and Forestry – article 3.3 and 3.4 of Kyoto**
- **Included forestry component focusing on advancing carbon sequestration opportunities through Feasibility Assessment of Afforestation for Carbon Sequestration and Forest 2020 Plantation Demonstration and Assessment initiative**
- **Led us into the work on the spatial aspects of the economics of fast-growing plantations (wood supply, bioenergy, carbon valuation, etc)- Canadian Biomass Innovation Network, ecoETI – bio-based energy systems, PERD**



# Economic Models at GLFC



## Three models developed and being applied to our work:

### **CFS-AFM (Afforestation Feasibility Model)**

- Infinite rotation Faustmann-type model including carbon and fibre benefit flows
- Extensively used in Forest 2020 Plantation Demonstration and Assessment Initiative (PDA) to assess feasibility of fast-growing plantations, published in peer-reviewed media

### **CFS-FBM (Forest Bioeconomic Model)**

- More complex and uses finite time horizon
- Improved 18-pool ecosystem carbon model (based on CFS-CBM2)
- Better addresses more complex forest management and bioenergy scenarios (species rotation, fixed time horizons, multiple thinnings)

### **SRC-GHM (Greenhouse Bioenergy Cost-Benefit Model)**

- Cost-benefit spread-sheet model of joint project options:  
Heating greenhouses with SRC biomass –  
(also includes break-even metrics of fossil fuel substitution)



# Typical Output Metrics from Models



**ROI, (%)** – real rate of return yielding  $NPV = 0$

**Break-even carbon value, (\$/t CO<sub>2-e</sub>)** –  
the carbon unit price yielding  $NPV = 0$

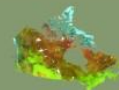
**Physical carbon, (t/ha)** – total net ecosystem carbon sequestered over  
a project life (minus harvest and decay emissions)

**Geographical variation** of the output metrics  
(e.g. helps to identify economically attractive areas for afforestation)

Other metrics include **Present Values, break-even prices**







## Canadian Biomass Innovation Network (CBIN) Feedstock Options: National Network of Sites

B.N. Joss, D.M. Sidders, T.J. Keddy, Natural Resources Canada, Canadian Forest Service, Fibre Centre

### Canadian Biomass Innovation Network

- Formed to coordinate the Federal Government's research and development activities in the area of bioenergy, biofuels, industrial biotechnology.
- Four areas of activity: 1) new and existing biomass supply; 2) biomass conversion and utilization technologies; 3) integrated bio-applications; and 4) cross cutting activities (strategy, policy, regulations, assessment, dissemination, etc.)

### High Yield Afforestation

- Stand oriented design (1,100 - 1,600 stems/ha).
- Designed to meet yields of 13.6 - 20.0 gross cubic metres MAI or 5.0 - 7.4 ODT 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.
- Uses: 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).
- Established to develop feedstock for energy conversion and carbon credits (offsets).
- Various cultivars of hybrid willow and hybrid poplar are used.
- High intensity, coppice management regime with 5-7 generations from one root system.
- Other values: living sound barriers, crafts and furniture.

### Agroforestry: Alley Cropping

- Integration of trees in farmland that diversifies and sustains production for increased social, economic and environmental benefits.
- Trees area planted in single or multiple rows at close spacing within row and wide (10-30 m) alleys between rows to leave room for herbaceous cropping.
- Established on moderate- to high-quality land across Canada.
- Hybrid poplar and willow.

#### Ellerslie (AB)

Established: 2002-05  
Species: Hybrid Poplar, Aspen, Willow  
Clones: Various  
Hectares: 16.0  
Density: 1,600 / ha; 16,000 / ha  
Management: High Intensity  
Location: 53.41° N Lat., -113.54° W Long.

#### Sturgeon Lake First Nation (SK)

Established: 2004  
Species: Hybrid Poplar  
Clones: Assiniboine, Brooks #1  
Hectares: 39.5  
Density: 1,600 / ha  
Management: Moderate Intensity  
Location: 53.40° N Lat., 106.07° W Long.

#### Rivière-du-Loup

Established: 2003  
Species: Willow  
Clones: Viminalis  
Hectares: 1.0  
Density: 18,000 / ha  
Management: High Intensity  
Location: 47.83° N Lat., 69.55° W Long.

#### Legend

- Afforestation Plantations
- Bioenergy Plantations
- Concentrated Biomass Energy / Short Rotation Intensive Culture Plantations
- Major Centres

Caption: Canadian Forest Service  
Edmonton South Afforestation  
and Concentrated Biomass for  
Energy Development Site.  
(Photo: September 2005)

# Case Study Comparing SRC and High-yield Afforestation Block Plantings in Canada



## Cost Assumptions

**Note:** there will be re-occurring cost with the SRC scenarios, cultivation will be required in the first season after harvest/coppice. Afforestation does not incur vegetation control costs beyond year 4.

Year 1		
Management Activity	SRC (15,625 stems/ha)	Afforestation (1600 stems/ha)
Site Preparation	\$900	\$600
Marking	\$150	\$150
Plant Material	\$4,500	\$960
Planting	\$781	\$320
Split Cultivation x 2	\$300	--
Mechanical Cultivation x 2	--	\$200
Rotovate	\$300	--
Hand Weeding	\$2,000	\$500
<b>Totals</b>	<b>\$8,931</b>	<b>\$2,730</b>

Years 2&3 SRC, Years 2-4 Afforestation		
Management Activity	SRC (15,625 stems/ha)	Afforestation (1600 stems/ha)
Split Cultivation x 2	\$150	--
Mechanical Cultivation x 2	--	\$600
Rotovate	\$800	--
Enviromist	--	\$600
<b>Totals</b>	<b>\$950</b>	<b>\$1,200</b>

\*\* Harvest costs  
\$50/ODT

**Farm gate scenario**



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# Sensitivity Analyses in Ontario ("Aspirational targets")



Break-even chip farmgate price, \$/ ODT (IRR, % in brackets)

	SRC		vs. Hybrid poplar	
Scenario	15 year opportunity costs on	21 year opportunity costs on		20 year opportunity costs on
current costs, expected yield	270 (0)	242 (0)	<->	147 (0)
half costs, expected yield	163 (0)	148 (0)	<->	103 (2.3%)
current costs, expected yield, carbon @ \$5 CO2e	270 (0)	235 (0)	<->	121 (0.8%)
half costs, expected yield, carbon @ \$5 CO2e	155 (0)	142 (0)	<->	77 (6.4%)
half costs, expected yield, carbon @ \$50 CO2e	83 (29.9%)	77 (29.6%)	<->	-161 (867.1%)
current costs, double yield	160 (0)	146 (0)	<->	100 (2.6%)
half costs, double yield	106 (5.4%)	98 (7.7%)	<->	78 (6.4%)

We present results that represent what we call "Current expectations" and "Aspirational targets".



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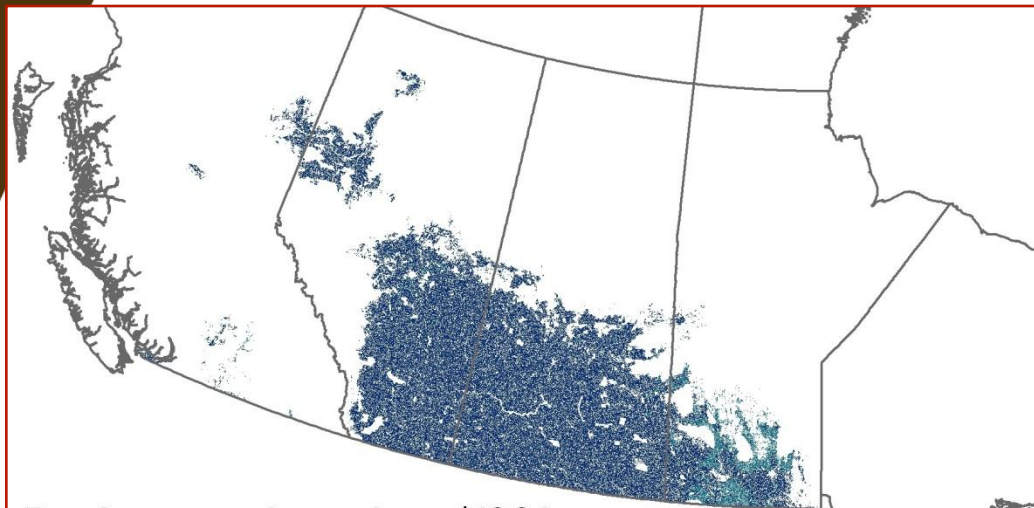
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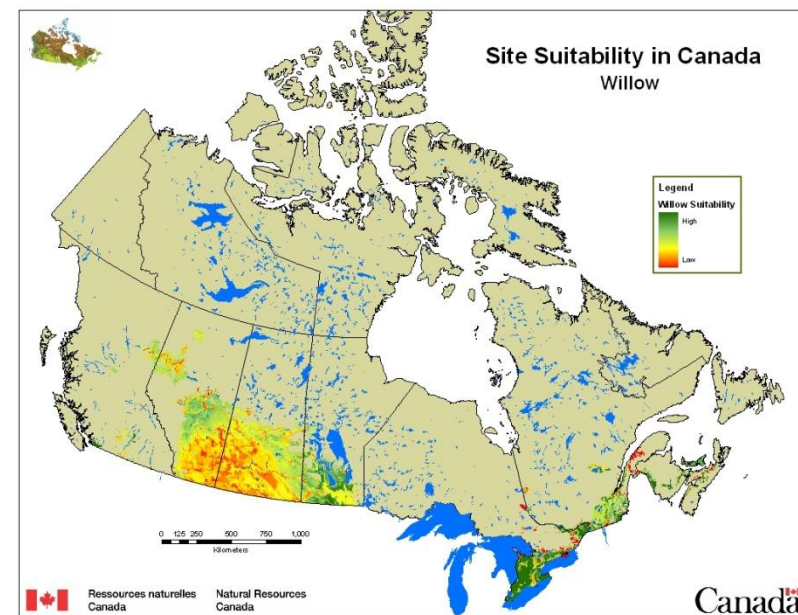
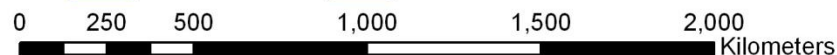
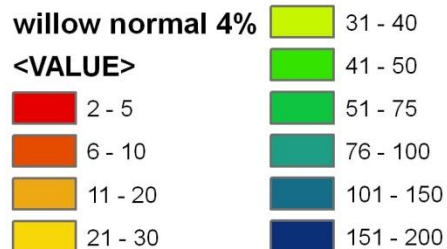


# Economics of carbon sequestration in forest plantations: supplying biomass from SRC

Break-even carbon prices, \$/t CO<sub>2</sub>e  
– current costs, 4% discount rate



Break-even carbon prices, \$/CO<sub>2</sub>e



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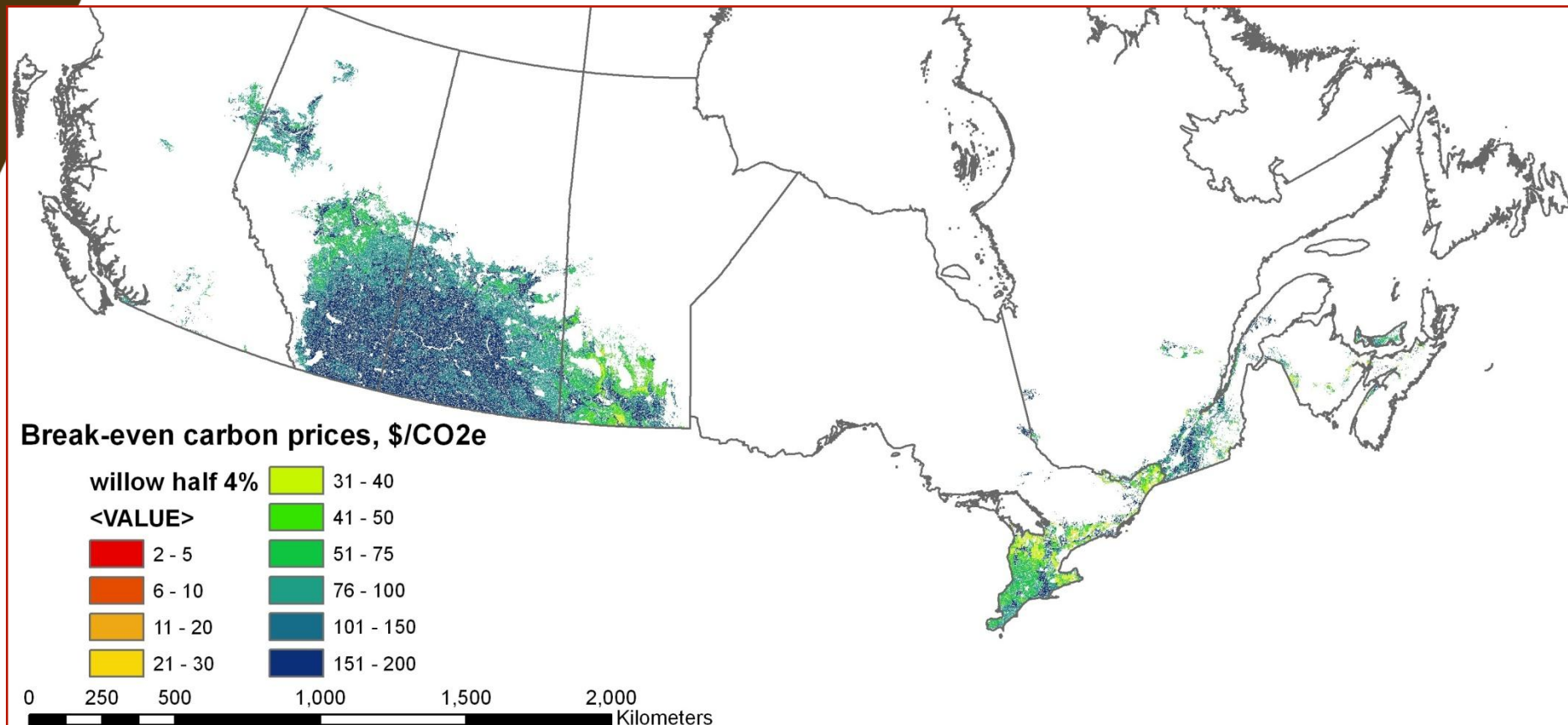
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# Bioenergy opportunities: supplying biomass from SRC



Break-even carbon prices, \$/t CO<sub>2</sub>e  
– half costs scenario, 4% discount rate



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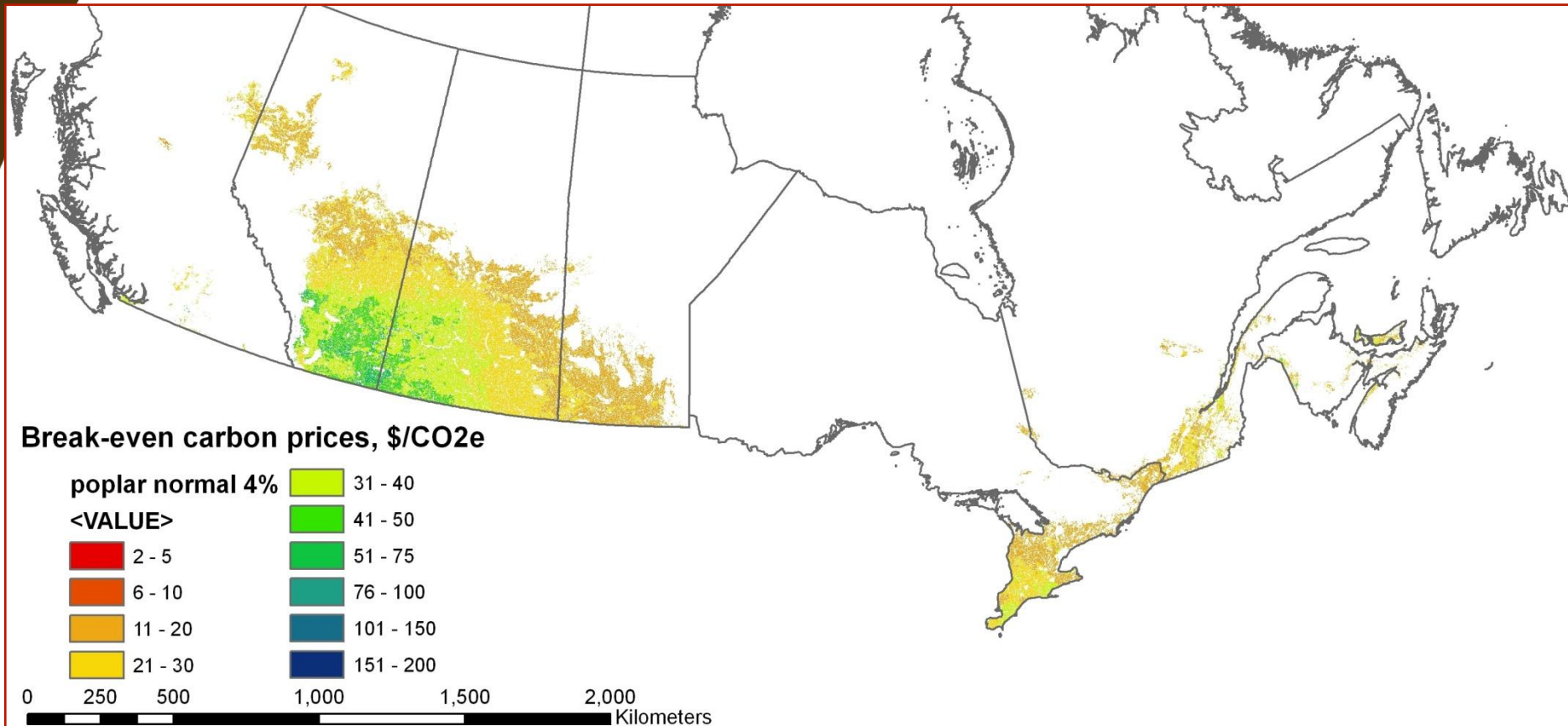
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# Bioenergy opportunities: supplying biomass from hybrid poplar



Break-even carbon prices, \$/t CO<sub>2</sub>e  
– current costs scenario, 4% discount rate



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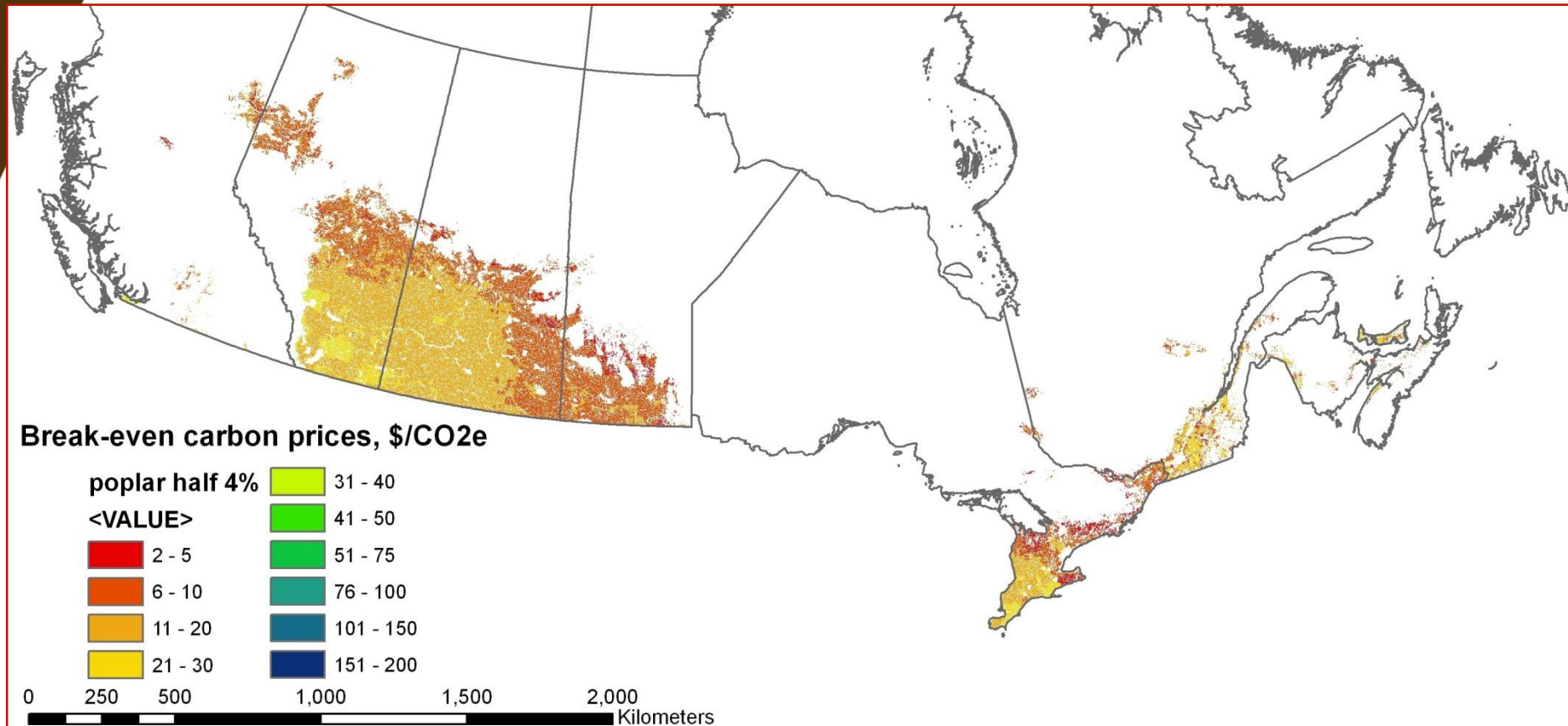
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# Bioenergy opportunities: supplying biomass from hybrid poplar



Break-even carbon prices, \$/t CO<sub>2</sub>e  
– half costs scenario, 4% discount rate



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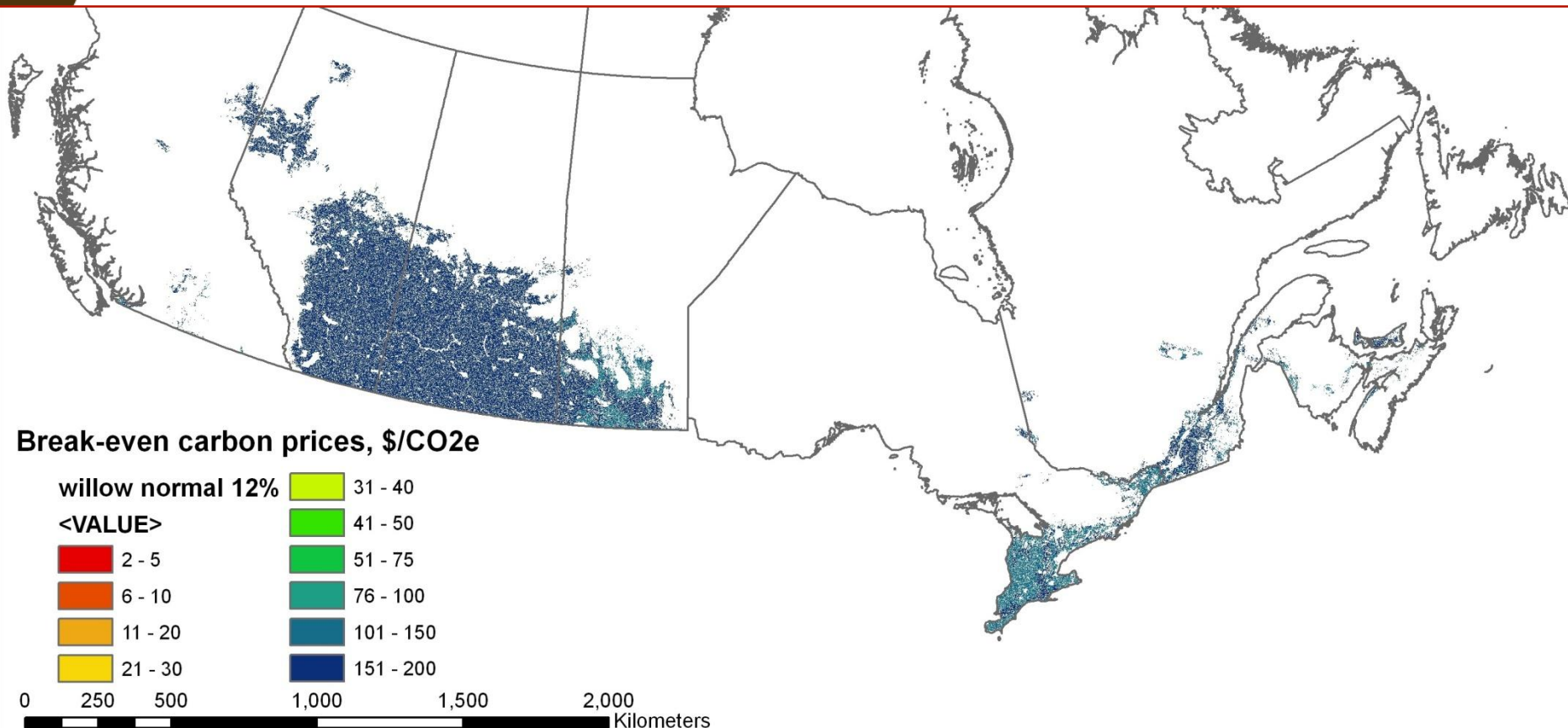
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# Bioenergy opportunities: supplying biomass from SRC



Break-even carbon prices, \$/t CO<sub>2</sub>e  
– current costs scenario, **12% discount rate**



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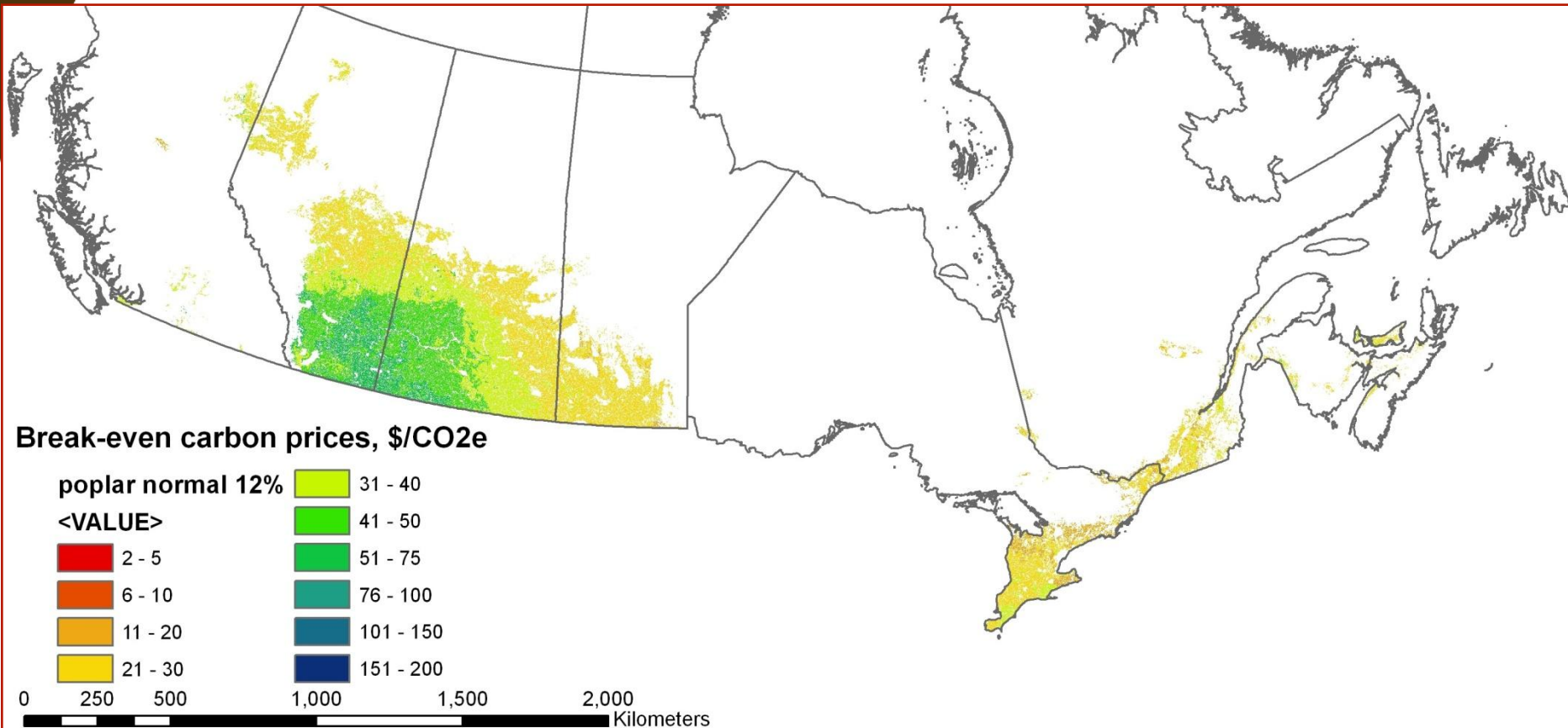
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# Bioenergy opportunities: supplying biomass from hybrid poplar



Break-even carbon prices, \$/t CO<sub>2</sub>e  
– current costs scenario, **12% discount rate**



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## Some interpretation...



- Afforestation is relatively more attractive than SRC at this time
- “Current expectations” would suggest neither system are particularly economically attractive at the present time depending on carbon values.
- The “Aspirational target” scenarios identify important cost and growth conditions that may be required to make this kind of biomass production more attractive.
- Higher SRC growth rates will require **more** intensive silviculture – one possible option is the application of **biosolids**.
- Joint afforestation projects (bioenergy + using biosolids to boost productivity) may be the way to lower costs, but many issues to address



# Conclusions and Future Work



- Model / data development quite well advanced
- Models have already been used to support policy development
- Incorporating economic aspects very important for good policy development

## EcoETI now underway

- Examine more economies of scale issues/opportunities
- More joint product simulations (eg biosolids, carbon)
- Make use of finer scale data



# Example references from previous work



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