NATURAL RESOURCES CANADA - INVENTIVE BY NATURE

From local to global – impediments and opportunities for realizing biomass-based energy aspirations

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Talk Outline

- Bioenergy Aspirations
- Bioenergy Use
- Understanding the gap
- Canadian example
- Path(s) forward

Biomass-based Energy Aspirations

- High hopes for bioenergy
  - The global theoretical biomass availability could be 1500 EJ y^{-1} by 2050 (Bauen et al. 2009)
  - Energy plantations are expected to contribute significantly to future biomass availability (25 to 675 EJ y^{-1} by 2050, Creutzig et al. 2015)
- High theoretical bioenergy estimates do not directly translate into actual biomass availability
  - Bioenergy potential/availability estimates often rely on generous assumptions
  - Significant variation exists for literature estimates of bioenergy availability; there is no standard method for estimating actual bioenergy potential
  - Literature estimates range between a supply of less than 50 EJ y^{-1} to over 1000 EJ y^{-1} by 2050, with most studies estimating approximately100 EJ y^{-1} (e.g. Creutzig et al. 2015)
- The inclusion of "feasibility" constraints and behavioural economics provides more realism
  - For example the inclusion of European Union sustainability criteria limits the potential bioenergy from 977.2EJ to 98.5EJ (Schueler et al. 2013)

Bioenergy Use

- Current adoption, use and production of bioenergy is relatively limited (eg. Hoogwijk et al. 2003; Sims et al. 2006)
  - Globally, traditional biomass use represents approximately 28-48 EJ y^{-1} and is mostly used as cooking and heating fuels
  - Modern bioenergy use (biomass converted to fuels or used to generate electricity) accounted for only 7 EJ y^{-1} in 2000
- Bioenergy adoption varies across continents

  (Vakkilainen et al. 2013)
  - Brazil consumes the largest proportion of the modern global bioenergy supply (16%), followed by the U.S. (9%) and Germany (7%)
  - Six developing countries represent half of the industrial global bioenergy consumption, while developed countries represent approximately 28% of the industrial global bioenergy consumption
- In market-based economies adoption is likely to be mostly driven by perceived benefits of bioenergy to the private sector
- Local decisions add up to global totals

Understanding the Gap Between Aspirations and Adoption

- **The economics of production at local scales cannot be forgotten**
  - Unit costs may be impacted in unexpected ways by changes in technology and knowledge – physical gains in productivity do not always result in lower unit costs
  - Transaction costs are real and will affect adoption (e.g. time commitments, knowledge requirements, finding markets)
  - If public/non-market benefits outweigh private losses, government incentives will be needed to encourage adoption
  - Even when government incentives are in place behavioral economics are likely to delay the adoption process
  - However government incentives are no guarantee to induce land-use change as they still compete with individual perceptions of relative prices and opportunity costs (Pannell, 2008; McKenney et al. 2014)

- **Integrated biological and economic models can help**
  - Combining biological, economic and other behavioural drivers into bioeconomic models can help generate more realistic estimates of local decisions, potential global totals and provide insights to support increased adoption

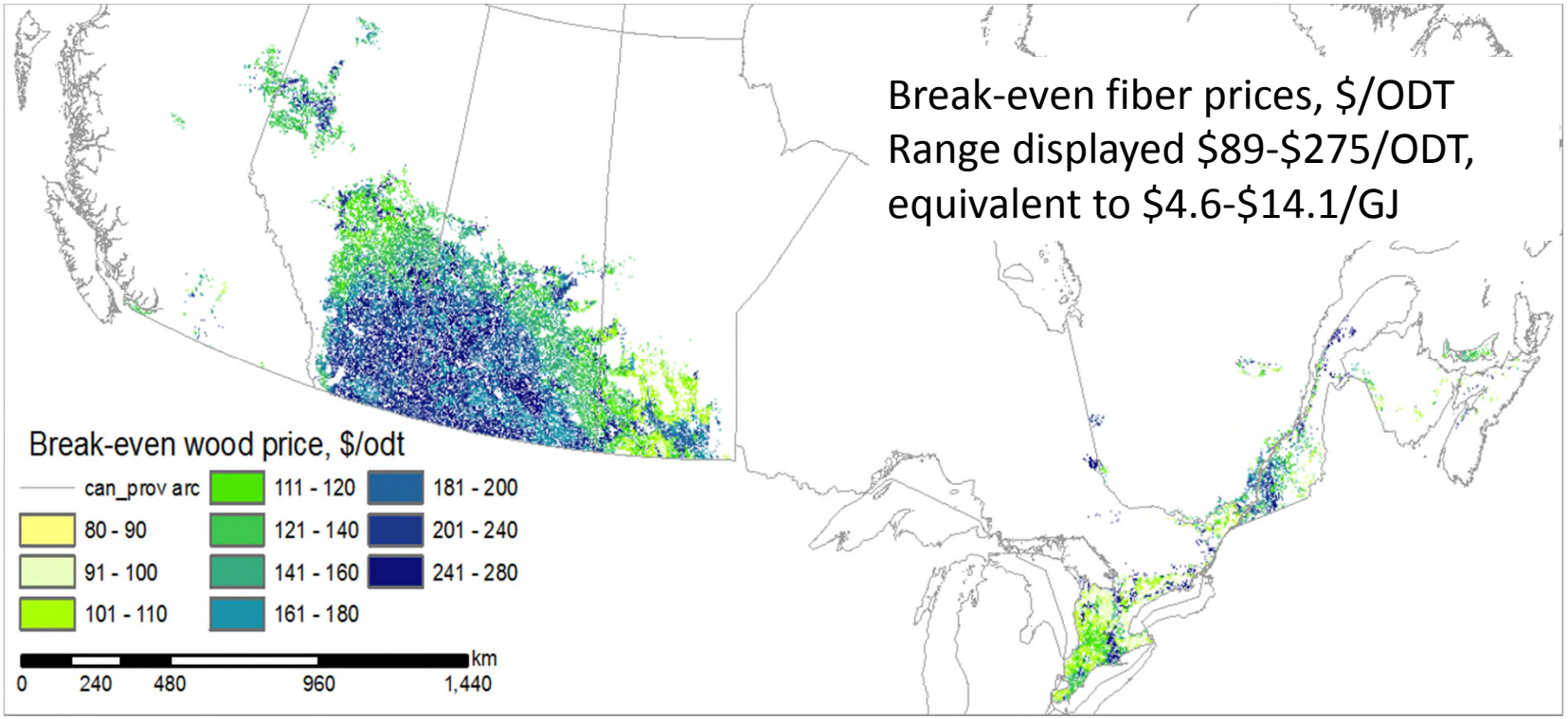
A Country Study: Canada

- Theoretical estimates suggest that 5.1 EJ y^{-1} could be currently available from biomass in Canada (Wood and Layzell 2003)
  - 61% of Canada's estimated bioenergy potential is from forest biomass
- Domestic use of bioenergy is limited but growing
  - Most current bioenergy use in Canada is within the forestry sector, and is used to help power sawmills and pulp and paper mills using manufacturing residues (Pare et al. 2011)
  - High transportation distances and biomass extraction costs limit production and consumption, although the use of bioenergy for localized power and heat generation is growing (Bradburn 2014)
- Currently, biomass markets are largely driven by European demand and government subsidies (Bradburn 2014)
  - Exports of biomass to supply Europe's demand for bioenergy limit the local availability of biomass
  - The development of biomass markets within Canada has been slowed at least partly due to inexpensive and easily accessible fossil fuels

An integrated spatial model

Fast-growing poplar plantations as a bioenergy supply source for Canada
(Yemshanov and McKenney, 2008)

- The amount of energy available from poplar plantations could be between $2.5x10^{-4}$ to 5.0EJ y^{-1}, depending on the price bioenergy facilities are willing to pay – MAPS CAN SHOW VARIATION IN ATTRACTIVENESS!



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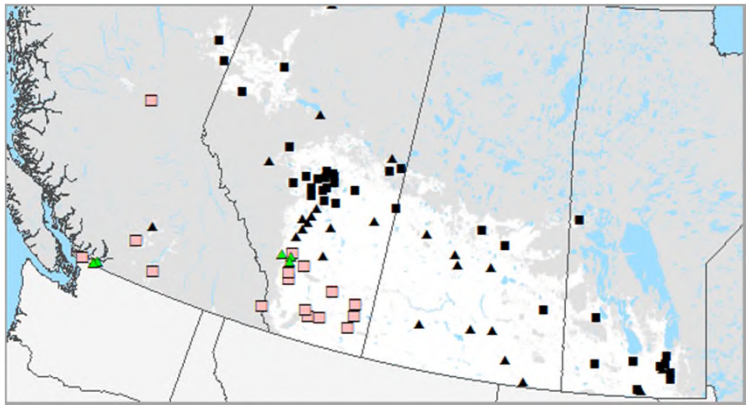
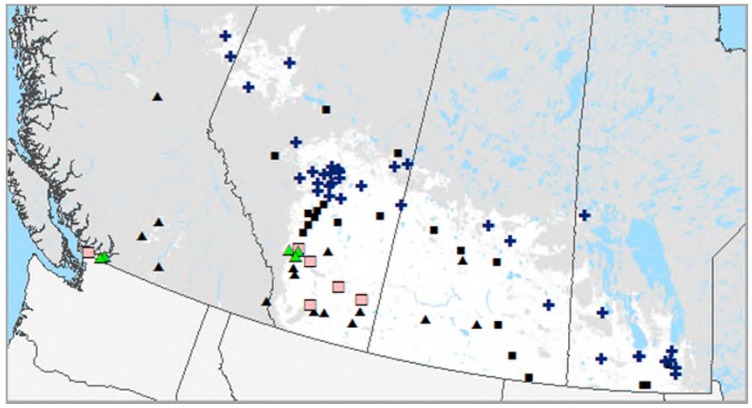
Biomass only scenario



Biomass + carbon co-benefits scenario



Break-even cost of biomass supply, $/GJ, 450kODT-yr.-1 capacity

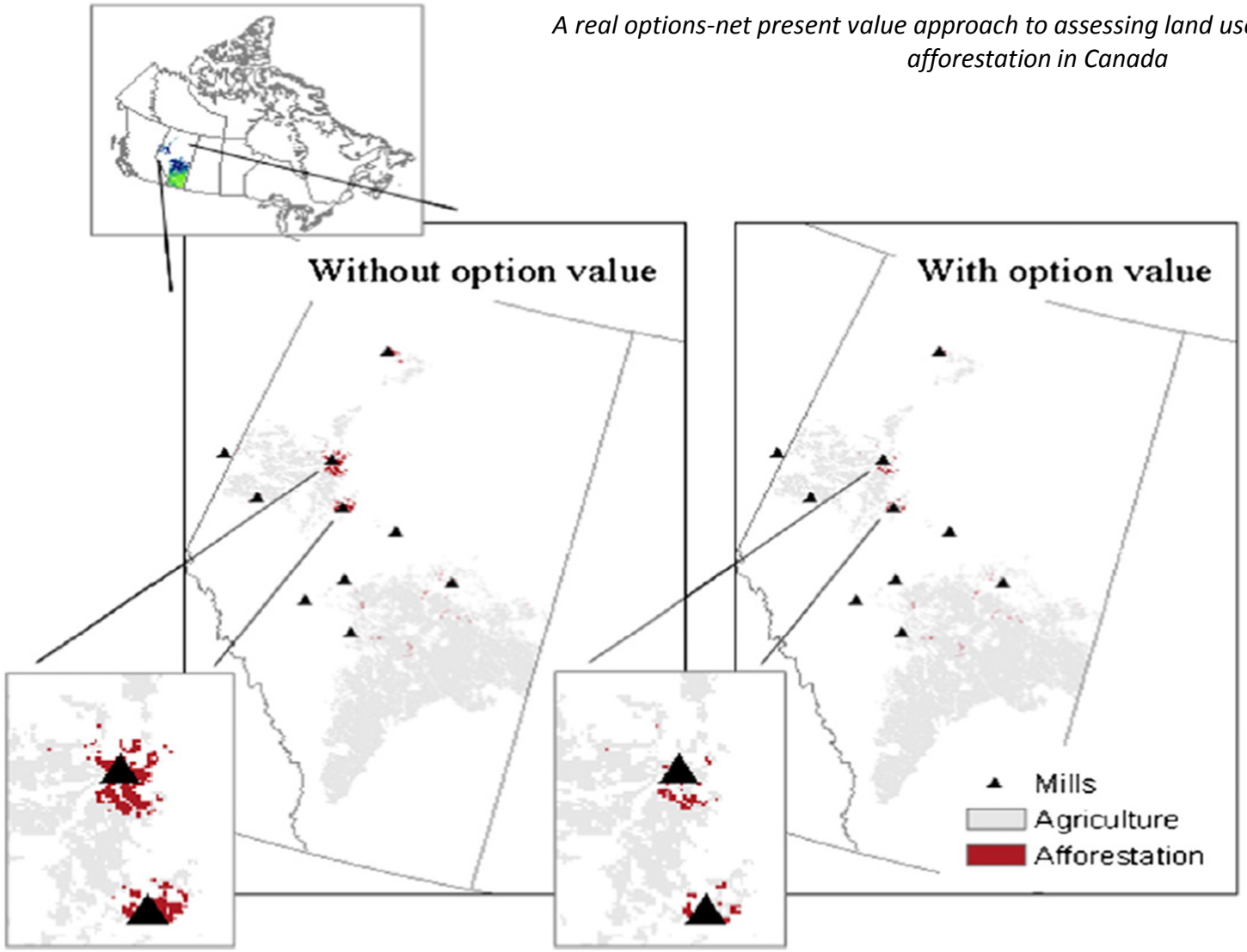
× 3 - 4 + 4 - 5 ▪ 5 - 6 ▲ 6 - 7 ▫ 7 - 8 ▲ 8 - 14

- Adding in a "non-energy" co-benefit value helps to identify break-even prices – a very useful metric that identifies what prices/values would have to be to induce adoption
- Benefits perceived by land-owners will depend on the details in carbon offset systems and carbon accounting protocols

Some “behavioural economics” added in

A real options-net present value approach to assessing land use change: a case study of afforestation in Canada

(Yemshanov et al. 2015)

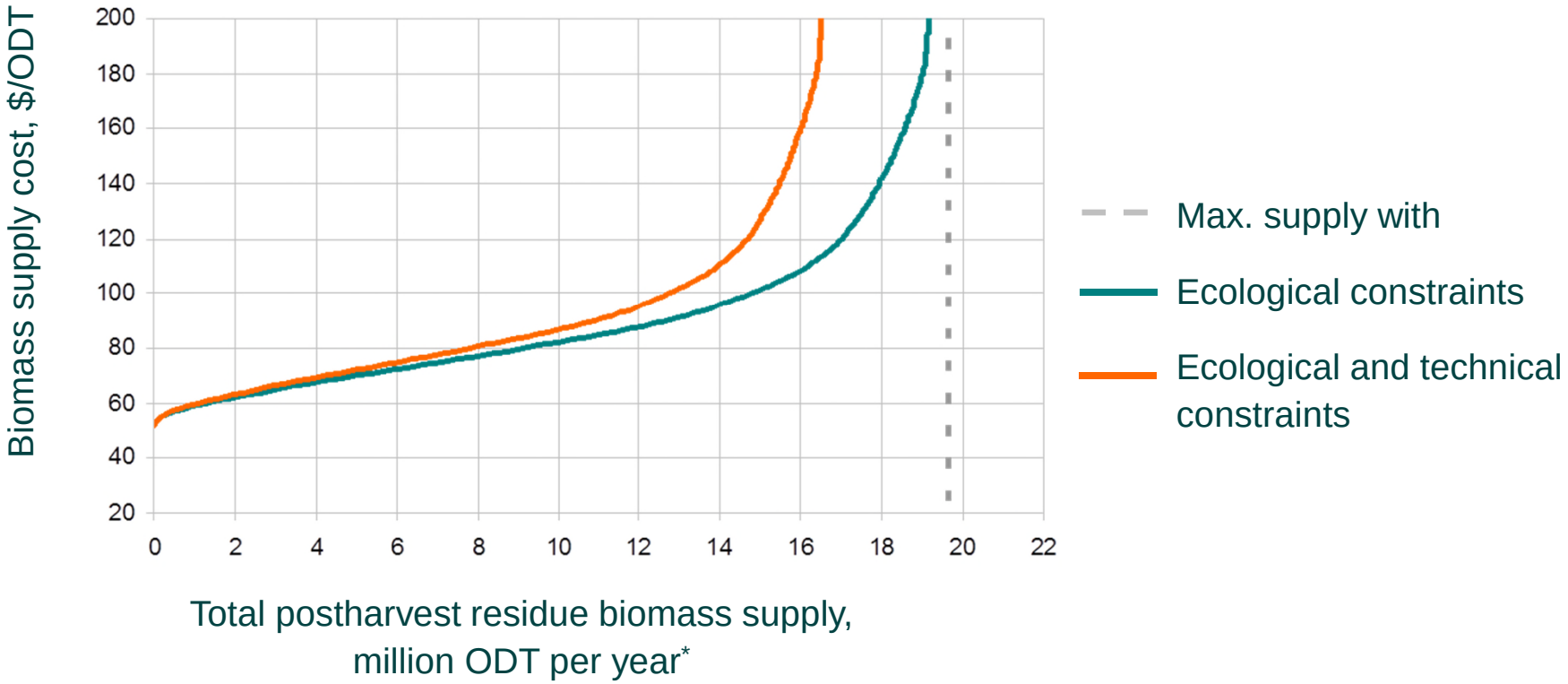


- When the costs of reduced managerial flexibility are included in NPV calculations, less land is converted from agriculture to woody crop plantations

The integrated model with constraints

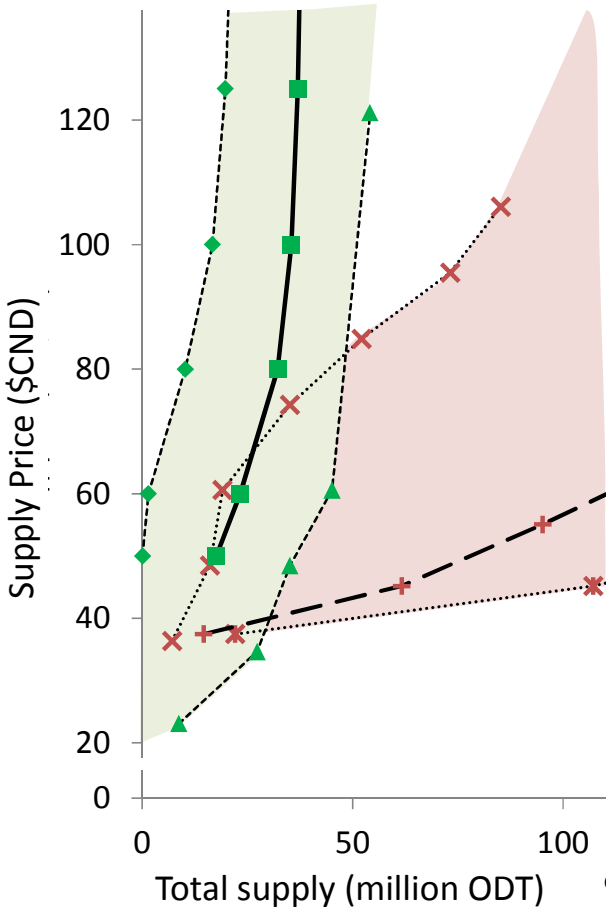
Cost estimates of post-harvest forest biomass supply for Canada
(Yemshanov *et al*. 2014)

- Between 0.019 and 0.39 EJ y^{-1} are estimated to be available across Canada, depending on constraint assumptions and CHP plants' willingness to pay for forest residuals



* Not including manufacturing residues

Comparing alternative options



- Managers, policy makers and Investors need to consider the trade offs between alternative bioenergy supply options
- For example, woody crops could potentially offer more abundant supply but will take time to grow, and their adoption may be slow due to inertia among landowners and land use competition

Alternatively, forest residue biomass is readily available and does not have the adoption and timing issues but generally has higher extraction and transportation costs

Fast-growing woody crops:

- Highest cost estimates (Gronowska et al. 2009)
- Average cost (based on literature)
- Lowest cost (Walsh 2008; Kumarappan et al. 2009)

Forest residue supply:

- Highest cost (Yemshanov et al. 2014)
- Average cost (based on literature)
- Lowest cost (Walsh 2008; US DoE 2011)

Possible Path(s) Forward to Meet Aspirational Targets

- Increase the role of production and behavioral economics in cost/supply models – both individual decision-making models and aggregate outcome or global models
- Market–based solutions are likely more stable/sustainable, especially when governments are fiscally constrained
  - Even if public benefits suggest bioenergy is a good thing it must still outweigh landowner perceptions of the opportunity costs (eg alternative crops, managerial flexibilities, etc)
  - Government support for biomass production can be volatile and could undermine market confidence and price expectations
  - Behavioural economics suggests Landowners may use higher discount rates when assessing the future costs and net returns from bioenergy projects
- R&D Managers and scientists should think more about production (e.g. unit costs) in the development of bioenergy systems to make bioenergy more competitive
- Policy makers should also think more about behavioral economics to help “nudge” aggregate decisions of agents involved in the adoption of bioenergy programs

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