Environmentally Sensitive Growth Models in Canadian Forestry: Current Challenges and Future Opportunities

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Natural Resources Canada | Ressources naturelles Canada | Canada

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Sustainable Forest Management requires reliable projections of the future forest

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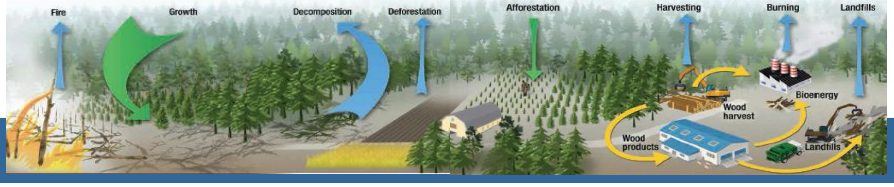
- Includes all aspects: Growing Stock (wood, biomass), carbon, habitat, and all other ecosystem services
- Changing environment: climate (temp and precip), [CO2], N deposition, others
- Changing forest: tree growth, mortality, recruitment, species composition
- Magnitude and direction of responses and the relative importance of drivers remain uncertain, despite decades of research
- Models based on past observations may no longer be reliable



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What is a Climate/Environmentally sensitive Growth Model

"Growth and Yield": predictions of tree growth, tree mortality and recruitment generated using input data and a series of component equations (models) that produce outputs for indicators of interest such as wood volume, biomass, ecosystem production, harvested wood products.

"Climate Sensitive": the ability of a growth and yield model to consider in its projections the impacts of changes in climate and other environmental conditions, such as temperature, precipitation, water balance, increases in atmospheric CO_2 concentration and atmospheric nitrogen deposition.

Disturbances (fire, insects, harvest, etc.)

Two related but not identical questions

Magnitude and cause of inter-annual variation and trends: are trees growing faster or dying sooner?

Environ. Res. Lett. 13 (2018) 093001 https://doi.org/10.1088/1748-9326/aad82a

Environmental Research Letters

TOPICAL REVIEW

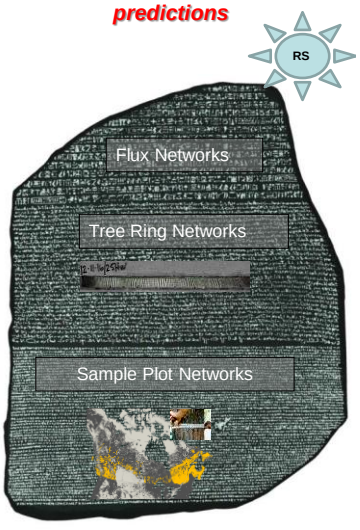
Untangling methodological and scale considerations in growth and productivity trend estimates of Canada's forests

William Marchand, Martin P Girardin, Sylvie Gauthier, Henrik Hartmann, Olivier Bouriaud, Flurin Babst and Yves Bergeron

Many growth and mortality trend studies, not always consistent
Depends on region, species, data used, and method of analysis

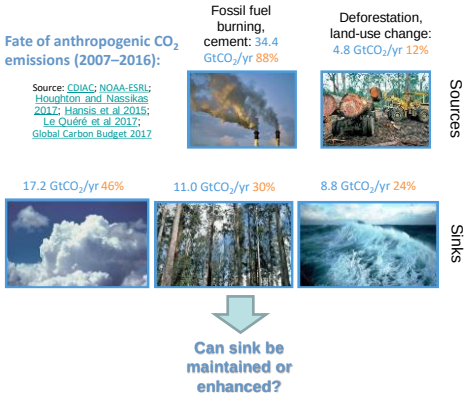
- Datasets are available, more are coming:
  - Climate/weather (many)
  - Tree growth and mortality (MAGPlot, CFS-Trend)
  - Remote sensing (many)
- Computing capability increasing
- Analytical approaches getting better
- There is an opportunity here

Models to explain observations and make SFM relevant predictions



Not just important for SFM

- Natural climate solutions
- Keeping warming to <2^{O}C needs land sector contributions
- Governments and society expect land contributions to net zero emission pathways.
- Forests will be included, but they are also at risk from CC impacts
- Credible data and tools needed



Canadian Forest Service Context

Canada's National Forest Carbon Monitoring, Accounting and Reporting System (NFCMARS)

One system with many uses.

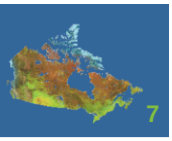
- Past C dynamics (GHG Inventory)
- Future C dynamics (Emissions trend reporting)
- Climate mitigation and adaptation strategies (Natural Climate Solutions)

CBM-CFS3 (in the future GCBM)

- Timber/wood supply data are key inputs
- Forest Inventory (vector polygon map)
- *Yield curves from P/T empirical growth and yield models (not climate/environmentally sensitive)*

As a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), Canada is obligated to prepare and submit an annual national greenhouse gas (GHG) inventory covering anthropogenic emissions by sources and removals by sinks.

Recent Canadian Forest Service Initiative on CSGYM



Started in February 2020: Internal workshops and steering committee, engagement with P/T experts (interviews, virtual workshops), third party literature review and recommendations
Desired Outcome: A cohesive, strategic research roadmap towards a national level approach to CSGYM in both managed and unmanaged forests.
Desired Features: Draws from a diversity of approaches and models, is inter-operable and modular, scalable, and open-source; complementary to models developed by provincial management agencies.

Big problems can't be solved by individuals or groups working in isolation. **Collaboration is key**

1. Within our own organization
2. With experts in provincial and territorial agencies
3. With academics and research groups

Building the collaboration

1. Winter 2021 we interviewed P/T experts interviews (1-2 hours, semi-structured), to try to understand:
   - Climate sensitive GY models as a research and/or policy priority
   - General approach being taken to developing a climate sensitive GY model
   - Major gaps in climate-sensitive GY model development
   - Current and desired collaborative efforts
2. We engaged senior GY consultant to provide a comprehensive review of CSGYM in Canada and abroad and to prepare recommendations

Objective: build picture of the current status of climate sensitive G&Y modelling in Canadian Forest Management

Interview Highlights

1. Climate sensitive GY models as a research and/or policy priority

- Climate change affecting forestry. Need to "do something" (planning, mitigation, reporting) recognized at senior and operational levels
- But, no (little) new resources, few specific actions, little coordination

2. General approach being taken to developing a climate sensitive GY model

3. Major gaps in climate-sensitive GY model development

- All P/T are maintaining GY models (systems of components) for wood supply and some are investigating using and/or localizing other models.
- None have CSGYM and current capacity for new model development is usually limited
- Development Efforts
  1. Add climate sensitivity to component models (e.g., Site index)
  2. Maintain PSP and trials (e.g. provenance trials/assisted migration)
  3. Improve inventory (eFRI)

4. Current and desired collaborative efforts

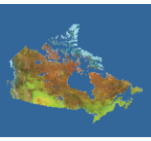
- P/T will collaborate with each other, universities, CFS, research groups, cooperatives.
- This includes sharing data, approaches and results.

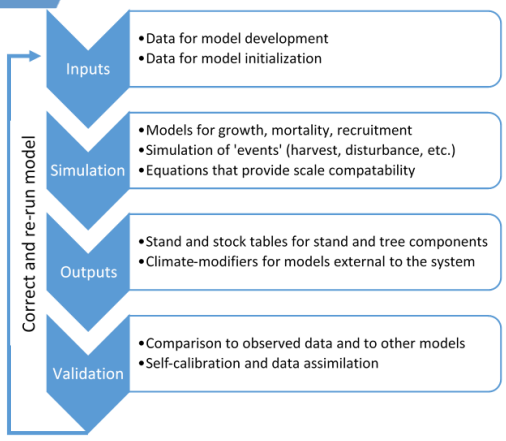
Consultant report recommendations

- All P/T's are concerned with CC and interested in continuing national-level discussion, but no current operational CSGYM in Canada
- CFS should coordinate development of national-scale model complementary to P/T work

- ✓ CFS to begin developing a national action plan
- ✓ Continue regular meetings with P/Ts
- ✓ Continue efforts to compile data and models
- ○ Host another science summit & include academics and research groups
  - ○ This would clearly include working with some of the people in this audience that are working on this problem in Alberta (some of these conversations have started)

CSGYM Road Map



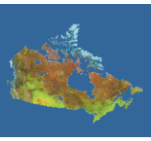


Currently being developed by CFS. The vision is CSGYM(s) for Canada that

1. Draw(s) from a diversity of approaches,
2. is/are inter-operable, modular, scalable, open-source; and
3. is/are complementary to P/T's models.

Aim is to report back to P/T expert group very soon

In Summary



- Sustainable forest management requires reliable projections of the future forest (growth, mortality, recruitment, disturbances)
- Existing empirical models may not be reliable, CSGYM needed
- Government of Canada need for CSGYM initially driven by GHG/carbon/mitigation, but all others can benefit
- Solving this problem requires open collaboration. Individuals or small groups can't do it alone.
- CFS is leading the development of a strategic national plan for CSGYM in collaboration with provincial and territorial agencies (academics and research groups also to be engaged)