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Using bioeconomic modeling tools to assess the impact of invasive species on wood supply: a *Sirex noctilio* case study in Eastern Canada

Shepherdstown, WV, May 30, 2008

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Background

- A collaborative effort between CFS- GLFC (D.Yemahsnov, D. McKenney, P. de Groot), USDA FS (D. Haugen) and CFS-NoFC (D. Sidders and B. Joss)
- Provides a new approach in projecting economic impacts of invasive species
- Focuses on impacts of interest to forest industry and forest policy worlds – wood supply and harvest levels
- Accounts for existing forest management practices in Canada and Provincial regulations
- Assesses invasive species impacts versus “Business-As-Usual” scenarios
- This overview:

  - Basic principles and impact assessment methodology

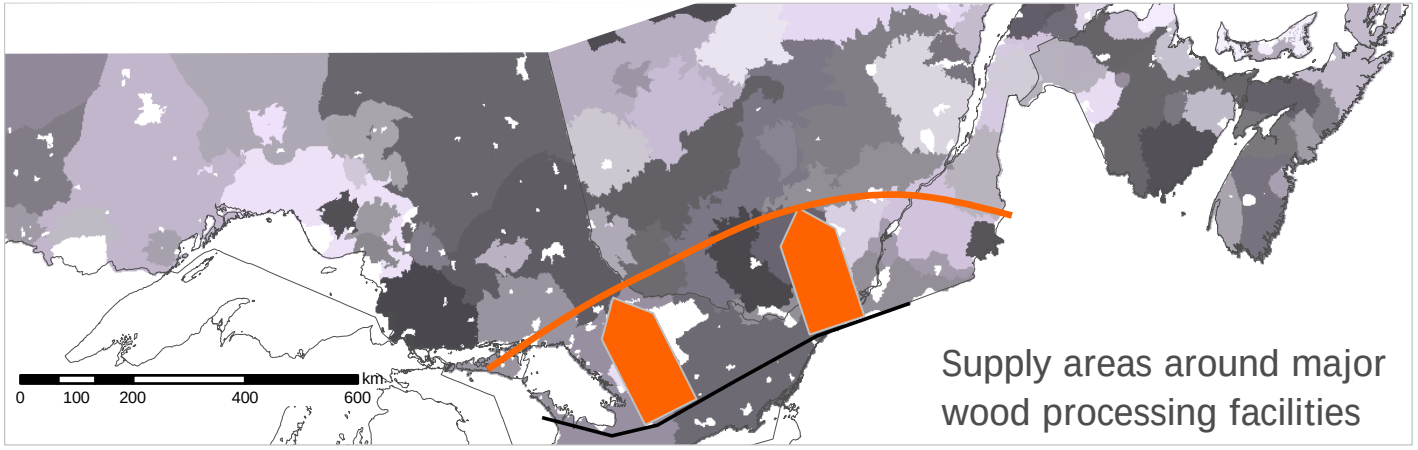
  - *Sirex noctilio* example: data and assumptions

  - First results

Basic methodology

Integration of key components

- **Spread model** – simulates *Sirex* outbreak in space and time
- **Pine biomass distribution / growth model** – need to know how much pine, where, and how quickly it could grow and regenerate
- **Harvest model** - projects BAU forest management activities,
  - emulates harvest within Provincial guidelines
  - links harvest with pine biomass growth and spread models
- **Cost-benefit model** with BAU price and cost assumptions



Supply areas around major wood processing facilities

Assessing impacts on wood supply and harvests

Wood supply from a forest management perspective (in Canada):

- In Canada, Provinces regulate harvest
- Annual Allowable Cut (AAC) specifies the harvest limits without diminishing the long-term wood supply
- AACs are planned at the level of Forest Management Units (10^3-10^4 km^2 supply areas around major wood processing facilities)
- Harvests allocated in the model dynamically

Two reference points to estimate the impact of invasion on wood supply: (1) AAC and (2) harvest allocation – both are dynamic variables!

Data requirements

– Pine biomass distribution and age
– Growth rates and susceptibilities of major pine species to *S. noctilio*
– Wood supply regions of industrial forestry (forest management units)
– Mills and wood processing facilities and their wood consumption levels
– Initial *S. noctilio* infestations

Linking models with spatial data – in the CFS-FBM Forest Bioeconomic Model

Study assumptions

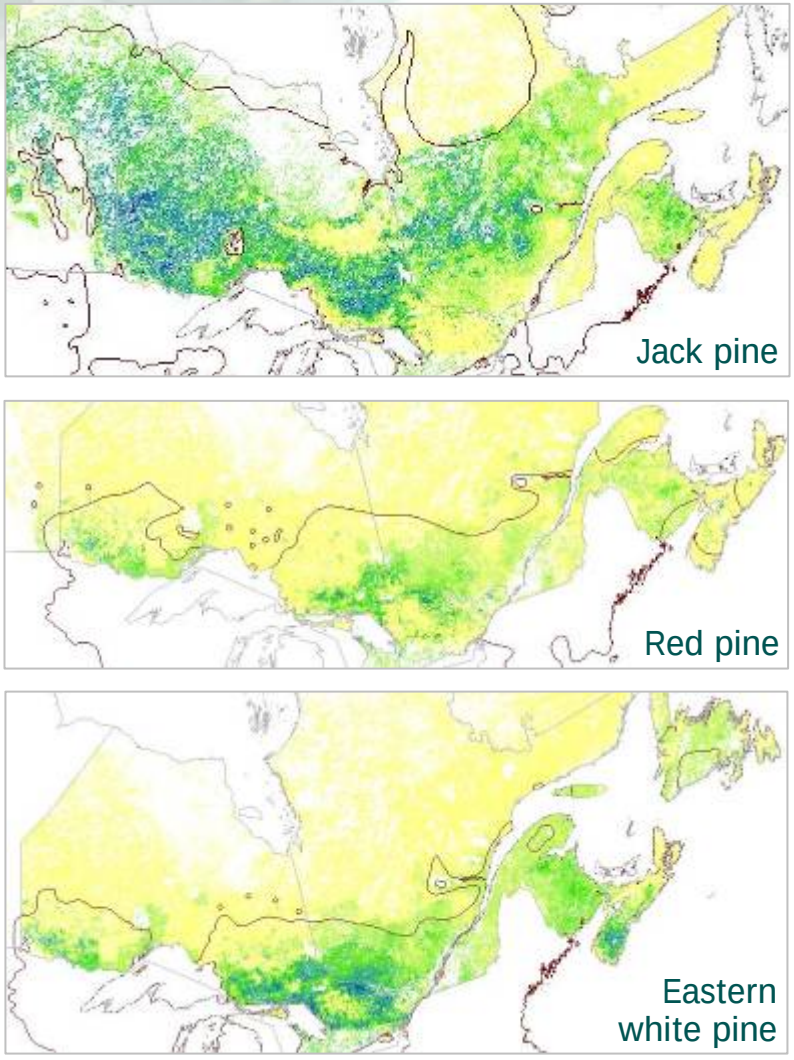
Simplified spread model – adapted from Sharov and Liebhold 1998 gypsy moth model

- Spread is simulated as a travelling wave (coalescing colony, not a PDE!)
- Population model – geometric growth rate with maximum carrying capacity
- Dispersal kernel - $f(x) = p_0/(a + bx^c)$, for $x < x_{max}$ and $f(x) = 0$ for $x \geq x_{max}$
- Survival and establishment: age-dependent pine susceptibility model
- Coarse scale (400m) - no Allee effect or population collapse conditions

Basic assumptions

- 50 km/year maximum spread rate
- Pine susceptibility assumptions – **FHTET ranks / D. Haugen / P. de Groot**
- "What-if" Sirex population dynamics scenarios (hi-low range, D. Haugen, pers. comm.)
- Pine biomass consumption rates 4.4 and 16.7 m^3/ha/year (for 100% pine stands)
- Initial *Sirex noctilio* infestations - 2006 CFS-CFIA survey
- Pine distribution map derived from CFS CanFI and EOSD National datasets
- Pine yield model - Bernier and Ung (CFS)
- Regional AAC levels are based on the current capacity of major wood processing facilities

Pine distribution model



Data sources:

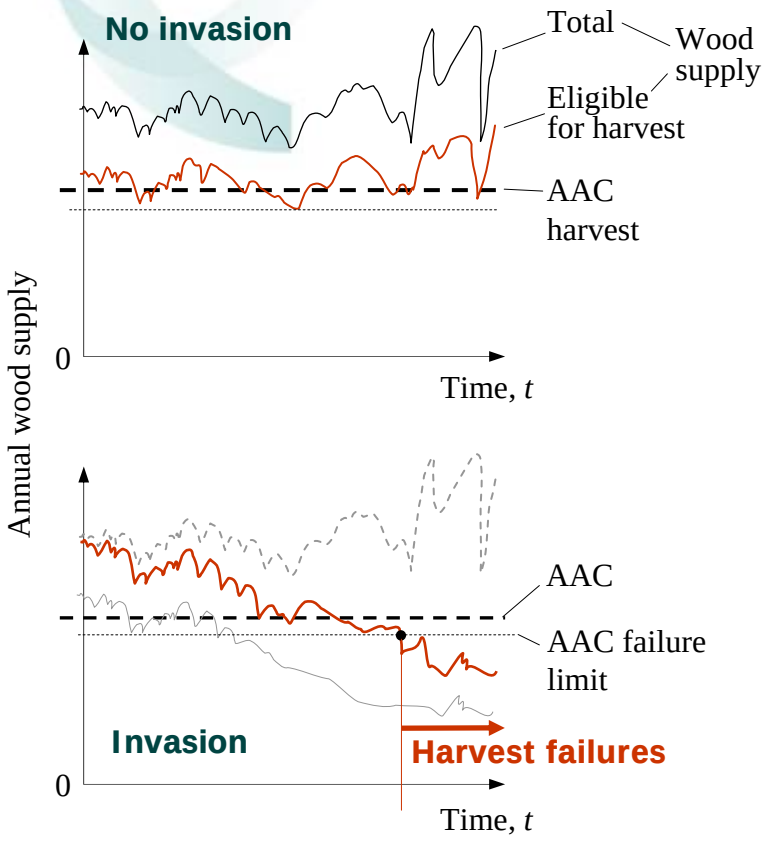
- CFS **CanFI** database based on Provincial forest inventory summaries (100-400 km^2)
- **EOSD** 250 m satellite land classification – National land cover map

Pine biomass model:

- Integrating **EOSD land cover** and the **CanFI** datasets using a stochastic model

  - Round-off error – 0.01-0.31%
  - Volume disagreement vs. Provincial totals:
    Ontario, Quebec – 0.2%-2.35%
    Maritime Provinces – 0.5%- 11%

IAS spread and wood supply



Harvest allocation:

- Finds the least cost harvest pattern to reach the Annual Allowable Cut (AAC) limit

Invasion usually leads to a new harvest allocation with **higher** wood supply costs

Two sets of metrics:

- Wood supply losses and direct costs (quantitative)
- The timing and area extent of "harvest failures" (a somewhat qualitative threshold)

Three possible harvest adaptation policies :

- H1 ("Do nothing") - use BAU harvest pattern
- H2 Cost minimization - maximize $PV_{(timber\ supply)}$
- H3 Prioritizing harvest in "quarantine zones"

All impacts are calculated invasion vs. no-invasion BAU

Economic impacts on wood supply and harvest

Eastern Canada:
(ON,QC,NB,NS)

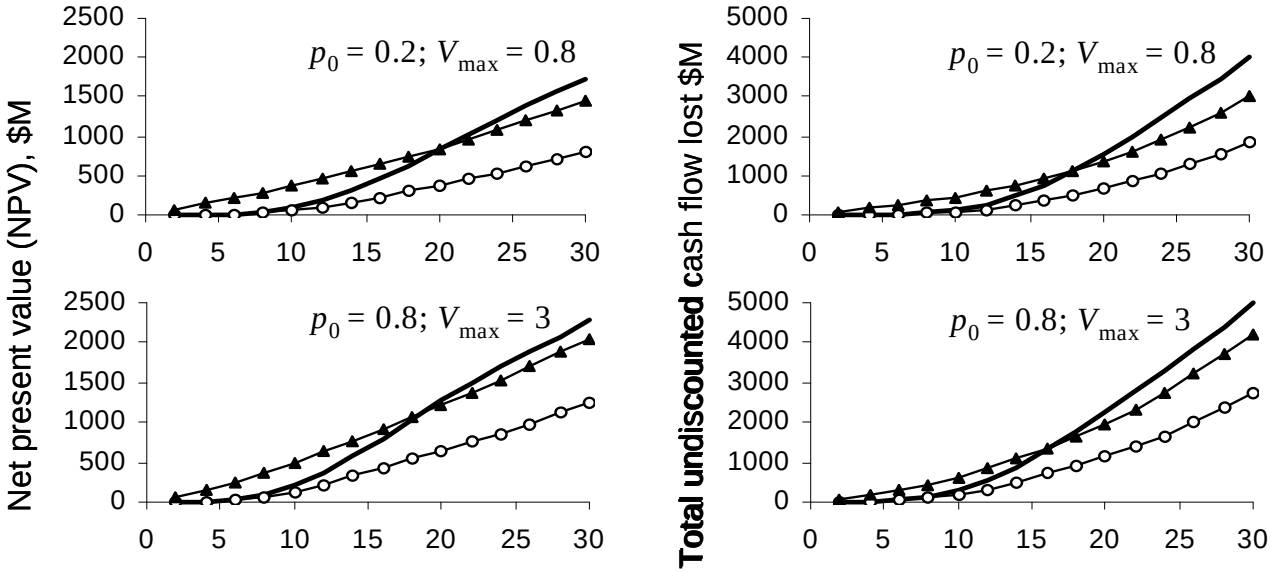
Infestation potential:

Low

High

Lump sum NPV, $M
(4% discount rate)

Total cash flows, $M
(undiscounted)

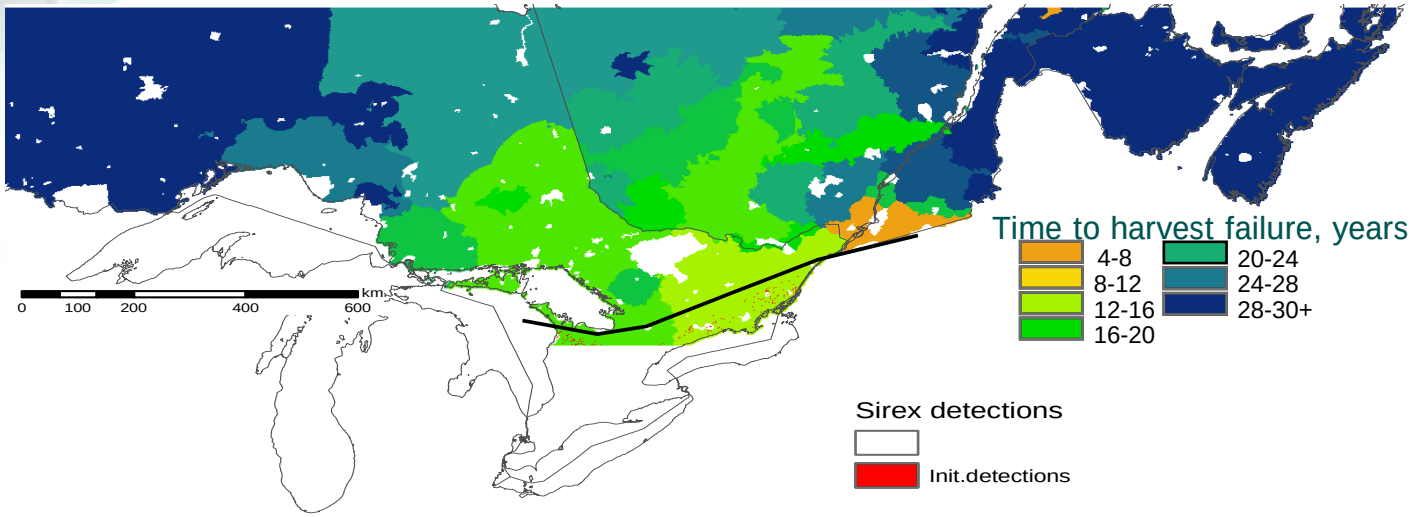


H1 – no adaptation;
H2 – maximize $PV_{(timber)}$;
H3 – move harvest closer to infested areas

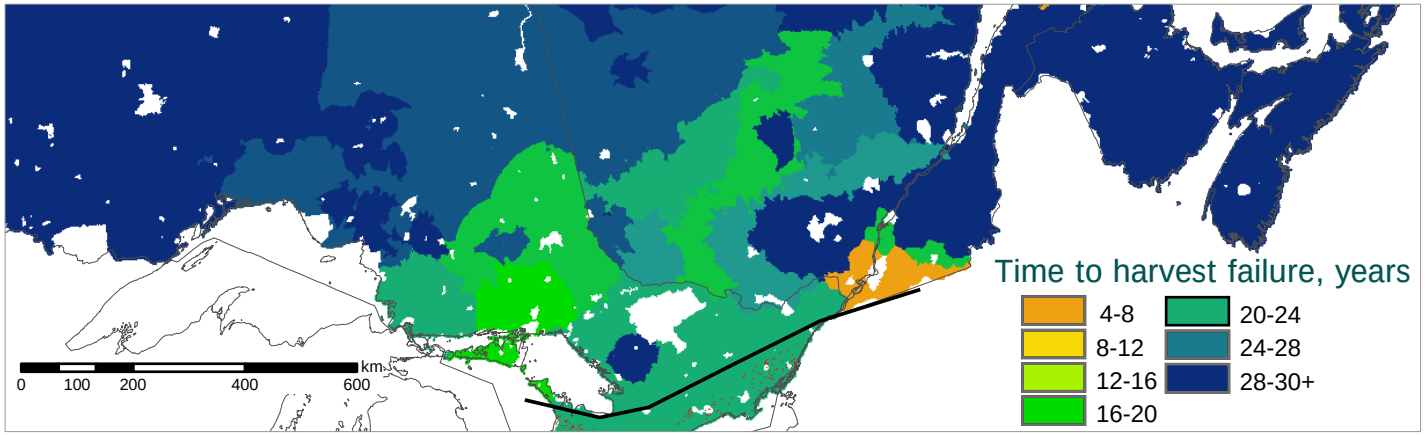
Timing and the location of harvest failures

Infestation potential:

High

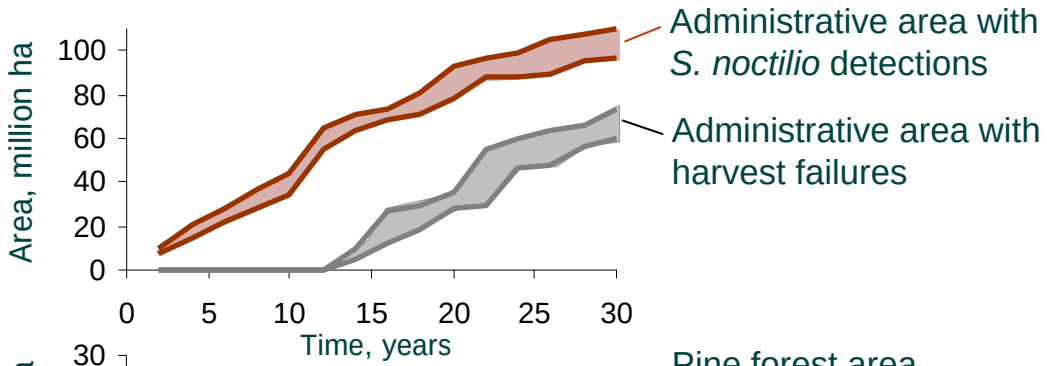


Low

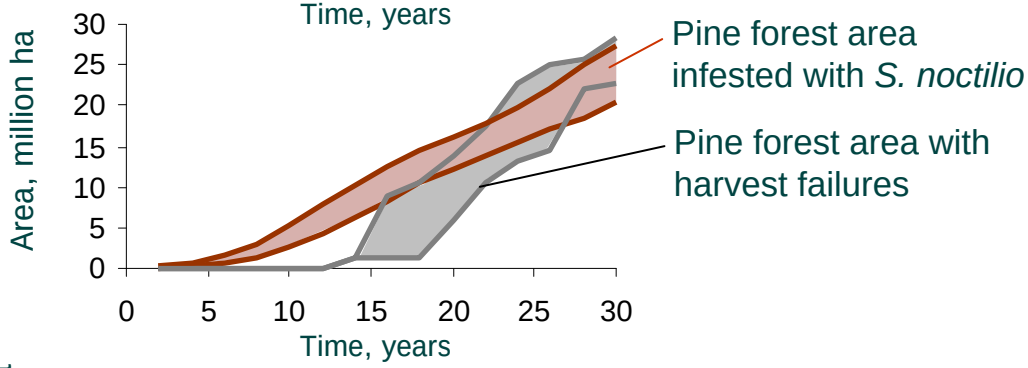


Area extent and time lags for harvest failures

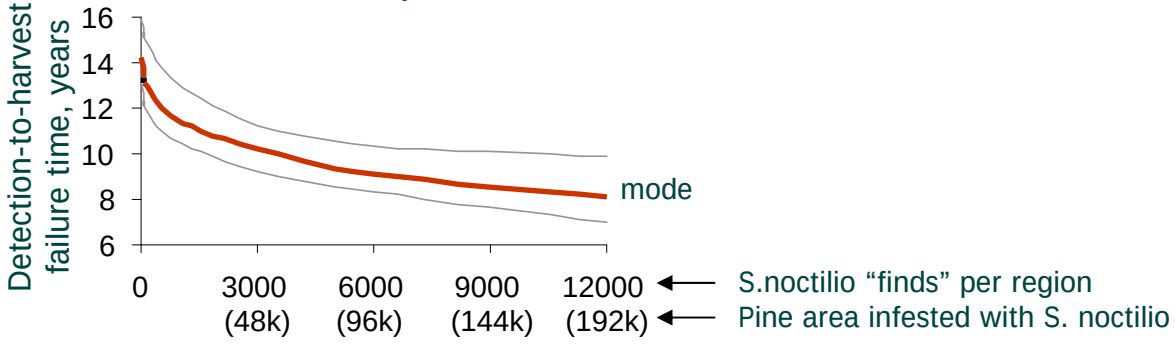
Administrative area of harvest failures (inclusive of non-forest land):



Pine forest area affected by harvest failures:



Time between detection and harvest failures (all regions):



Initial impact estimates

- Total killed volume - 26-115 M m^3 over 20+ years
- Inclusion of the AAC concept changes the calculus
- Short-term impacts are “moderate” (NPV $B 0.7-2.1 over 28 years)
- Ontario and Quebec, share most losses
  (assuming no new entries from US)
- Harvest adaptations suggest 46%-55% lower losses
- Without adaptation large-scale wood supply shortages could start after 20+ years when total infested area exceeds ~12.5-14M ha
- Preventive harvest practices may not be least cost
- Irreversible harvest failures in some regions may occur within 8-16 years.
  Poor detection accuracy may shorten this time by 5-6 years