Exploring forest productivity at an early age after fire:

a case study at the northern limit of commercial forests in Quebec

Rik Van Bogaert, Sylvie Gauthier, Frédéric Raulier, Jean-Pierre Saucier, Dominique Boucher, André Robitaille, and Yves Bergeron

Van Bogaert, R., Gauthier, S., Raulier, F., Saucier, J. P., Boucher, D., Robitaille, A., & Bergeron, Y. (2015). Exploring forest productivity at an early age after fire: a case study at the northern limit of commercial forests in Quebec . *Canadian Journal of Forest Research, 45, 579-593*

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Context:

-Limite nordique: In 2005, the Quebec Ministry of Forests, Fauna and Parcs (MFFP) initiated a large scientific project

→Their mandate: explore the biophysical environment north of the current (2002) commercial forestry boundary to evaluate the possibility of sustainable forestry

→ To our knowledge this is the first time that a province or country has scientifically explored the potential of northward expansion of sustainable forestry!

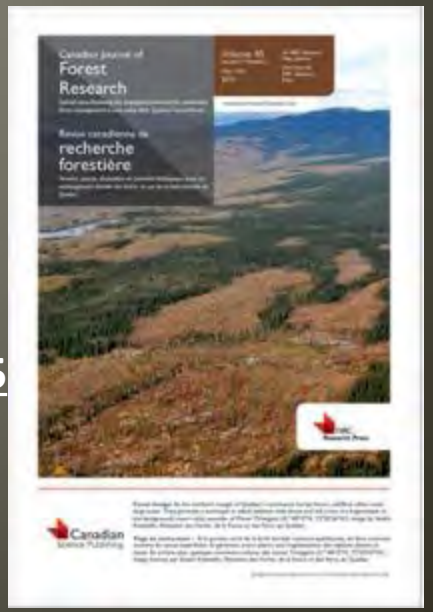
Scientific Committee

→**Special Issue** in **Canadian Journal of Forest Research, May 1st, 2015**

7 research papers. I will present one of them:

Exploring forest *productivity* at an early age after *fire*

–a case study at the northern limit of commercial forests in Quebec–



This study: what and why?

- *Why study productivity at an early age after fire?*

→Long-term forest productivity and resilience to fire are inherently connected, particularly if we move northwards with our control on fires being reduced!

→ Very few studies have focused on the productivity of young (<30 years) stands. However, a lot of valuable site information can already be derived from these stands. Particularly if we move northwards, earlier productivity assessments would be helpful as it takes stands much longer to reach commercial stand heights. The obtained knowledge should allow for earlier and more appropriate management decisions.

Exploring forest *productivity* at an early age after *fire*

10-30 years after fire

→ 116 sites

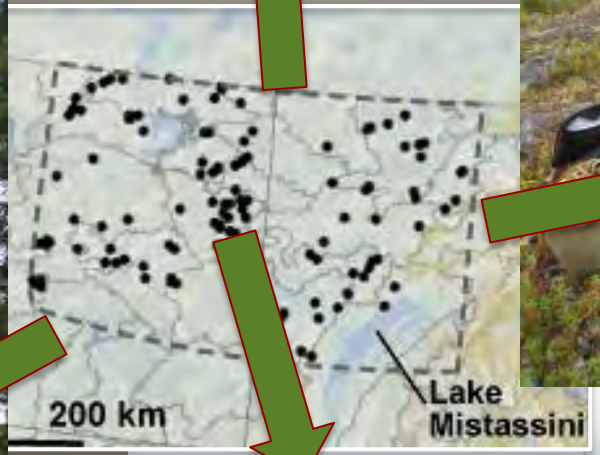
40% of study area

= 90,000 km^2

Photo Credits : MFFP

52.4 ˚N (460m)

52.3 ˚N (600m)



51.3 ˚N (340m)

51.8 ˚N (360m)

Exploring forest *productivity* at an early age after *fire*

Productivity = Number of trees.ha-1 x Tree Size (volume)

OR: Density / stocking ←→ Growth quality

→this study: Productivity = stocking x growth quality
(see Material & Methods in paper)

→To have a productive stand: Minimum **thresholds** apply :

(a). minimum stocking = crown closure, Krajicek et al. 1961)
= 666 stems.ha^{-1} (commercial-sized 50-70 dm3 stems)

= 60% (using 10 microplots of 9m^2)
≥60% (good) vs. <60% (bad)

Krajicek, J.E., Brinkman, K.A., and Gingrich, S.F. 1961. Crown competition — a measure of density. Forest Science 7: 35–42

Exploring forest *productivity* at an early age after *fire*

Productivity = Number of trees.ha-1 x Tree Size (volume)

OR: Density / stocking ←→ Growth quality

→this study: Productivity = stocking x growth quality

(see Material & Methods in paper)

→To have a productive stand: Minimum **thresholds** exist for both factors:

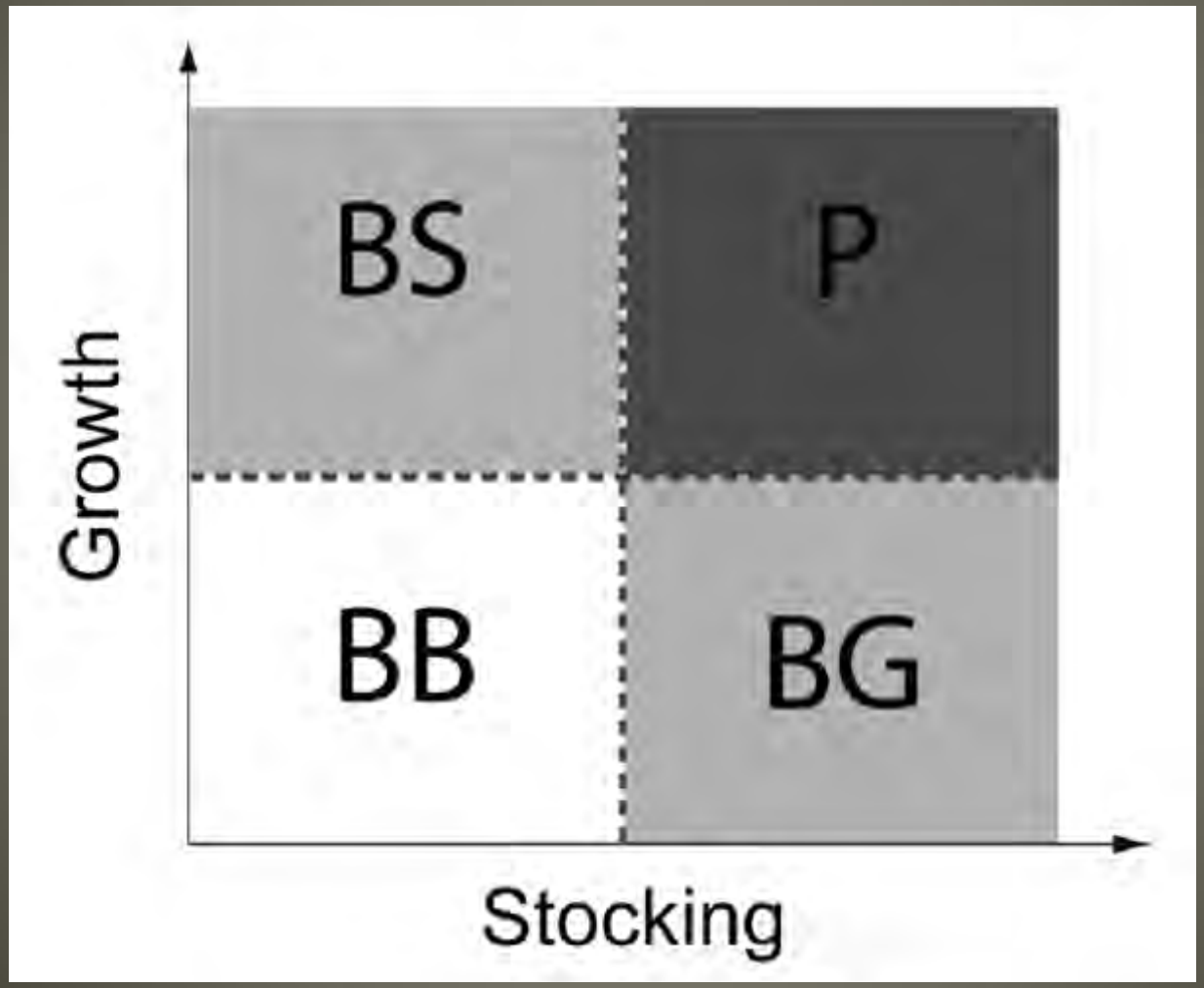
(b). minimum growth = minimum Site Index used in QC/ N-America)

= 7.5 (black spruce) and 9 (jack pine)

Exploring forest *productivity* at an early age after *fire*

BS= unproductive because of **Bad Stocking** (Growth is good)

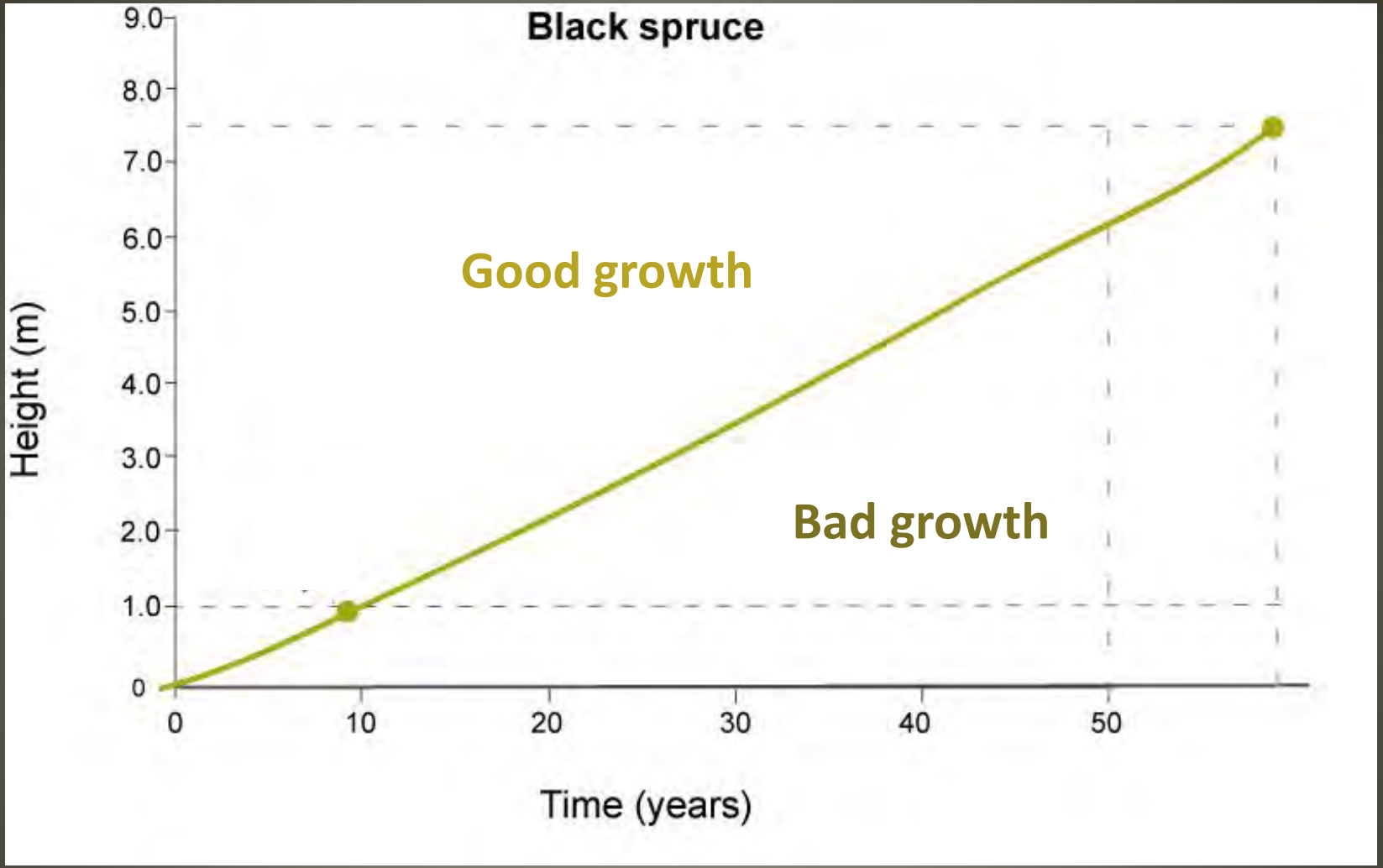
BB= unproductive because of **Both Bad Stocking and Growth**



P= productive

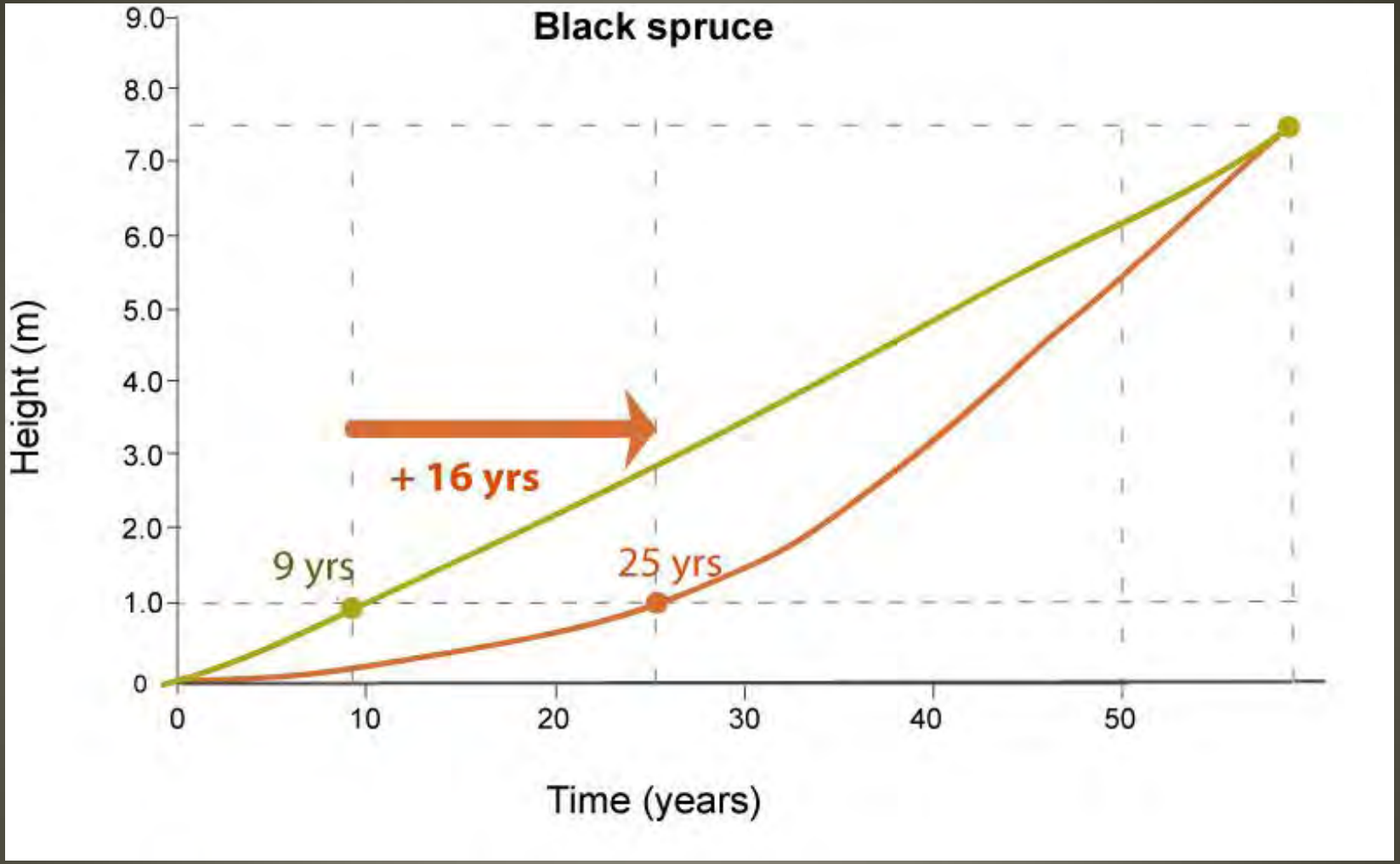
BG= unproductive because of **Bad Growth** (stocking is good)

SI 7.5 (worst commercial in N-A)



Applying the stocking threshold (60%) to our 116 sites is obvious, but how to apply the growth threshold?

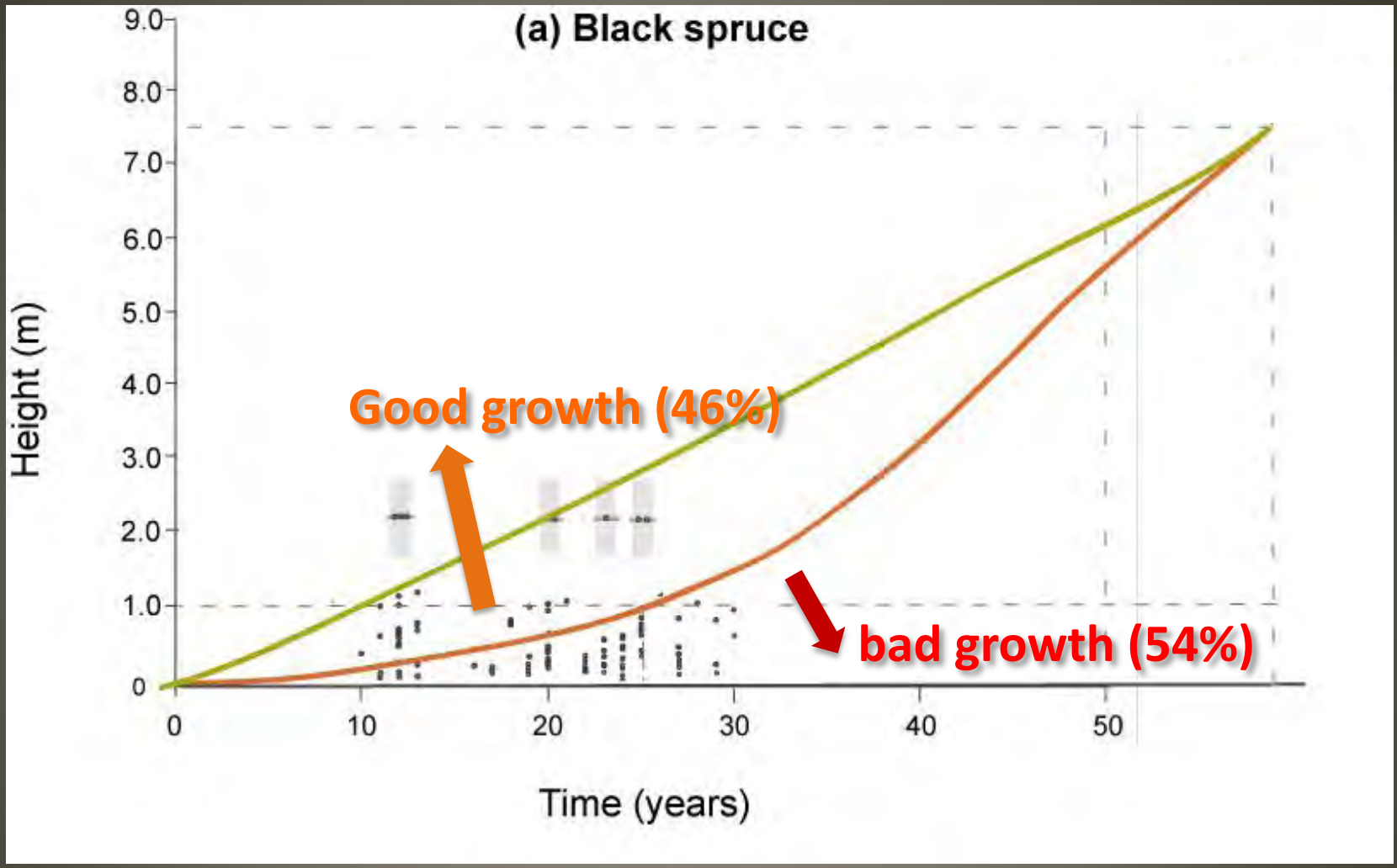
SI 7.5 (worst SI in N-A)



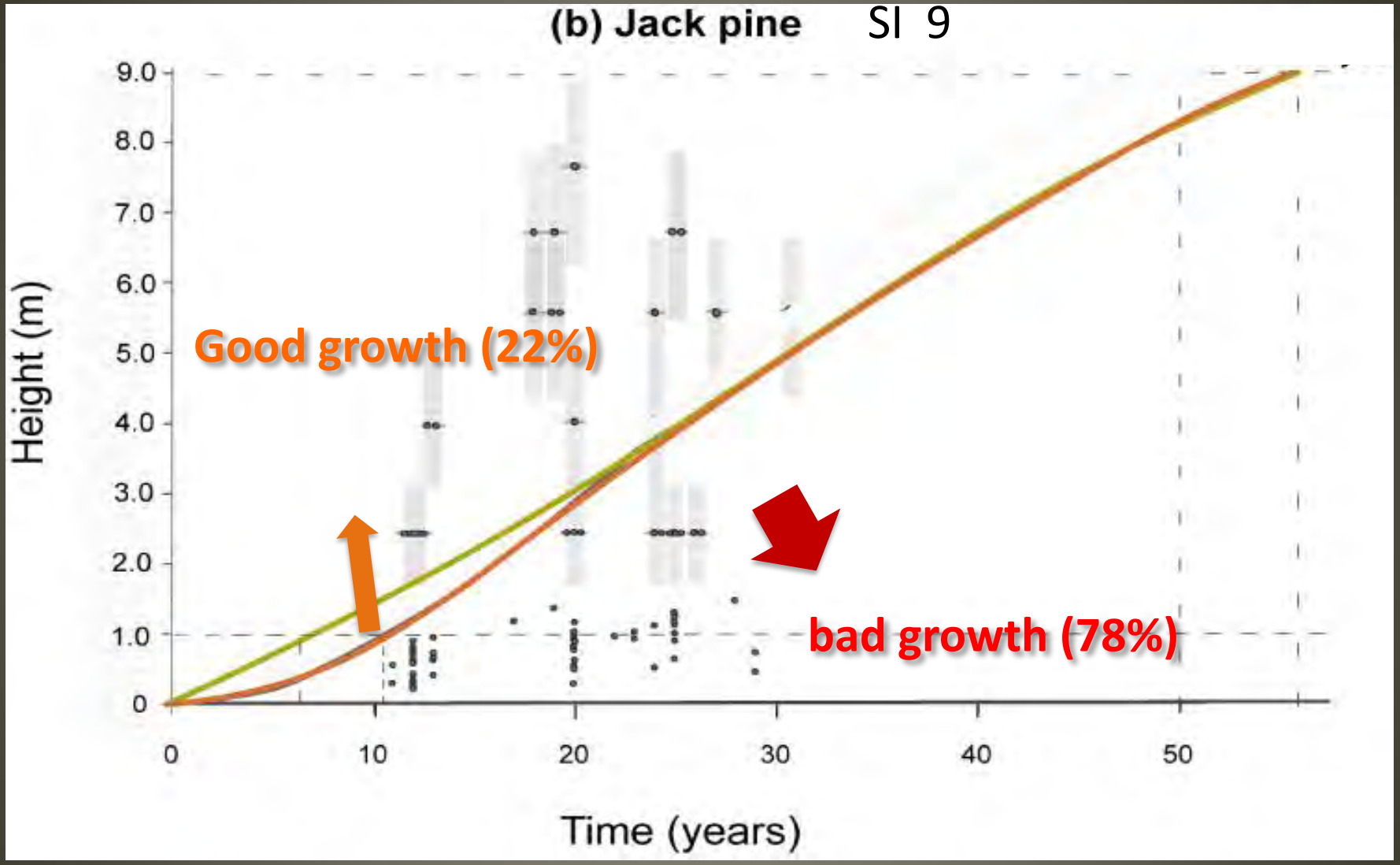
A SI of 7.5 assumes that it takes 9 years for a *P. mar.* individual to attain 1.0m height. However, to reduce the risk of classifying potentially productive sites as unproductive, we used a 25 yr threshold (+16 years!) that takes into account ground-layer competition at early stand ages in northern natural forests (Rheault 2013).

Rheault, H. 2013. Éricacées. Fascicule 4.10. In Manuel de détermination des possibilités forestières 2013–2018. Gouvernement du Québec, Bureau du forestier en chef, Roberval, Quebec. pp. 201–206.

Growth quality results Black Spruce



Growth quality results Jack Pine



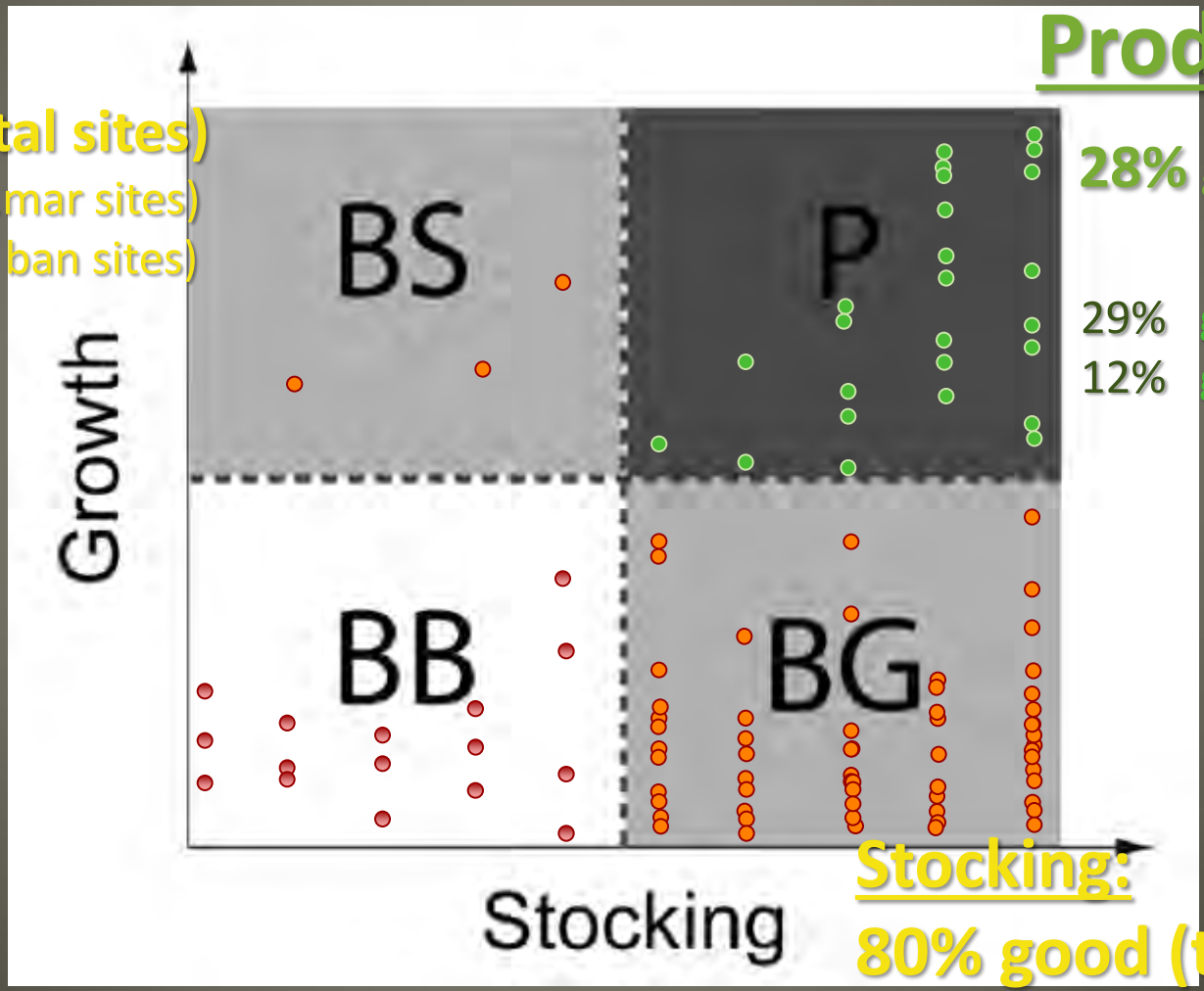
Exploring forest *productivity* at an early age after *fire*

Growth:

39% good (total sites)

46% good (BS=P.mar sites)

22% good (JP= P. ban sites)



Productivity

28% good (total sites)

29% good (BS=P.mar

12% good (JP=P. ban

Stocking:

80% good (total sites)

77% " (BS= P.mar sites)

45% " (JP= P. ban sites)

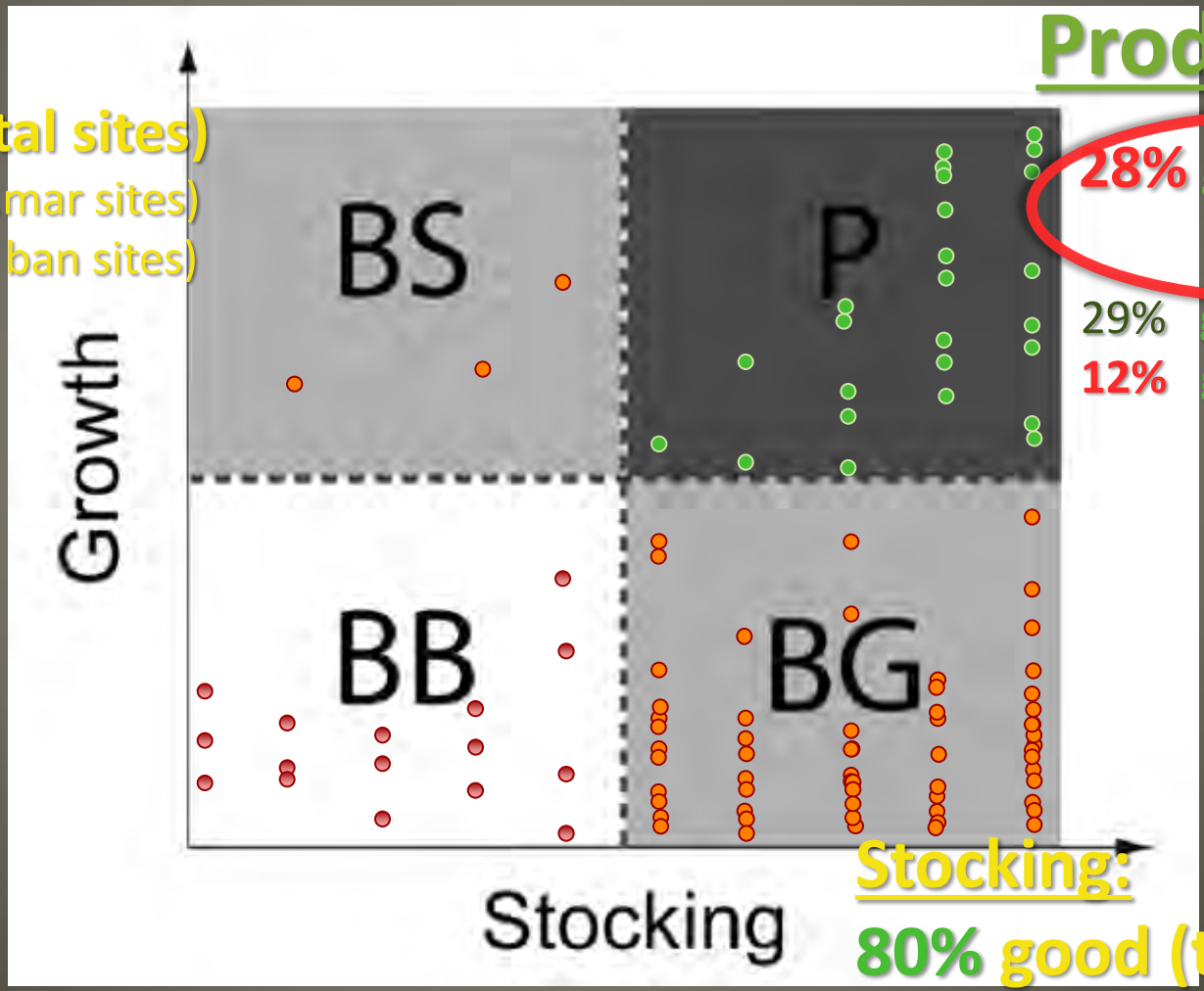
Main source of low productivity is Poor Growth!!

Growth:

39% good (total sites)

46% good (BS=P.mar sites)

22% good (JP= P. ban sites)



Productivity

28% good (total sites)

29% good (BS=P.mar

12% good (JP=P. ban

Stocking:

80% good (total sites)

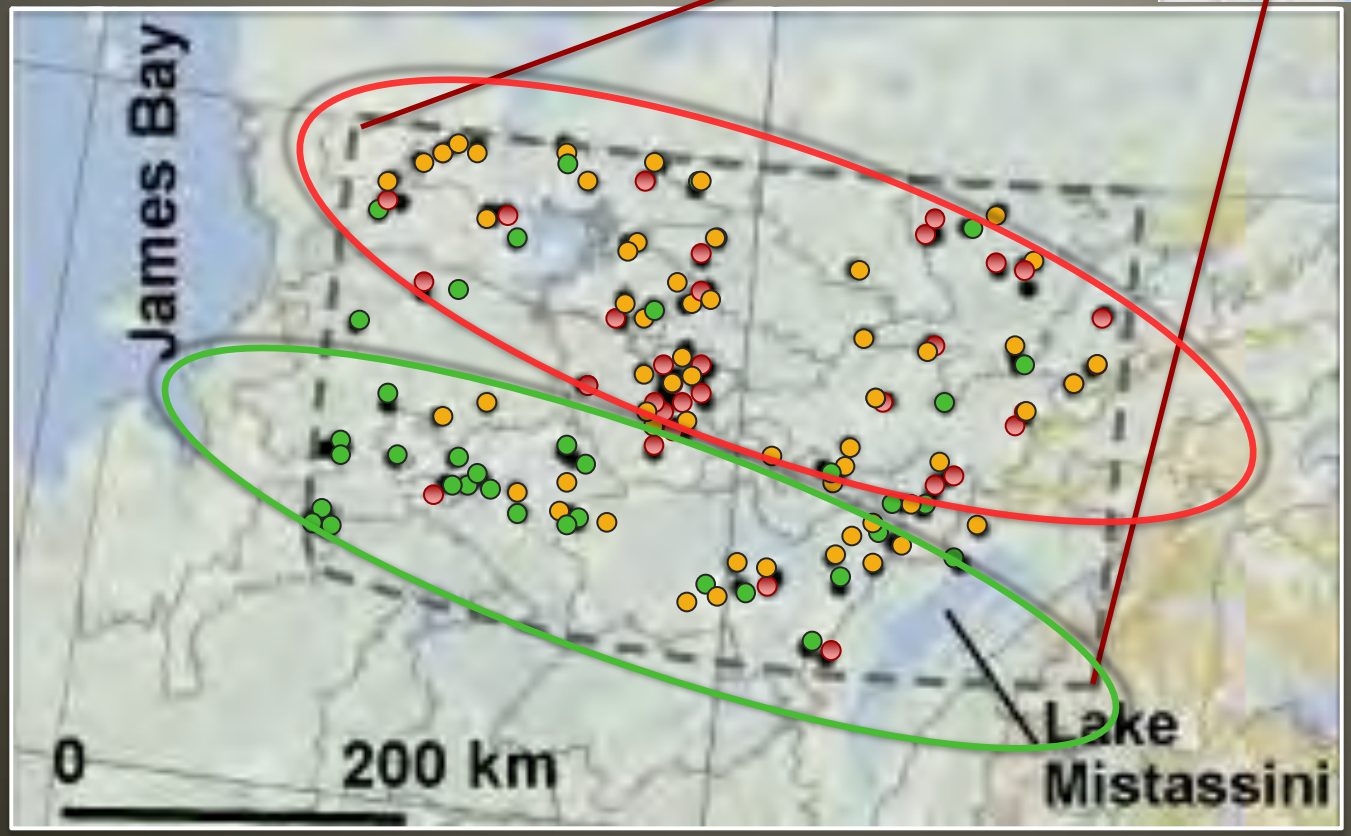
77% " (BS= P.mar sites)

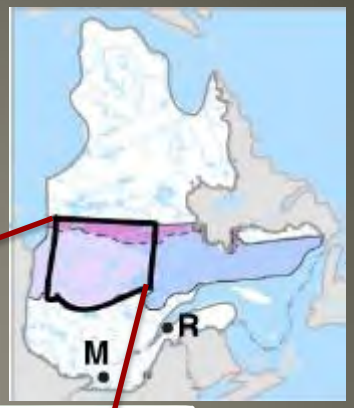
45% " (JP= P. ban sites)

-Red= Unproductive site because of poor stocking and growth

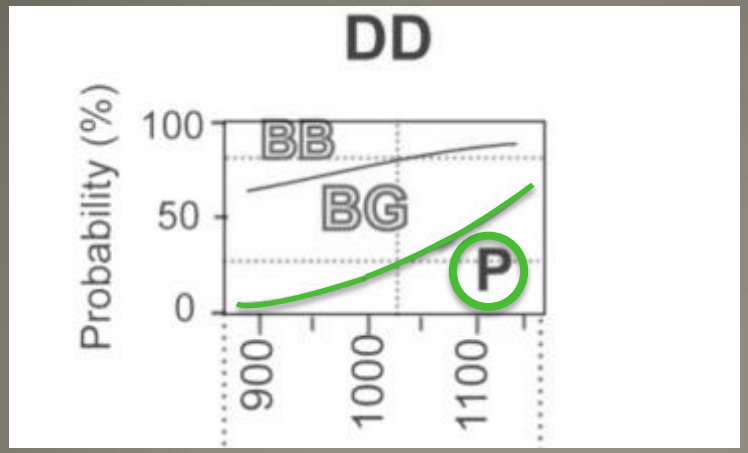
-Orange= Unproductive because of poor growth OR stocking

-Green = Productive site





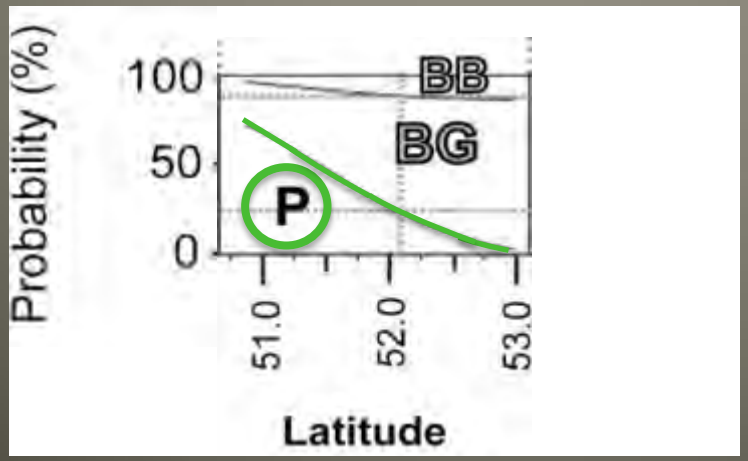
Causal factors (multinomial logistic regression, AICc, prediction profiler)



DD = growing degree days >5˚C

DD= 1150
→61% probability of finding a productive site;

DD=900 → 9% prob of finding a productive site



Latitude

LAT= 51.0 ˚N
→69% probability of finding a productive site;

LAT= 53.0 ˚N → 3% prob of finding a productive site

Causal factors (multinomial logistic regression)

	Total	*P. mariana*	*P. banksiana*
-Stocking	prefire	DD	sand/DD
-Growth	DD	DD	altitude
-Productivity	DD	DD	sand / DD

Growth & Productivity are best explained by climate (DD)!!

Jack pine may be less resilient to fire in some (drier) areas. cfr. Rapanoela et al 2015

	P. banksiana
Before fire	**42**
After fire	**24**
Co-dominance (10)	
P. mariana (5)	
Treeless (3)	

Before fire:

42 sites dominated by jack pine;

After fire only 24 sites!! (18 sites were no longer dominated by jack pine: these sites were either codominated or dominated by black spruce or became treeless)

Jack pine may be less resilient to fire in some (drier) areas.

	P. banksiana
-Stocking	sand/DD
-Growth	altitude
-Productivity	sand / DD

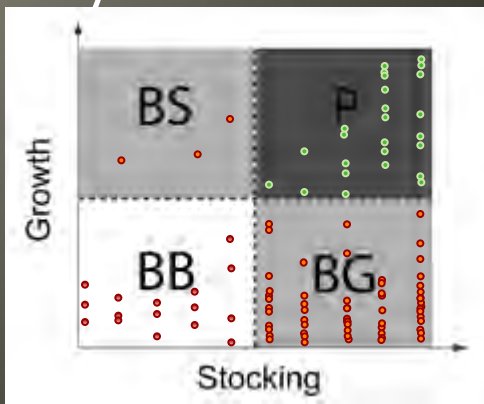
Site history (already low pre-fire stocking) alone cannot explain the observed opening of jack pine sites! Climate (DD) and edaphic factors (sand% in mineral soil) were also determining factors!!

→ Important implications for management: e.g. afforestation plans of northern open woodlands by jack pine to mitigate climate change

Conclusions

- This is one of the first studies to explore productivity issues at an early age in natural northern forests
- 72% of sites (n=85) were classified as **unproductive**

  → **poor growth**!!
- Because growth was mostly determined by **climatic** factors, *afforestation* alone may *not be sufficient* to increase stand productivity in our study area
- *P. banksiana* on dry sites may be less resilient to fire than previously thought
- The **analysis scheme** that defines forest productivity as the result of growth and stocking could provide a useful tool to identify similar issues elsewhere.



Merci beaucoup!
Des questions?

- Courriel: rikvanbogaert@gmail.com