In search of robustness: modelling a portefolio of forest stand responses to different silvicultural treatments under global change threats

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RMT Adaptation des forêts au changement climatique

Forest and Climate Change:
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Global Change

« Glo sing from
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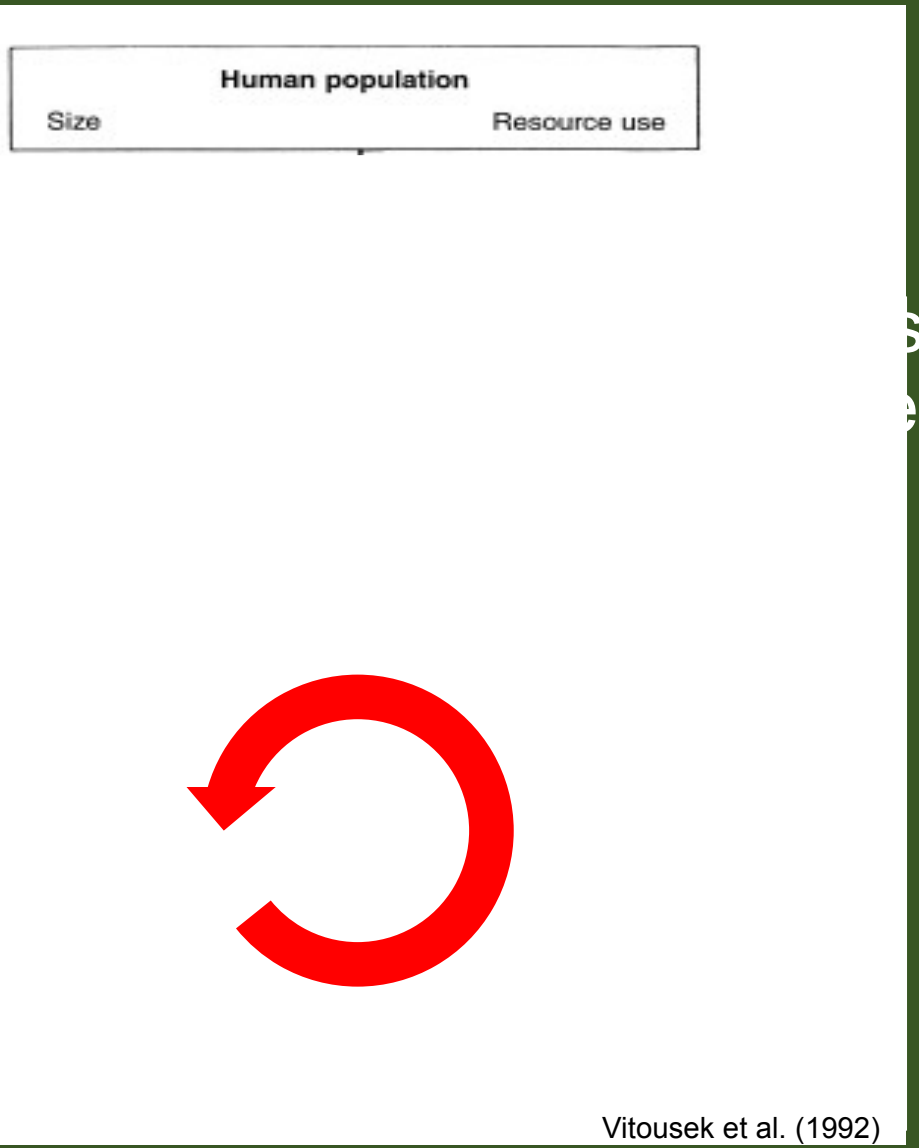
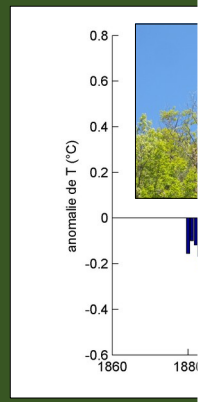


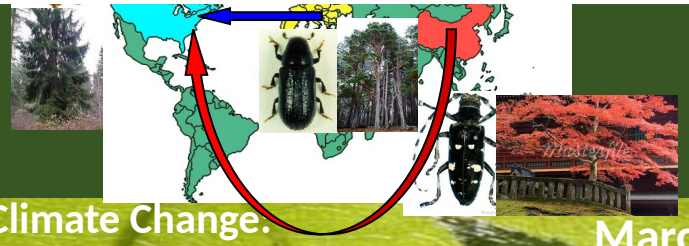
Vitousek et al. (1992)

Biophysical and biological forcings may cause changes in the composition, structure and functions of forest ecosystems, jeopardizing their ecological integrity and the ecosystem services they provide.



Silviculture of adaptation

However, forest management can alter ecological functions to reduce the negative effects of global change on forests.

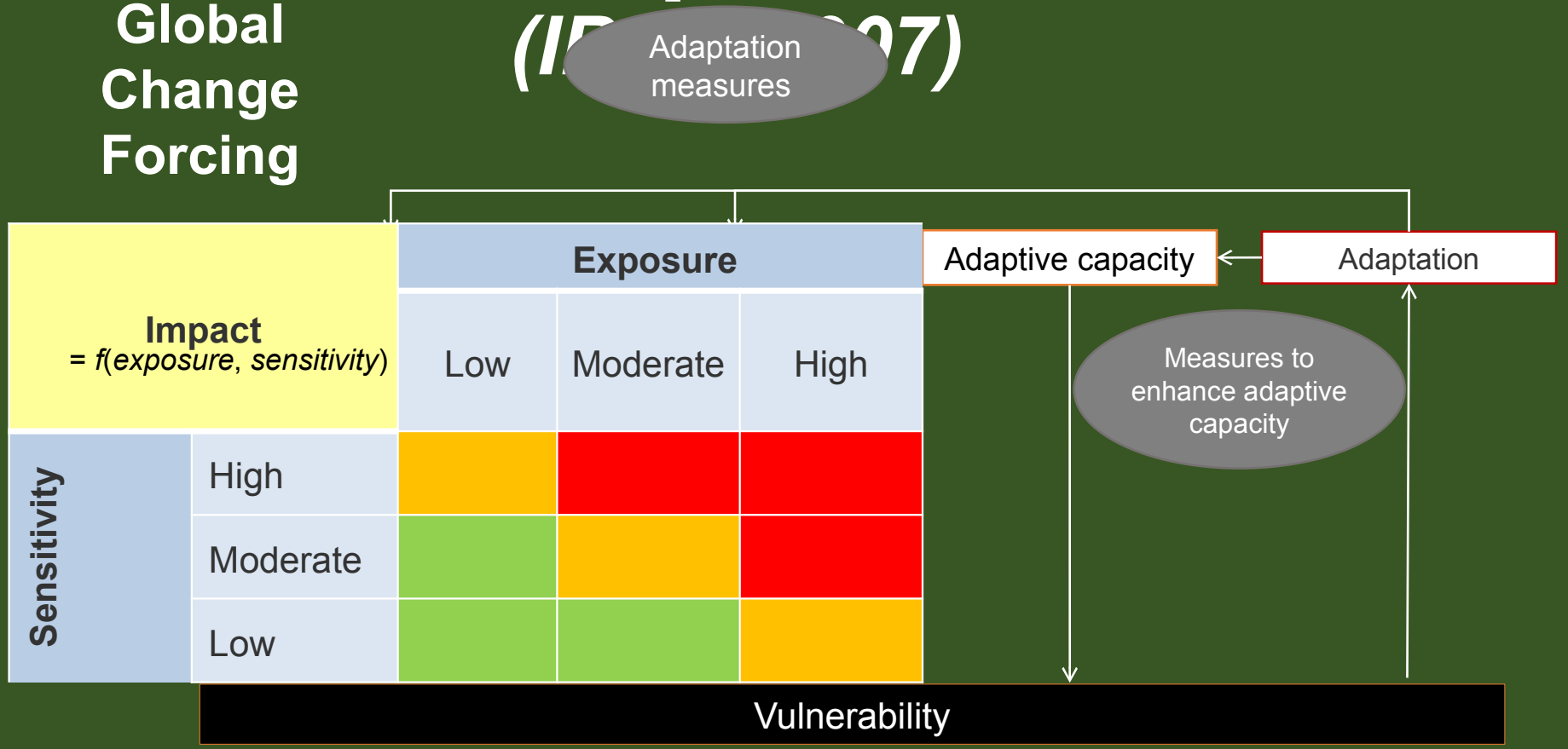


Objectives

- To propose a multitrajectory approach for a silviculture of adaptation;
- To test the application of the approach using stand modeling;

(1) Vulnerability & Adaptation (IP[illegible]07)

Global Change Forcing



Smit, B. and Pilifosova, O., 2001. Adaptation to climate change in the context of sustainable development and equity, in: Climate Change 2001: Impacts, Adaptation, and Vulnerability— Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, UK, pp. 877–912.

Silviculture of ADAPTATION

Approach *(Choi 2008)*

- Ackowledging that the future is uncertain (with surprises!);
- Multiplying the possible trajectories of ecosystem development;
- Exploring the envelope in order to identify:
  - The most robust solutions that converge to desired states;
  - The risks to irreversibility for undesired states

There is no best predictions;

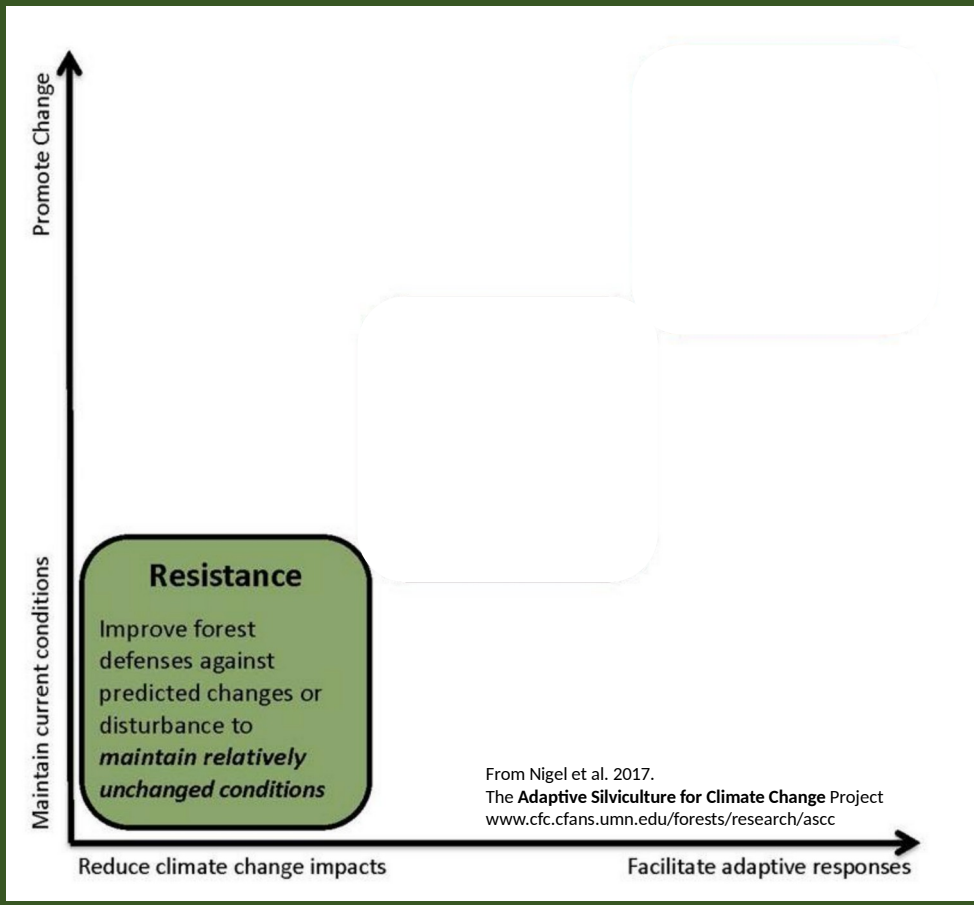
No best treatment at the best place!

Silviculture of ADAPTATION options (*Millar et al. 2007*)

" No single solution fits all future challenges, especially in the context of changing climates, and that the best strategy is to mix different approaches for different situations. "

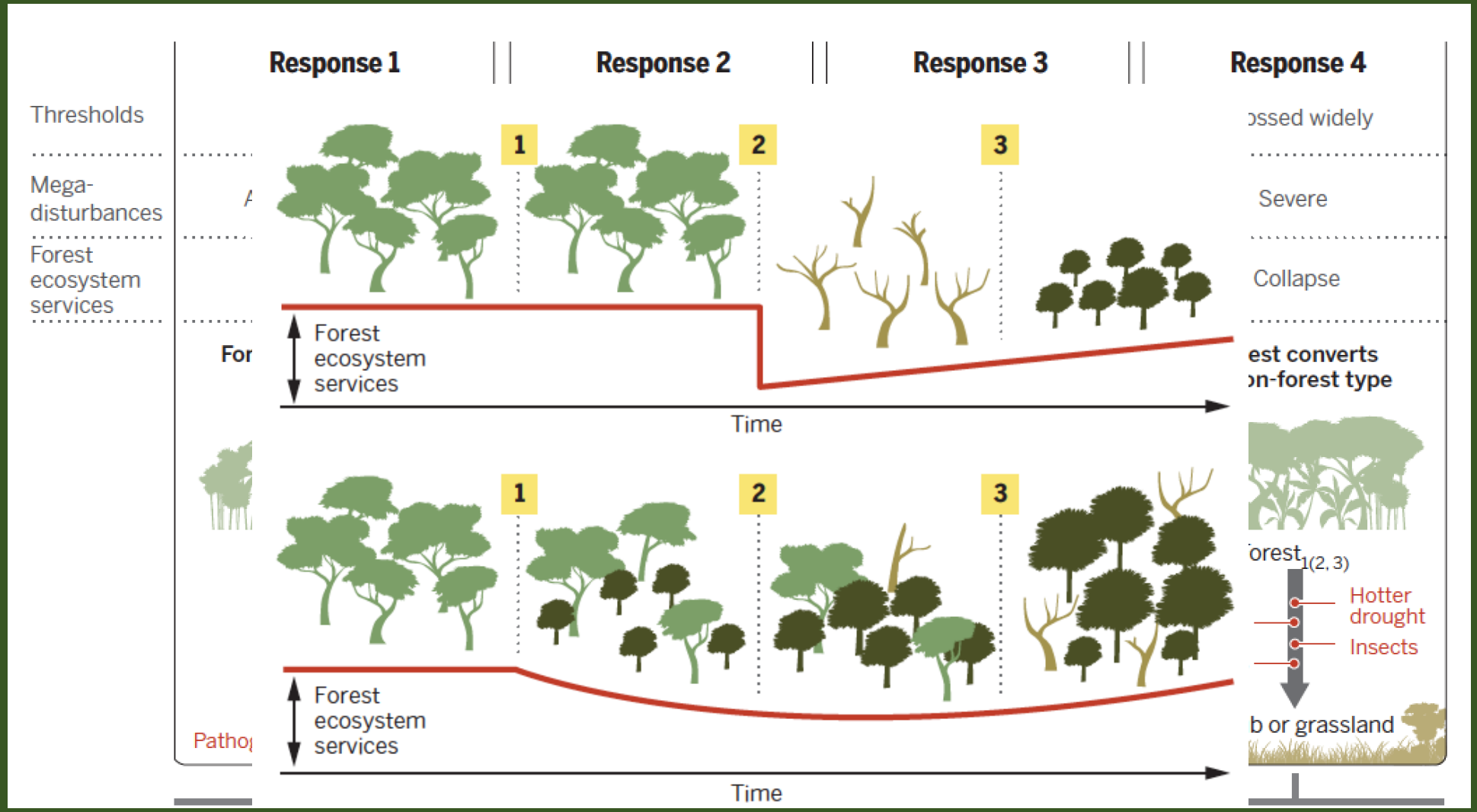
Three adaptation principles

- Resistance (Limiting changes – Protection of specific important value)
- Resilience (Functional diversity for promoting fast ecosytem functions recovery)
- Transition (Helping the forest to transit to a new and more stable state)



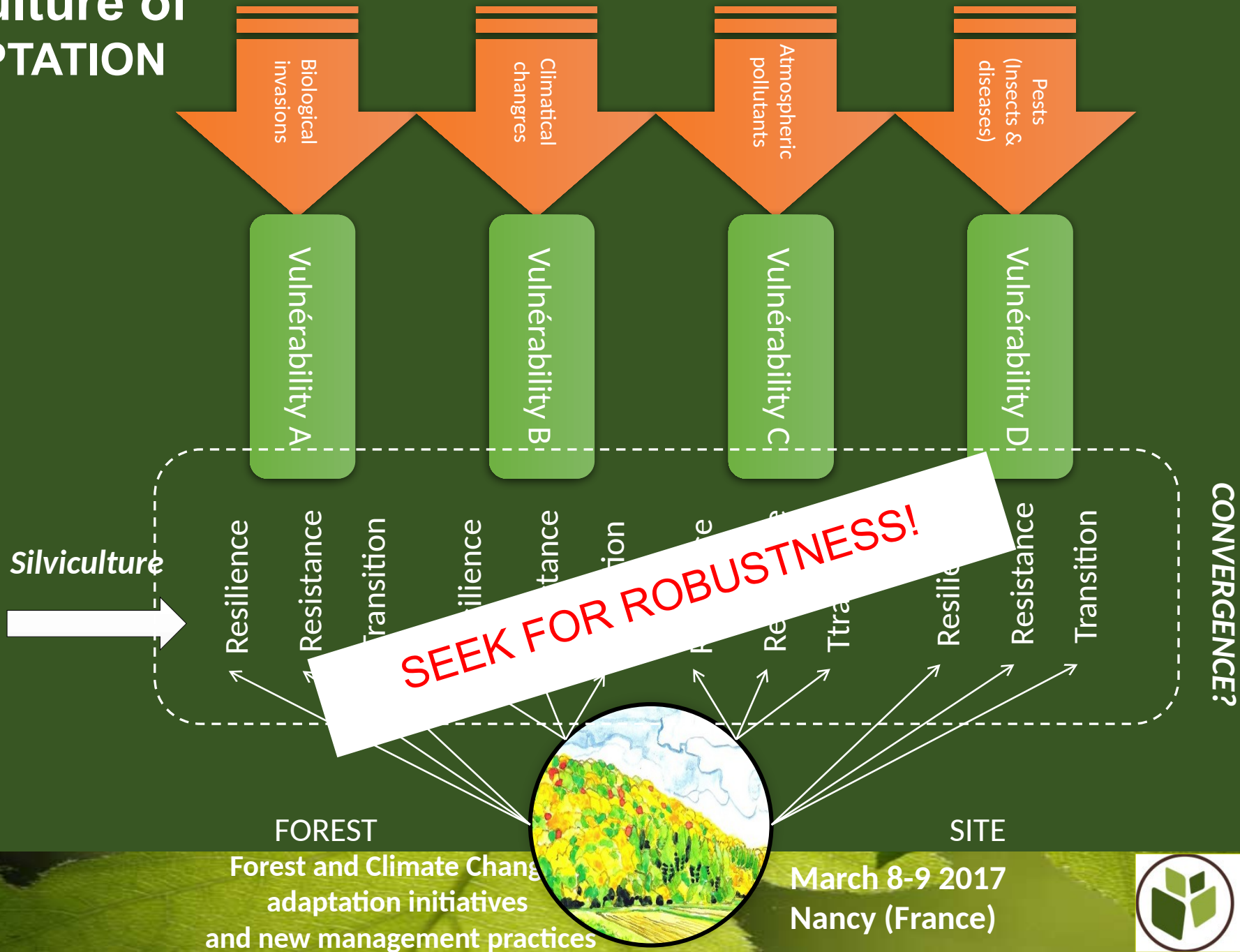
From Nigel et al. 2017.
The **Adaptive Silviculture for Climate Change** Project
www.cfc.cfans.umn.edu/forests/research/ascc

Resistance, Resilience & Transition



Millar & Stephenson 2015

Silviculture of ADAPTATION



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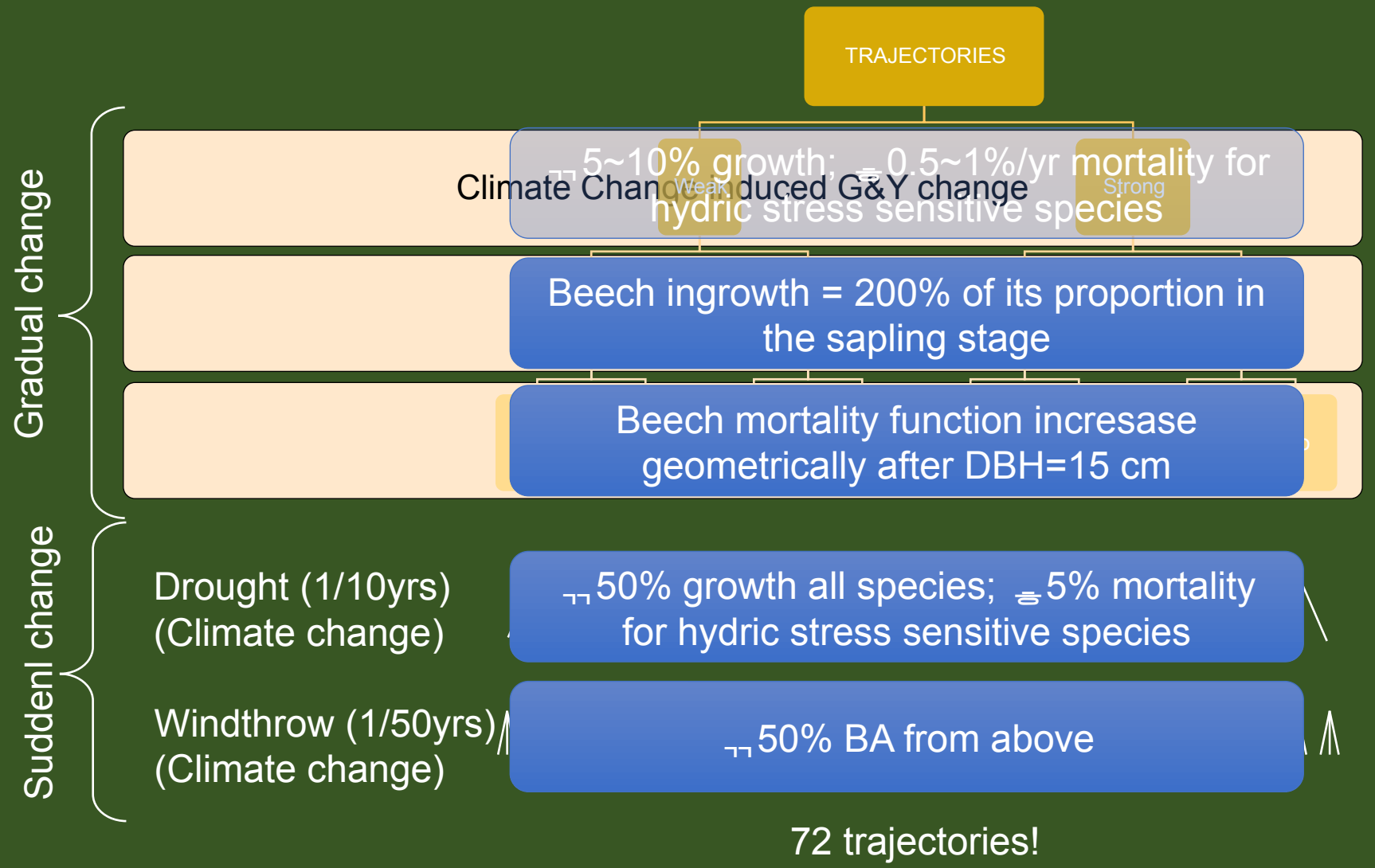
Silviculture of ADAPTATION

Multitrajectories approach



Size class transition model

- Distant independant tree (size class) model
- Transitions : fct(species, competition <- growth + mortality)
- Regen recruitment : fct (G_total, G_sapling)

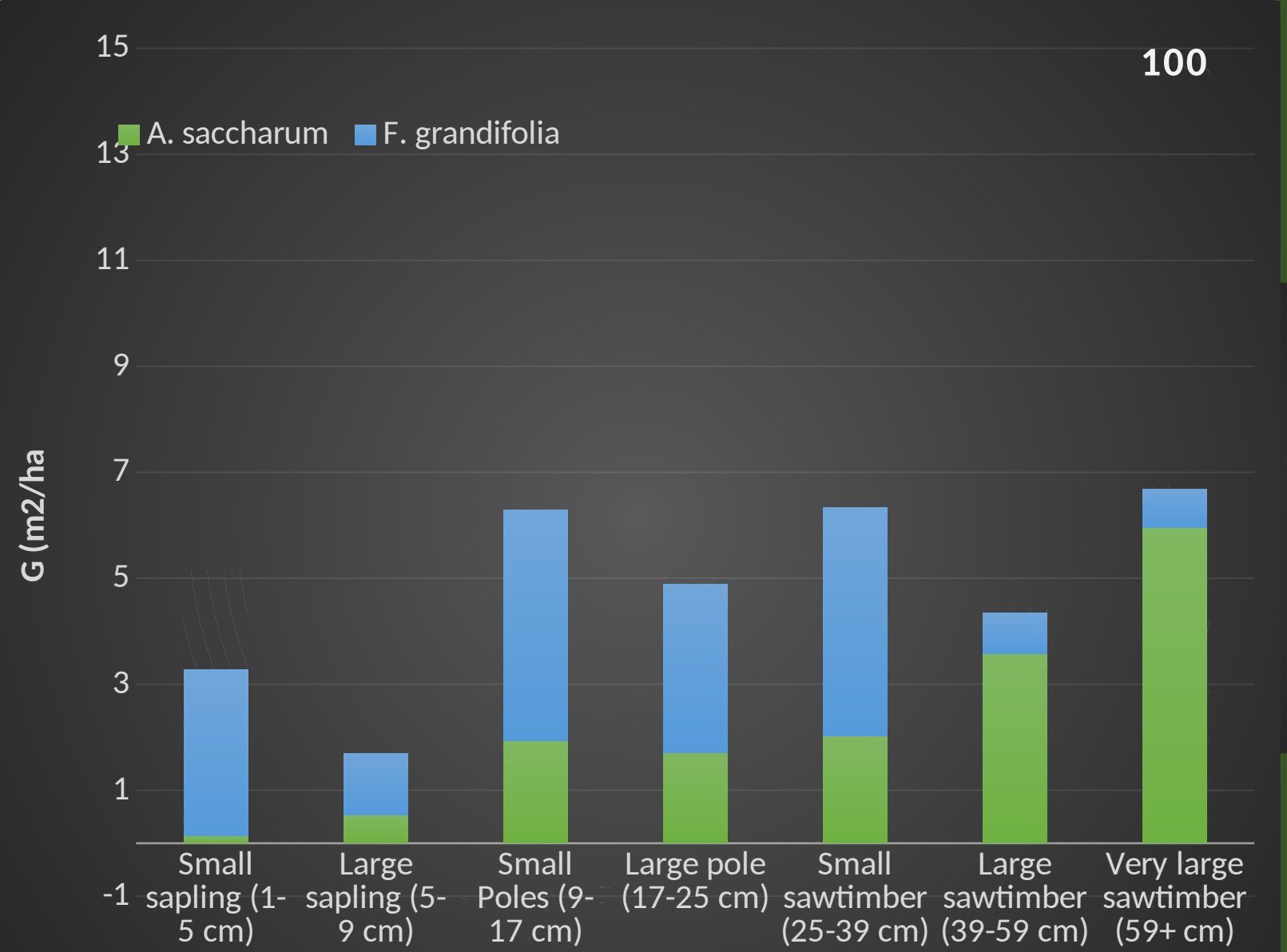
Recruitment

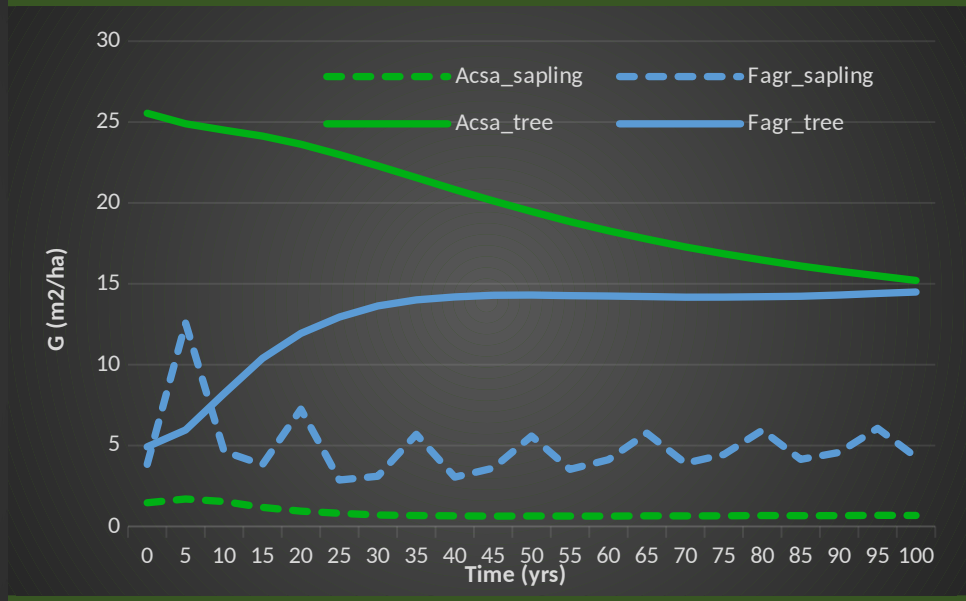
Size (mm)	Dens (Nb./ha)
10-29	388
30-49	227
50-69	129
…	…
990-1009	0

X

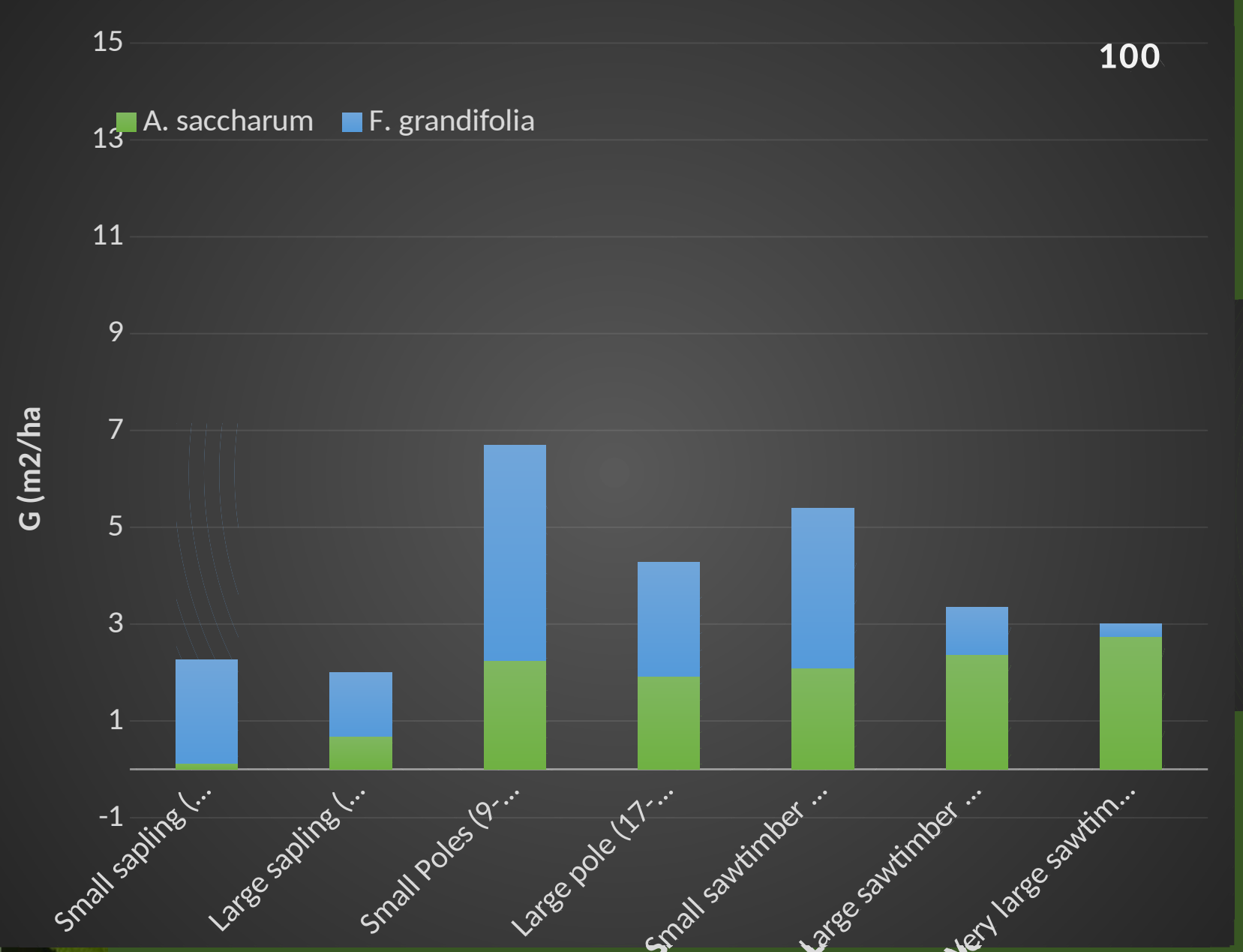
	10-29	30-49	50-69	…	990-1009
10-29	.25	0	0		
30-49	.52	.18	0		
50-69	.14	.47	.33		
…	…	…	…	…	…
990-1009					.84

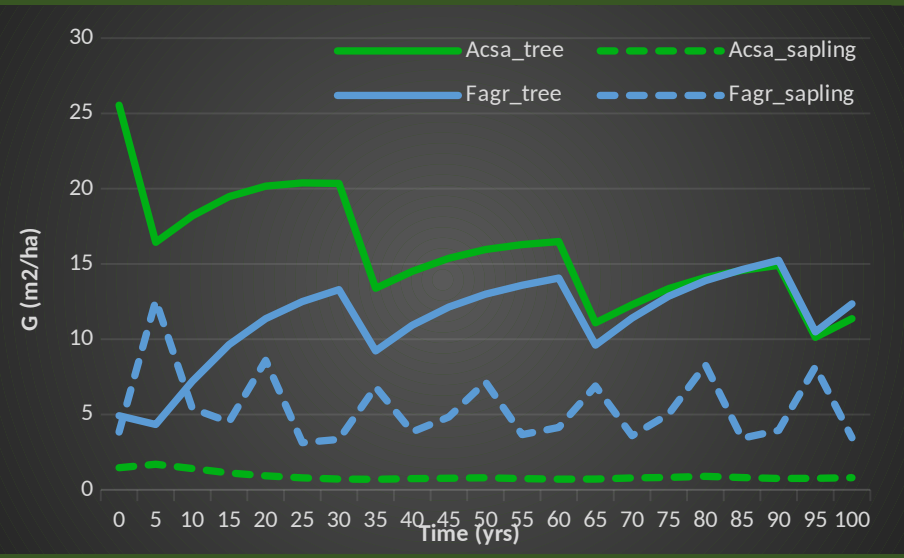
No cut


100
A. saccharum
F. grandifolia
G (m2/ha
15
13
11
9
7
5
3
1
-1
Small sapling (1-5 cm)
Large sapling (5-9 cm)
Small Poles (9-17 cm)
Large pole (17-25 cm)
Small sawtimber (25-39 cm)
Large sawtimber (39-59 cm)
Very large sawtimber (59+ cm)


Acsa_sapling
Fagr_sapling
Acsa_tree
Fagr_tree
G (m2/ha)
30
25
20
15
10
5
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100
Time (yrs)

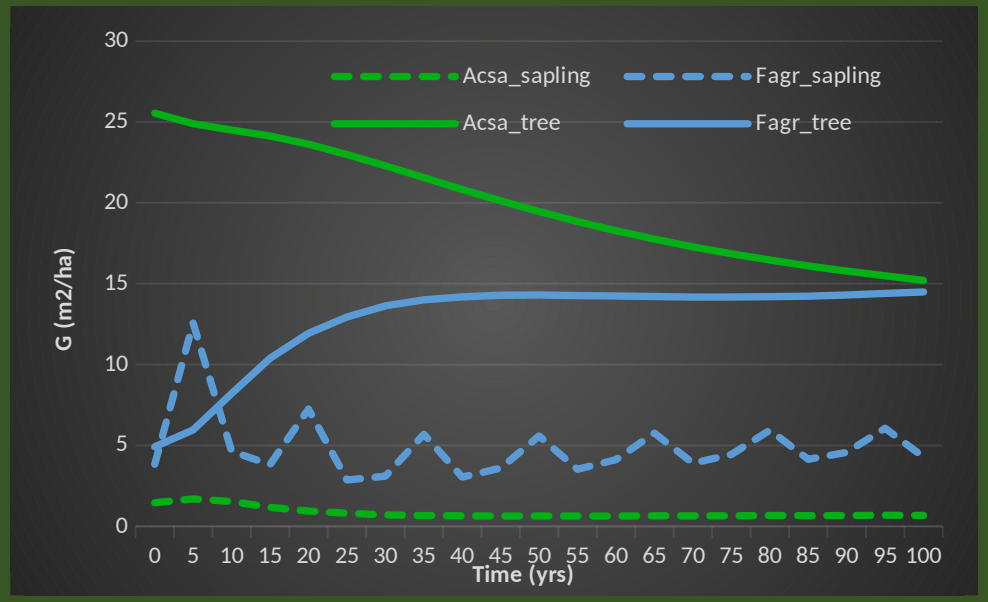
Selection cut 30%
Balanced



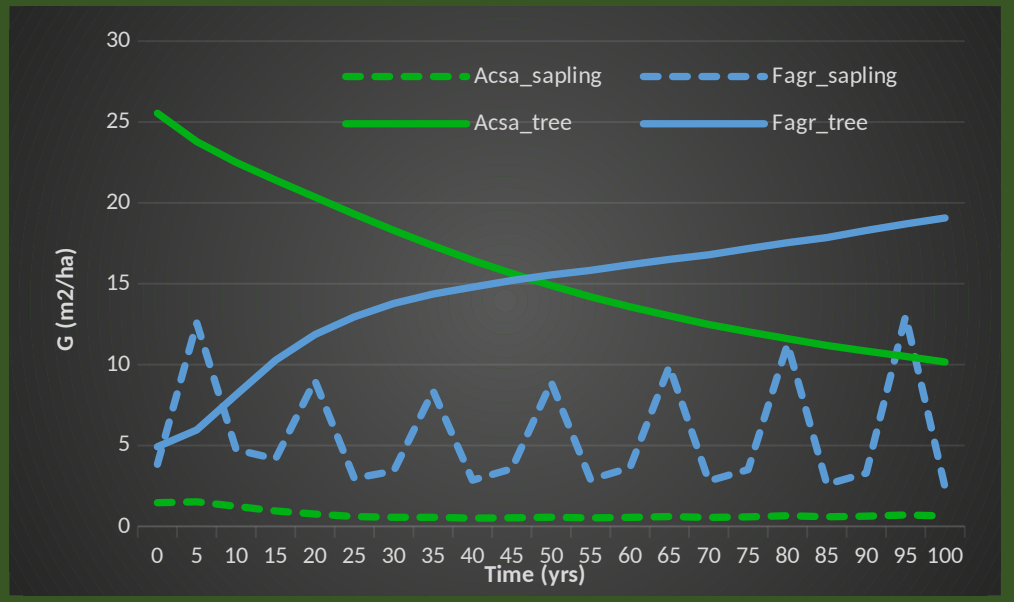


No harvesting

Actual

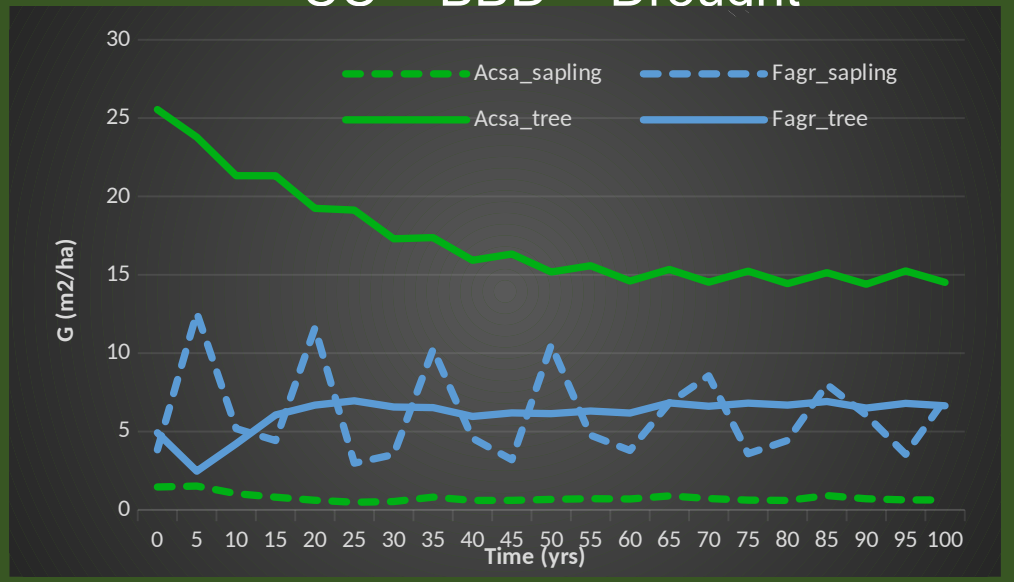


+ CC



+ CC + BBD

+ CC + BBD + Drought



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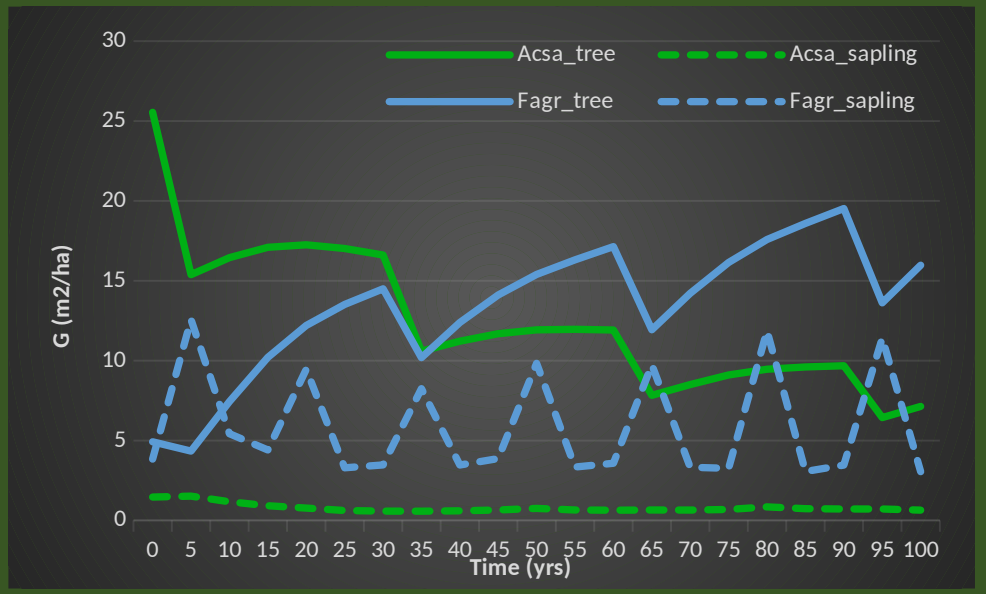
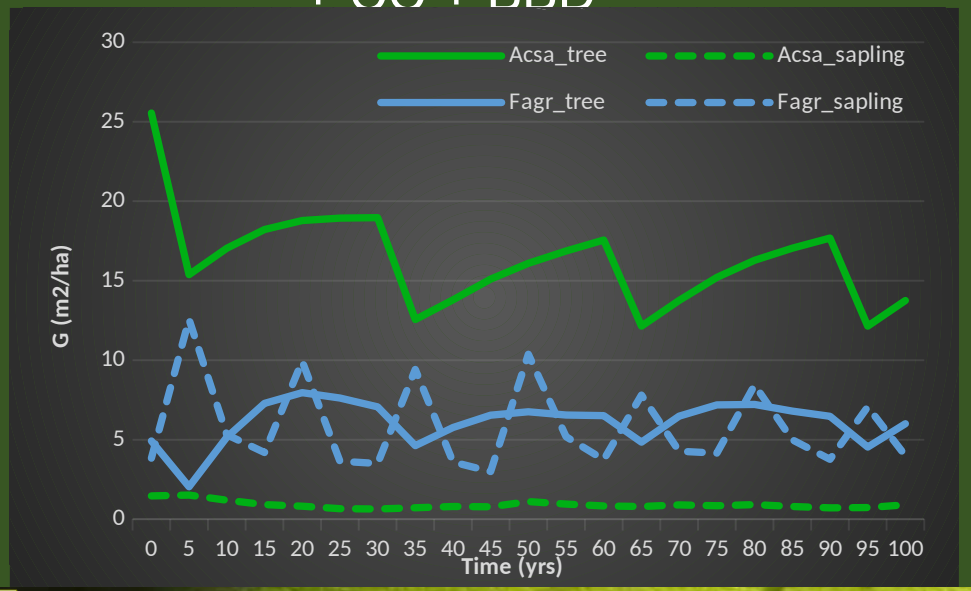
Balanced selection cut

Actual

+ CC



+ CC + BBD



+ CC + BBD + Drought

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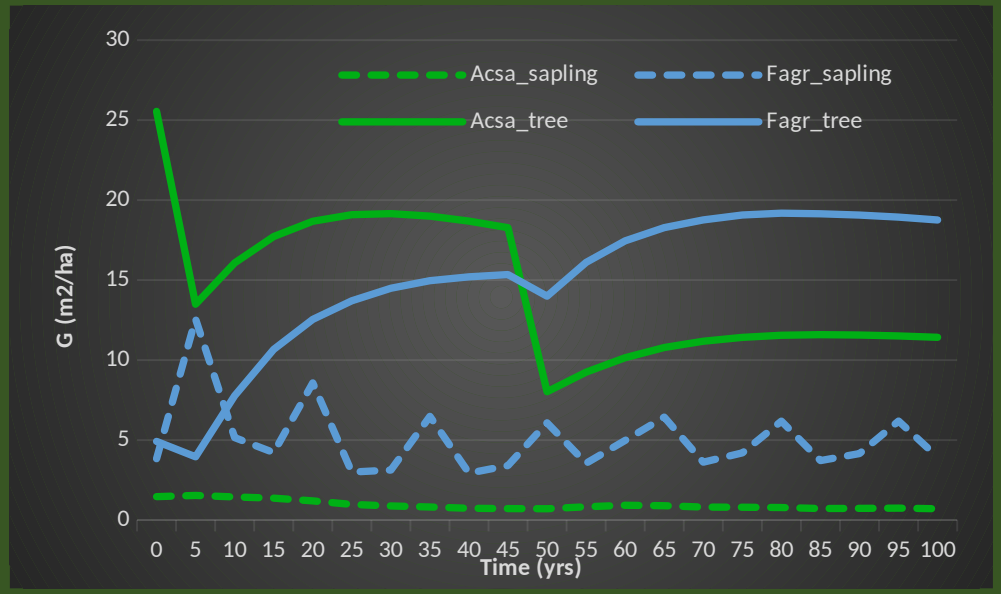
Irregular shelterwood

Actual



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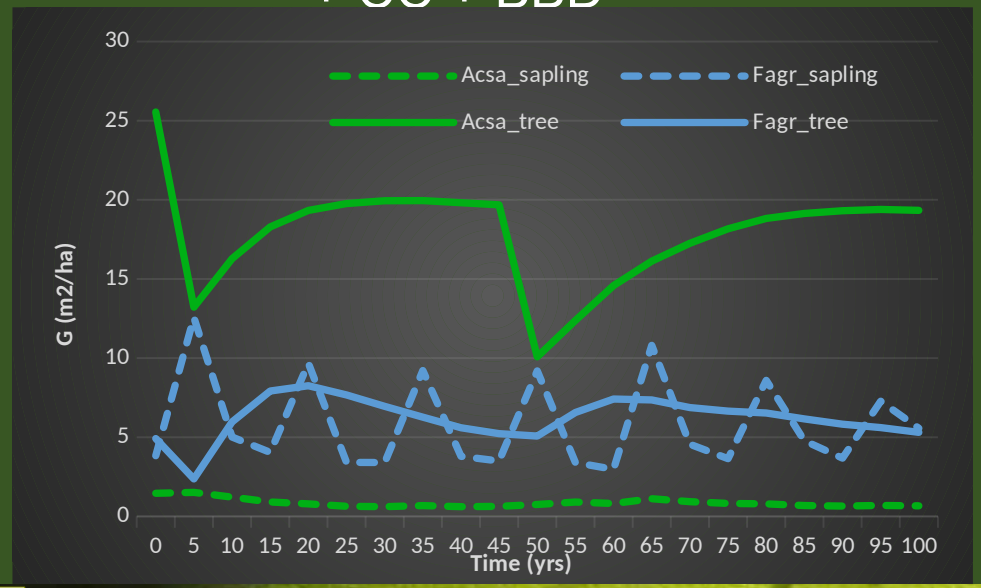
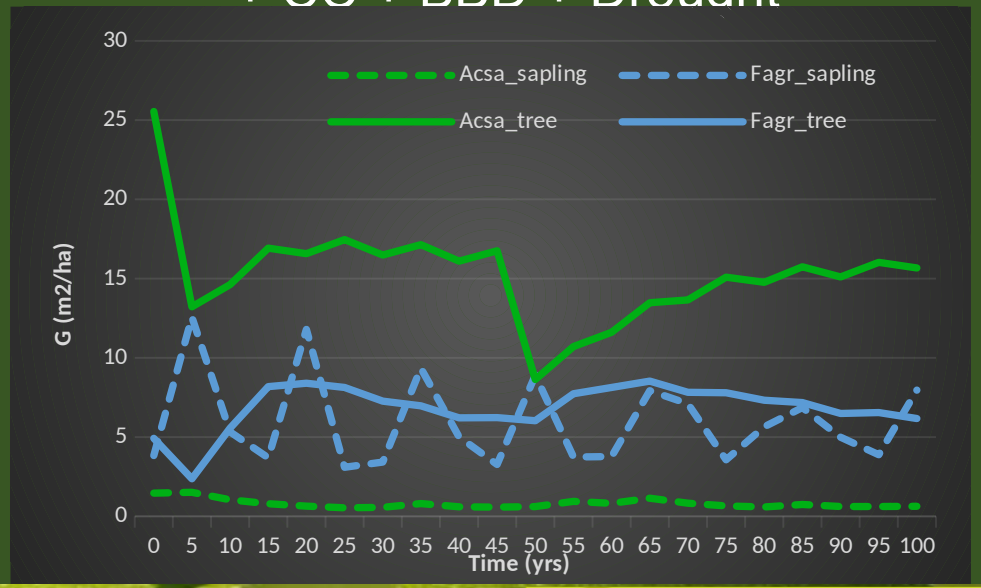


+ CC + BBD + Drought



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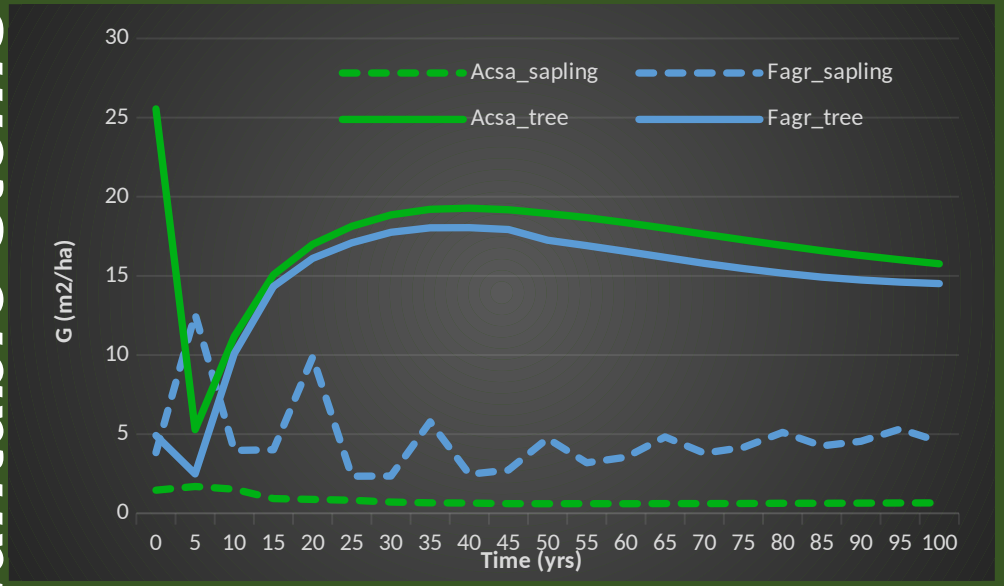
Clearcutting with the protection of small merchantable stems

Actual



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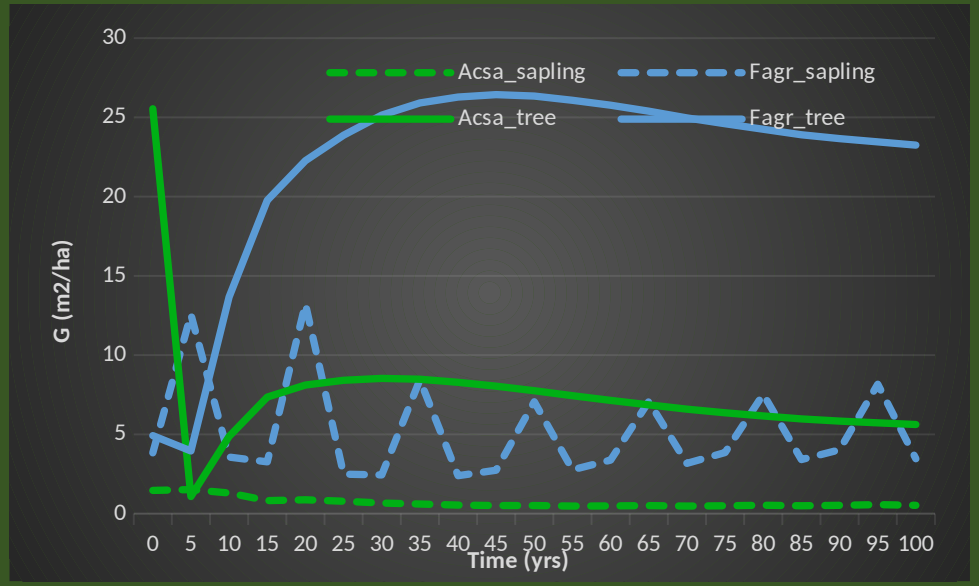

+ CC + BBD

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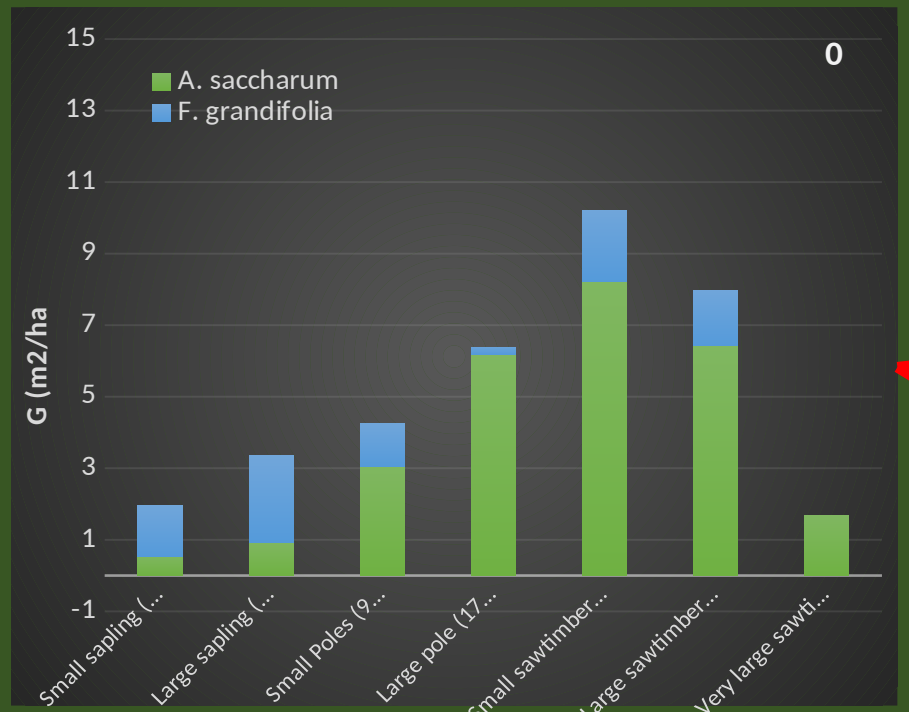
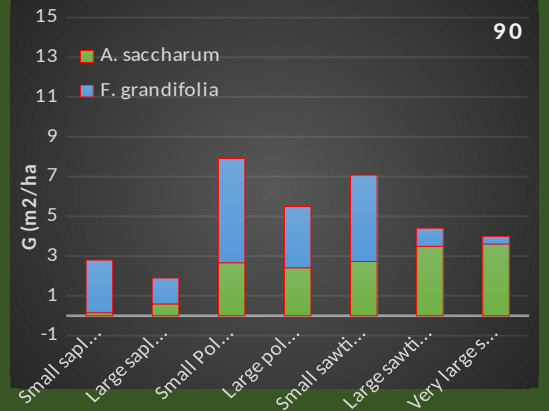
Resilience

No harvesting



Structure

Composition



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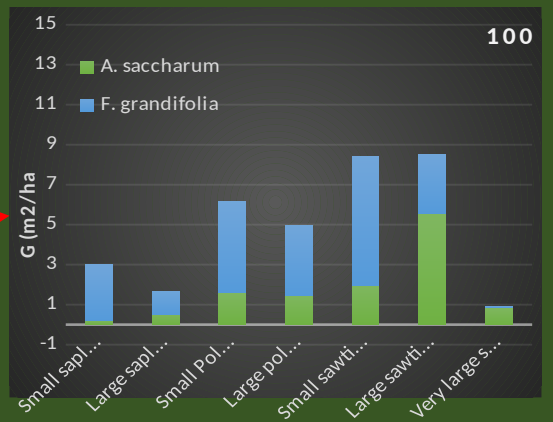
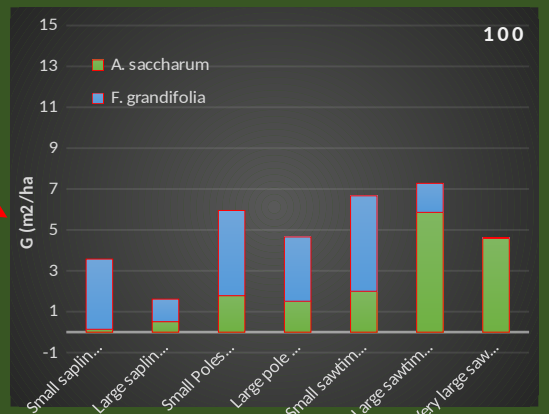


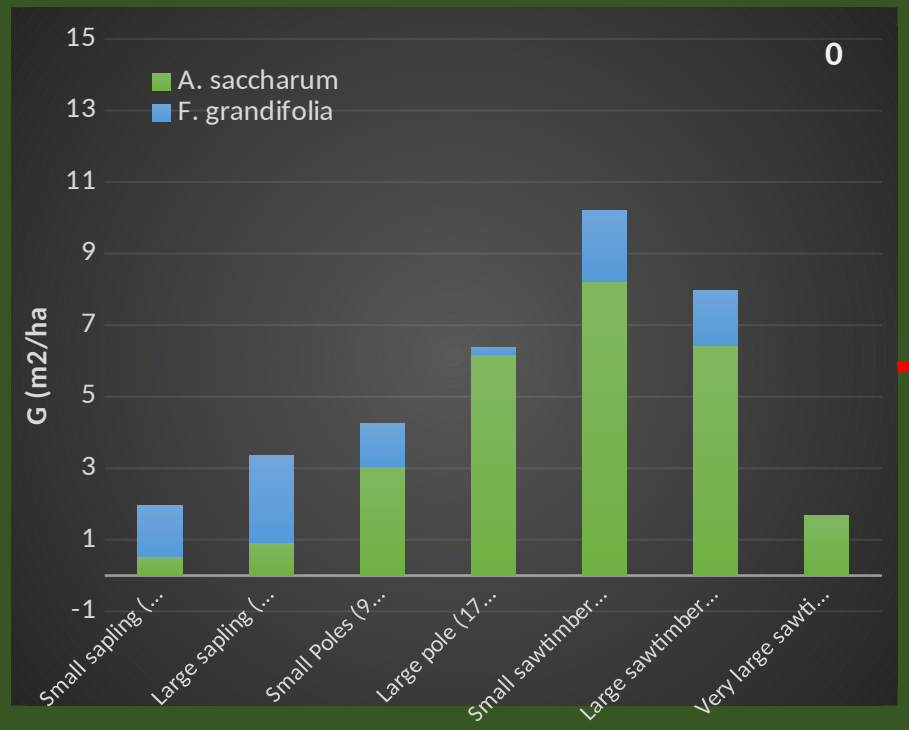
Irr_Shel



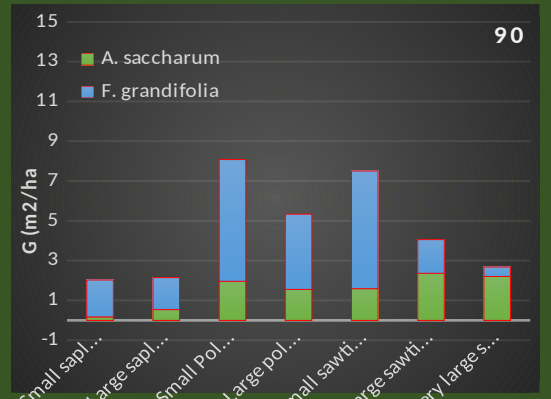
HPSMS

Resilience

+ CC



Structure
Composition ?



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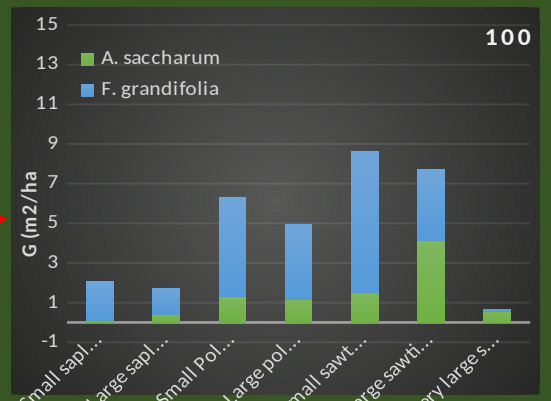

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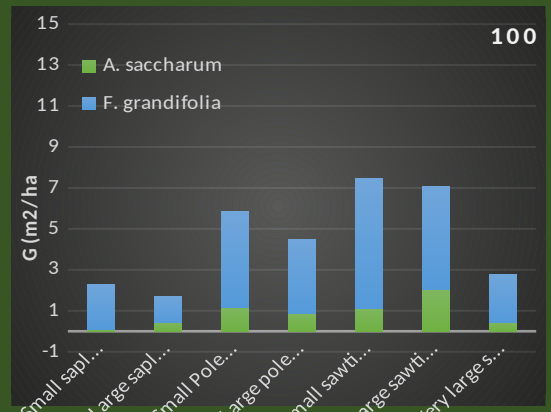

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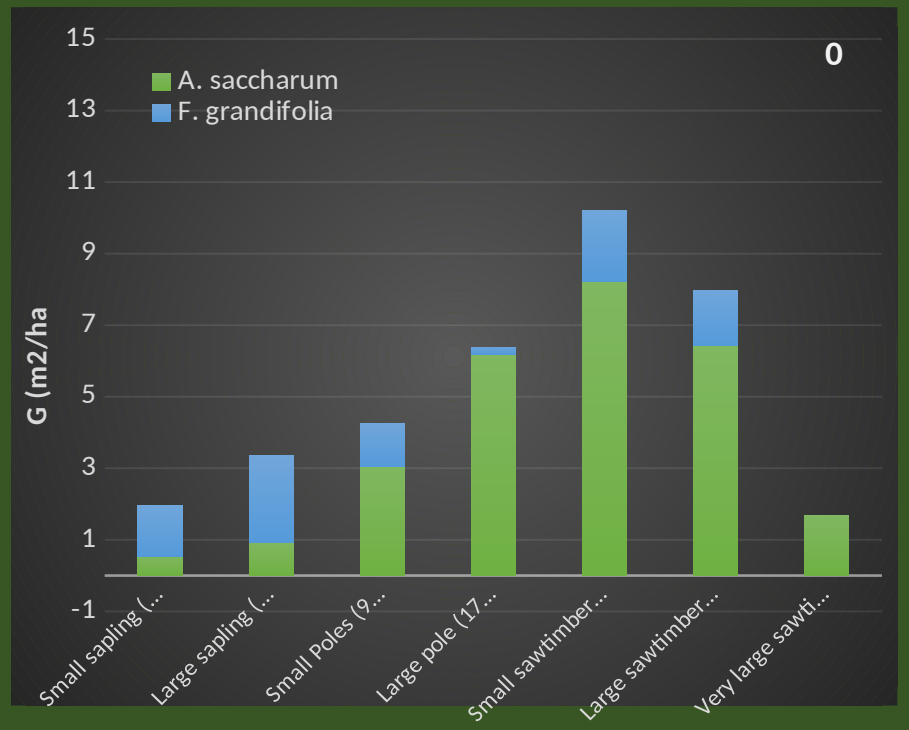
Resilience

+ CC + BBD



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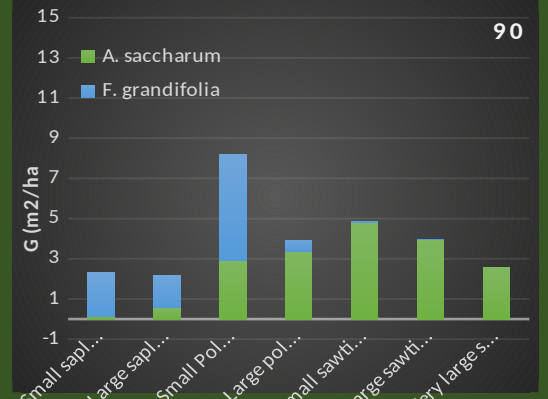

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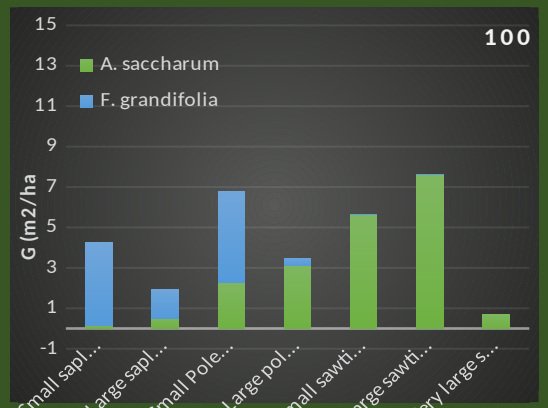

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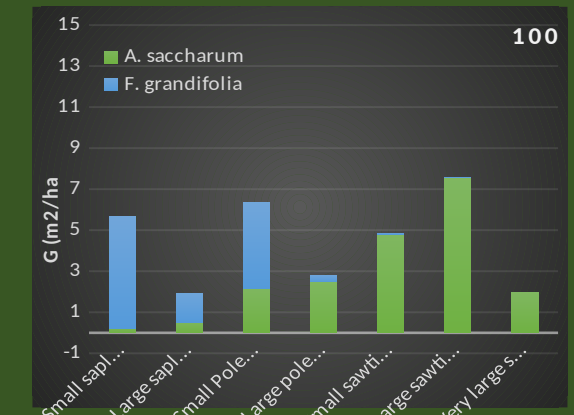

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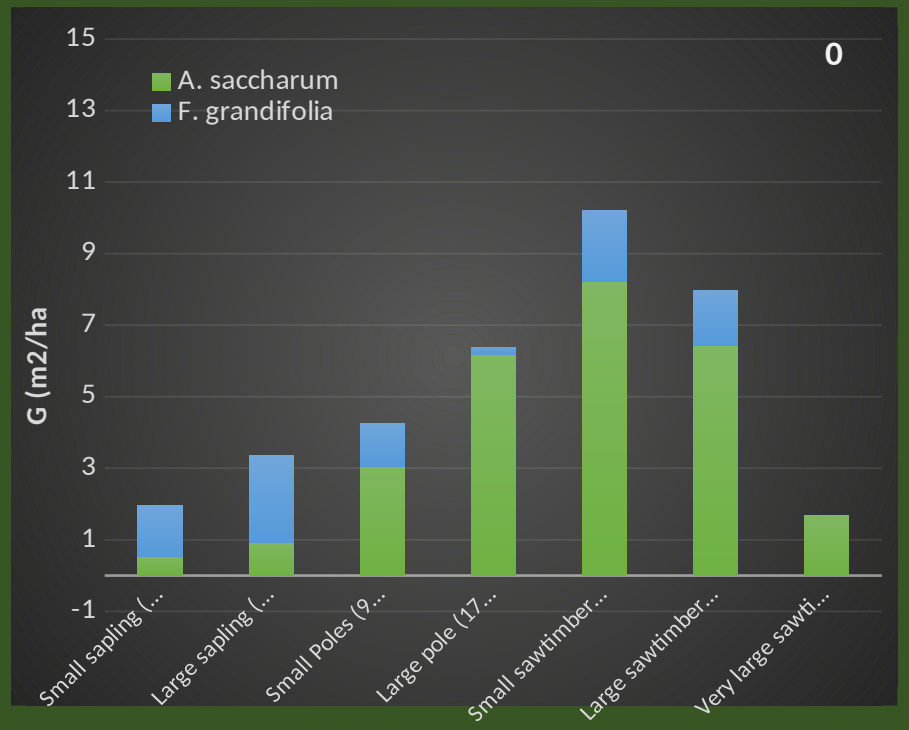
Resilience

+ CC + BBD + Drought



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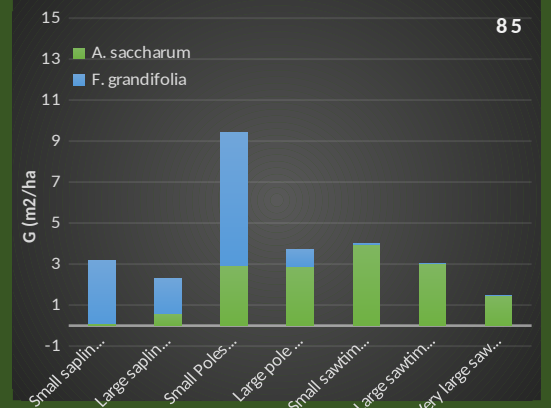

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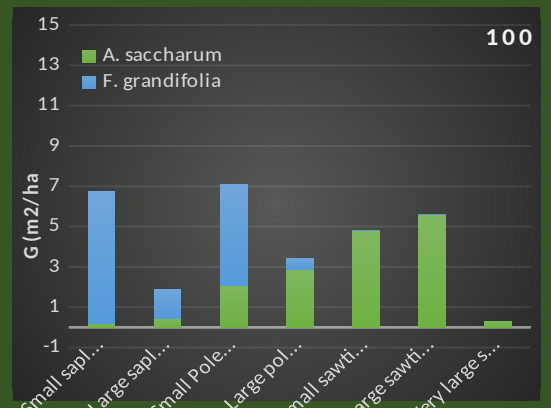

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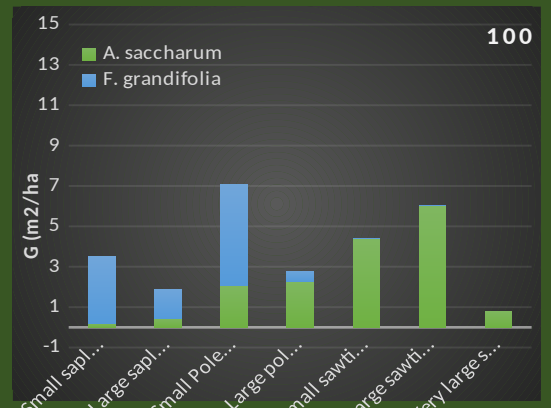

HPSMS

Summary

- We proposed a structured approach combining:
  - Vulnerability & Adaptation
  - Multitrajectories
  - Options portefolio
- Adaptation silvicultural strategies
  => resilience, resistance and facilitation (& triage)
- Stand models => trajectories under scenarios
  + gradual and + sudden (stochastic) changes
- Stand response to GC stresses
  - Complex : multiple stresses interact (CC + BDD)
  - Caution: some treatment can accelerate transformation towards undesired conditions

Adaptation: new challenges for silviculture

- New concepts
  - Strong need for operationalizing these new concepts;
  - Switch from optimality to robustness;
  - Review the forest management / silviculture binomial – Landscape vs. stand interactions under uncertainty
  - Incorporate more of functional ecology into silviculture
- New tools
  - Quantitative silviculture using parameter-rich simulation models (that allow to include GC effetcs);
  - Multitrajectories : requires exploring the enveloppe of possible futures => risk assessment approach for identifying robust solutions;
  - DataMining techniques for making sense of the simulation ensemble

Acknowledgements

FORÊT S'ADAPTER

La Coop des Frontières

CRÉ Vallée-du-Haut-Saint-Laurent

OURANOS

CRSNG NSERC