31 maggio 2012 – Facoltà di Agraria – Università di Firenze

SEMINARIO

From Theory to Practice: managing forests as complex adaptive systems

Managing World Forests as Complex Adaptive Systems in the Face of Global Change

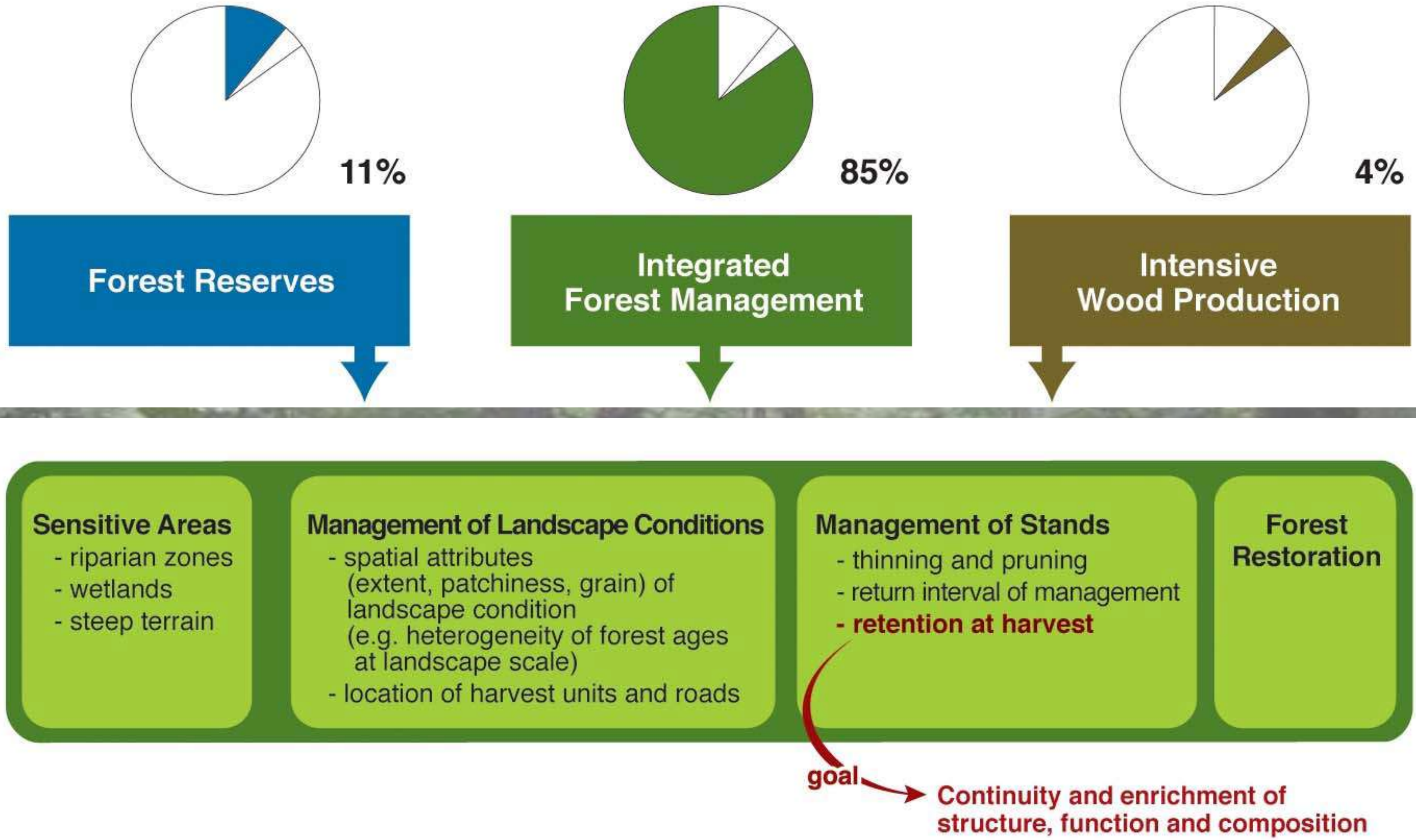
Prof. Christian Messier, Université du Québec à Montréal (UQAM), Research Chair in Urban Forestry, Centre d'Étude de la Forêt (CEF)

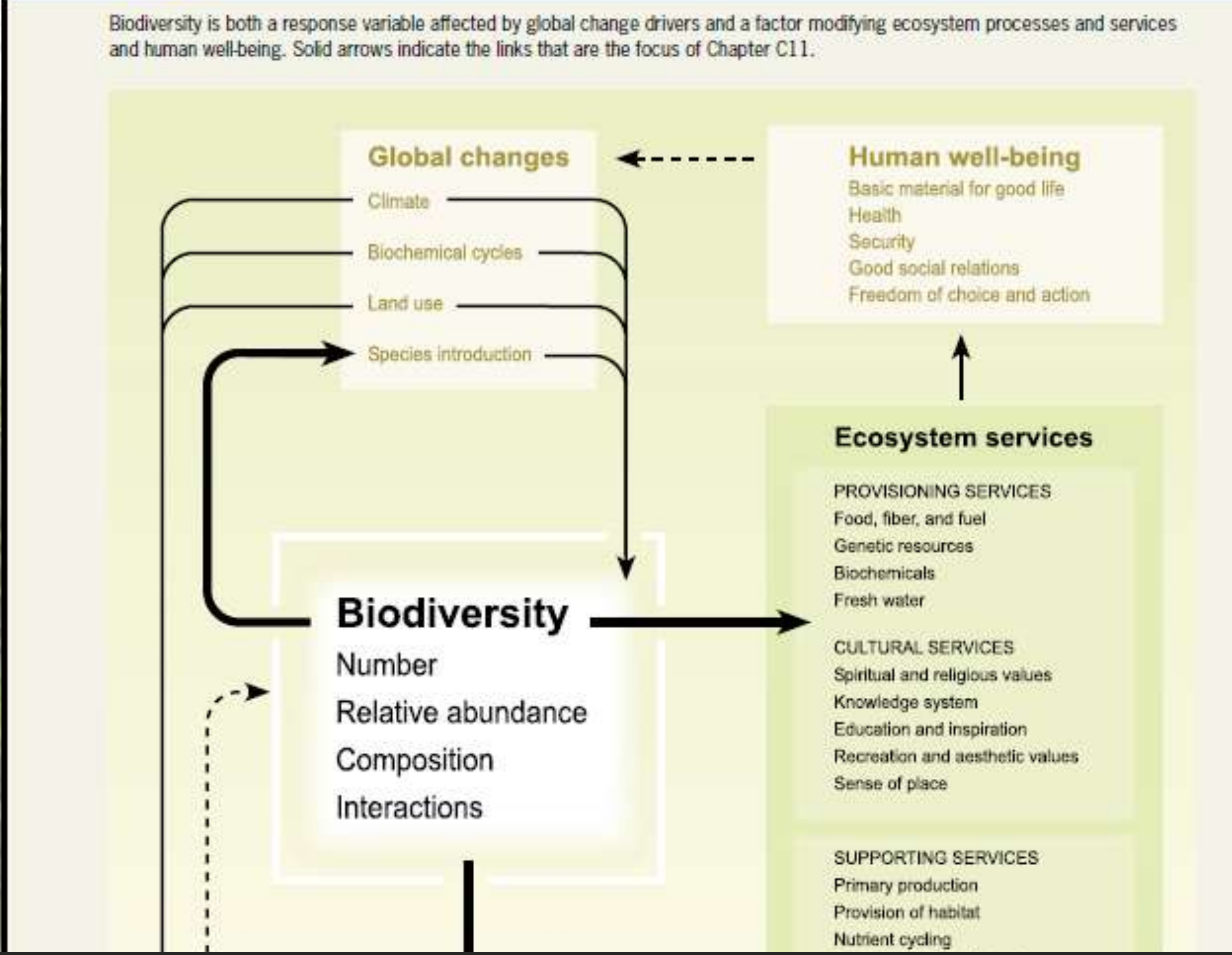
Université du Québec à Montréal

Centre d'étude de la forêt

Forest management in the world today

Lindermayer et al. Cons. Letters (in press)





- ***Wood production might not be the most important reason to manage forests***

Messier, Puettmann & Coates. *Managing World Forests as Complex Adaptive Systems in the Face of Global Change*. *EarthScan*

Setting the stage

Chapter 1: ***Puettmann et al. Forests as CAS***

Chapter 2: ***Parrott et al. The study of complex systems: An overview***

Chapter 3: ***Lange & Hauhs. Modeling CAS***

Complexity and CAS in different forest biomes

Chapter 4: ***Chazdon et al. Tropical forests as Complex Adaptive Systems***

Chapter 5: ***Canham et al. Temperate forests as CAS***

Chapter 6: ***Burton. Boreal Forests as Complex Adaptive Systems***

Management under the CAS and resilience paradigm

Chapter 7: ***Cornett et al. Forest Restoration as CAS***

Chapter 8: ***Simard et al. Networks of fungi, fauna & flora as agents of complex…***

Chapter 9: ***Putz. A complex adaptive systems approach to tropical forestry***

Chapter 10: ***Bauhus et al. Complex adaptive system as guiding approach…***

Chapter 11: ***Kuuluvainen. Scandinavian silviculture & forest complexity…***

Chapter 12: ***Nocentini et al. Mediterranean forests: human use, complexity and resilience***

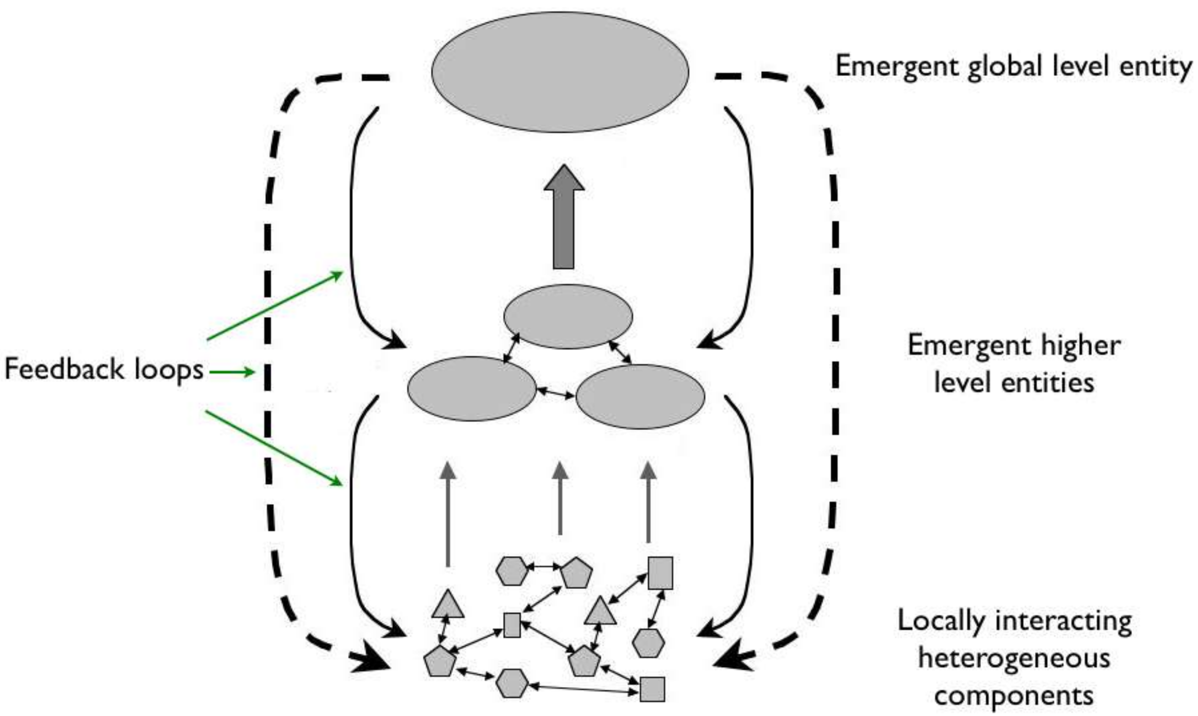
Chapter 13: ***Paquette & Messier. Plantations as CAS***

Chapter 14: ***Baker. Management of Tasmanian as CAS***

Chapter 15: ***Messier et al. Conclusion: Where are we, where do we go from here?***

Table of contents:

Setting the stage



Properties of Complex Adaptive Systems

Openness:. **Capacity of a system to exchange energy, material or information with the external environment.**

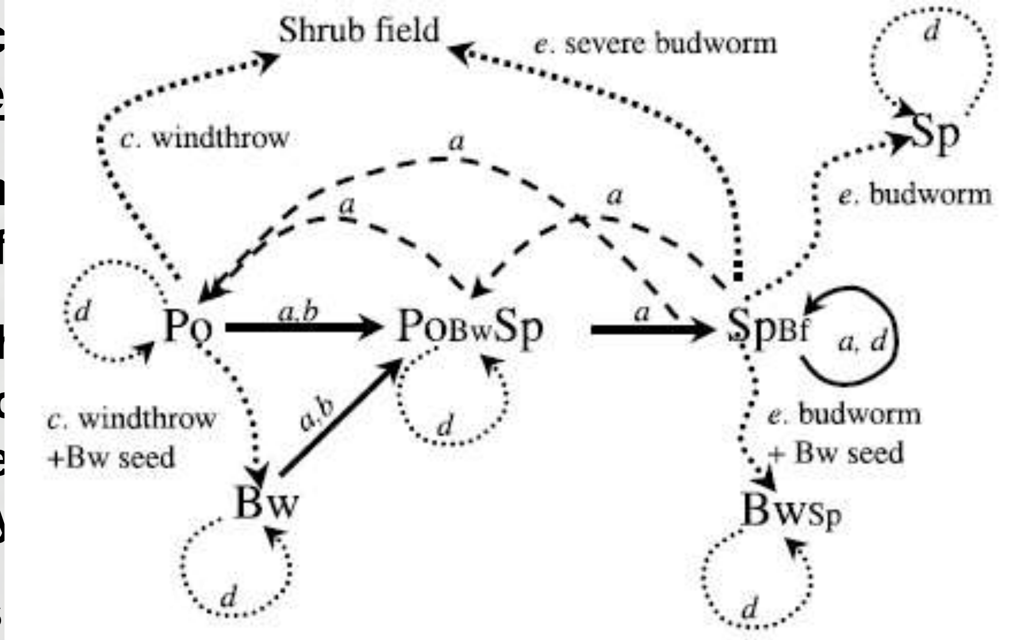
Heterogeneity: **Variety of the components forming the system. Can be in their nature, behaviour, spatial location, history, etc.**

Hierarchy: **Organization of a system that spreads over multiple levels or scales.**

Self-organization: **Process by which local interactions between components create emergent entities at a higher scale of the hierarchy which in turn affect the original components through feedbac**
process which does not require any e

Adaptation: **Ability of natural system**
perturbations so as to maintain their f

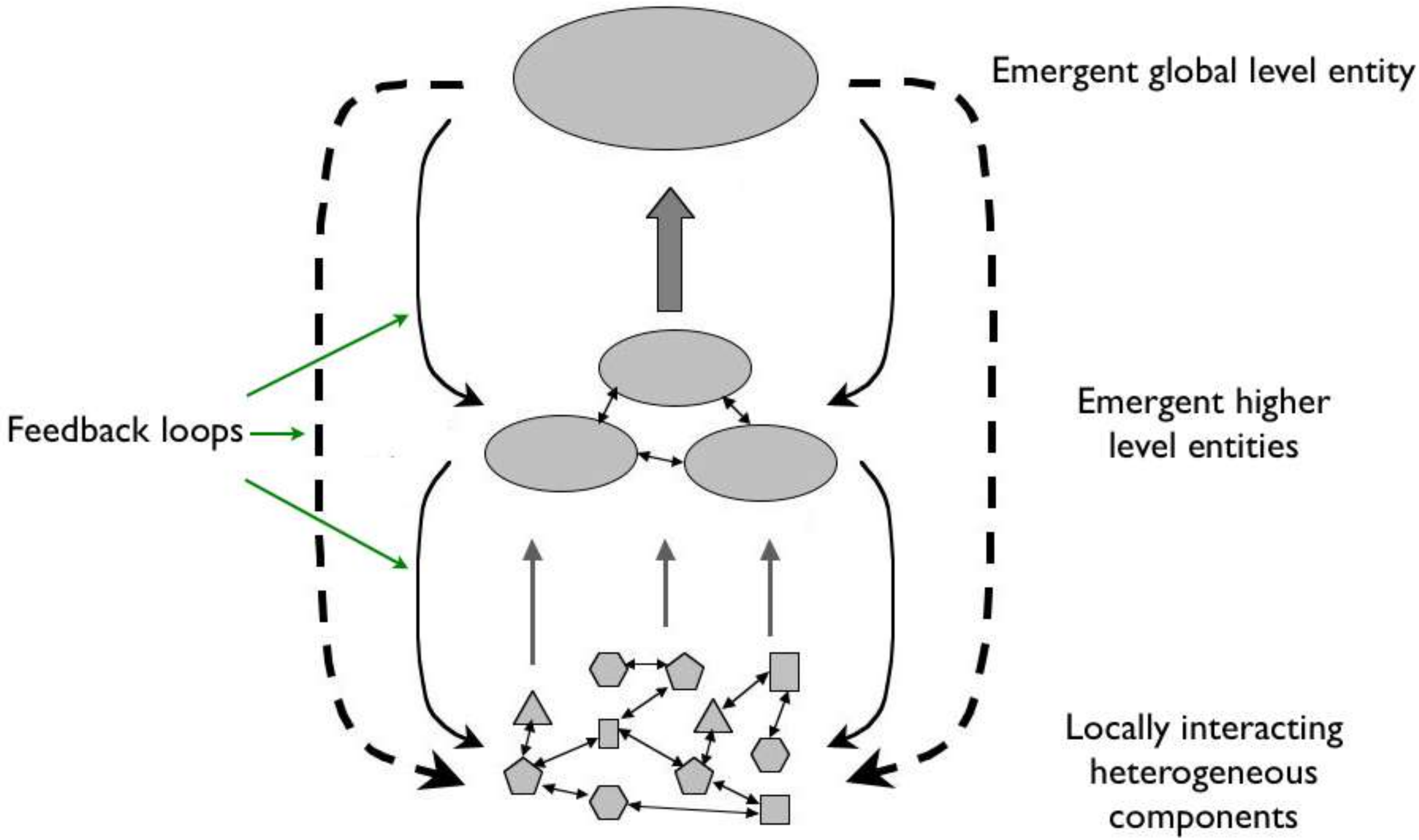
Memory: **Long-lasting influence on th**
by the of certain behaviours or interac
higher-level entities, or external influe
components or entities forming the sy

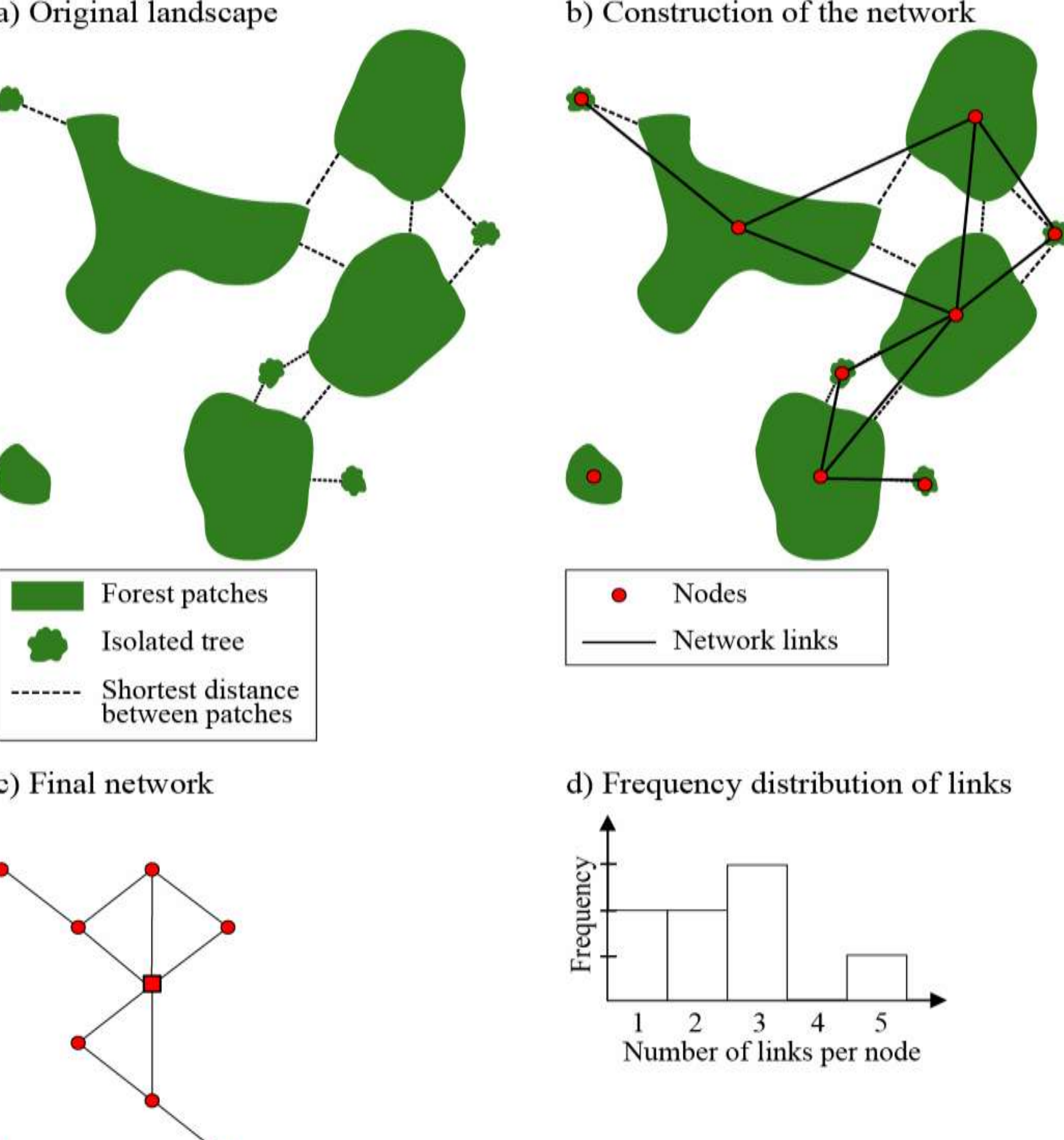


Non-linearity: **Characteristics of dis**
cause.

Uncertainty: **Inability to make exact predictions about the state of the system**

Conceptual representation of a complex system.




a) Original landscape
b) Construction of the network
Forest patches
Isolated tree
Shortest distance between patches
Nodes
Network links
c) Final network
d) Frequency distribution of links
Frequency
1
2
3
4
5
Number of links per node

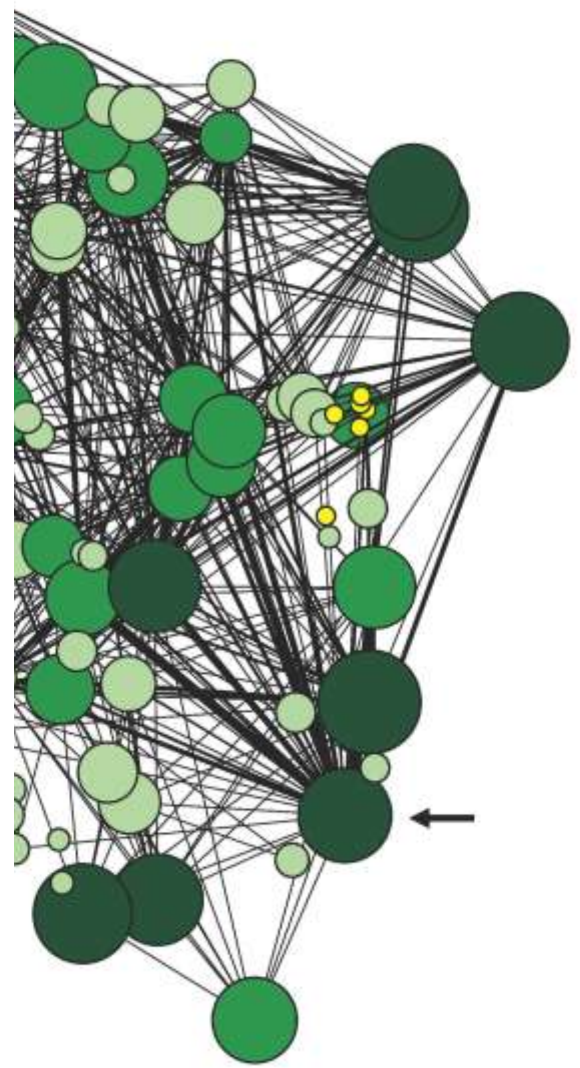
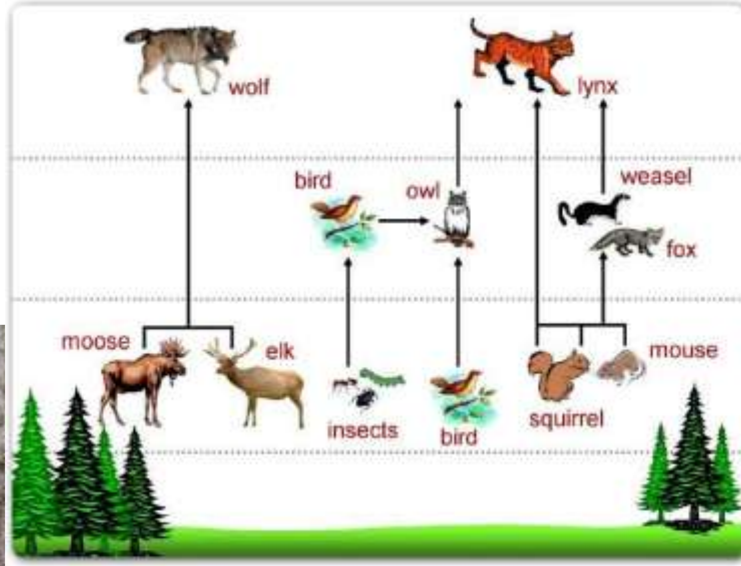


Table of contents:

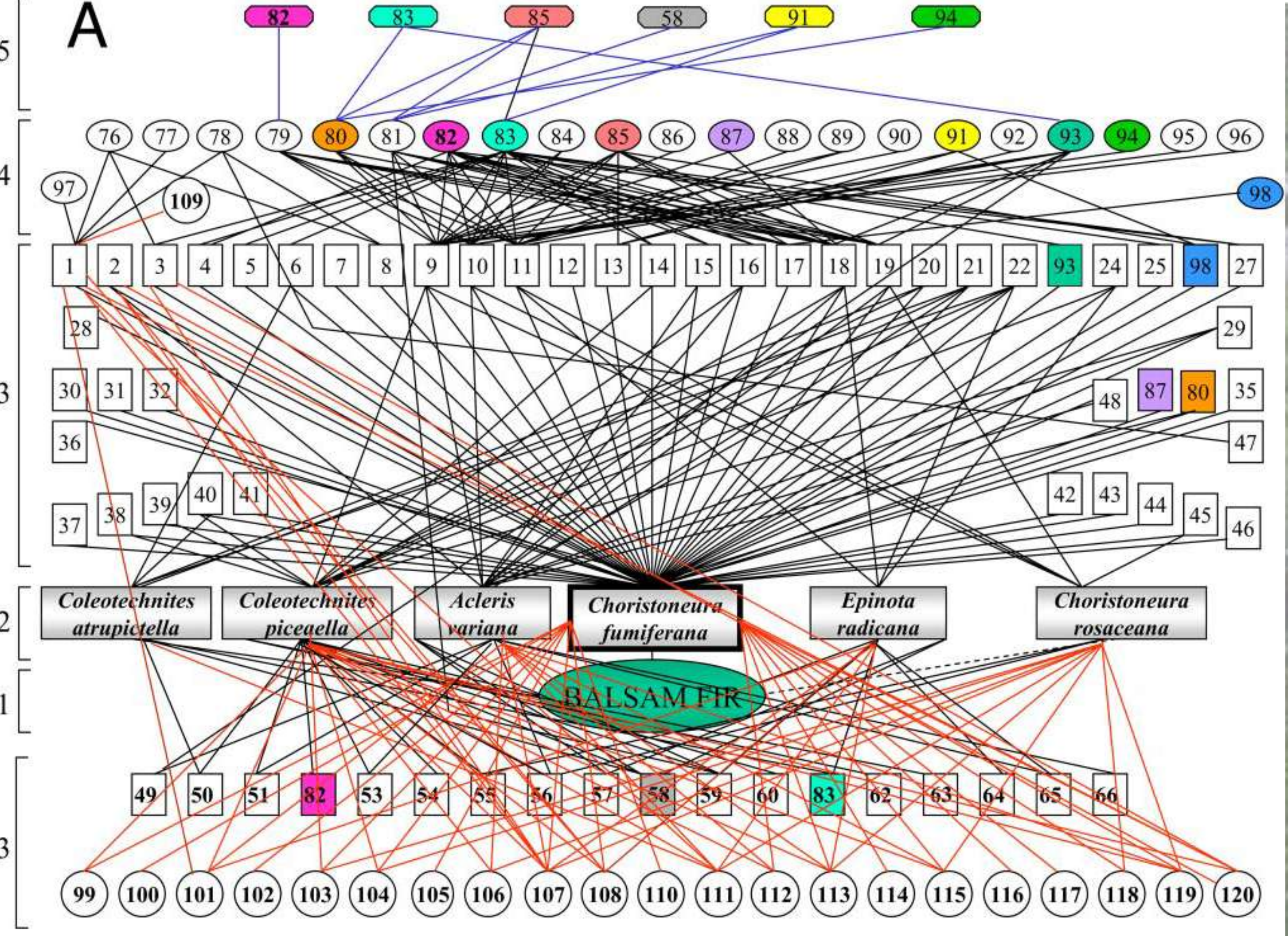
Simple, but extremely complex!

Boreal forest

- “Simple structures and dynamics”



- CAS: cross scale interactions
  - Spatial
  - Temporal
  - Hierarchical

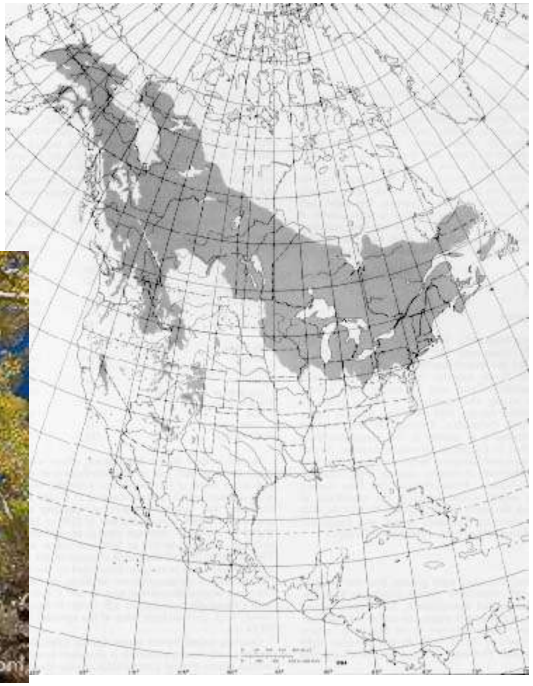


Aggregated food web of the **Balsam fir****:** ***1 host plant, 6 herbivores, 66 primary parasitoids and 21 primary entomopathogens, 23 secondary parasitoids and 1 secondary entomopathogen, and 6 tertiary parasitoids*****.**

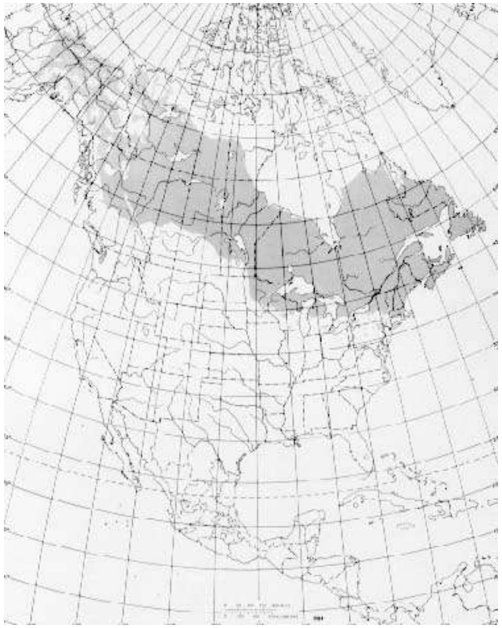
Omnivore species occur in more than one trophic level and are represented by a solid color (not white). From Eveleigh et al. 2007.

Hierarchical Scales

Low species diversity



Populus tremuloides



Picea mariana

Range maps from
USDA Forest Service Agriculture Handbook 654

Hierarchical Scales

Genetic within -species diversity, e.g., clones

photo courtesy of Weyerhauser Ltd

http://watchingtheworldwakeup.blogspot.com/
2008/09/best-fall-colors-ever.html

Genetic cross-species diversity,
e.g., hybridization


Nunavut
British Colombia
Alberta
< 100 yrs
Saskatchewan
Manitoba
Ontari
Pacific Ocean
Vegetation Zones
Boreal forest
Subalpine forest
Great Lake/St-Lawrence forest
Acadian forest
Others

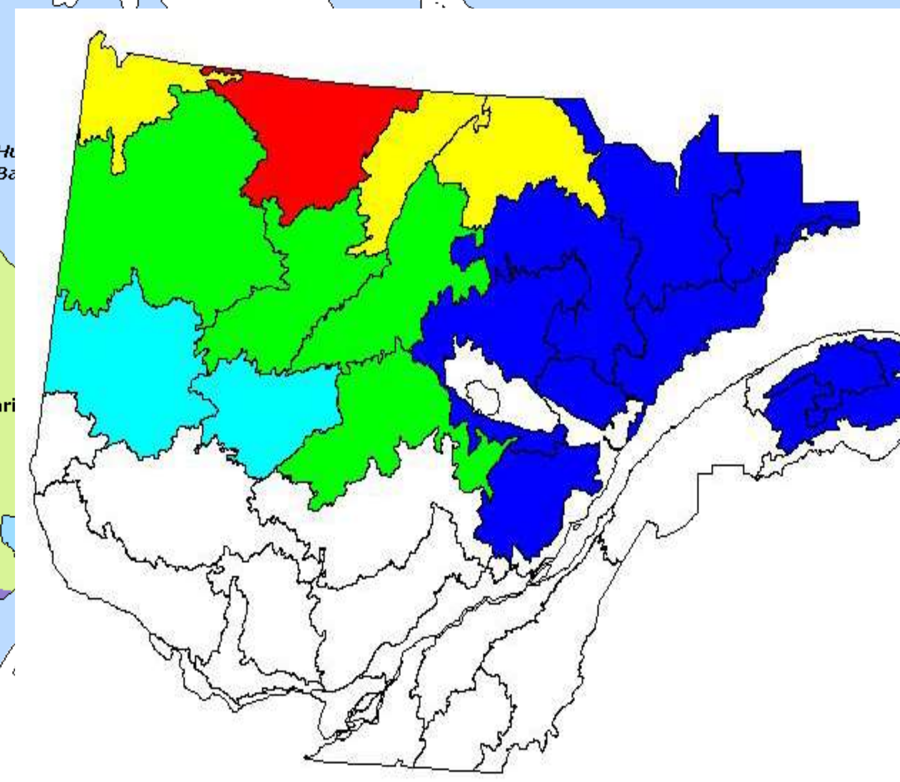

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Table of contents:

Setting the stage

Complexity and CAS in different forest biomes

Diversified, complex & resilient

Generalized features of *tropical forests* (*shaded rectangles*) are linked with attributes of Complex Adaptive Systems (*circles*).

The *high resilience* of tropical forest ecosystems derives from complex biotic interactions, density-dependent feedbacks, functional redundancy, and intrinsic spatial and temporal dynamics following disturbances.

Table of contents:

Political & Social CAS

x systems: An overview

omes

Complex Adaptive Systems

s CAS

x Adaptive Systems

ence paradigm

Intensively-managed CAS! Is this possible?

on as CAS

i, fauna & flora as agents of complex adaptive systems: an example from the interior Douglas-fir forests

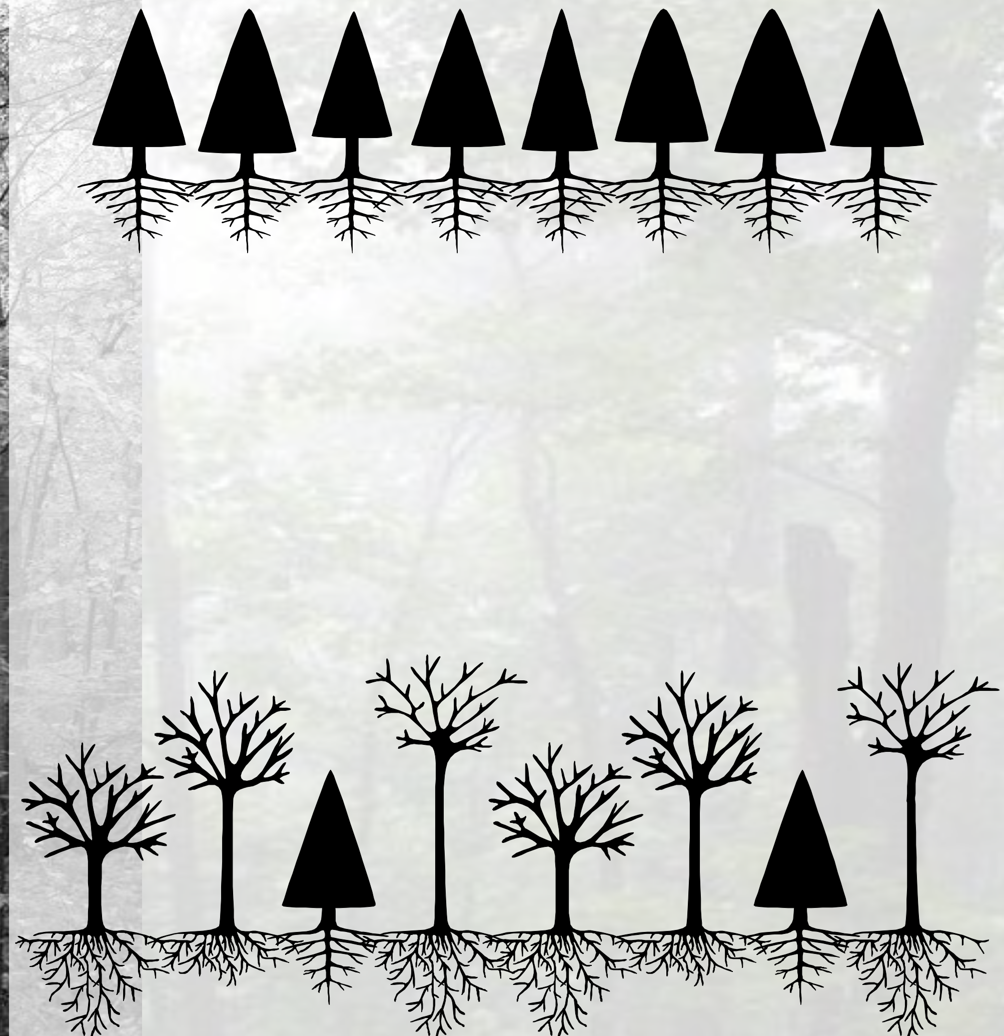
Chapter 9: Putz. A complex adaptive systems approach to tropical forestry

Chapter 10: Bauhus et al. Complex adaptive system as guiding approach for the management of semi-natural European forests

Chapter 11: Kuuluvainen. Scandinavian silviculture & forest complexity…

Chapter 12: Nocentini et al. Mediterranean forests: human use, complexity and resilience

Chapter 13: *Paquette & Messier. Plantations as CAS*



Global Ecology and Biogeography, (Global Ecol. Biogeogr.) (2011) 20, 170–180

RESEARCH PAPER

The effect of biodiversity on tree productivity: from temperate to boreal forests

Alain Paquette* and Christian Messier

Center for Forest Research, Université du Québec à Montréal, PO Box 8888, Centre-Ville Station, Montréal, QC H3C 3P8, Canada

ABSTRACT

Aim An important issue regarding biodiversity concerns its influence on ecosystem functioning. Experimental work has led to the proposal of mechanisms such as

Results This is the first large-scale demonstration of a strong, positive and sig-

- ***Argument against mono-culture and simplification of forests***
- ***Argument in favor of mixed plantations and more spatially and temporally diverse silvicultural practices***

More diversified plantations

- **12 indigenous species**
- **7 exotic species**
- **Functional diversity gradient**
- **Mixed of 1, 2, 4 and 12 species**

An overview

daptive Systems

Systems

Management under the CAS and resilience paradigm

Chapter 7: *Cornett et al. Forest Restoration as CAS*

Chapter 8: *Simard et al. Networks of fungi, fauna & flora as agents of complex adaptive systems: an example from*

On the path to CAS!

Chapter *to tropical forestry*

Chapter 10: *Bauhus et al. Complex adaptive system as guiding approach for the management of semi-natural European forests*

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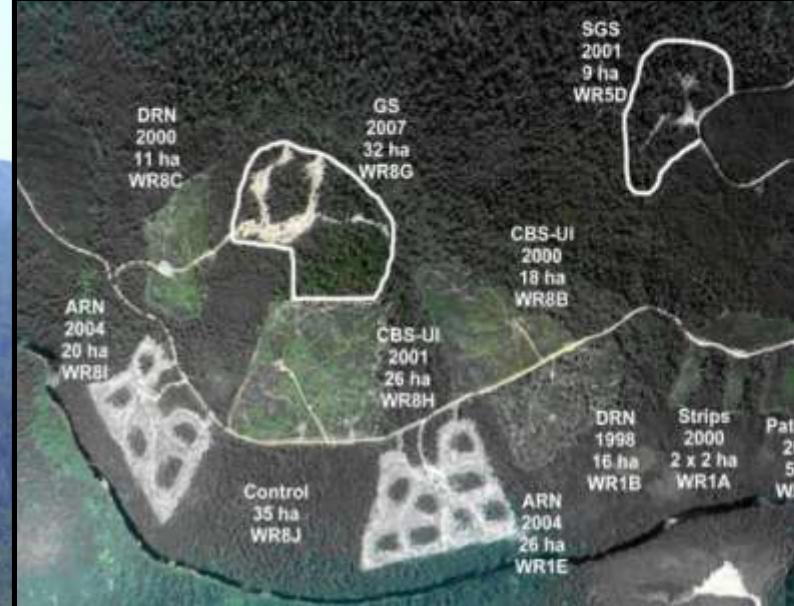


Regeneration burning following clearcutting in wet eucalypt forest to maintain adaptability

Variable retention in wet eucalypt forest to maintain structural and compositional heterogeneity

Management approaches that help maintain Tasmanian native forests as complex adaptive systems

1. **High reservation at *multiple scales* via a Comprehensive, Adequate and Representative reserve network favouring *cross-scale interactions*.**

2. **Regeneration burning as part of site preparation provides a seedbed for species *adapted to natural wildfire favouring a variable and heterogeneous forest structure and composition*.**

3. **Herbicides, insecticides and fertilizers are not used and no subsequent tending other than occasional thinning is done following tree establishment *allowing self-organisation to occur*.**

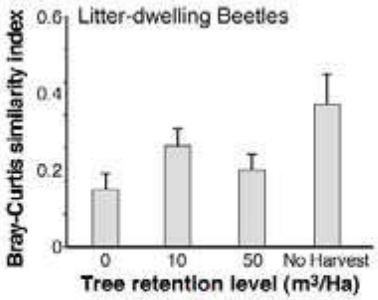
4. **Instead of planting, locally-collected seed is aerially sown. Genetic diversity insuring increased adaptability.**

5. **Variable retention is used in place of clear-cutting in wet old-growth forests to *maintain structural and compositional heterogeneity*.**

6. **Approaches to mitigating climate change impacts include seed banks, identification & protection of refugia and restoration of connectivity corridors as a way to deal with the increasing uncertainty caused by global change.**

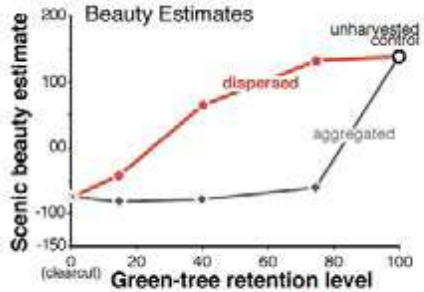
A. Biodiversity

Tree retention mitigates harvesting impacts on beetle assemblages
(Hyvarinen et al., 2009)



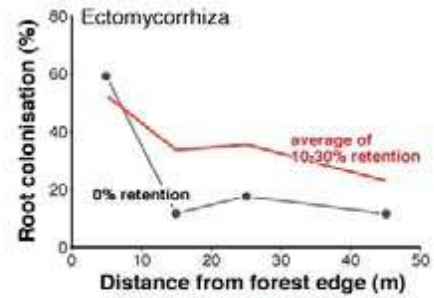
B. Social Acceptability

Dispersed tree retention is more socially acceptable than aggregated retention
(Ribe 2005)



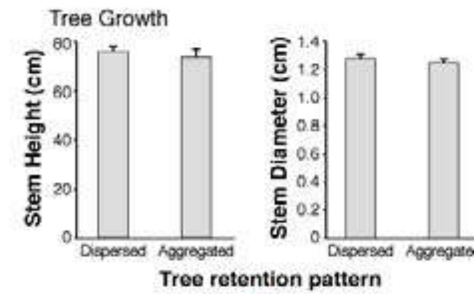
C. Ecological Function

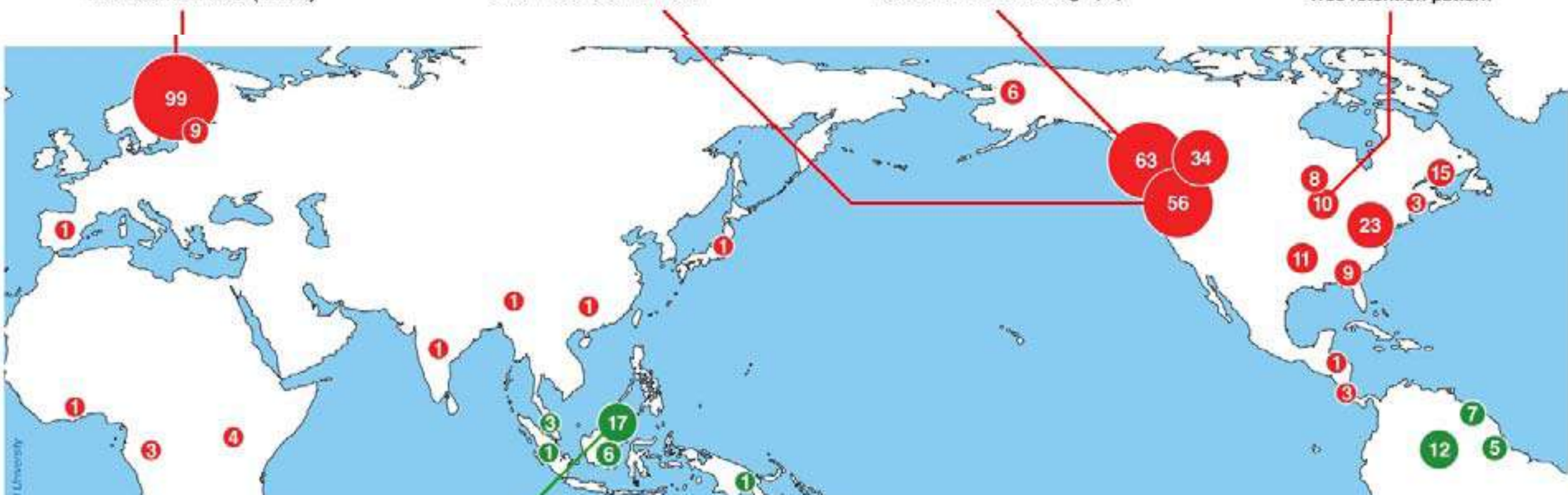
Tree retention maintains ectomycorrhiza in harvested stands
(Outerbridge and Trofymow 2009)



D. Growth & Productivity

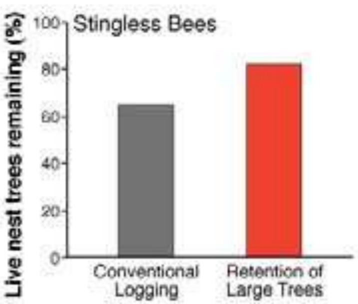
At the same retention levels there is no difference in new cohort (seedling) productivity
(Powers et al., 2011)





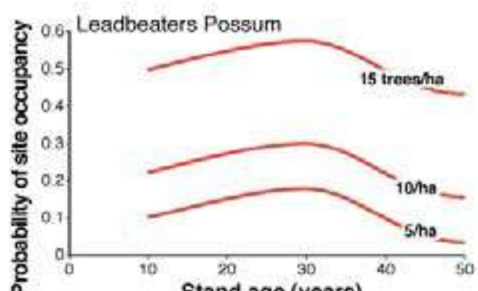
E. Biodiversity

Tree retention promotes the maintenance of stingless bee populations in reduced-impact logged rainforest. *(Eltz et al., 2003)*



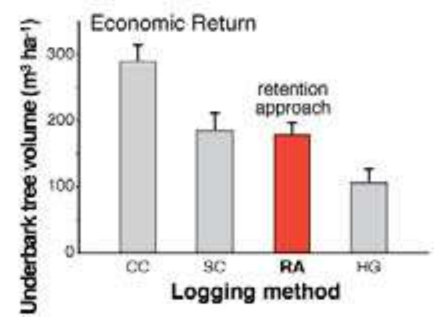
F. Biodiversity

Retention levels on logged sites affect probability of colonization by Leadbeaters Possum after only 10 years
(Lindenmayer et al. 1991, 2011)

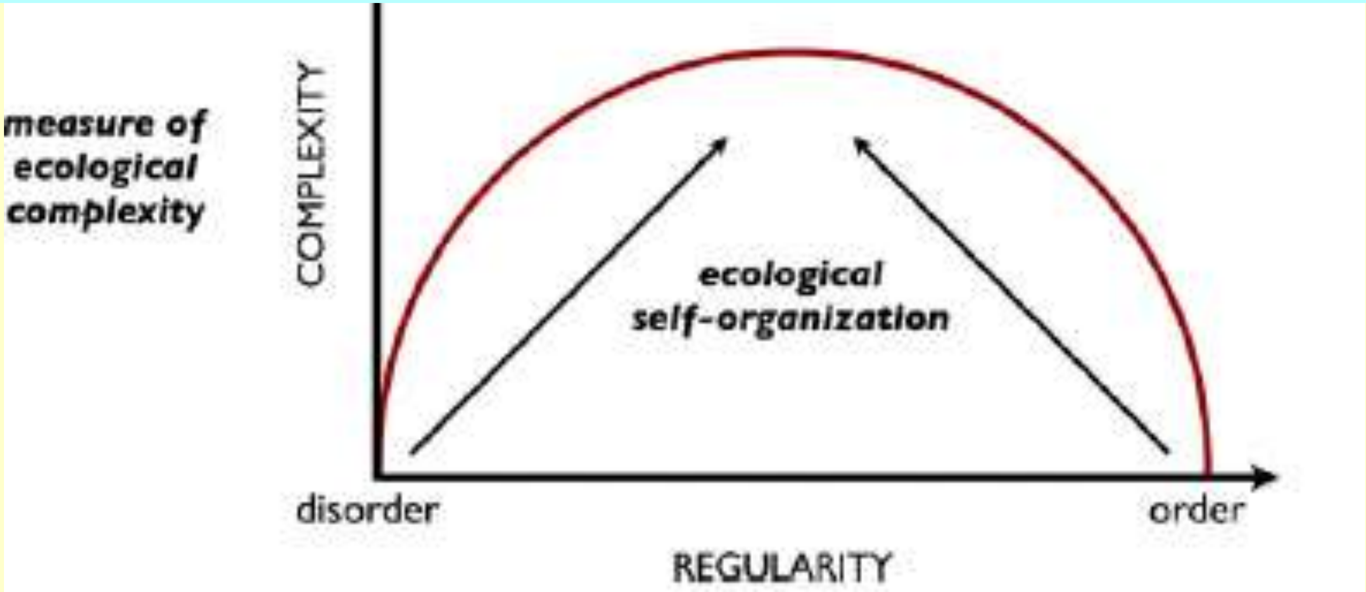


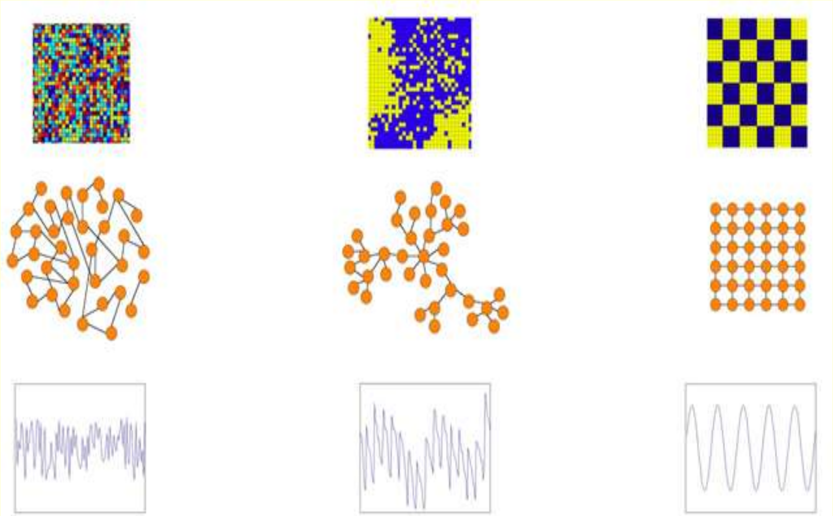
G. Economics

At the same retention levels, retention harvesting gives the same economic return as traditional shelterwood harvesting
(Martinez Pastur et al., 2009)



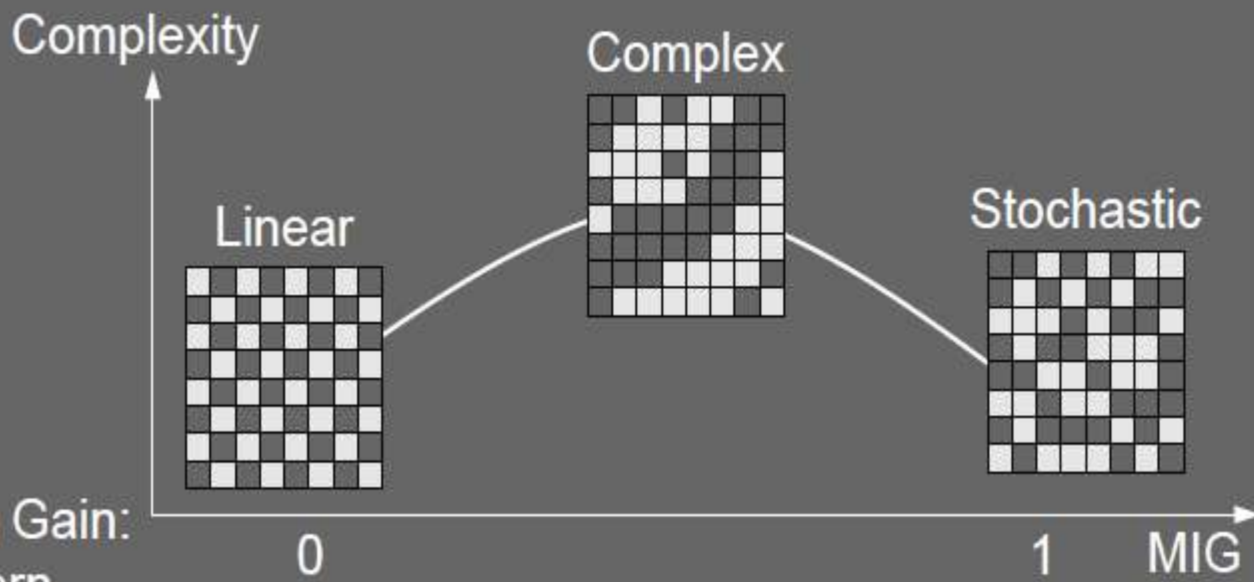
How to measure complexity in the forest: a first attempt!





Isabelle Witté

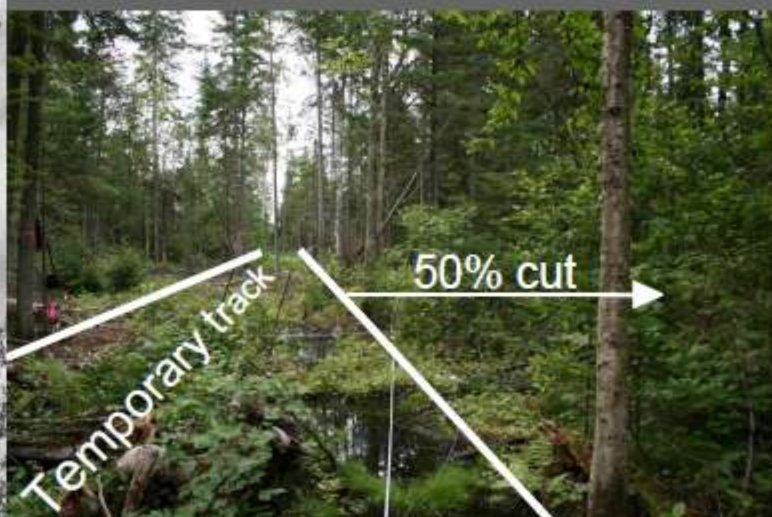
METHODOLOGY
Spatial patterns as indicators of complex processes?



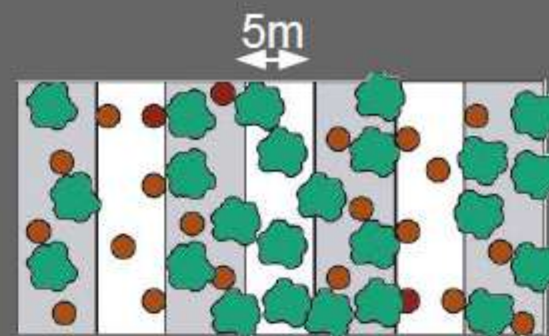
Mean Information Gain: length of the pattern description

Parrott, 2005; Proulx et Parrott, 2008

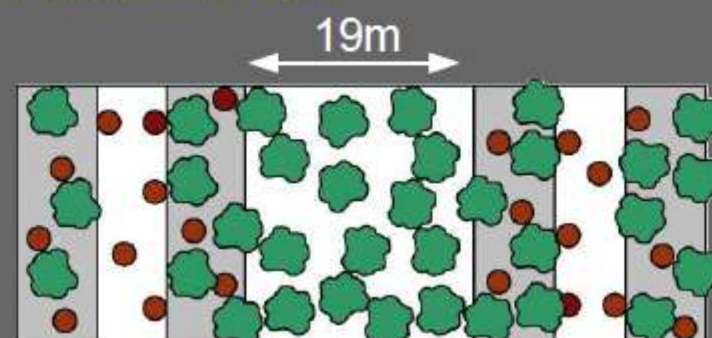
3 PARTIAL-CUTS INCREASE THE COMPLEXITY OF FOREST PATTERNS
Partial-cuts protocole in TRIADE



Partial cut 50%



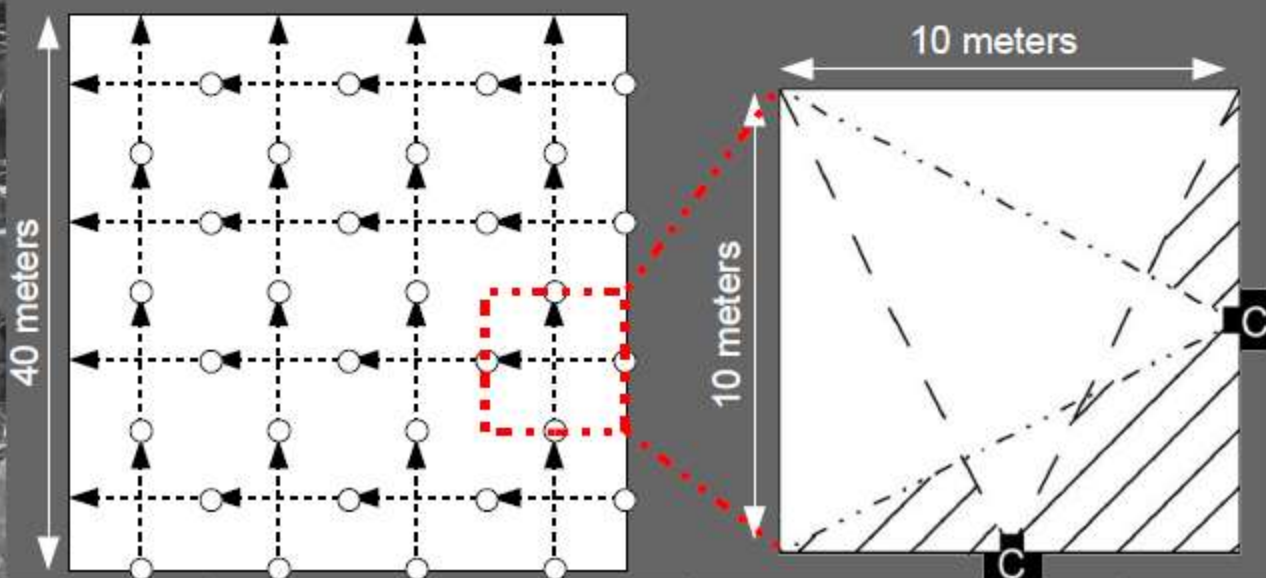
Partial cut 35%



Images et méthode : Meek, 2006

METHODOLOGY
Photographs sampling

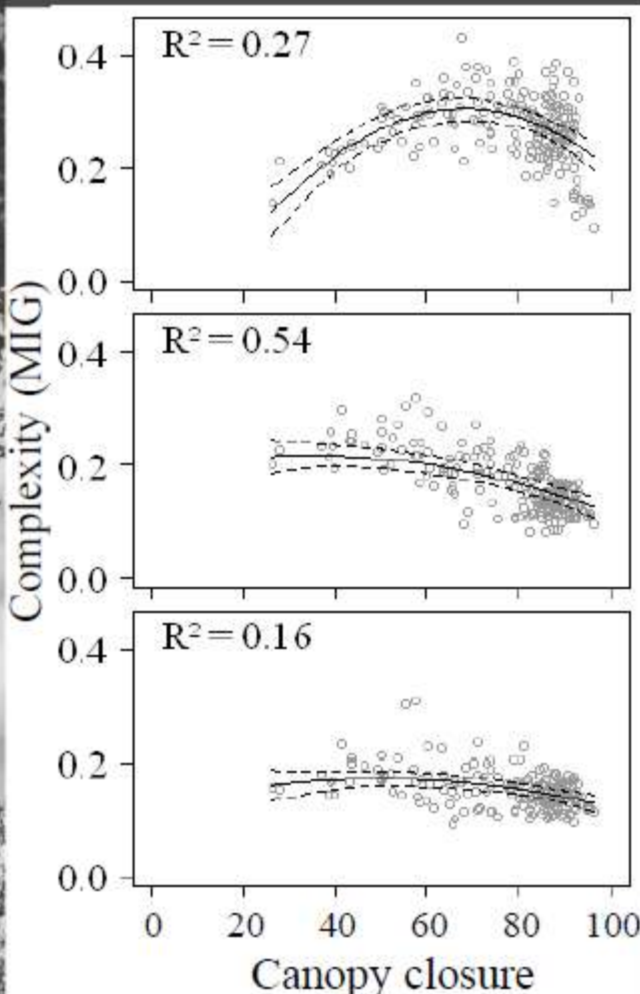
1440 photographs
15 forest plots from 5 forest types
3 layers (Canopy,Horizon,Understorey)



3

PARTIAL-CUTS INCREASE THE COMPLEXITY OF FOREST PATTERNS

Do intermediate disturbances increase complexity? Hue Patterns



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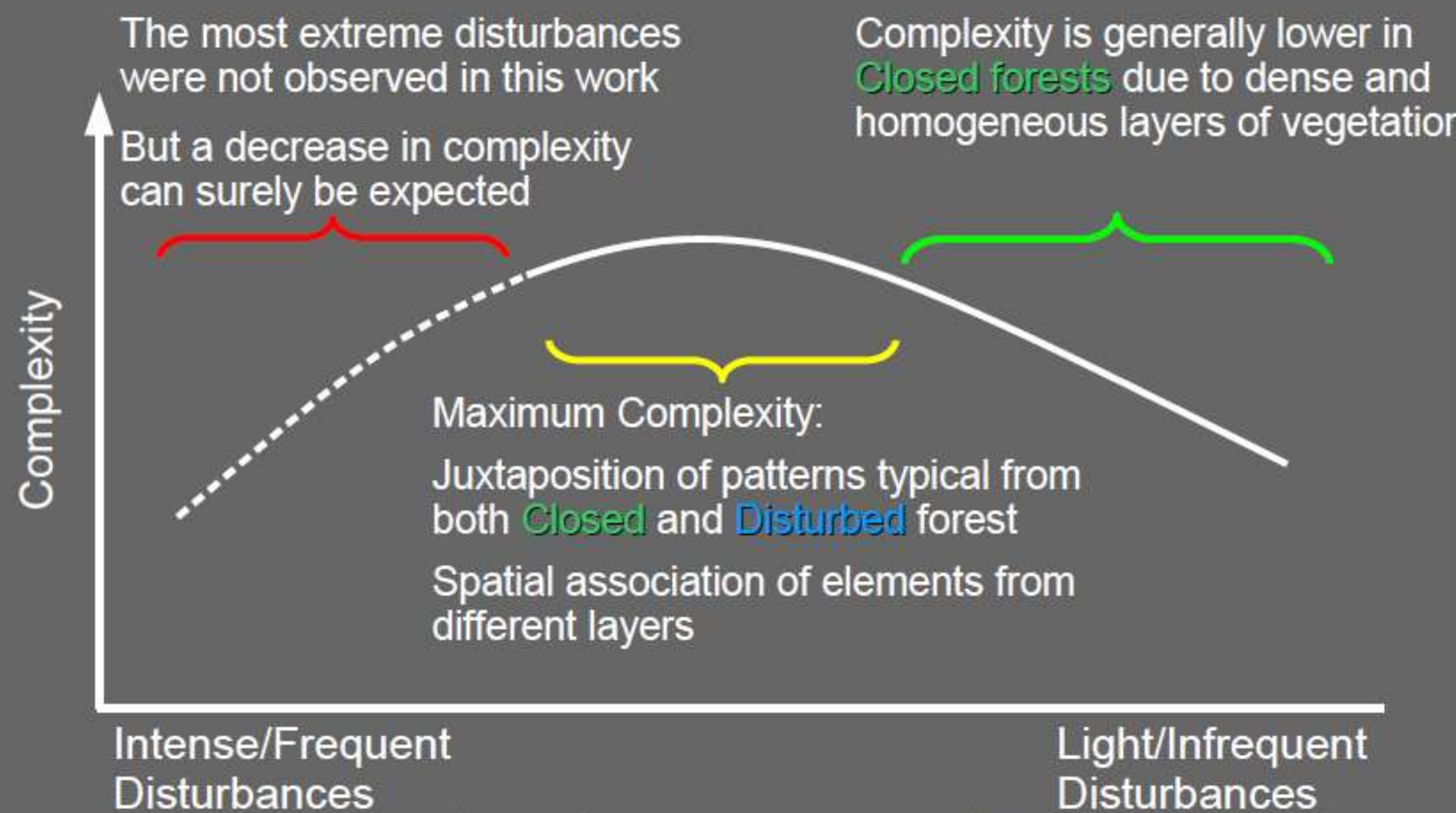
PARTIAL-CUTS INCREASE THE COMPLEXITY OF FOREST PATTERNS

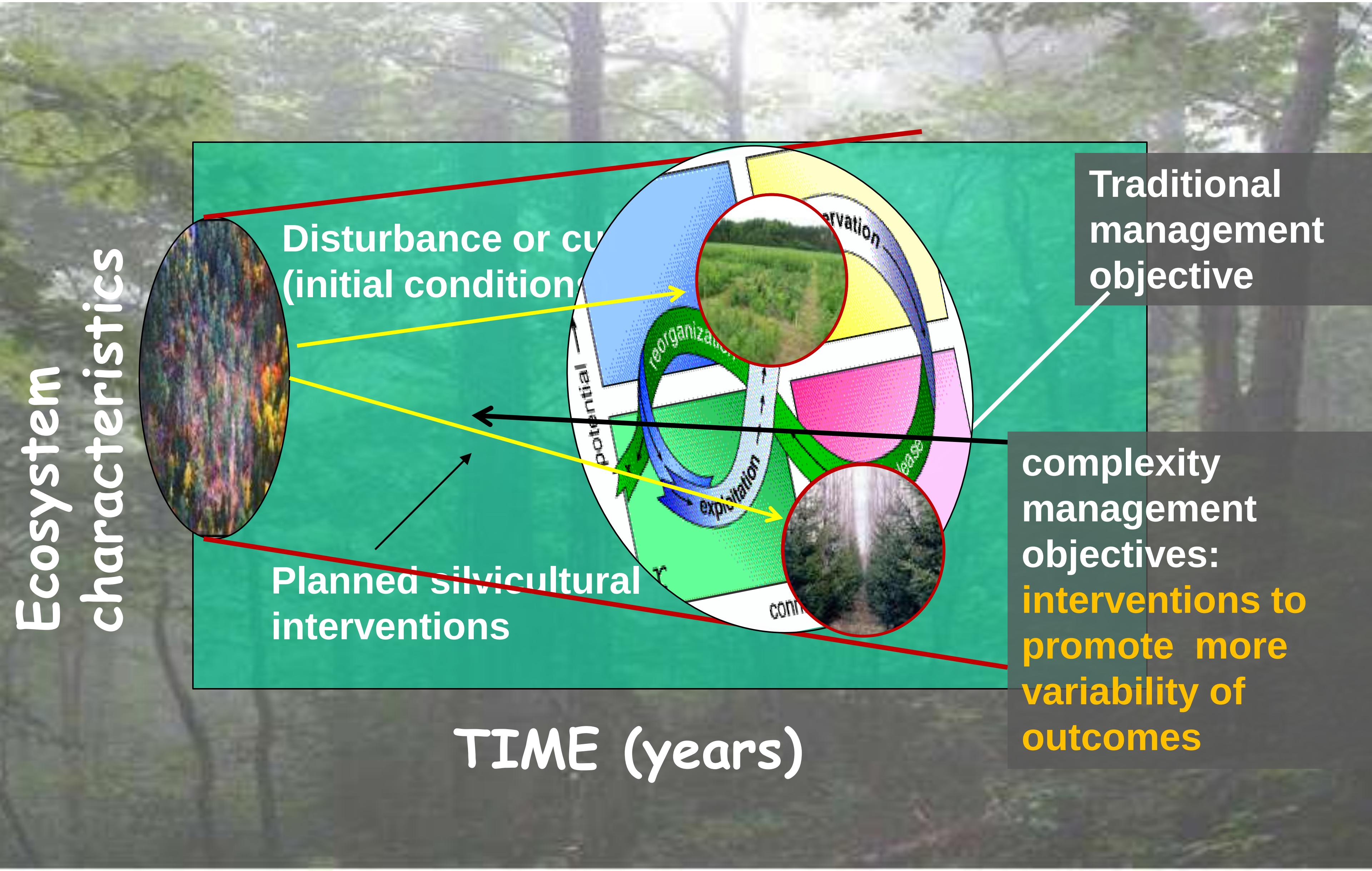
Do intermediate disturbances increase complexity?



Simple things that we can do

- Facilitate and/or ASSIST tree species migration;
- Develop/use varied silvicultural systems that favor both functionally diverse and redundant species both spatially and temporally;
- Favor multi-species stands and plantations with functionally diverse and redundant tree species both within and across stands;
- Maintain forest connectivity across landscapes and regions

Managing for complex adaptive systems




Grazie/Thanks/
Merci