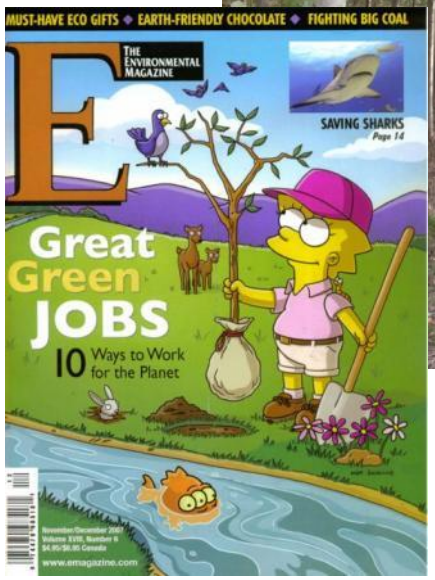
UQÀM
Université du Québec à Montréal

Le rôle des plantations dans l'aménagement des forêts de l'Anthropocène

Alain Paquette, Ph.D.
Centre d'étude de la forêt, UQAM, Projet TRIADE
Groupe de réflexion - plantations AIPL

cef
Centre d'étude de la forêt

Plantations forestières, une relation … compliquée



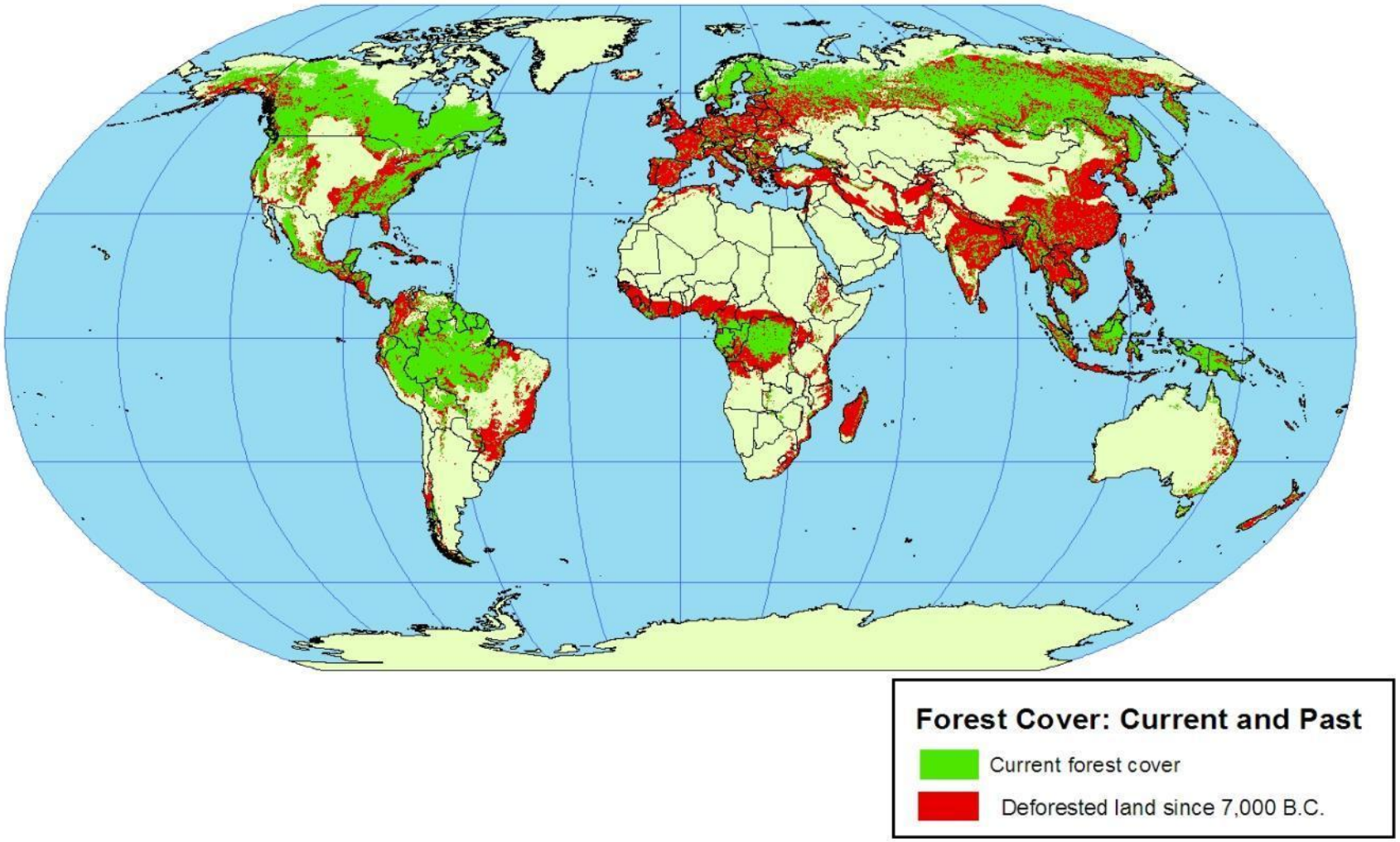
Paquette, A., and C. Messier. 2009. The role of plantations in managing the world's forests in the Anthropocene. Frontiers in Ecology and the Environment 8(1): 27-34.

Quelques constats / Plan

- **Plantations en expansion / forêts primaires en déclin**
- **Les plantations ont mauvaise presse**
- **AIPL / zonage au Québec, et ailleurs**
- **Est-ce qu'on peut faire mieux?**

< 4 milliards ha de forêts restant (sur **8**)

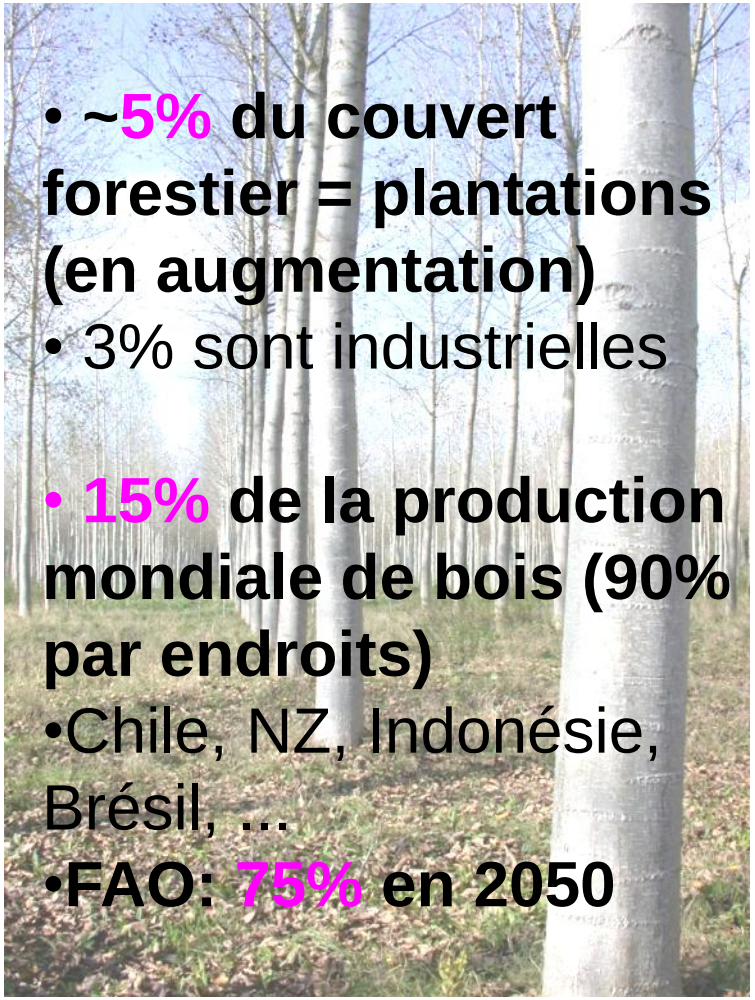
1.5 (20%) sont ~ intactes



Plantations versus forêts

- **30% of des surfaces en forêt (40 Mkm²)**
- 1/3 primaire

- **0.2% sont encore perdues chaque année, soit ~10 Mha**
- 60 000 km² étaient des forêts primaires



- **~5% du couvert forestier = plantations (en augmentation)**
- 3% sont industrielles

- **15% de la production mondiale de bois (90% par endroits)**
- Chile, NZ, Indonésie, Brésil, ...
- **FAO: 75% en 2050**

Reproches faits aux plantations

Sylviculture traditionnelle

Réduire la variabilité pour augmenter la capacité prédictive et l'efficacité

→ Concentrer productivité primaire

→ Diversité réduite surtout pour certain groupes fonctionnels

Questions

- **Quelle est la place des plantations forestières dans l'Anthropocène?**
- **Peuvent-elles se substituer à la forêt naturelle pour la production de bois (changement d'échelle)?**
- **Peut-on réduire leur impact, voir le rendre positif?**

- **Est-ce qu'on peut le faire?!**

Anthropocene: the current period in the Earth's history when human activities have had a significant global impact on the Earth's ecosystems. Paul Crutzen (Max Planck Institute - Nobel Prize-winning atmospheric chemist), 2000.

The role of plantations in managing the world's forests in the Anthropocene

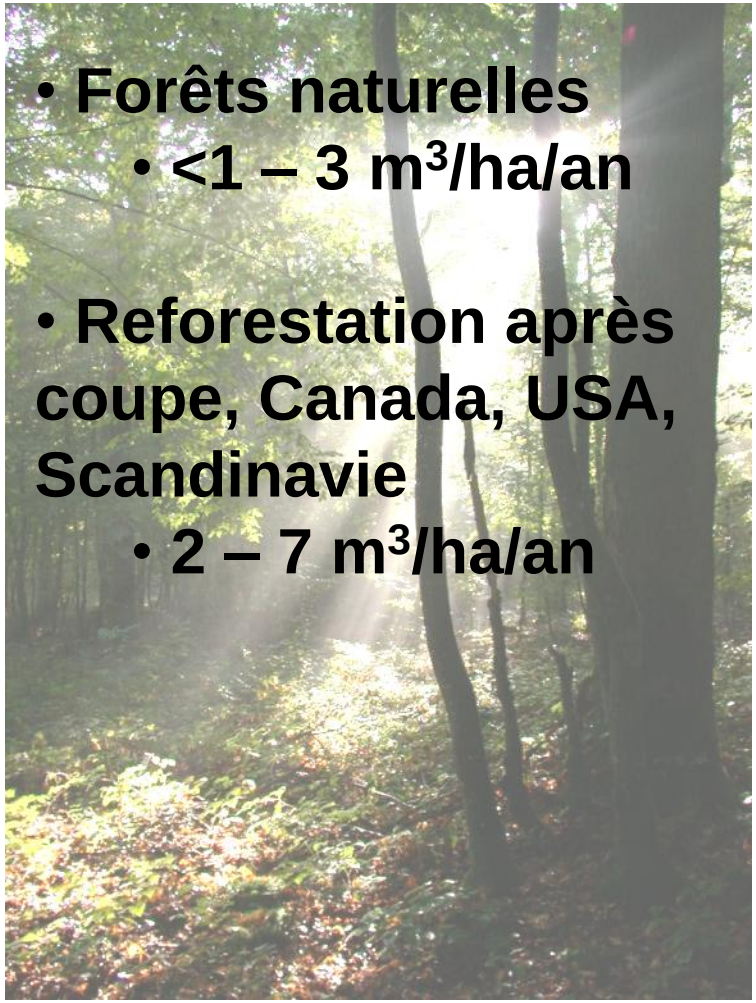
Alain Paquette* **and Christian Messier**

The public view of tree plantations is somewhat ambiguous. While planting a single tree is generally considered good for the environment, planting a million trees raises concerns in some circles. Although plantations are often used to compensate for bad forestry practices, to willingly simplify otherwise complex forest ecosystems, or as a strategy for allowing the current petroleum-based economy to continue on its course, we believe plantations have a legitimate place in the sustainable management of forests. Multipurpose plantations, designed to meet a wide variety of social, economic, and environmental objectives, can provide key ecosystem services, help preserve the world's remaining primary forests, and sequester an important proportion of the atmospheric carbon released by humans over the past 300 years.

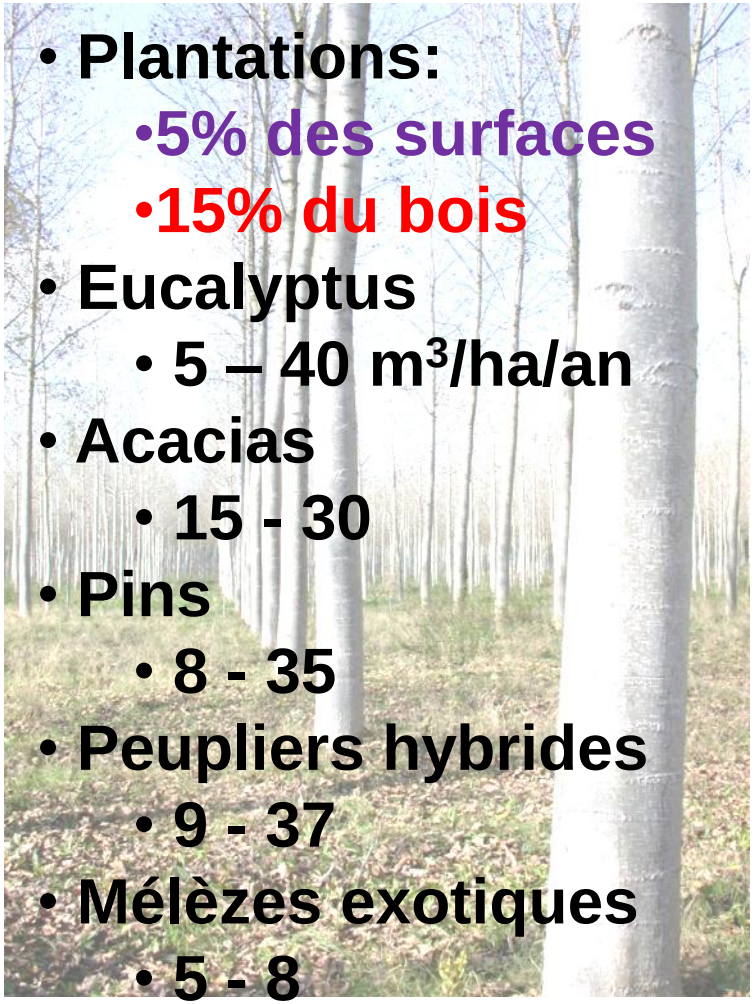
Front Ecol Environ 2009; 7, doi:10.1890/080090

The Earth is currently undergoing an unprecedented ... Forest plantations are often put forward as part of the

Plantations versus forêts, la suite…



- Forêts naturelles
  - <1 – 3 m^3/ha/an
- Reforestation après coupe, Canada, USA, Scandinavie
  - 2 – 7 m^3/ha/an



- Plantations:
  - 5% des surfaces
  - 15% du bois
- Eucalyptus
  - 5 – 40 m^3/ha/an
- Acacias
  - 15 - 30
- Pins
  - 8 - 35
- Peupliers hybrides
  - 9 - 37
- Mélèzes exotiques
  - 5 - 8

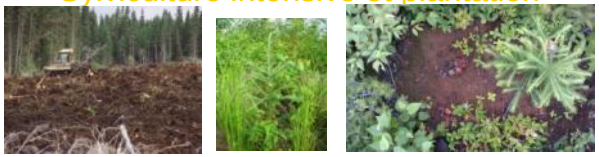
Protection par le zonage fonctionnel

TRIAD (Seymour and Hunter 1992 - Maine)

Zonage fonctionnel du territoire en trois zones

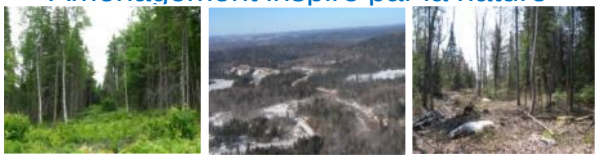
Zone de production

Sylviculture intensive et plantation



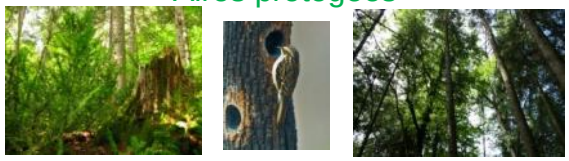
Zone d'aménagement extensif

Aménagement inspiré par la nature



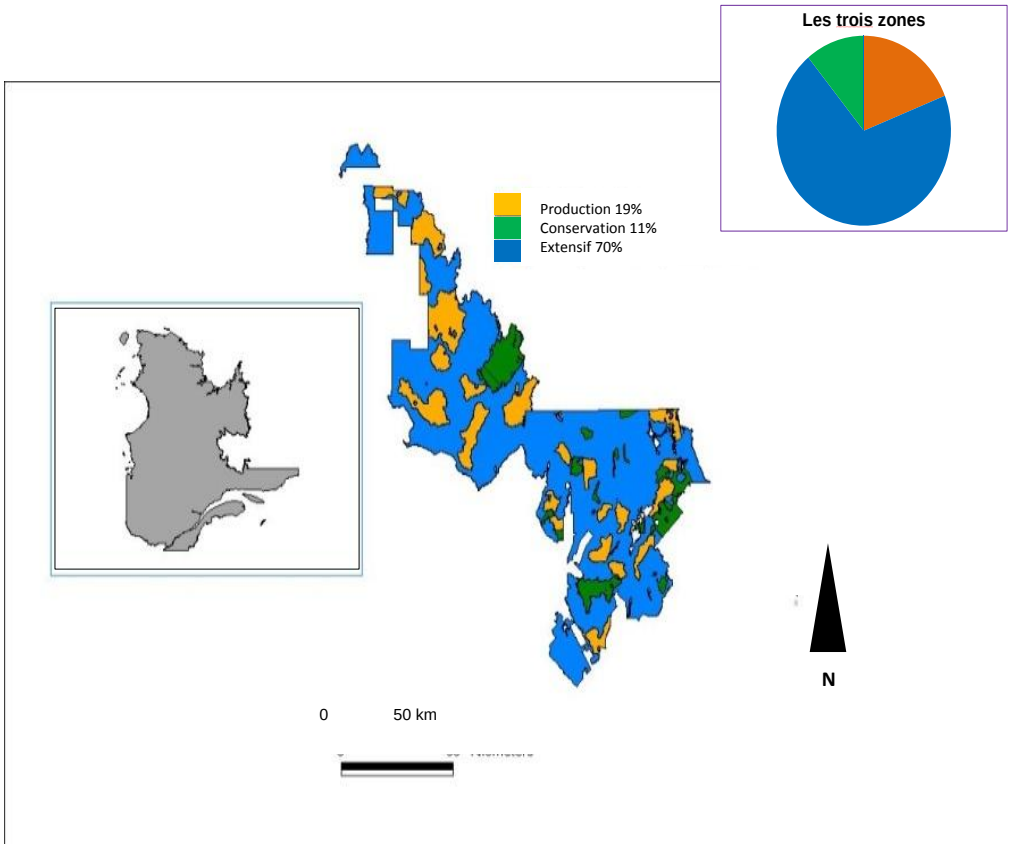
Zone de conservation

Aires protégées



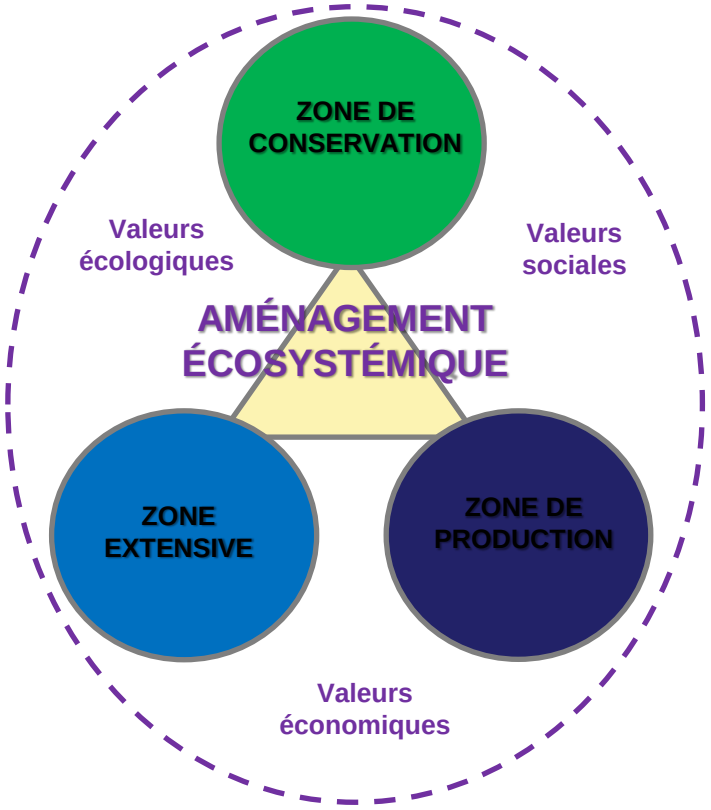
Messier, C., Tittler, R., Kneeshaw, D. D., Gélinas, N., Paquette, A., Berninger, K., Rheault, H., Meek, P. & Beaulieu, N. (2009) TRIAD zoning in Quebec: experiences and results after five years. *The Forestry Chronicle, 85, 885-896.*

Le projet TRIADE



- UAF 42-51 en Haute-Mauricie
- 1 million hectares (10,000 km^2): une UAF au complet
- Initié en 2003. Projet pilote depuis 2005

TRIADE, aménagement écosystémique



- **C'est l'ensemble qui est aménagé de façon écosystémique, incluant la zone intensive**

- **Le zonage TRIADE permet de mieux atteindre tous les objectifs de l'aménagement écosystémique (sociaux, économiques, et écologiques) que les autres scénarios**

ECOLOGY LETTERS

Ecology Letters, (2010) doi: 10.1111/j.1461-0248.2010.01528.x

LETTER

Comparing organic farming and land sparing: optimizing yield and butterfly populations at a landscape scale

Global Change Biology (2009) 15, 1716–1726, doi: 10.1111/j.1365-2486.2009.018

Global food demand and the sustainable intensification of agriculture

David Tilman[a,1], Christian Balzer[b], Jason Hill[c], and Belinda L. Befort[a]

Do increases in agricultural yield spare land for nature?

ROBERT M. EWERS*†[1], JÖRN P. W. SCHARLEMANN‡[2], ANDREW BALMFORD† and RHYS E. GREEN†§

*Institute of Zoology, Zoological Society of London, Regent's Park, London NW1 4RY, UK, †Conservatio
Department of Zoology, University of Cambridge, Downing St, Cambridge CB2 3EJ, UK, ‡Smithsonian Tr
Apartado 0843-03092, Balboa, Panama, Republic of Panama, †§Royal Society for the Protection of Birds,

Reconciling Food Production and Biodiversity Conservation: Land Sharing and Land Sparing Compared

Ben Phalan,[1] Malvika Onial,[1] Andrew Balmford,[1] Rhys E. Green[1,2]

GUEST EDITORIAL GUEST EDITORIAL GUEST EDITORIAL

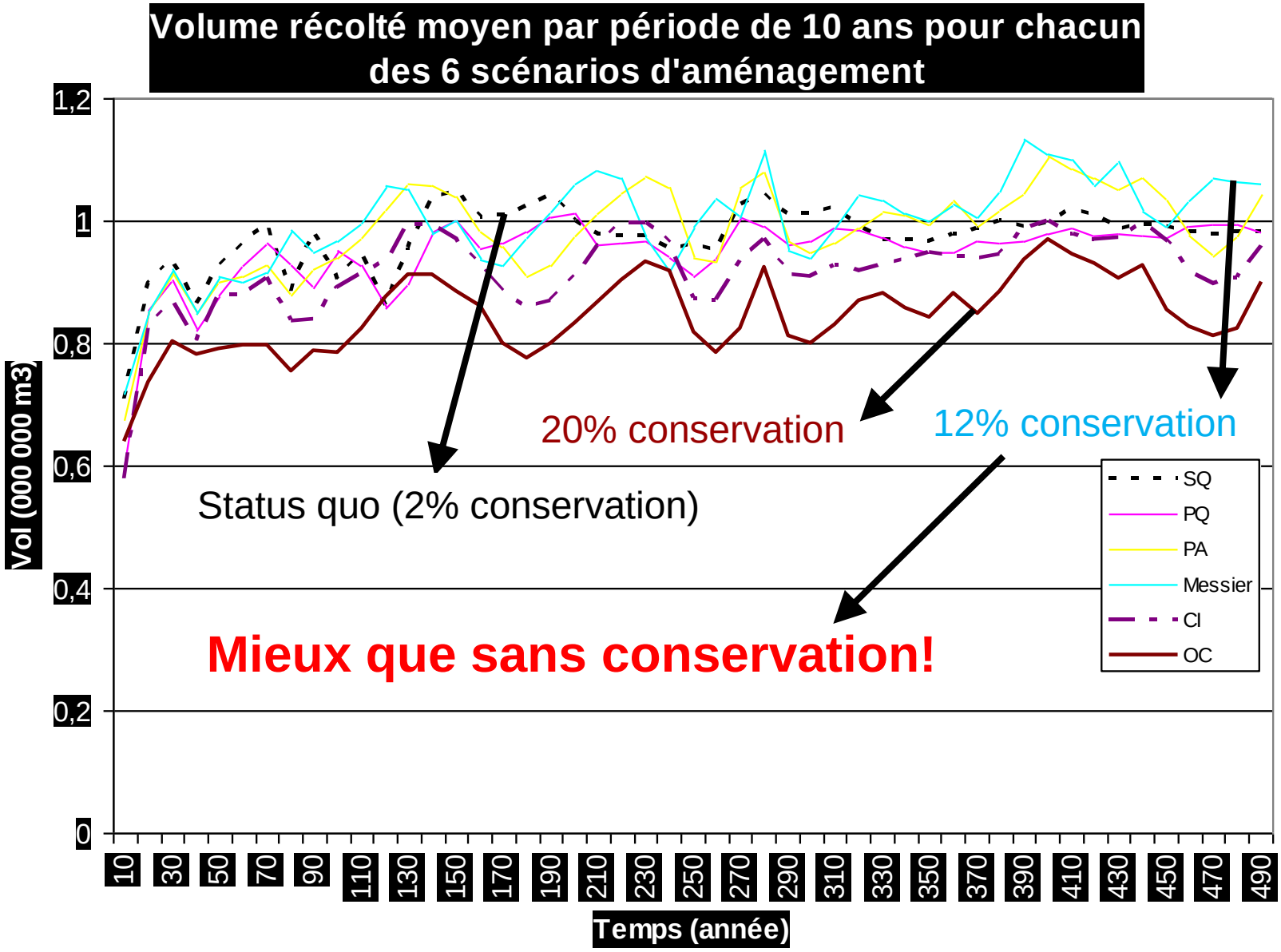
Can intensive farming save nature?

CONCEPTS AND QUESTIONS

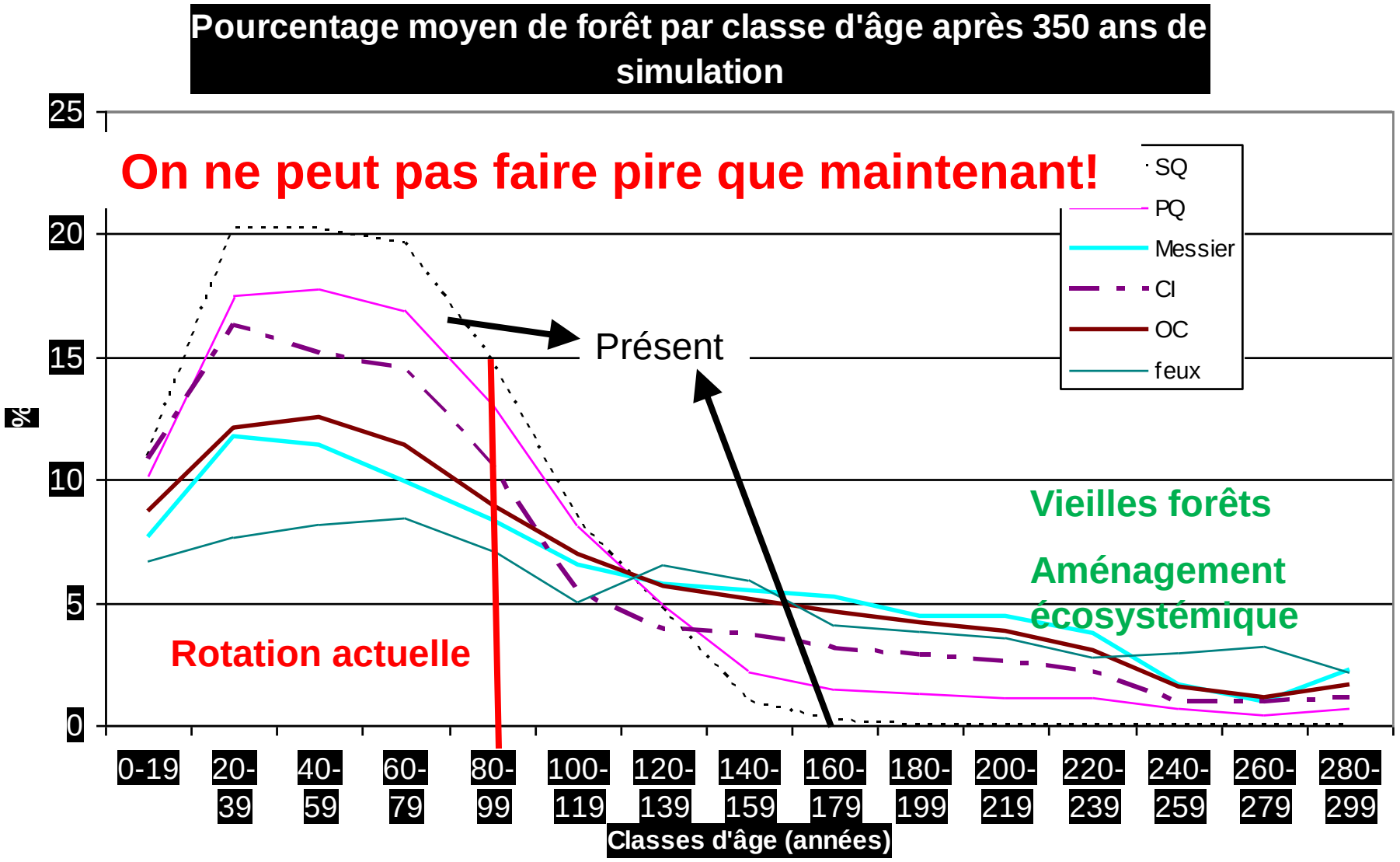
Should agricultural policies encourage land sparing or wildlife-friendly farming?

Joern Fischer[1*], Berry Brosi[2], Gretchen C Daily[2], Paul R Ehrlich[2], Rebecca Goldman[2], Joshua Goldstein[2], David B Lindenmayer[1], Adrian D Manning[1], Harold A Mooney[2], Liba Pejchar[2], Jai Ranganathan[2], and Heather Tallis[2]

Simulations : volumes récoltés



Simulation : structure d'âge

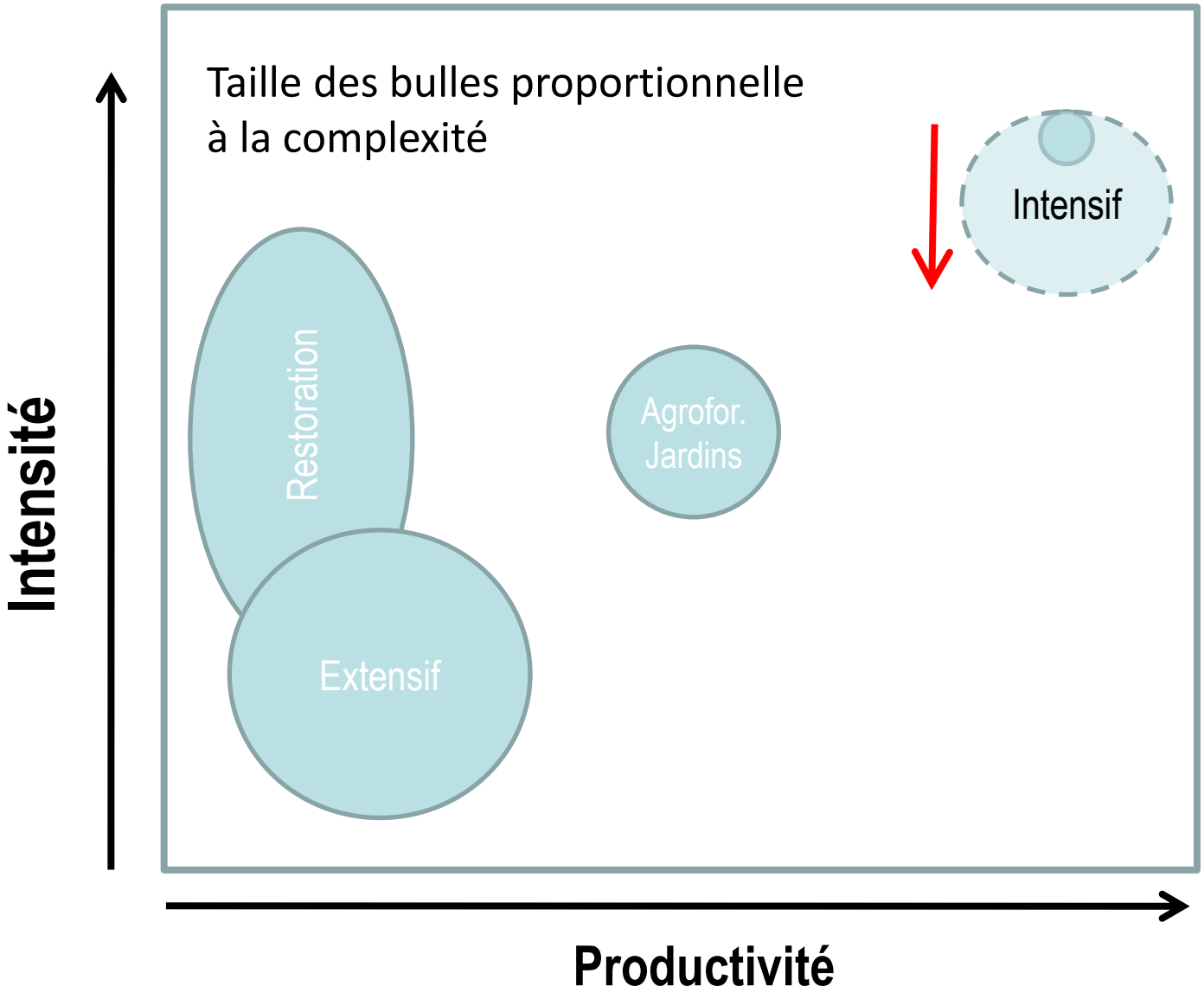


Côté, P., R. Tittler, C. Messier, D. D. Kneeshaw, A. Fall, and M.-J. Fortin. 2010. Comparing different forest zoning options for landscape-scale management of the boreal forest: Possible benefits of the TRIAD. Forest Ecology and Management 259:418-427.

Tittler, R., C. Messier, and A. Fall. 2012. Concentrating anthropogenic disturbance to balance ecological and economic values: applications to forest management. Ecological Applications 22:1268-1277.

Quels sont les enjeux pour les plantations TRIADE?

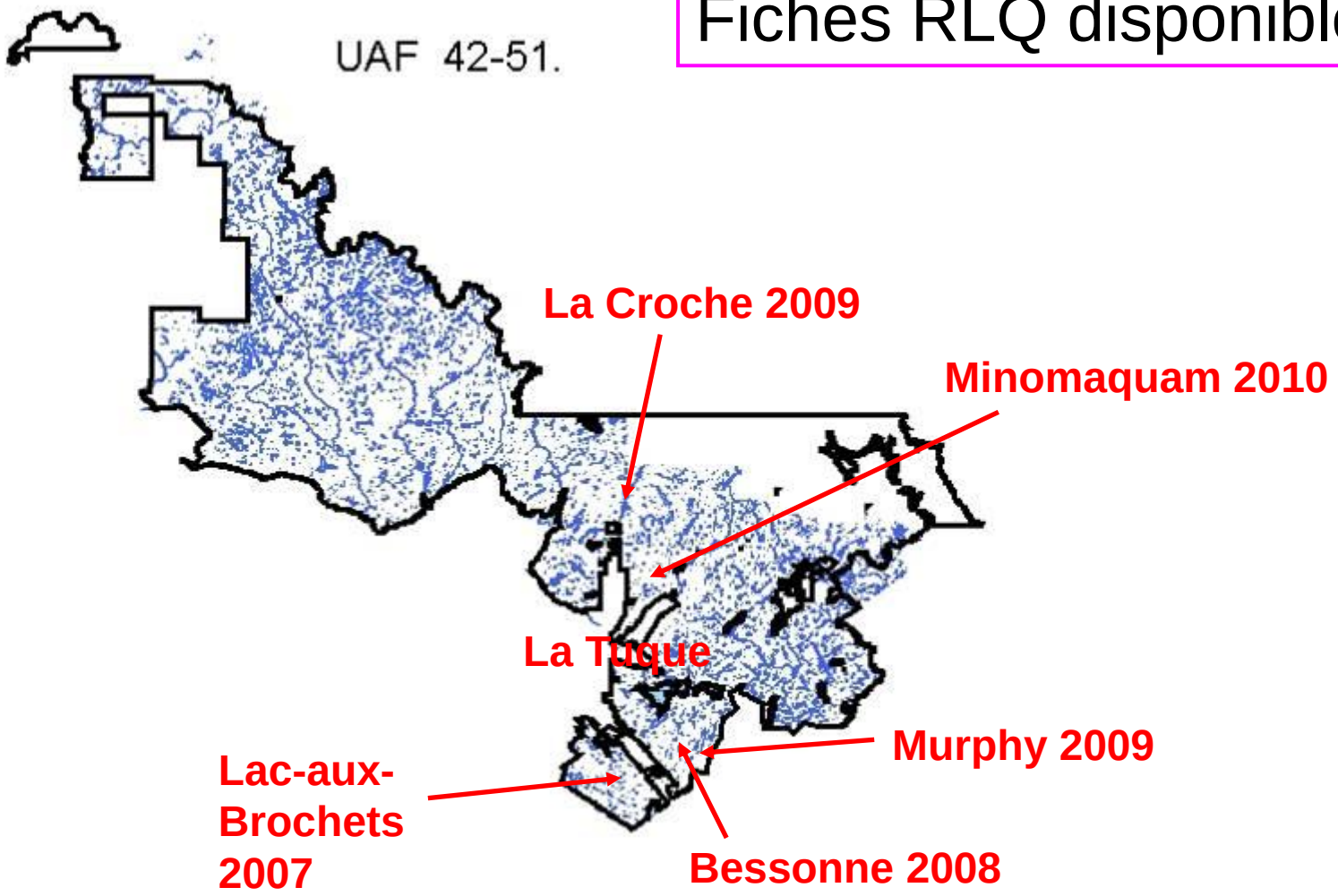
- **Trouver suffisamment de terrain (500 ha / année)**
- **Garantir un niveau de rendement pour l'atteinte des objectifs de zonage, et diminuer les coûts**
- **Rendre les plantations plus acceptables socialement, augmenter leur résilience**
- **Changement d'échelle, du peuplement au paysage**
  - Ne laissez pas la plantation cacher la forêt!



Paquette, A. and C. Messier. 2013. Chapter 13 - Managing Tree Plantations as Complex Adaptive Systems. *in* C. Messier, K. Puettmann, J., and K. D. Coates, editors. Managing forests as complex adaptive systems: Building Resilience to the Challenge of Global Change. EarthScan (January 2013), New York.

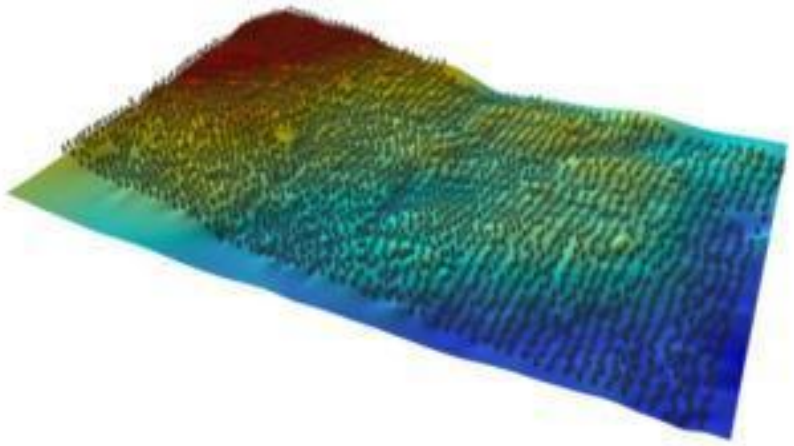
Survol des dispositifs de recherche

Fiches RLQ disponibles



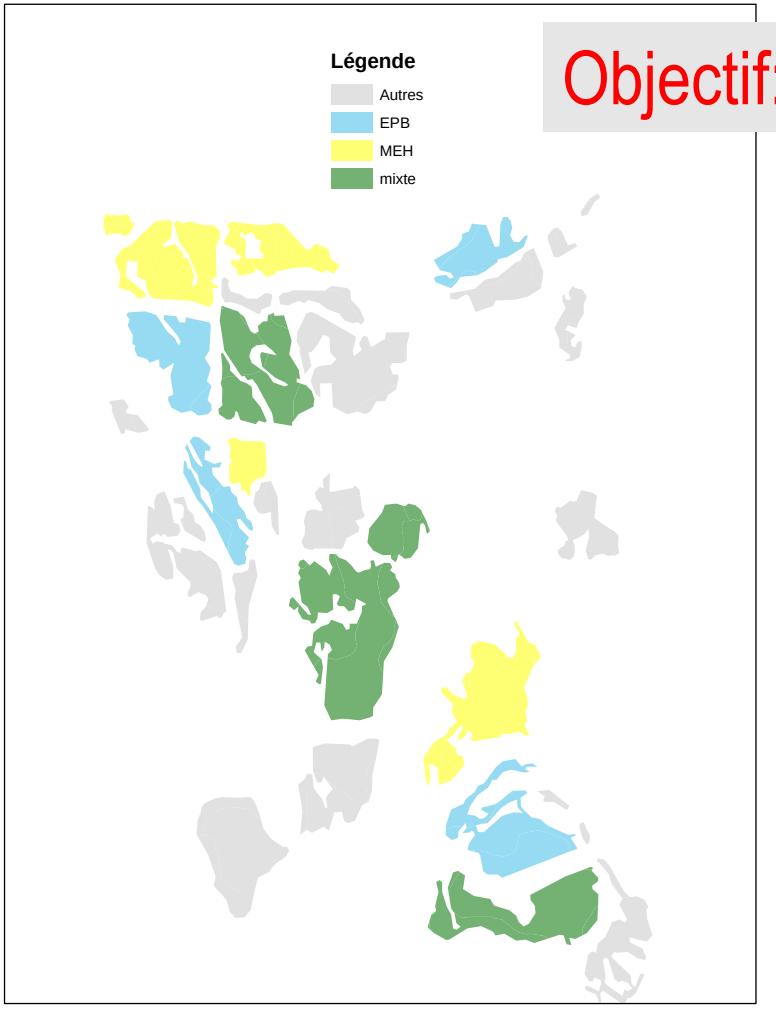
Lac-aux-Brochets (2007)

- **Espèces à croissance rapide**
  - Épinette blanche
  - Peuplier hybride
  - Mélèze hybride
- **Toutes combinations possibles**
  - Monocultures
  - 2-spp combos
  - 3-spp sur 3 arrangements



Bloc 3			Bloc 4		
3C	MEU	PEH	3C	EPB-MEU	MEU-PEH
3B	EPB-MEU	EPB	3A	PEH	EPB
MEU-PEH	3A	EPB-PEH	MEU	3B	EPB-PEH
3A	EPB-MEU	3B	EPB	EPB-PEH	3C
3C	MEU-PEH	MEU	3A	MEU-PEH	EPB-MEU
EPB-PEH	EPB	PEH	PEH	3B	MEU
Bloc 1			Bloc 2		

Bessonne (2007-8)



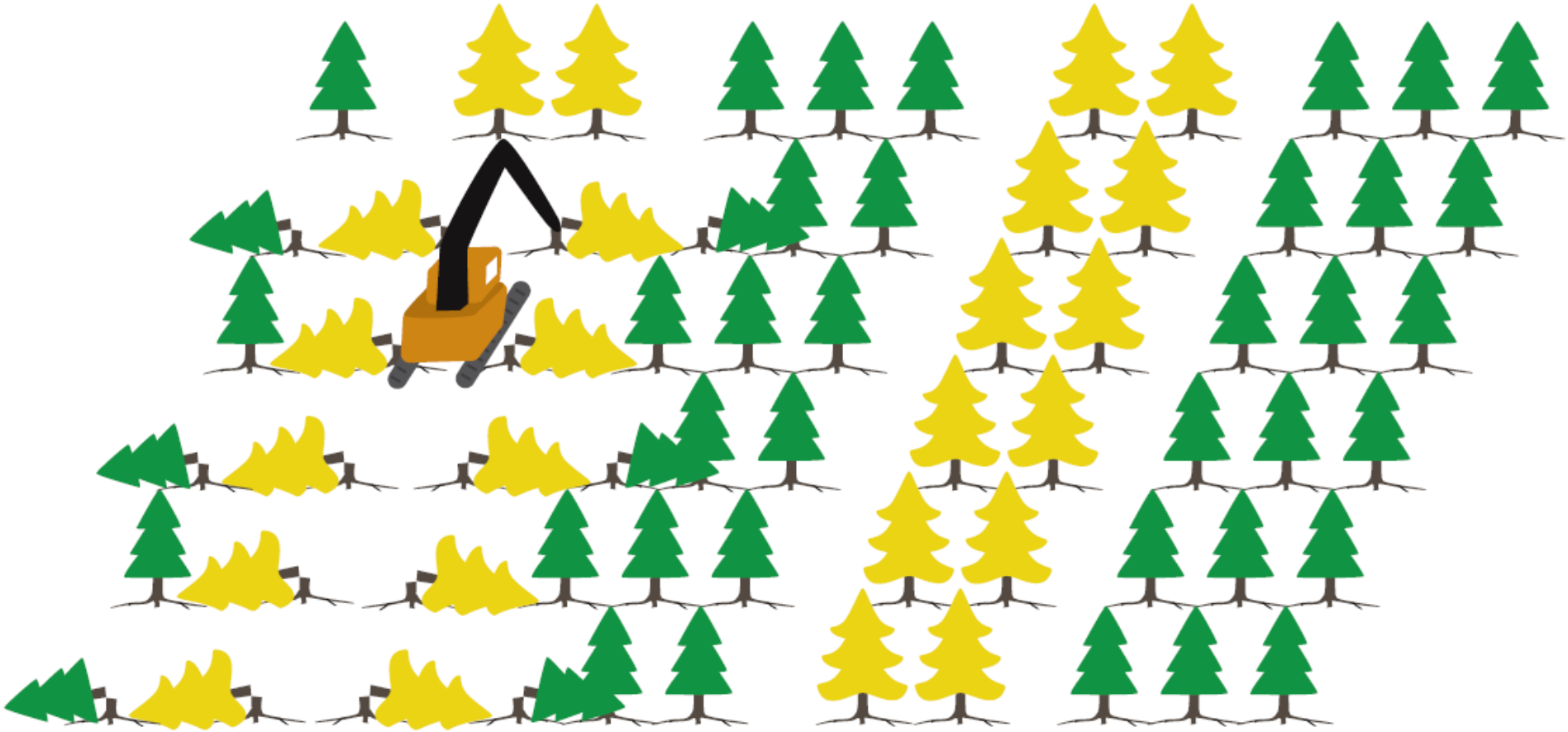
Objectif: rendre ces idées opérationnelles! ☺

Mélèze hybride en monoculture (3x2)

Épinette blanche en monoculture (2x2)

Plantation mixte
MEH 3x2 et EPB 2x2

Plantation mélangée mélèze – épinette → 1re récolte



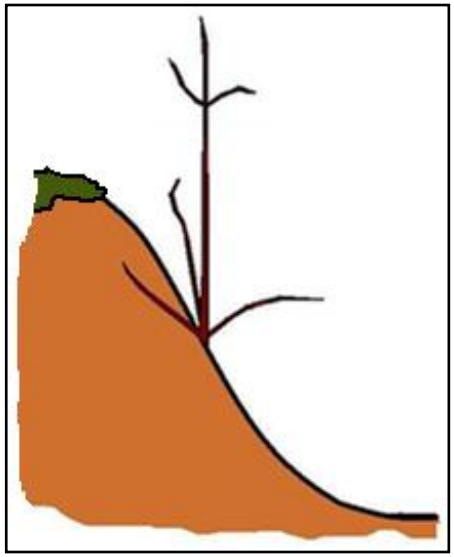
|---------- 9 ----------|

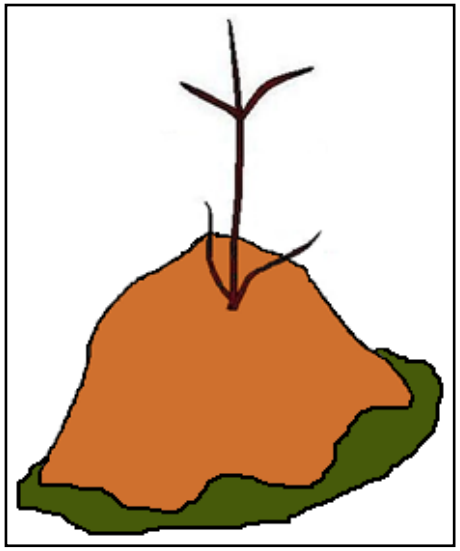
Urgent besoin de dispositifs opérationnels de démonstration, et de recherche!

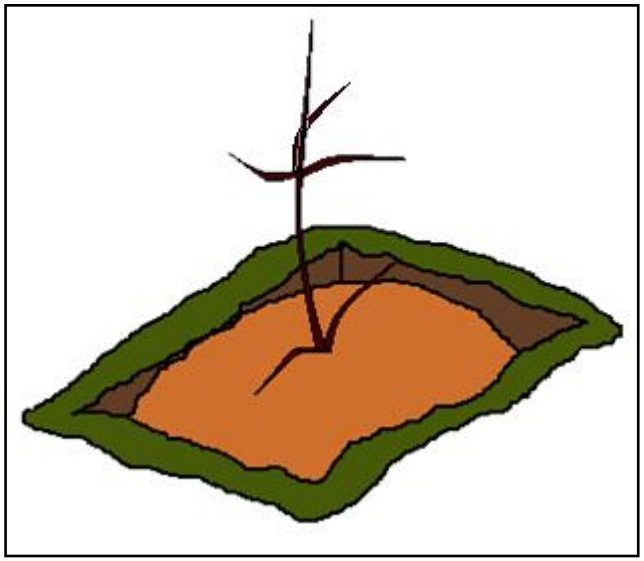
Murphy/Croche (2008-9) et Minomaquam (2009-10)

- **Tests de préparation de terrain, profondeur de plantation , et entretien pour les mélèzes exotiques**
  - Revue de littérature RLQ – AbitibiBowater
  - 3 sites, 200 ha environ, important gradient de conditions
- **6 préparations de terrain**
- **3 blocs expérimentaux (réplication) par site**

Établissement du mélèze hybride suivant différentes préparations de terrain



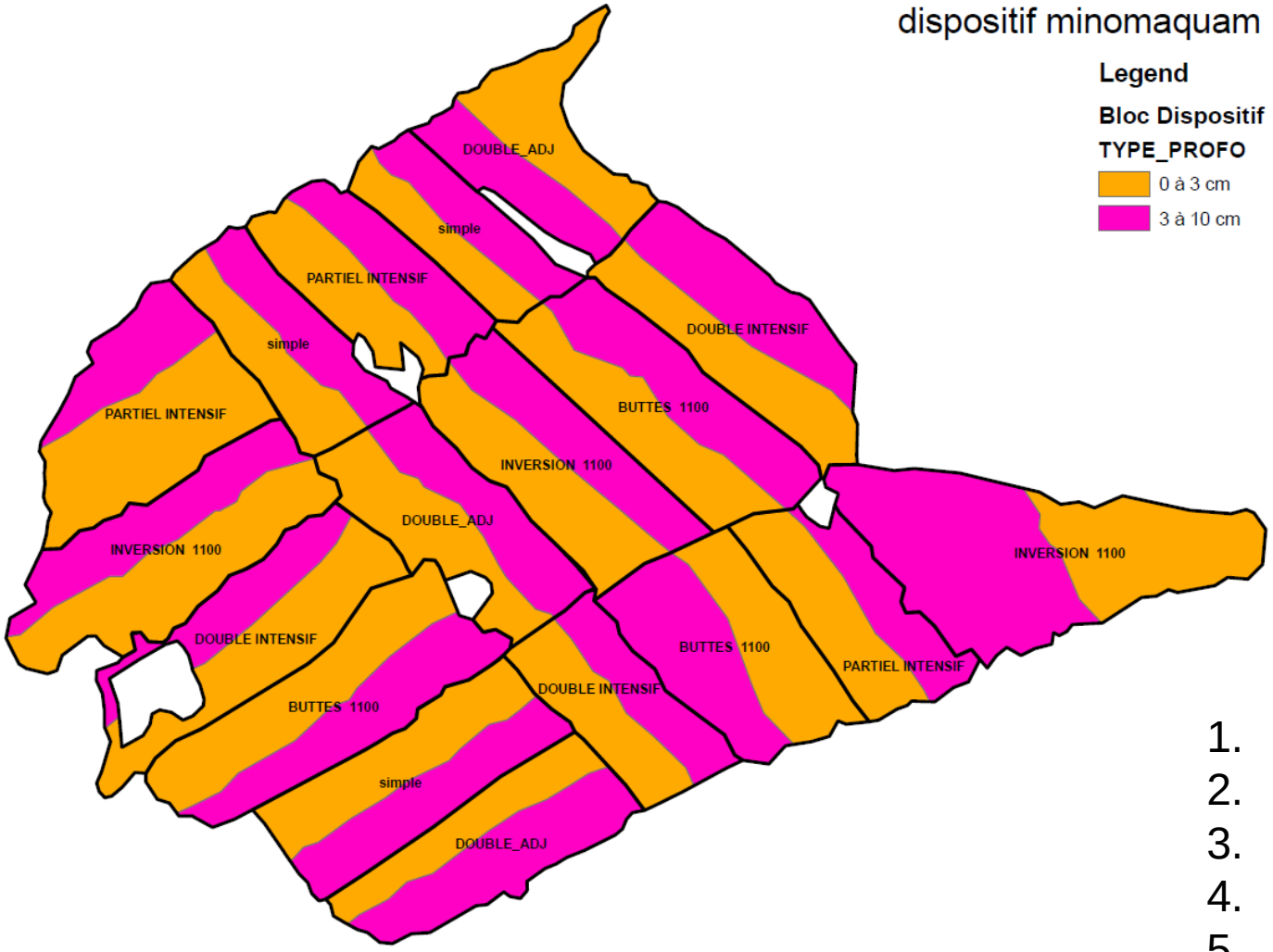




Mario Buitrago, Alain Paquette, Nelson Thiffault,
Nicolas Bélanger, Christian Messier

UQÀM | Ressources naturelles et Faune Québec | cef Centre d'étude de la forêt | abitibi bowater | TRIADE

Minomaquam (2009-10)



Mélèze hybride
Six préparations de terrain
Deux profondeurs de plantation
Trois blocs de réplication

1. TTS 1x
2. TTS 2x adjacent
3. TTS 2x intensif
4. TTS 2x partiel
5. Buttes
6. Inversions

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

A Journal of Macroecology

RESEARCH PAPER

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

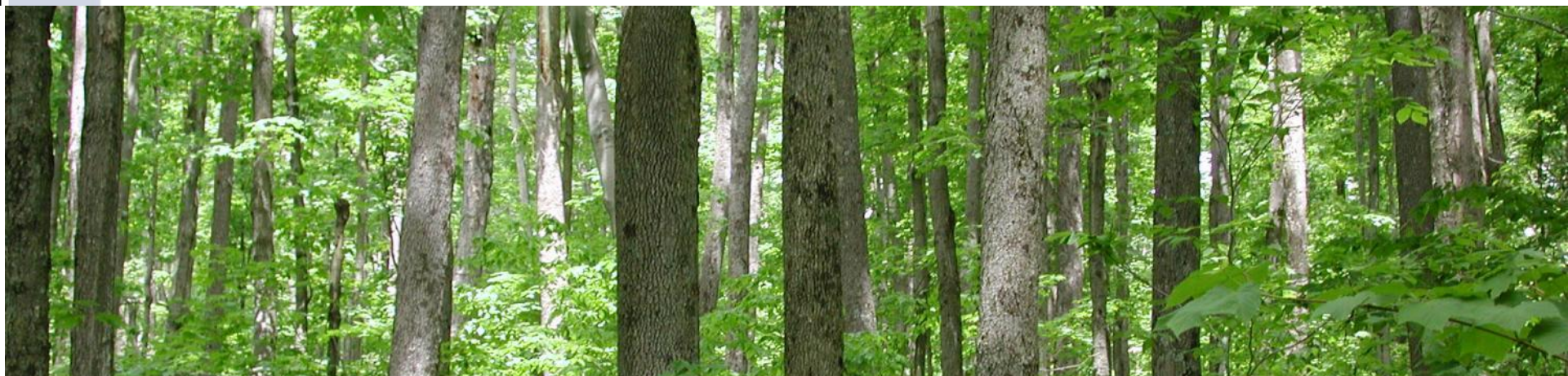
Alain Paquette* and Christian Messier

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

LES 10 DECOUVERTES DE L'ANNEE

ABSTRACT

Aim An important issue regarding biodiversity concerns its influence on ecosystem functioning. Experimental work has led to the proposal of mechanisms such as niche complementarity. However, few attempts have been made to confirm these in natural systems, especially in forests. Furthermore, one of the most interesting unresolved questions is whether the effects of complementarity on ecosystem functioning (EF) decrease in favour of competitive exclusions over an increasing productivity gradient. Using records from permanent forest plots, we asked the following questions. (1) Is tree productivity positively related to diversity? (2) Does the effect of diversity increase in less productive forests? (3) What metric of diversity (e.g. functional or phylogenetic diversity) better relates to tree productivity?



IDENT : International Diversity Experiment Network with Trees

La Tuque, Montréal, Auclair, Cloquet, Solsona, SSM, Sardegna, Freiburg

Partner of the TreeDivNet

Collaborators:

Christian Messier, Alain Paquette, Tanya Handa, Nicolas Bélanger, Dan Kneeshaw et Tim Work (UQAM), Dominique Gravel (UQAR), Alison Munson (Laval), Bill Shipley (Sherbrooke).

Peter M. Reich (UofM), Michael Scherer-Lorenzen (TreeDivNet), Lluís Coll (CTFC), Bill Parker (OMNR), Simone Mereu (U. Sassari).

Does Biodiversity influence Ecosystem Processes?
- An Experiment with Trees -

Cornelia Marie Garbe, Alain Paquette, Christian Messier

UQÀM

cfr Center for Forest Research

What is Biodiversity?

Biological diversity or biodiversity is the variability among living organisms and can be measured on three levels

- genetic diversity
- species diversity
- ecosystem diversity

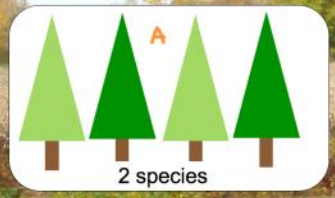
Why study Biodiversity?

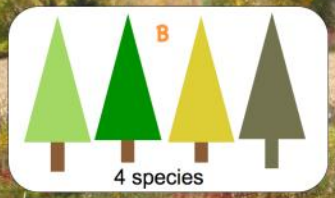
At the beginning of the 1990's, researchers realized that we are loosing species at an unprecedented rate. Naturally, we wonder:
Does this loss affect the ecological processes (e.g. productivity, decomposition, etc.) of those ecosystems.

How do we measure Biodiversity ?

- at the species level -

Is A more diverse than B?





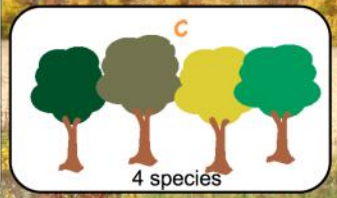
Species Diversity (SD)

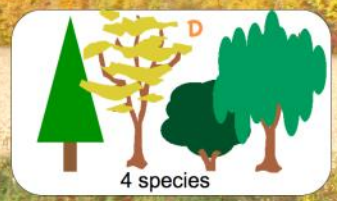
Biodiversity can be measured in number of species.
In this case, B (4 species) would be more diverse than A (2 species).

Functional Diversity (FD)

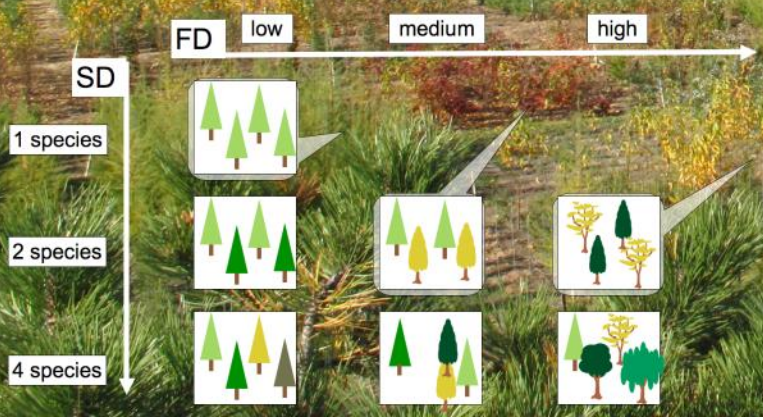
C and D have the same SD but are they equivalent?
By including functional traits, FD metrics reveal a different side of diversity (and D would be more diverse).

Is C more diverse than D?





The Experiment



Methods:

- almost 15.000 trees over 54 communities, replicated 4 times -
SD varying from 1 to 12 species
- large FD gradient (8 levels)

2009

Questions:

How does biodiversity influence:

- productivity
- decomposition
- arthropod diversity
- carbon stock
- roots

2011

Complémentarité: meilleure utilisation des ressources disponibles
Mécanisme: partition de niche
Mesure: diversité fonctionnelle

FIGURE A

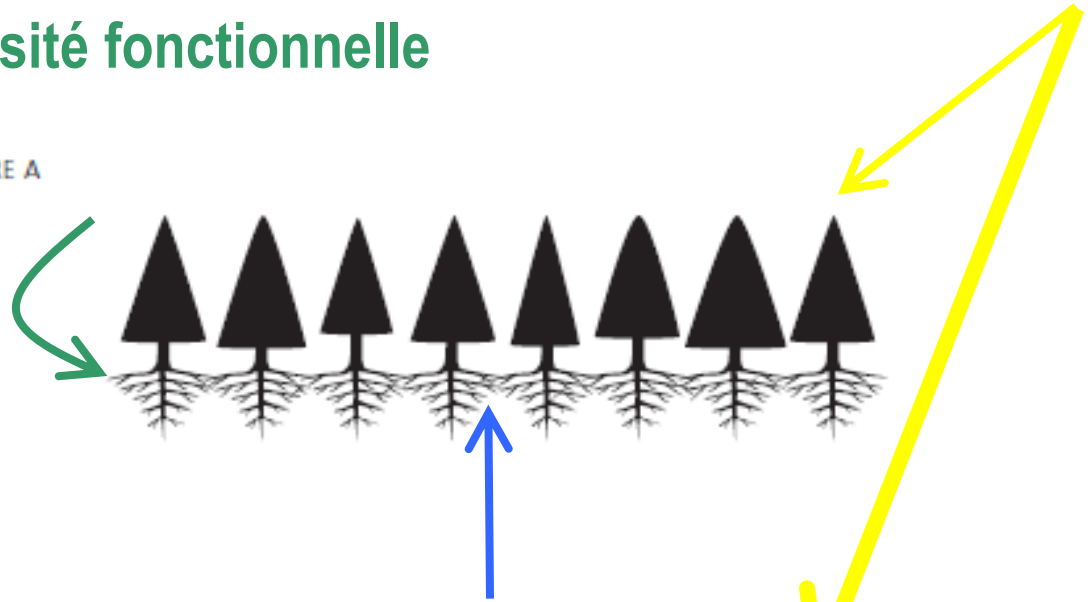
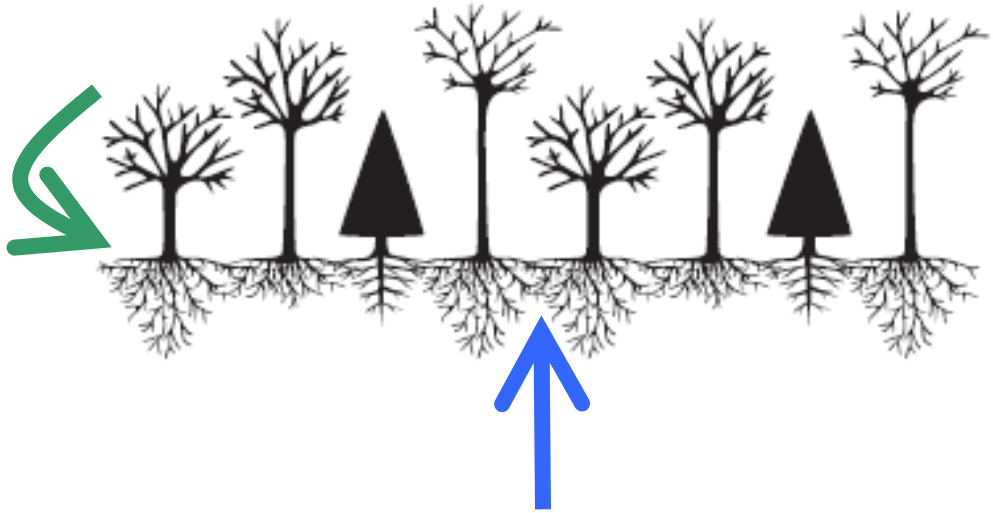


FIGURE B



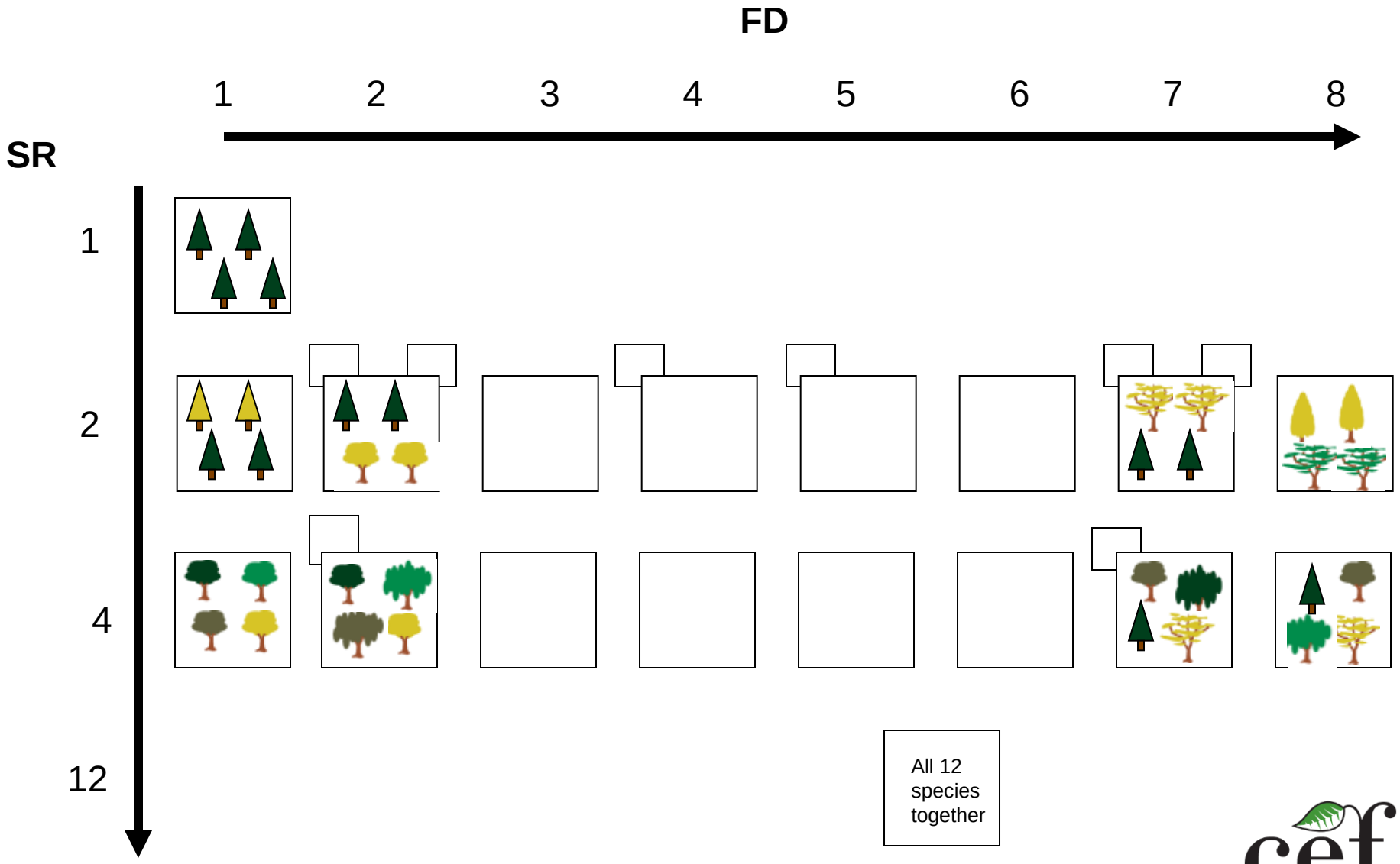
MAC 2009 (Montréal, Québec)

Auclair 2010 (Témiscouata, Québec)

Agroforesterie et CC

OURANOS

Montréal: 12 espèces



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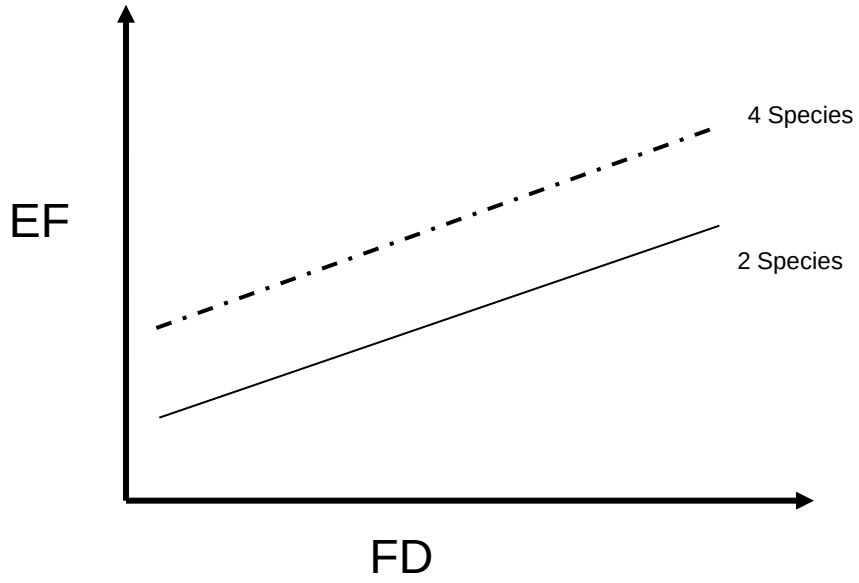
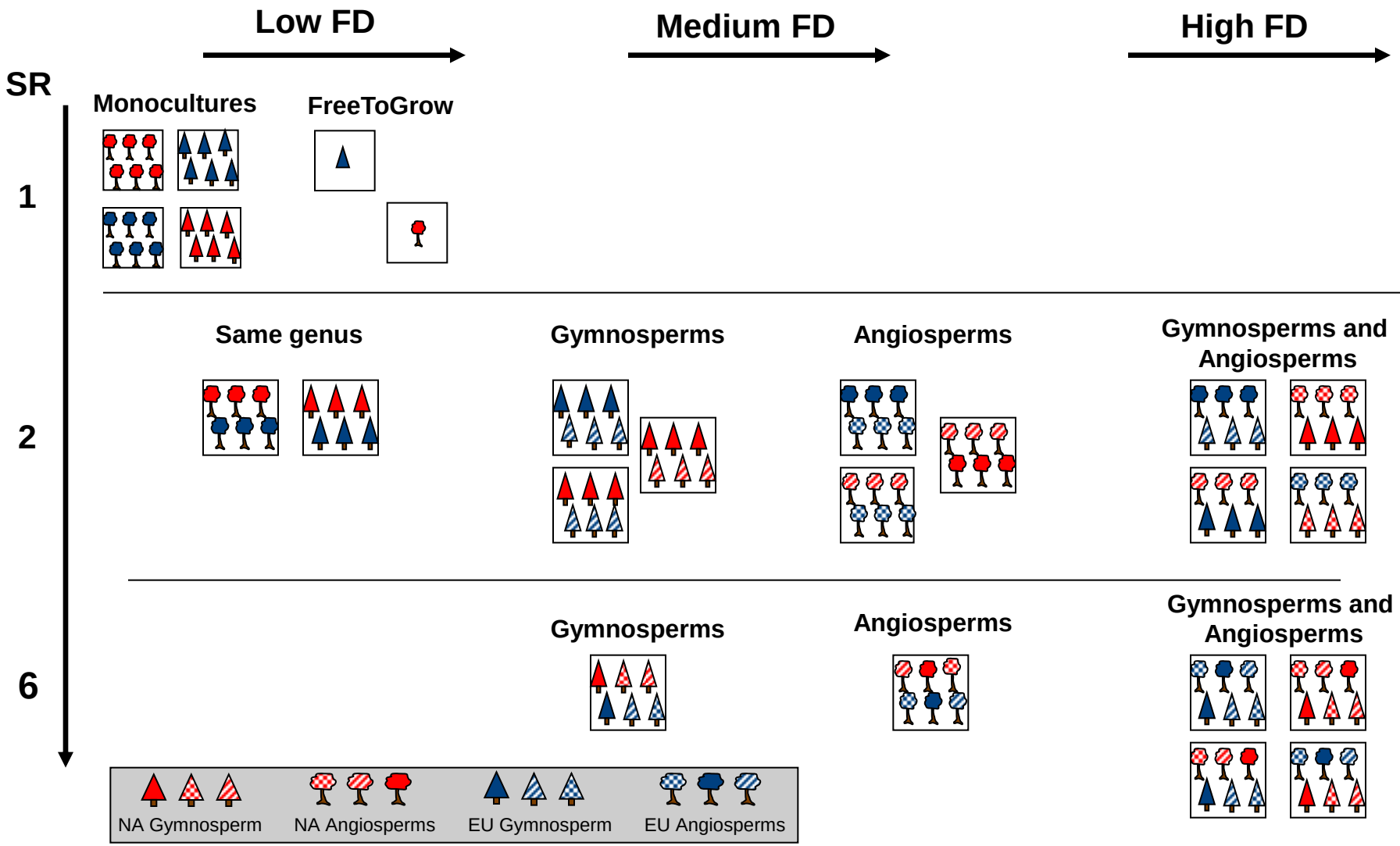
Centre d'étude de la forêt

Montréal: est-ce que la richesse apporte quelque chose de plus?



Auclair / Cloquet ; 12 espèces



Auclair / Cloquet : plan d'expérience 2010

Block A	1	2	3	4	5	6	7	8
A	QURU-QURO	LALA-BEPE	PIAB-PIST	PIST-PISY	BEPA-QURU	PIST	6 NA	NAgymno EUangio
B	PIAB-PISY	PIGL-PIST	PISY-LADE	PIAB	PIGL	PIGL-QURO	6 angio	BEPE-QURO
C	PISY	LALA-QURU	BEPA	ACPL-BEPA	6 EU	PISY-LALA	PIAB-ACSA	PIGL-LADE
D	LADE	QURU	ACPL	QURO	ACSA-ACPL	LADE-QURO	NAangio EUgymno	BEPA-BEPE
E	BEPE	QURO-ACSA	ACSA	PISY-BEPE	6 gymno	PIGL-PIAB	ACPL-BEPE	LALA-LADE
F	QURU-ACPL	PIST-LALA	ACSA-BEPA	PIGL-ACSA	PIAB-ACPL	PIST-BEPA	LADE-QURU	LALA

12 espèces

6 Gymno; 6 Angio

6 NA; 6 EU

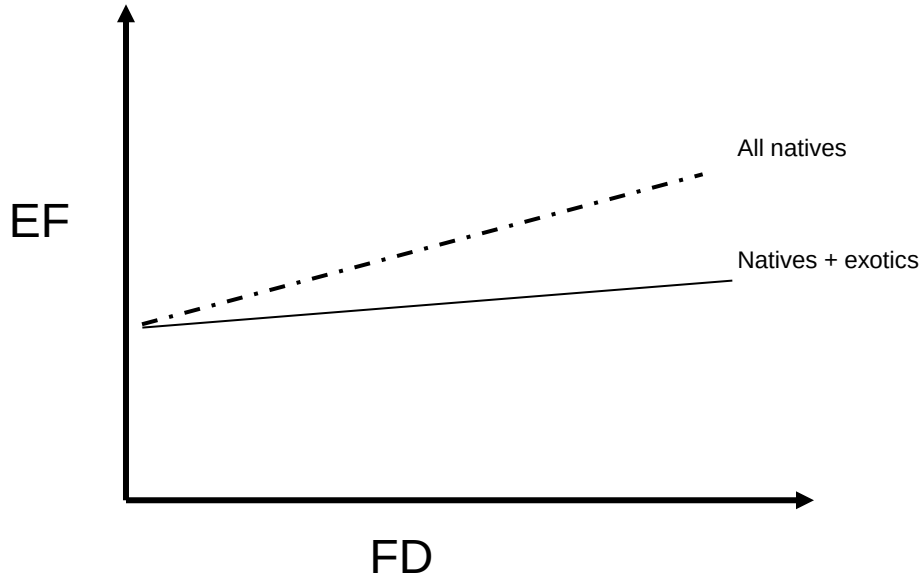
Coévolution

1, 2 et 6 espèces

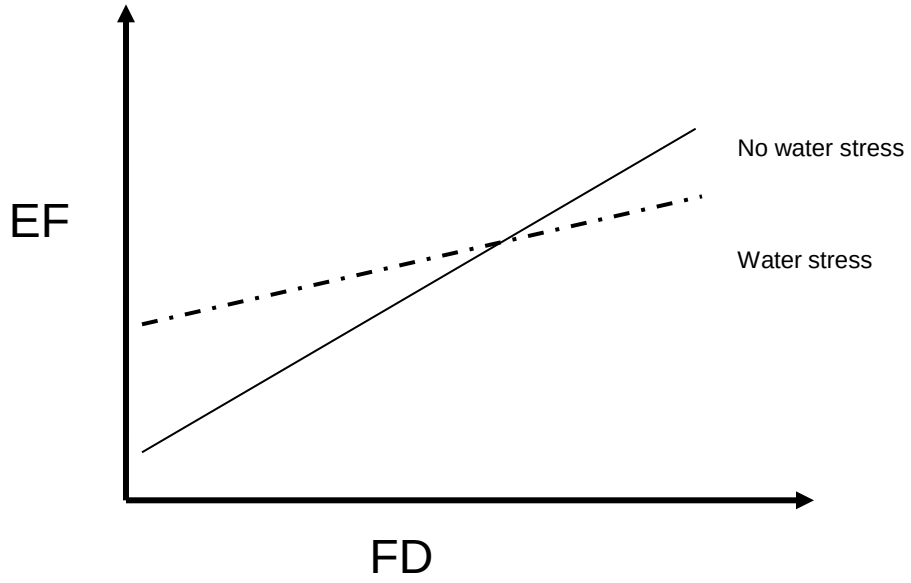
Gradient FD

Free-to-Grow

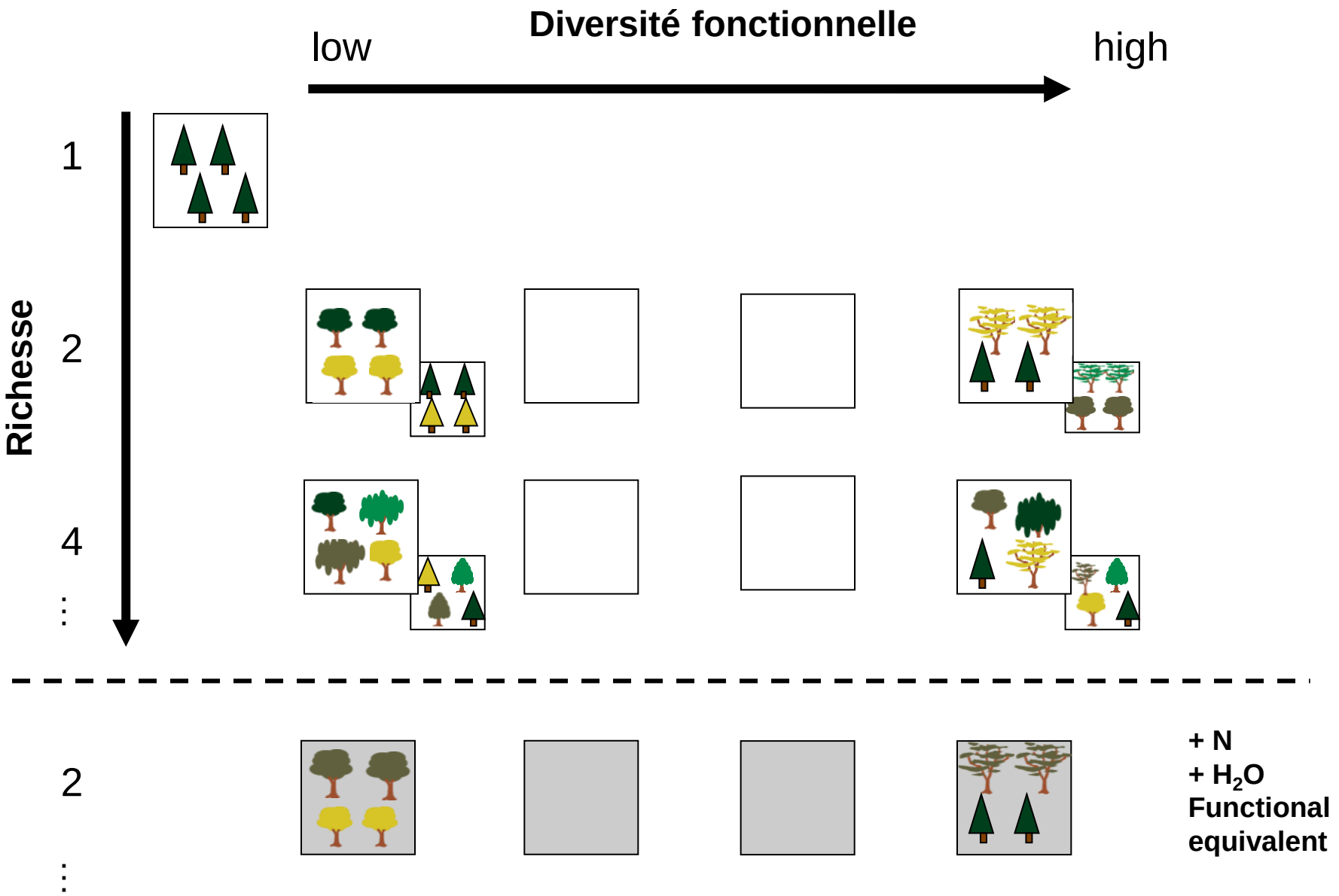
Auclair / Cloquet: niveau trophique, co-évolution?



Next generation IDENT: Changements globaux et stress environnmentaux



Sault-Ste-Marie, Solsona, et Sardaigne


Diversité fonctionnelle
low
high
Richesse
1
2
4
⋮
2
⋮
+ N
+ H_2O
Functional equivalent

Biodiversité des forêts et Résilience

Est-ce que des forêts diversifiées résistent mieux aux stress environnementaux, notamment ceux induits par les C.C.

Alain Paquette, Lluis Coll, Javier Retana, Jordi Vayreda, et Christian Messier

cef
Centre d'étude de la forêt

Question

Est-ce que les forêts diversifiées tolèrent mieux les CC → sécheresse?

Data = Espagne, Québec (5 biomes Koeppen)

Y= productivité

H_0: $\Delta_{low} = \Delta_{high}$
H_1: $\Delta_{low} > \Delta_{high}$

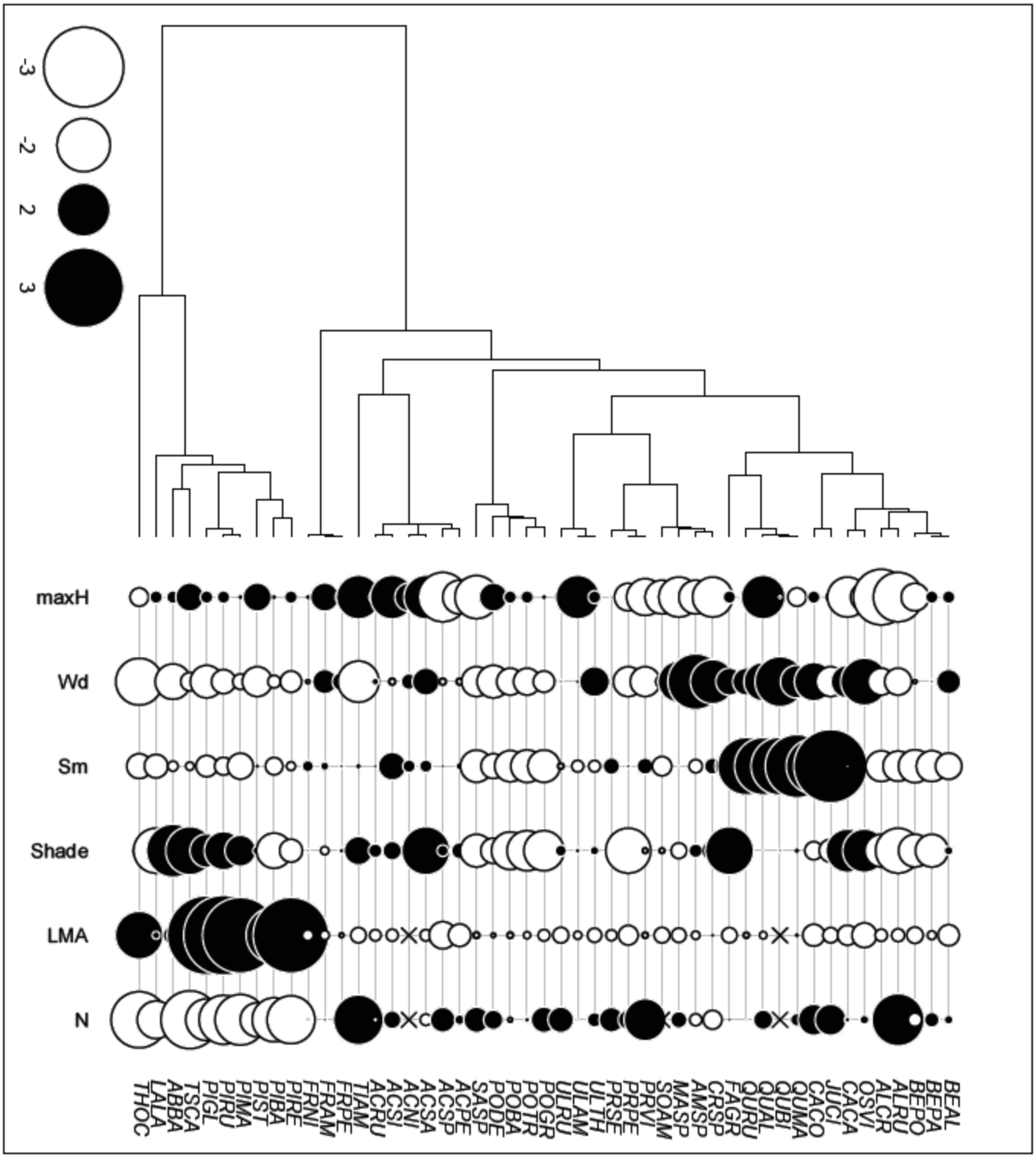
P = Anomalie + BD + Env. + Clim. + Ano. x BD

Diversité des traits fonctionnels liés à la productivité forestière et déterminants phylogénétiques

Alain Paquette, Simon Joly, Christian Messier, …

- Quel est le lien entre l'histoire évolutives des espèces et les traits fonctionnels?
- À quel moment se fixent les traits dans l'évolution?
- Est-ce possible d'utiliser cette information en science BEF, pour se projeter dans le temps, et comme outil à la planification?

cef
Centre d'étude de la forêt


-3
-2
2
3
maxH
Wd
Sm
Shade
LMA
N
THOC
LALA
ABBA
TSCA
PIGL
PIRU
PIMA
PIST
PIBA
PIRE
FRNI
FRAM
FRPE
TIAM
ACRU
ACSI
ACNI
ACSA
ACSP
ACPE
SASP
PODE
POBA
POTR
POGR
ULRU
ULAM
ULTH
PRSE
PRPE
PRVI
SOAM
MASP
AMSP
CRSP
FAGR
QURU
QUAL
QUBI
QUMA
CACO
JUCI
CACA
OSVI
ALCR
ALRU
BEPO
BEPA
BEAL

Densité et profondeur des plants

Préparations à la pelle mécanique souhaitable à 3x3m (1100/ha)

Étude du MRNF de 1991 à 2006-10 à Chapais et Amqui ne montre aucun effet de la profondeur de plantation, jusqu'à 10 cm

- EPN, PIG et EPB, 45-110 et 67-50, plantation manuelle et mécanisée, 0-1, 0-4, 6-8 et 10cm de profondeur
- Survie et croissance sur 15 à 19 ans ans : aucun effet
- Aucun effet sur le MEH au Minomaquam non plus

Paquette, A., Girard, J.-P., et Walsh, D. 2011. Deep planting has no short or long-term effect on the survival and growth of white spruce, black spruce and jack pine. North. J. Appl. For. 28(3): 146-151.