INRA
SCIENCE & IMPACT

EFIATLANTIC IEFC IUFRO

Intensification in the context of bioeconomy and circular economy : status and foresight

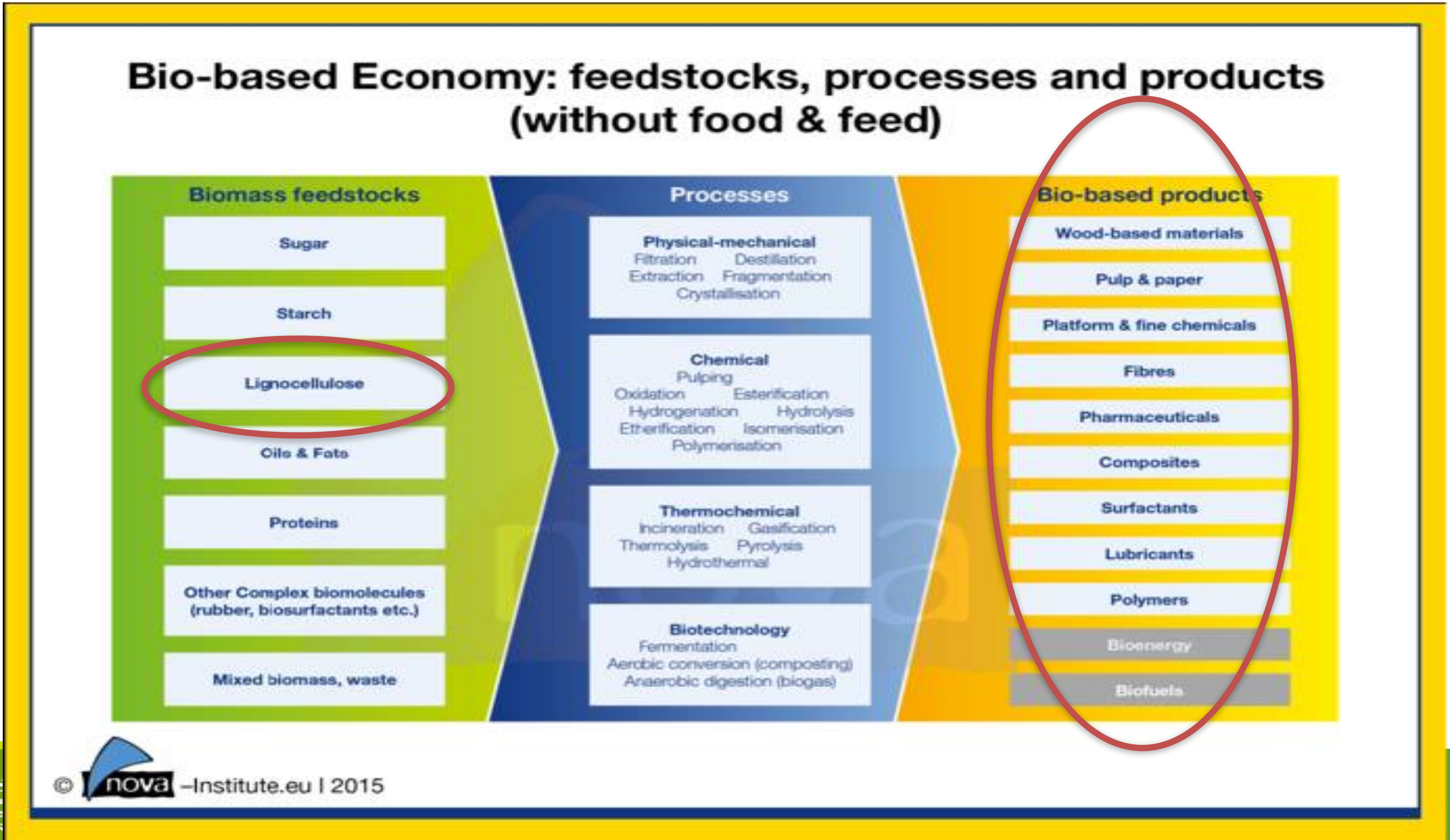
Jean-François Dhôte, Catherine Bastien, Jean-Michel Carnus,
Catherine Collet, Barry Gardiner, Myriam Legay, Laurent Saint-André

International Scientific Seminar, **Biarritz, June 13th 2016**
« Sustainable intensification of planted forests : how far can we go ? »

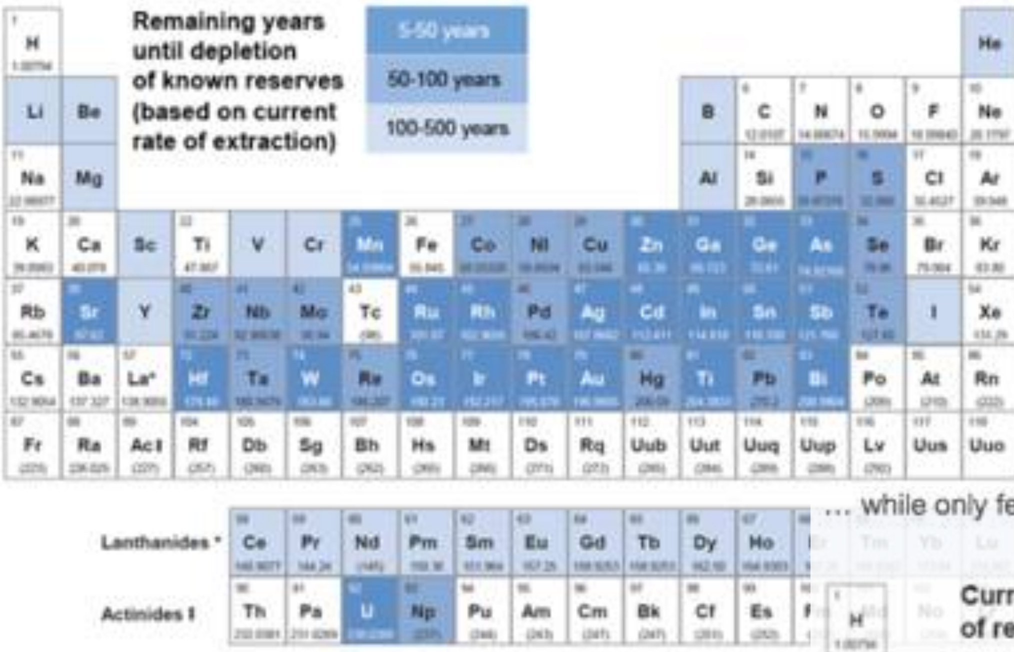
Objectives of the talk

- Background (trends & perspectives) :
  - world population & développement → demand of wood-products
  - forests : provide an increasing range of product/services, under stronger constraints, pressure by other land-uses (re-emerging)
  - bring **an integrated response to climate change** : adaptation, mitigation, regulation of ecosystem services, planning
  - need to **redesign production/management systems**
  - **imitation of nature** (Lorentz & Parade, 1837) → « *close-to-nature forestry* »
- 3 focus about nature/silviculture/intensification/ecology :
  - ➡ adaptive potential of close-to-nature forestry
  - ➡ options for diversification & planning
  - ➡ ecological intensification as **more efficient use of cycles**

Bioeconomy : consider wood in the *big picture*, supply new usages/production chains



Many resources are forcasted to run out within a relatively short period, …



http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains/mounting-pressure-on-resources/

… while only few materials are recycled at scale

Source: Professor James Clark, Green Chemistry, The University of York

From linear to circular economy: complexity management and modelling

dominique.luzeaux@polytechnique.org | 5/11/2014

http://www.mosim2014.org/sites/mosim2014.org/files/pdf/Pleniere_D.Luzeaux.pdf

« Grey » renewables energies (wind, PV) consume lots of rare elements : unsustainable !

« la **dépendance des éoliennes au néodyme et au dysprosium**, deux métaux de la famille des terres rares qui constituent les aimants permanents actuellement nécessaires pour l'alternateur, illustrent bien cette question sensible des ressources minérales :

un déficit en dysprosium est prévisible à partir de 2020 compte tenu de l'augmentation de la demande actuelle.

Autre exemple avec des technologies **photovoltaïques** très prometteuses comme le CIGS (cuivre, indium, gallium, sélénium) qui sont confrontées aux mêmes enjeux :

on estime à 20 ans seulement le ratio « réserves sur production de l'indium »

Isabelle Blanc, 21 oct 2015, ParisTech Review.
Comment calculer l'**impact environnemental des énergies renouvelables ?**

http://www.paristechreview.com/2015/10/21/impact-environnemental-renouvelables/?utm_campaign=NL%2052%20-%20112015%20-%20Global%20EN&utm_medium=email_eCircle&utm_source=Global%20FR

Circular economy – an industrial system that is restorative and regenerative by design

PRINCIPLE 1

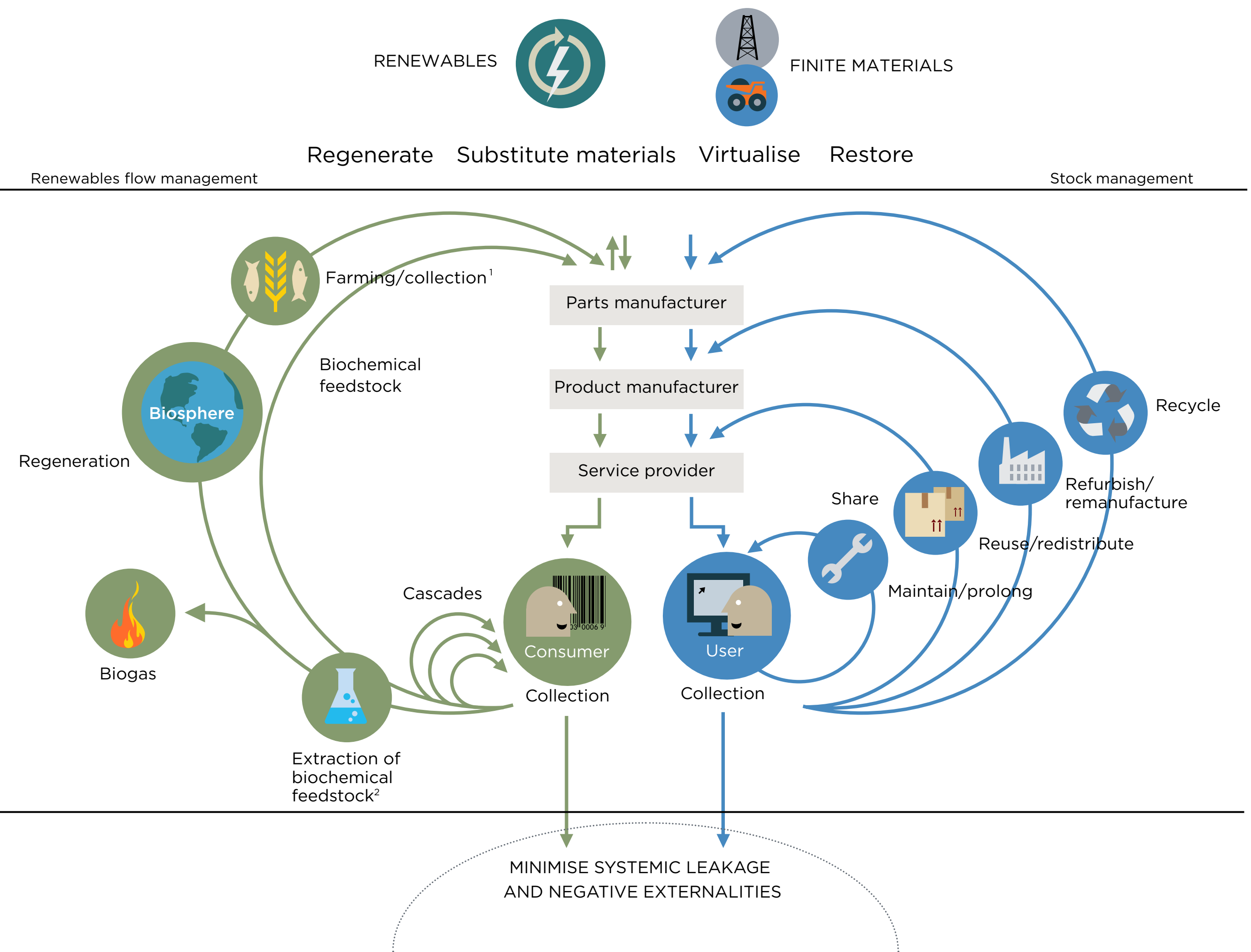
Preserve and enhance natural capital by controlling finite stocks and balancing renewable resource flows
ReSOLVE levers: regenerate, virtualise, exchange

PRINCIPLE 2

Optimise resource yields by circulating products, components and materials in use at the highest utility at all times in both technical and biological cycles
ReSOLVE levers: regenerate, share, optimise, loop

PRINCIPLE 3

Foster system effectiveness by revealing and designing out negative externalities
All ReSOLVE levers



1 Hunting and fishing
2 Can take both post-harvest and post-consumer waste as an input
SOURCE: Ellen MacArthur Foundation, SUN and McKinsey Center for Business and Environment, *Growth Within: A Circular Economy Vision for a Competitive Europe* (2015). Drawing from Braungart & McDonough, Cradle to Cradle (C2C).

_1

« Close-to-nature » forestry :

is it efficient as an adaptive strategy ? what does it mean (ref Anthropocene) ?

Extreme events such as storms, droughts, flooding, and heat waves are probably the **most important threats** in Temperate Oceanic regions […]

2010

natural mechanisms of **inherent adaptive capacity** are diverse and **will support adaptation** of forests to climate change. However, **natural processes alone are too slow to cope with** the projected rates of environmental change […]

from European biogeography it can be inferred that **adaptive capacity is smallest at the rear edge** of the forest biome, where only short-term adaptation and plasticity are able to counteract the threat of extirpation of forest species under less suitable climate conditions. There are **considerable differences in socio-economic adaptive capacity** within Europe and **it is worrying that this is smallest in the Mediterranean region where the largest potential impacts are expected**

Lindner, M., M. Maroschek, S. Netherer, A. Kremer, A. Barbati, J. Garcia-Gonzalo, R. Seidl, et al., 2010. « Climate change impacts, adaptive capacity, and vulnerability of European forest ecosystems ». Forest Ecology and Management 259(4): 698–709

2014

Review

Journal of Environmental Management 146 (2014) 69–83

Climate change and European forests: What do we know, what are the uncertainties, and what are the implications for forest management?

Marcus Lindner [a], Joanne B. Fitzgerald [a, *], Niklaus E. Zimmermann [b], Christopher Reyer [c, d], Sylvain Delzon [e, f], Ernst van der Maaten [g, h], Mart-Jan Schelhaas [i], Petra Lasch [c], Jeannette Eggers [a, j], Marieke van der Maaten-Theunissen [g, h], Felicitas Suckow [c], Achilleas Psomas [b], Benjamin Poulter [b, k], Marc Hanewinkel [b, l]

MOTIVE

Adapting forests to extreme storm events is - *outside Great Britain and Ireland with already existing particular storm adapted management strategies* - **an exception**, and **requires measures** such as limiting tree height **that are unpopular** and **against the dominating “close-to-nature” forestry** with long rotation periods in Central Europe

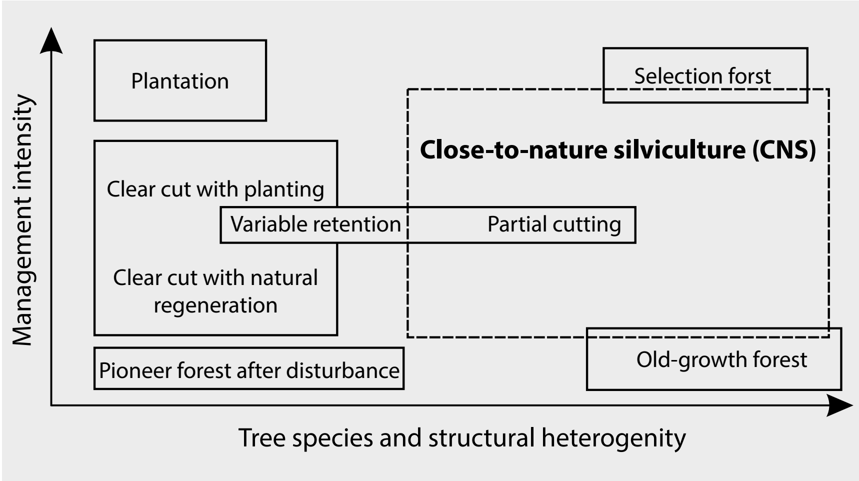


Figure 1
Classification of CNS according to management intensity as well as tree species and structural diversity. Adapted after Puettmann et al. (2009).

Utiliser des processus naturels pour guider les écosystèmes avec **le moins possible d'apports** en énergie (coûts) :

- promotion d'espèces naturelles et/ou adaptées à la station (non-natives acceptées en mélange avec des natives)
- forêts mélangées et structurées
- **éviter les coupes rases** autant que possible
- promotion de la **régénération naturelle**
- sylviculture d'arbres individuels
- **intégration** des services écosystémiques (eau, récréation…) **à grain fin**

Pommerening & Murphy (2004), Johann (2006), Spathelf (1997)

« **the restrictions of CNS** for the use of natural regeneration and 'low impact' interventions and the focus of CNS systems on mid- and late-successional tree species **limit the options for human-induced assistance of adaptation**, e. g. by introducing non-native or specific drought-resistant tree species and provenances »

Is Close-to-Nature Silviculture (CNS) an adequate concept to adapt forests to climate change?

Landbauforsch · *Appl Agric Forestry Res* · 2015 · online first · 1-10

Peter Spathelf*, Andreas Bolte**, and Ernst van der Maaten***

Forestry 2014; **87**, 492–503, doi:10.1093/forestry/cpu018
Advance Access publication 20 May 2014

Suitability of close-to-nature silviculture for adapting temperate European forests to climate change

Peter Brang[1]*, Peter Spathelf[2], J. Bo Larsen[3], Jürgen Bauhus[4], Andrej Bončina[5], Christophe Chauvin[6], Lars Drössler[7], Carlos García-Güemes[8], Caroline Heiri[1], Gary Kerr[9], Manfred J. Lexer[10], Bill Mason[11], Frits Mohren[12], Urs Mühlethaler[13], Susanna Nocentini[14] and Miroslav Svoboda[15]

6 strategic principles (to increase adaptive capacities) :

1. Increase tree species richness (at the stand scale)
2. Increase structural diversity
3. Maintain and increase genetic variation within tree species
4. Increase resistance of individual trees to biotic and abiotic stress
5. Replace high-risk stands
6. Keep average growing stocks low

3 types of close-to-nature silviculture (CNS)

1. Single-tree selection, which also includes 'continuous forest'
2. Group selection
3. Shelterwood

Single-tree selection has limitations :

- very small gaps favour few shade-tolerant species, exacerbated if no tending
- enrichment planting often not used (browsing damage constraint)
- rarely uses non-native species with high adaptive capacity (Douglas fir)
- variant « target diameter harvesting » may decrease genetic variation (trees with higher heterozygosity)

The **uniform shelterwood system :**

- has the lowest structural diversity in the long term
- but is more suitable for increasing tree species richness in the next forest generation, by facilitating the introduction of new species or provenances with enrichment planting

Shortcomings of CNS : 'species richness', 'genetic variation', 'replace high-risk stands'

➡ employ a **larger variation in regeneration methods**
➡ integrate light-demanding tree species, **non-native species** and **non-local provenances**
➡ **apply** different CNS types **at the landscape level**
➡ *overcome **restrictions** aimed at **conserving** genetic diversity of **local populations***

Forestry 2016; **89**, 1–6, doi:10.1093/forestry/cpv043
Advance Access publication 18 November 2015

What is close-to-nature silviculture in a changing world?

Kevin L. O'Hara*

The **silviculture of the future** will be **highly varied** and highly **flexible**, […] recognize the importance of adaptive or 'artificial' treatments such as tree **planting**, planting **non-native species**, **moving species beyond** their native range or **developing even-aged forests**. These are treatments that will **help forestry maintain productive** forest landscapes in a period of changing climate, conversion of forest land to other uses and expanding problems with invasive plants, insects and pathogens.

If the purpose of a close-to-nature forestry is to **persuade a doubtful public** that our intentions are good and our actions are sound, then **why risk alienation by using terms that are misleading** ? Why promote a suite of treatments that are artificially limited by **a selective interpretation of ecology** and truly unnatural ? […]

Whereas our understanding of natural processes and stand dynamics has advanced, **rebranding forestry** with new labels that use the words 'nature', or 'balance', or 'holistic' **is really just advertising** or a form of 'buzzword creep' (e.g. Park 2011). **If existing scientific information is ignored** to pursue management strategies based on **tradition, beliefs or old science**, the label of close-to-nature is simply **misadvertising**

Forestry 2013; **86**, 401–410, doi:10.1093/forestry/cpt012
Advance Access publication 21 May 2013

Silviculture in an uncertain world: utilizing multi-aged management systems to integrate disturbance†

Kevin L. O'Hara* and Benjamin S. Ramage

University of California, 137 Mulford Hall, Berkeley, CA 94720-3114, USA

Anthropocene : the distinction natural/artificial becomes less & less straightforward

« La caractéristique principale du naturalisme est son dualisme : s'il a permis, en objectivant la nature, d'en développer la connaissance scientifique, il est aussi ce qui permet d'opposer l'homme et la nature, alors même que **la distinction entre le naturel et l'artificiel, entre histoire humaine et histoire naturelle, est de plus en plus difficile à faire** »

Catherine Larrère, 2015. Pour une nouvelle approche de l'idée de « nature ». In « Guide des humanités environnementales » (éd. Aurélie Choné, Isabelle Hajek et Philippe Hamman), Presses universitaires du Septentrion

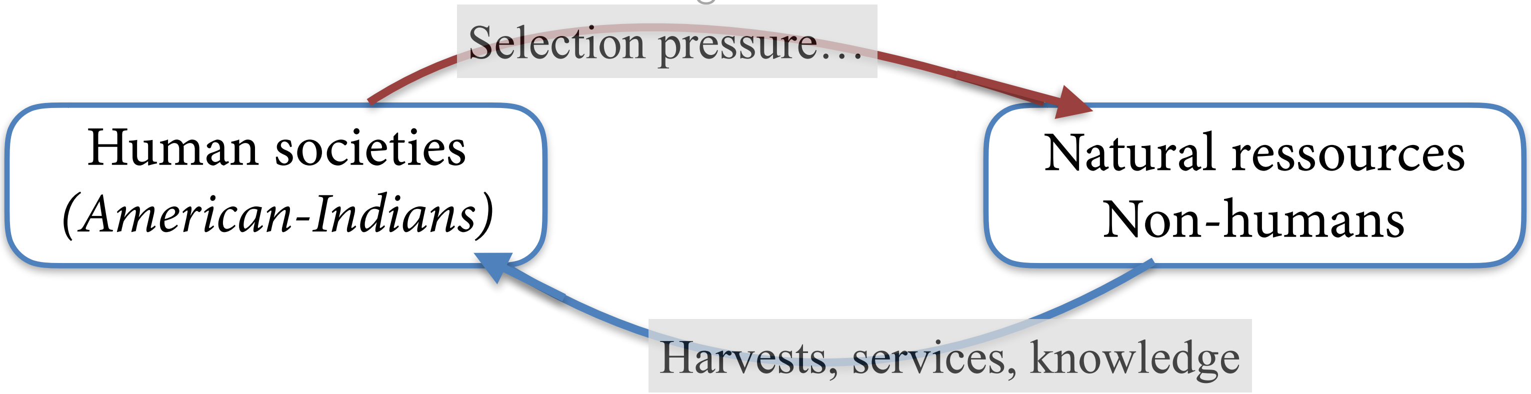
« Nous ne saurions penser et changer la société par les seules sciences. […] En revanche, elles ne peuvent plus être tenues à l'écart de nos décisions politiques. […] En ce seul sens, la nature entre résolument en politique.
Et **les sciences de la nature constituent dès lors les organes sensoriels de la politique** »

Dominique Bourg, 2 janv. 2016. Les sciences naturelles sont-elles révolutionnaires ?
http://sciences-critiques.fr/les-sciences-naturelles-sont-elles-revolutionnaires/

Descola, P., 2014. Les choix du monde de demain. *Presented at the meeting « L'homme peut-il s'adapter à lui-même? Options futures et marges d'acceptation », Collège de France, Paris, 23 mai 2014*

Philippe Descola : adaptation, co-evolution & Anthropocene

les humains participent évidemment de façon active à la production même des facteurs environnementaux qui affectent leur existence et, dans la très grande majorité des cas, sans en être conscients et dans la très longue durée



Avec l'**Anthropocène**, […]
ce qui s'était opéré de façon non intentionnelle, dans l'essentiel des cas,
et *sur une échelle de temps pluri-millénaire*, nous apparaît soudain […]
comme **réclamant une action volontariste à mener dans des délais très courts**

notre destinée **ne se résume pas à un face-à-face**, plus ou moins hostile ou plus ou moins bienveillant, **entre l'homme et la nature**, ainsi que la tradition naturaliste nous avait portés à le croire, mais que cette destinée est entièrement dépendante des **milliards d'interactions et de rétroactions** par lesquelles **nous engendrons**, au quotidien, **les conditions environnementales nous permettant d'habiter** la Terre

_2

Adaptation & mitigation :

paths for diversification under uncertainty, looking for performance and flexibility

Plant reproduction material produced in seed-orchards may bring a better mixing of initial genetic diversity

Diversité allélique

Mode de régénération	*Nb allèles SPAC 7.14*	*Nb allèles SPAC 12.5*	*déficit en hétérozygotes*
Régénération naturelle (après tempête)	**19 + 5**	**12 + 3**	**0,282**
Verger à graines	**27**	**18**	**0,074**

PSY-VG-003- Haguenau
4,3 ha
191 « arbres + » sélectionnés dans les parcelles autochtones Haguenau
5 à 17 copies par géniteur
Répartition aléatoire

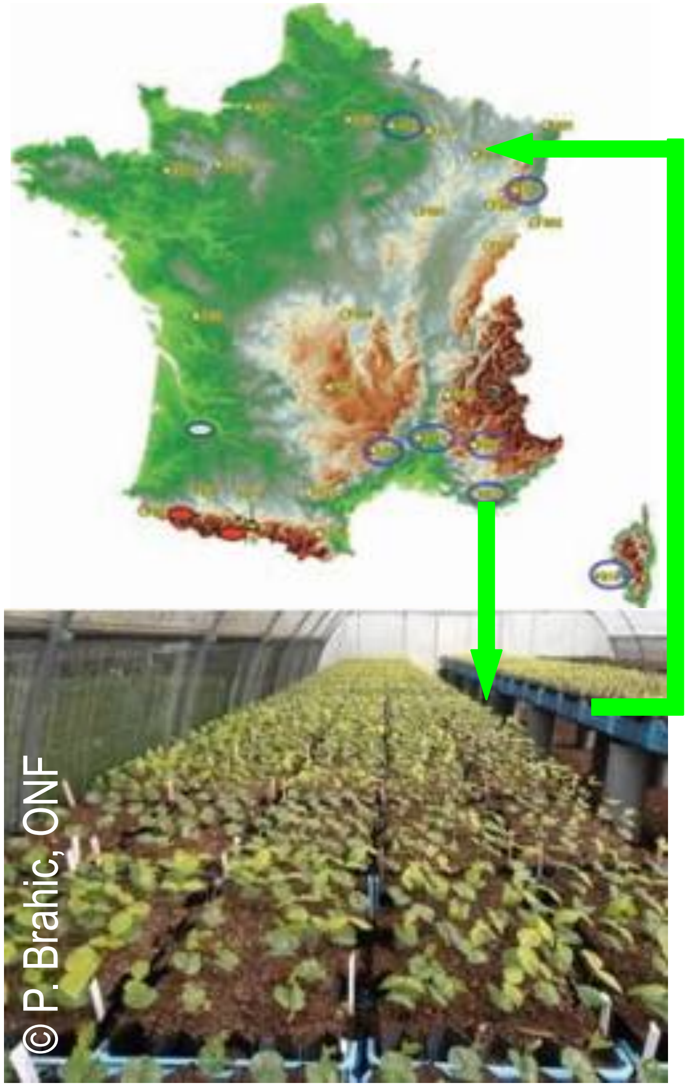
Diversité plus élevée en verger à graines

Réduction de l'apparentement dans le matériel collecté en verger à graines

Pas d'organisation spatiale de la diversité en plantation

Source : Catherine Bastien

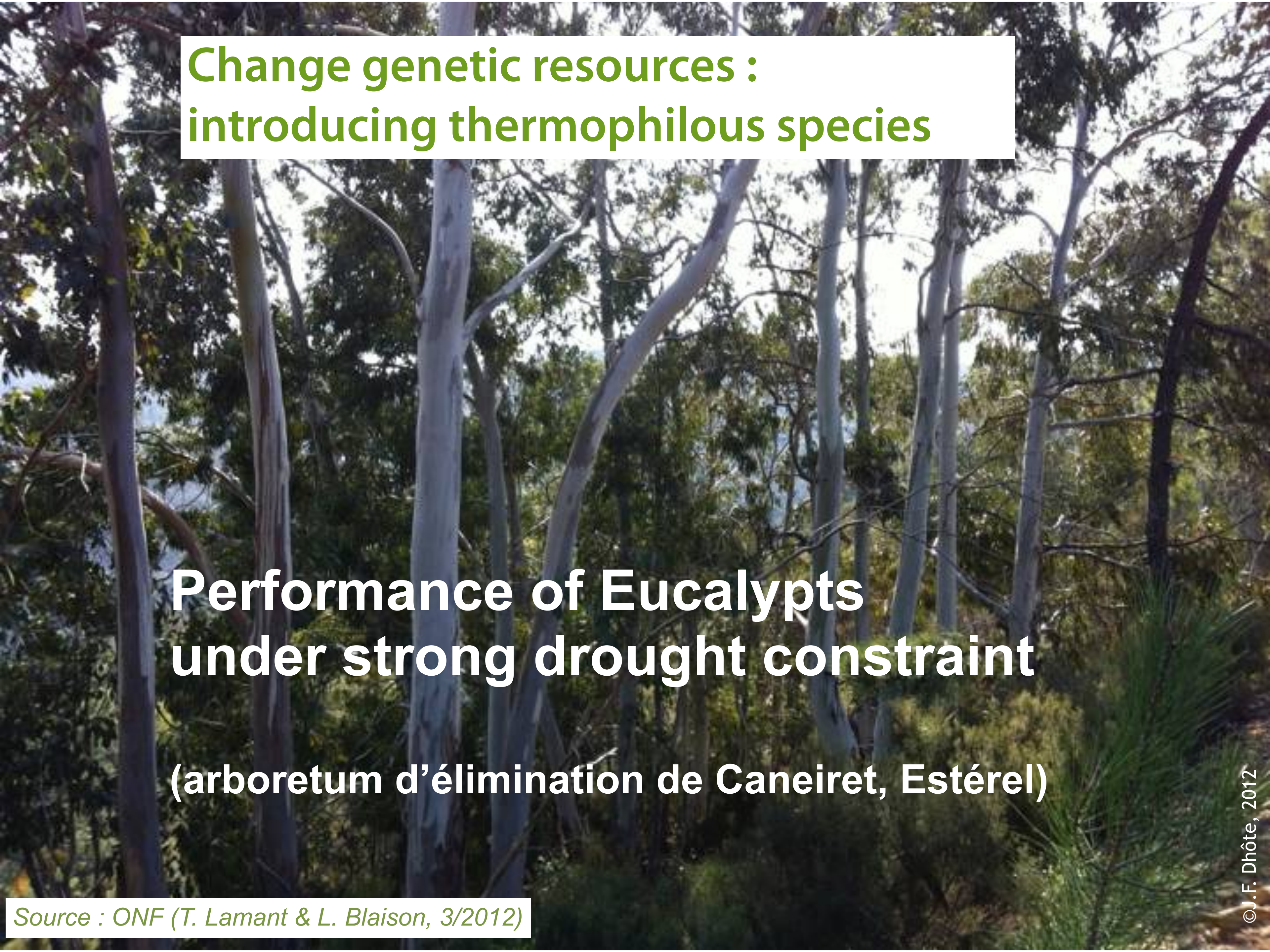
Change genetic resources :
moving populations polewards



Projet GIONO

- **Vulnerability of populations at southernmost margin of distribution areas**
  - monitoring/identification of vulnerabilities
  - safegarding in nurseries
  - planting on +northern locations
- **Applications :**
  - conservation of genetic resources
  - **strengthen local adaptation of autochthonous species**

Source : Brigitte Musch, Hervé Le Bouler, Olivier Forestier, Patrice Brahic, Myriam Legay (ONF)


Change genetic resources :
introducing thermophilous species
Performance of Eucalypts
under strong drought constraint
(arboretum d'élimination de Caneiret, Estérel)
Source : ONF (T. Lamant & L. Blaison, 3/2012)
©J.F. Dhôte, 2012