

Programme de recherche FORESTT

Résilience des forêts

REGE-ADAPT project

Forest regeneration and the adaptation of forest socio-ecosystems to climate change

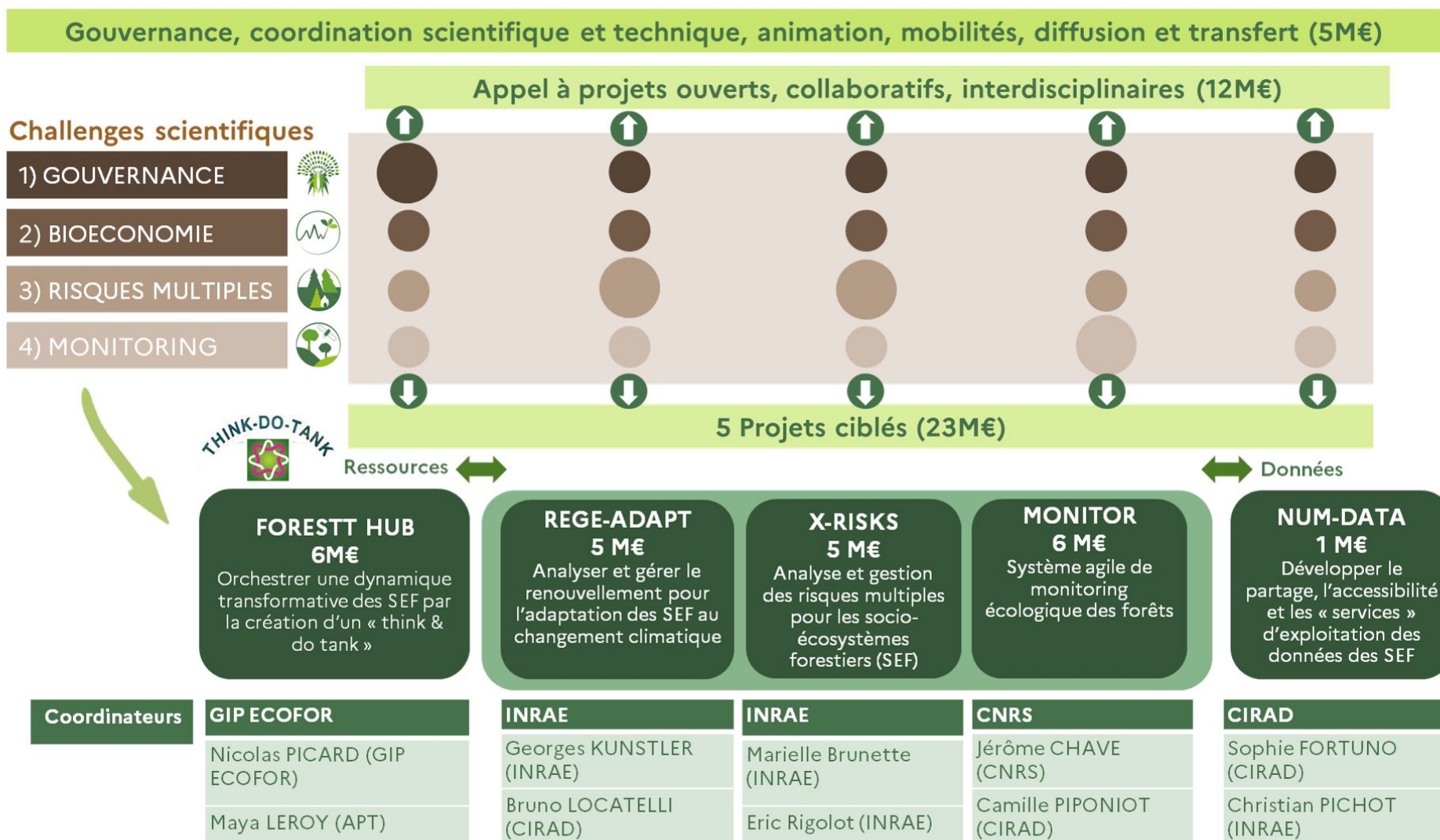


Georges Kunstler, Bruno Locatelli & team

28 June 2024

PEPR FORESTT

Forêts et changements globaux : systèmes socio-écologiques en transition



Pilotage : INRAE

Christophe Plomion &
Arnaud Sergent

Co-pilotage : CIRAD et CNRS

Partenaires éligibles: ONR,
ONF, CNPF, IGN, GIP ECOFOR

**Partenaires
non-académiques**

Durée : 6 ans (2024-2030)

Budget : 40 M€

- 5 Projets Ciblés (23M€)
- 1 appels à projets ouverts (12M€)
- Pilotage et gouvernance (5M€)

REGE-ADAPT

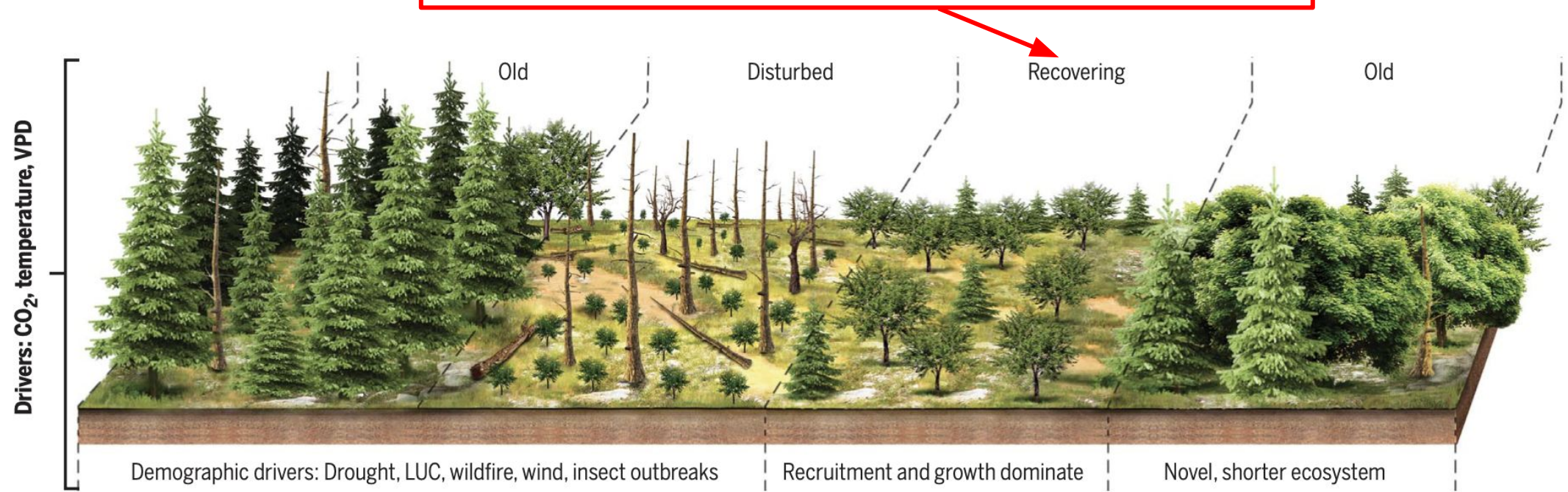
**Forest regeneration and the adaptation of forest
socio-ecosystems to climate change**



Forest regeneration to adapt to the 21st century climate

- Forest regeneration after natural disturbances and harvesting

Ecological & management processes



➔ **future forests**

Forest regeneration & societal choices



Pascal Xicluna / agriculture.gouv.fr

03 décembre 2020 Communiqué de presse

FranceRelance : le renouvellement forestier est lancé

[plan de relance](#) [forêt](#) [changement climatique](#)

Partager la page



Xavier Remongin/agriculture.gouv.fr

26 juillet 2023 Info +

« Objectif Forêt » : le rapport du comité spécialisé « gestion durable des forêts » en vue de l'élaboration du plan national de renouvellement forestier

[forêt](#) [changement climatique](#) [filière bois](#) [France Nation verte](#) [Carbone](#)

Regeneration pathways to adapt to 21st climate

Manage regeneration for

- Foster complexity
- Adapted species to CC
- Assisted gene flow
- Continuous-cover management
- Landscape connectivity

=> plantation & natural regeneration



Regeneration pathways impacts



- Biodiversity & soil conservation
- Nature's Contribution to People NCP (wood production, scenic beauty, recreation, watershed regulation)



Regeneration pathways to adapt to 21st climate



- Governance of regeneration by public and private sectors



- Influence of policies on regeneration pathways

Les pilotes et co-animateurs

REGE-ADAPT

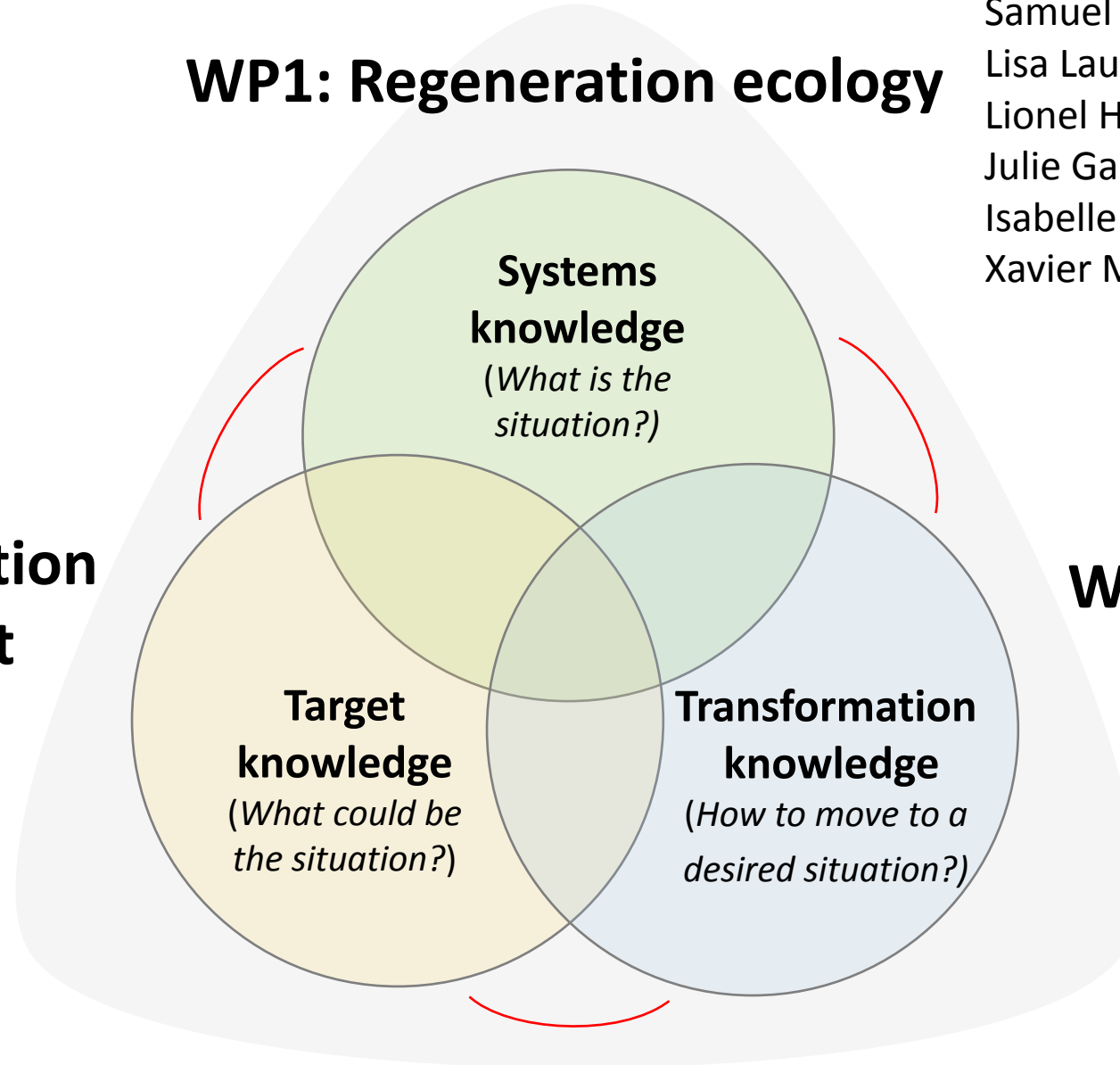
Georges Kunstler (INRAE)
Bruno Locatelli (CIRAD)

WP1: Regeneration ecology

Samuel Venner (LBBE),
Lisa Laurent (INRAE),
Lionel Hertzog (LIF IGN),
Julie Gauzere & Ivan Scotti (INRAE),
Isabelle Marechaux (INRAE),
Xavier Morin (CNRS)

WP2: Regeneration management

Catherine Collet (INRAE),
Emila Akroume (ONF),
Julie Gauzere (INRAE),
Benjamin Brachi (INRAE),
Ophélie Ronce (CNRS),
Philippe Balandier (INRAE),
Lisa Laurent (INRAE),
Xavier Morin (CNRS)

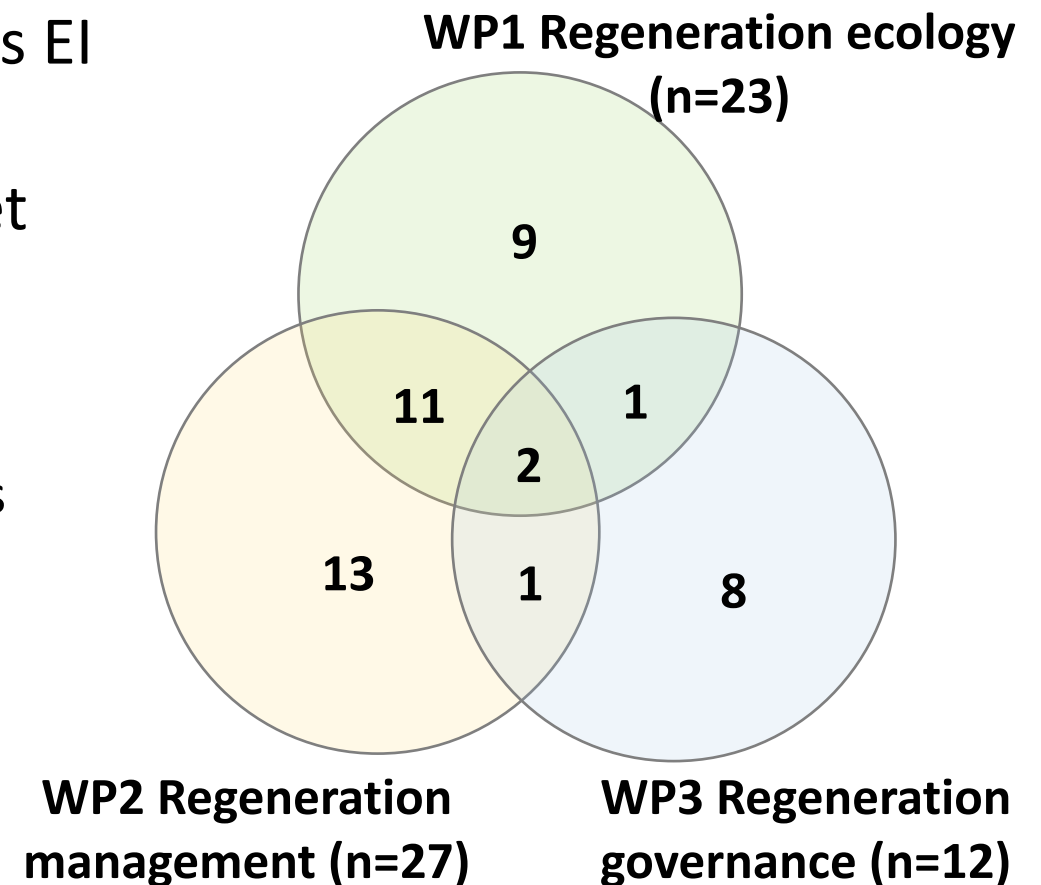


WP3: Regeneration governance

Laurent Berges (INRAE),
Sandrine Allain (INRAE),
Vincent Banos (INRAE),
Nelly Pares (MNHN),
Arthur Perrotton (CIRAD)
Pascal Marty (M. Oxford)

Le développement de REGE-ADAPT

- Webinaires de présentation fin septembre et début octobre 2023
 - 40 et 82 participants
- Appel à Expressions d'Intérêt clôturé le 31 octobre 2023
 - 45 réponses
- Travail entre co-animateurs pour organiser les EI
 - “Consolidation”
- Structurations en tâches dans 3 WPs + budget
 - Interactions co-animateurs & porteurs d'EI
- Résultats
 - Plus de 70 chercheurs identifiés sont mobilisés dans le projet
 - Plus les non-identifiés (par ex. futurs doctorants)
 - Coût total : 17 M€
 - Financement ANR : 5 M€
- Un grand merci !
 - Co-animateurs de tâches, Porteurs d'EI, Equipe du PEPR



Task overview

WP0: Synergies

0.1:
Animation

0.2:
Coordination

WP1: Ecology

1.1:
Seeds

1.2:
Advanced

1.3:
Genetic

1.4:
Models

WP2: Management

2.1:
Plantations

2.2:
Gene flow

2.3:
Diversity

2.4:
Barriers

WP3: Governance

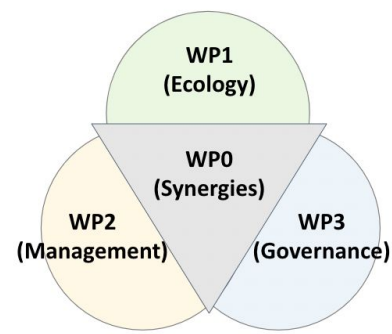
3.1:
Impacts

3.2:
Politics

3.3:
Actors

3.4:
Pathways

Quelques mots sur le WP0



WP0

Task 0.1: Synergies et animations scientifiques

Task 0.2: Coordination

Espaces d'échanges inter-WP

- sur approches, méthodes, modèles, pour recherche de complémentarité ou d'harmonisation.
- sur les moyens (terrains, dispositifs, données) pour partages, complémentarité, harmonisation

Le classique (planning, communication, outreach, reporting, etc.)

WP1
**Understanding the ecological
drivers of the regeneration
phase**

**WP1:
Ecology**

Task 1.1: Monitoring
seed production and
early seedling

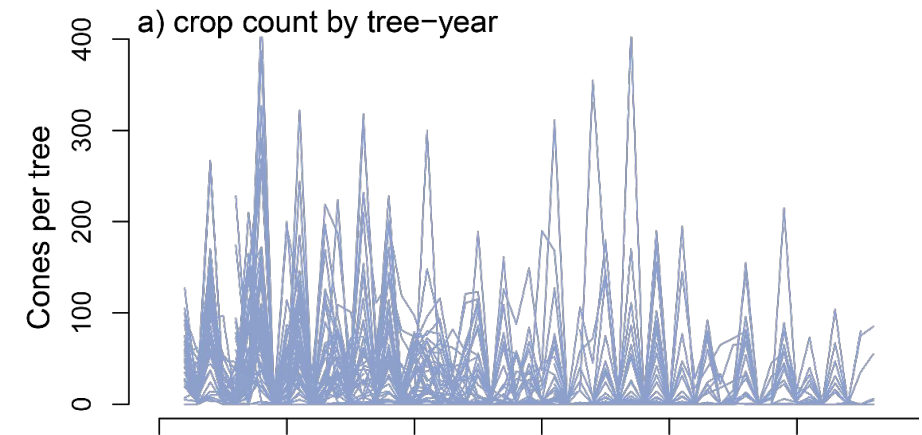
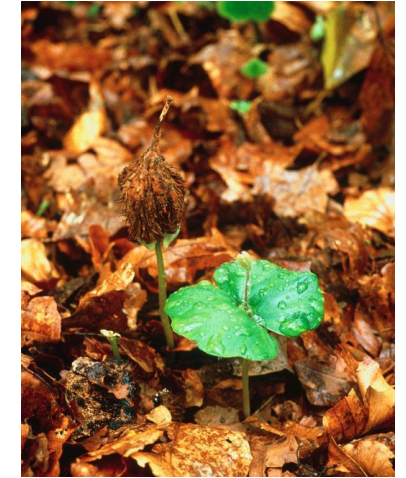
Task 1.2: Monitoring
advanced
regeneration

Task 1.3: Genetic
adaptive potential in
natural regeneration

Task 1.4:
Regeneration in
forest models

T1.1 Monitoring seed production and early seedlings

- Lack of national research network on seed production and seedling emergence
=> build on existing local networks to analyse:
 - Fecundity & Masting
 - Seed quality
 - Seedling emergence & browsing



Qiu et al. 2023

T1.1 Monitoring seed production and early seedlings

Task Leader(s): Georges Kunstler & Samuel Venner

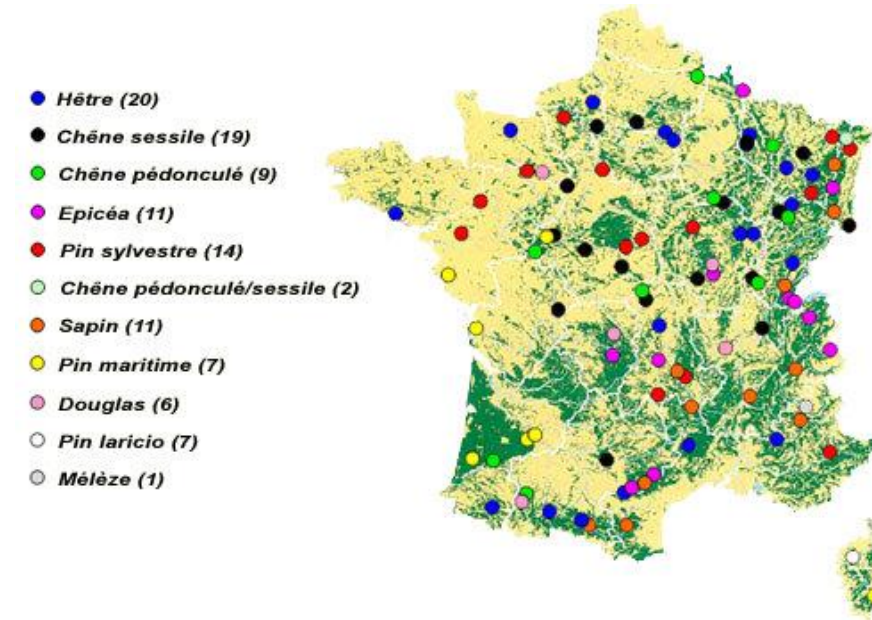
Partners: LESSEM (G. Kunstler B. Courbaud); LBBE (S. Venner M.-C. Venner); BIOGECO (S. Delzon, T. Caignard); BioForA (C. Teyssier); OFB (S. Saïd); ONF-RDI (V. Boulanger)

T1.1.1 Monitoring seed production & T1.1.2 Monitoring early seedling dynamics on RENECOFOR

T1.1.1b Analyse seed quality
(biochemical quality and
predation)

T1.1.2 Estimate pressure of large
mammals

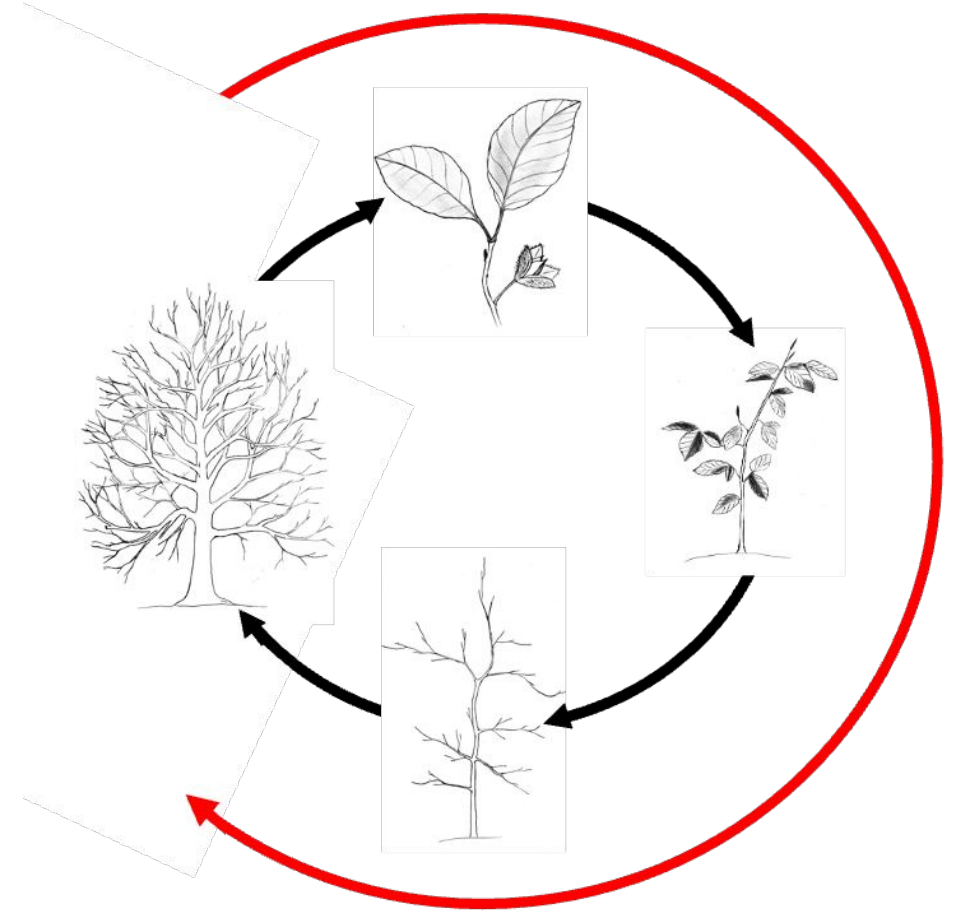
T1.1.3 PhD project on climate change effect on seed
production and seedling emergence



Selection of
RENECOFOR plots in
lowland and mountain
(and a few OFS sites)

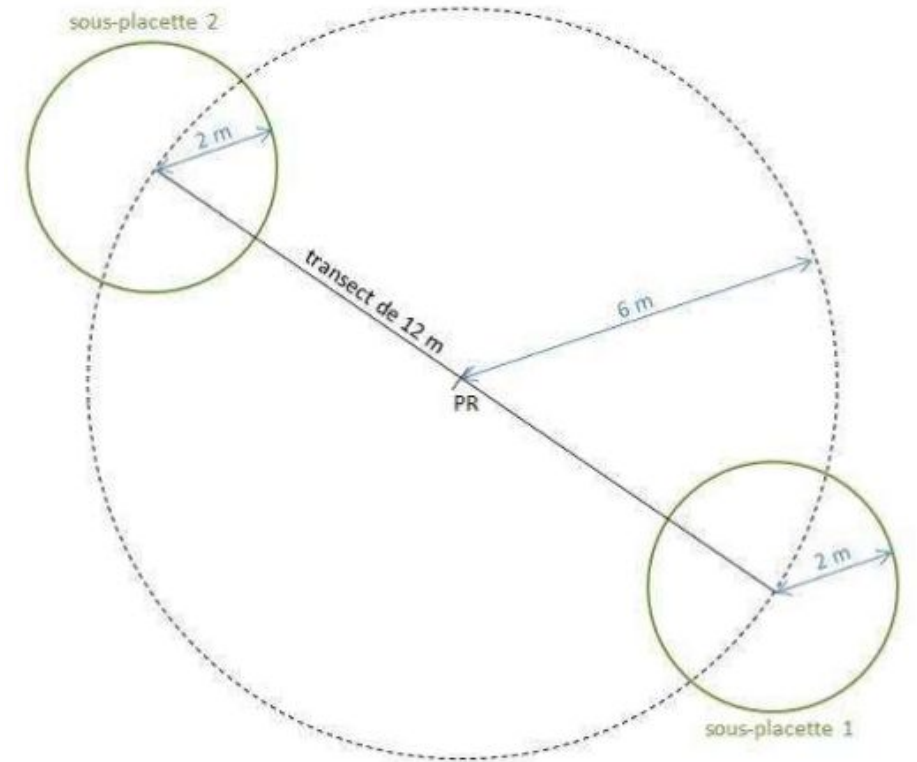
T1.2 Monitoring advanced regeneration

- Lack of national research network on seedling and sapling dynamics
 - New IGN NFI data with cohorts monitoring
 - method of analysis?
 - Need also individual data
 - ecological drivers
 - evolutionary processes



T1.2 Monitoring advanced regeneration

- Lack of national research network on seedling and sapling dynamics
 - New IGN NFI data with cohorts monitoring
 - method of analysis?
 - Need also individual data
 - ecological drivers
 - evolutionary processes



T1.2 Monitoring advanced regeneration

Task Leader(s): Lisa Laurent (INRAE EFNO) & Lionel Hertzog (LIF IGN)

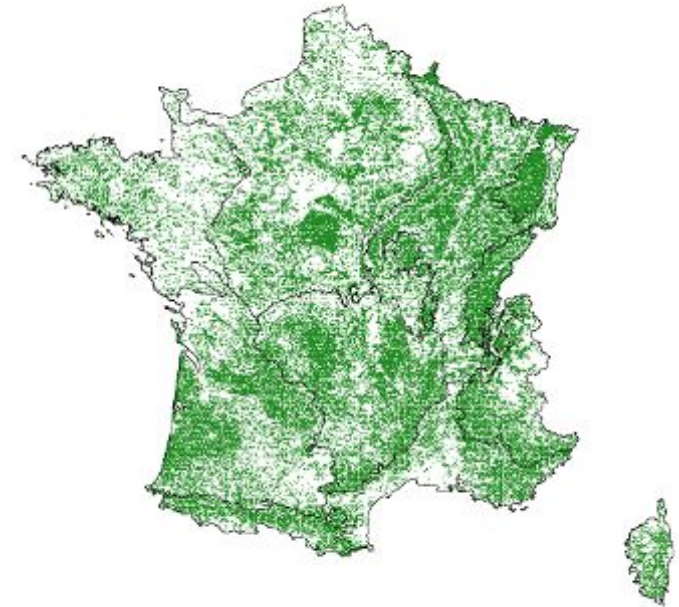
Partners: LIF (IGN); INRAE-EFNO; INRAE-LESSEM (G. Kunstler B. Courbaud V. Breton); AgrosParisTech Nancy (E. Lacombe); INRAE-URFM; INRAE-BIOGECO; (see partners in T1.3)

T1.2.1 PhD cofounded with IGN - Analysis of new IGN regeneration data and improve models (PhD focuses on MARGOT)

T1.2.2 How repeated cohorts measurements improve regeneration estimation (IGN & OFS) LIF - LESSEM

T1.2.3 Individual based seedling & sapling monitoring at a selection of sites (ecological factors) links with

T1.3



**Forêt
Irrégulière
École**

T1.3 Genetic adaptive potential in natural regeneration

Intense culling at the juvenile stages

=> **young cohorts are exposed to strong selection**

Magnitude of the process?

Differences between species with contrasted ecological strategies?



T1.3 Genetic adaptive potential in natural regeneration

Task Leader(s): Julie Gaüzère & Ivan Scotti

Partners: INRAE-URFM (J. Gaüzère, I. Scotti, C. Scotti); INRAE-EcoFoG (N. Tysklind, C. Stahl, S. Coste); INRAE-BIOGECO (B. Brachi, S. Gonzalez-Martnez), INRAE-UEFM

T1.3.1 Longitudinal studies of seedling cohorts with phenotypic and genetic diversity. To reveal temporal patterns of selection during natural thinning within cohorts.

Fagus sylvatica, *Quercus* sp., *Abies* sp., *Pinus pinaster*,
Pinus pinea, *Pinus nigra salzmanni*

T1.3.2 Common garden along environmental gradients to analyse local adaptation for *Dicorynia guianensis*



T1.4 Regeneration in forest models

Poor representation of regeneration in forest models

- either black-box
 - or complex physiological and genetic processes, and biotic interactions lack of sound parametrization
- => Need to confront model to data (inverse modelling)
- => Need to test mechanisms and management with models

Review

New
Phytologist



Tansley review

Forest regeneration within Earth system models:
current process representations and ways
forward

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Tamm reviews

Tree regeneration in models of forest dynamics – Suitability to assess
climate change impacts on European forests

Louis A. König^{a,b,*}, Frits Mohren^b, Mart-Jan Schelhaas^a, Harald Bugmann^c,
Gert-Jan Nabuurs^{a,b}

^a Wageningen Environmental Research (WENR), Wageningen University and Research, Droevendaalsesteeg 3, 6708 PB, Wageningen, the Netherlands

^b Forest Ecology and Management Group, Wageningen University, Droevendaalsesteeg 3, 6708 PB, Wageningen, the Netherlands

^c Forest Ecology, Department of Environmental Systems Science, ETH Zurich, Universitätsstrasse 16, 8092 Zurich, Switzerland



T1.4 Regeneration in forest models

Task Leader(s): Isabelle Maréchaux (INRAE AMAP) & Xavier Morin (CNRS CEFE)

Partners: LESSEM (G. Kunstler B. Courbaud); PIAF (P. Balandier); URFM (F. Lefevre); ISEM (O. Ronce) LIF-IGN (L. Hertzog)

2 years postdoc (AMAP): Inter-comparison et evaluation of models prediction of regeneration

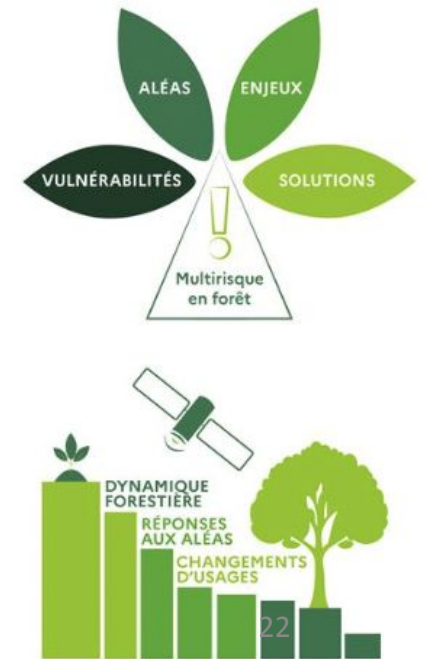
- **T1.4.2** - past against new NFI data (with T1.2)
- **T1.4.3** - future with climate change

Master 2

- improve regeneration modules
- Regeneration & Evolution

T1.4.1 Workshops on regeneration modelling

collaboration with
X-Risks & Monitor



Questions/commentaires sur WP1 ?



WP2
**Management to promote
regeneration dynamics that
enhance resilience**

**WP2:
Management**

Task 2.1: Species
choice and planting
methods

Task 2.2:
Hybridization in
assisted gene flow

Task 2.3: Species
diversity and mixed
forests

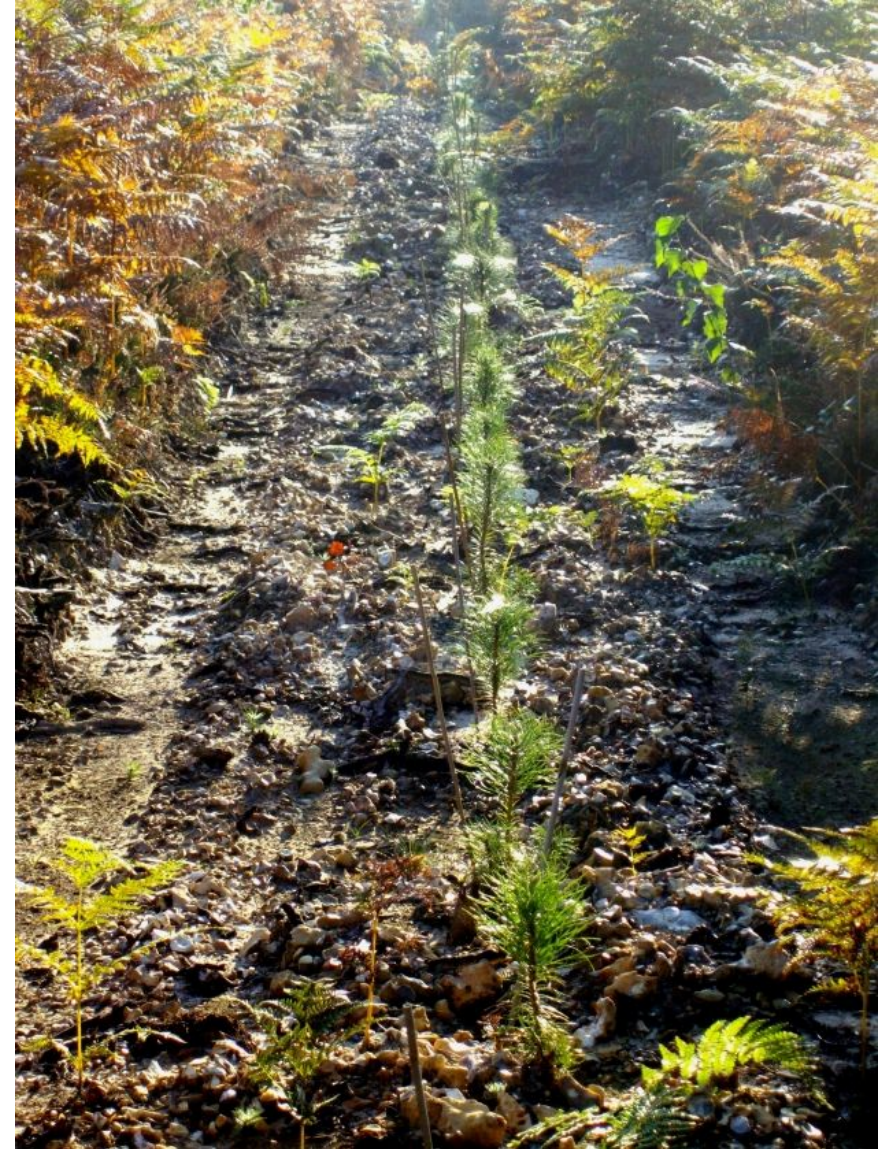
Task 2.4: Barriers to
natural regeneration

T2.1 Species choice and planting methods

Successful plantations depend on appropriate tree selection and planting methods

- uncommon and exotic species
- seedling preparation (seedling type, mycorrhization, substrate, ...)
- site preparation

=> need evaluation of these new species, methods and their impacts on soil functioning & biodiversity



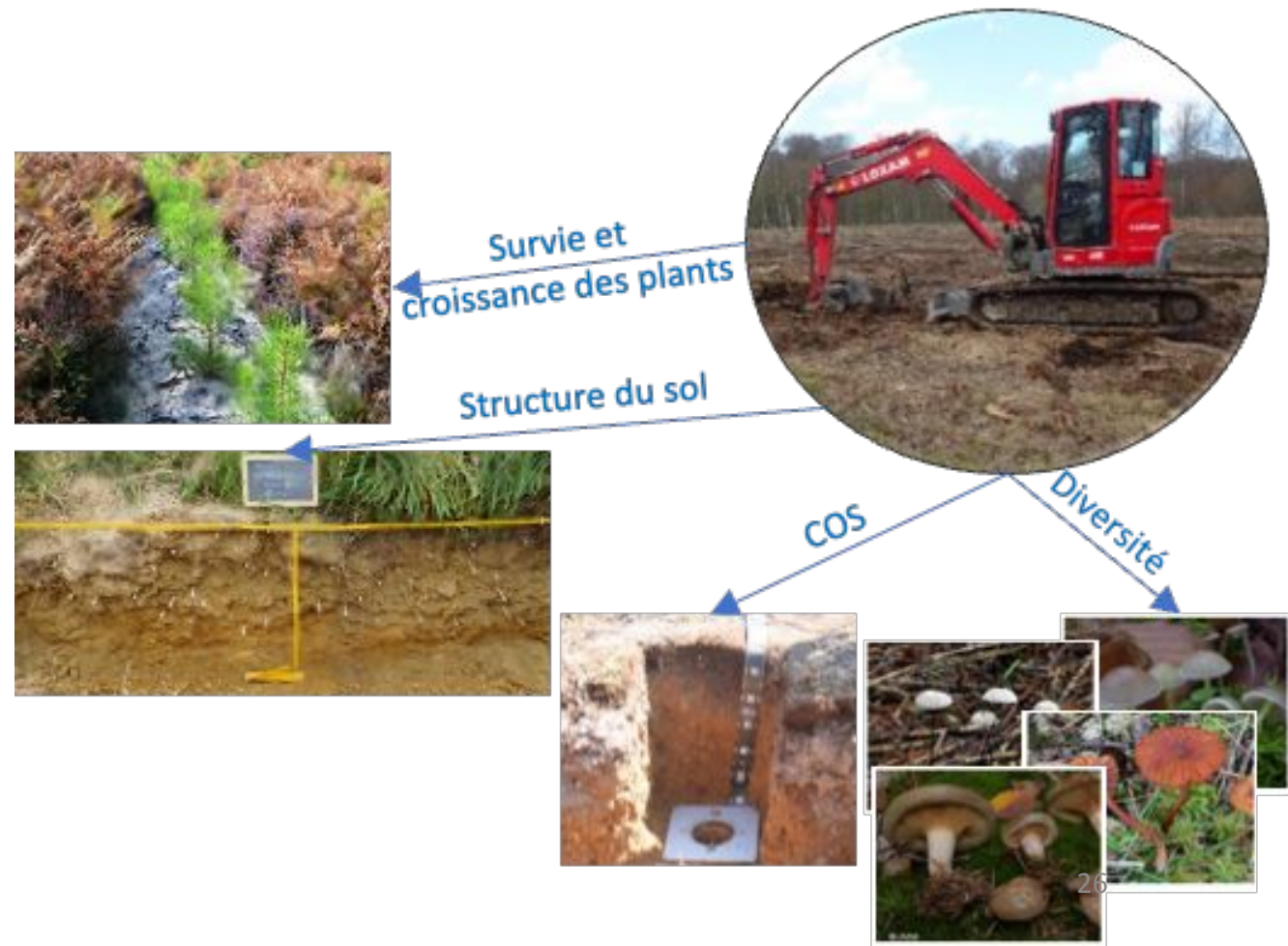
T2.1 Species choice and planting methods

Task Leader(s): Catherine Collet & Emila Akroume

Partners: INRAE Silva (C. Collet); ONF(E. Akroume, B. Musch); INRAE BIOGECO (C. Meredieu, H. Schimann); INRAE ISPA (L. Augusto); INRAE IAM (A. Deveau); Univ Rouen ECODIV (L. Vincenot, F. Bureau, P. Ganault); MASA DSF (C. Husson)

T2.1.1 Analyse long-term survival and growth of uncommon and exotic species plantation based on a large plantation network & arboreta (Ilôts d'avenir, ...)

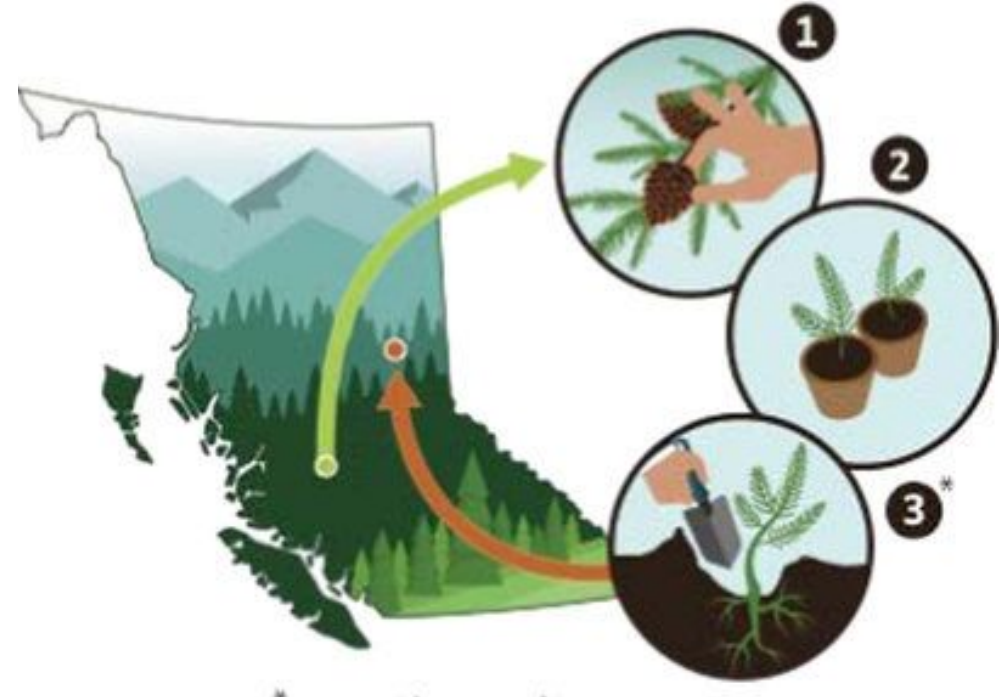
T2.1.2 5 experiments in northern and south-western France to evaluate mechanical site preparation and mycorrhization effects on seedling survival and growth and their impacts on soil functioning & biodiversity



T2.2 Hybridization in assisted gene flow

Assisted gene flow based: the introduction of provenance better adapted to warmer and drier climates

- 1) Are crosses between local and introduced genetic material frequent?
- 2) Do the population of offspring display increased genetic variation for adaptive traits?
- 3) Are there risks associated with introducing foreign genetic material?
 - a) maladaptation?
 - b) outbreeding depression?



T2.2 Hybridization in assisted gene flow

Task Leader(s): Benjamin Brachi, Julie Gaüzère & Ophélie Ronce

Partners: INRAE-URFM (J. Gaüzère, I. Scotti, C. Scotti); INRAE-EcoFoG (N. Tysklind, C. Stahl, S. Coste); INRAE-BIOGECO (B. Brachi, S. Gonzalez-Martnez); ISEM (O. Ronce)

Use old plantation where crosses already occurs or create control crosses to compare the fitness of offspring from local parents or crosses with distant parents in the field and controlled experiments

Fagus sylvatica, Quercus petraea, Abies alba, Pinus nigra salzmanni, Aniba rosaeodora

Workshop with research community
on consequences of assisted gene
flow on crosses

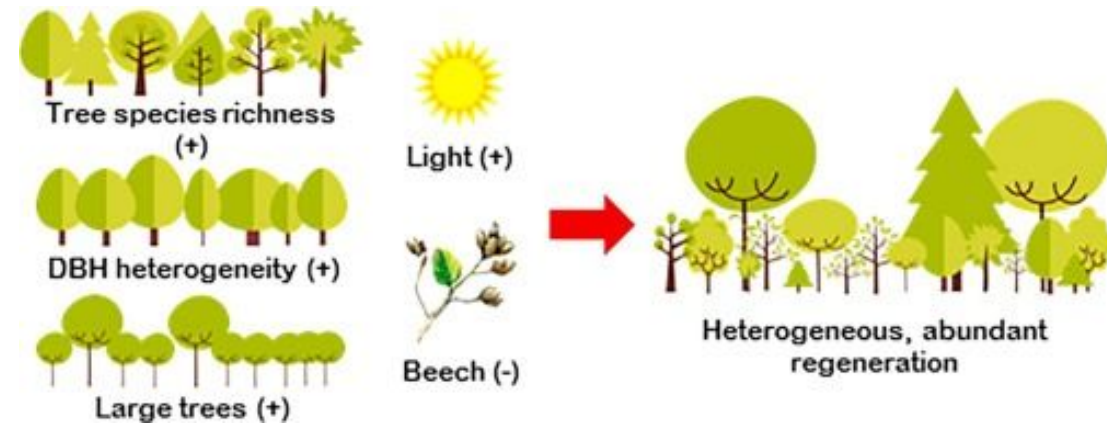


T2.3 Species diversity and mixed forests

Preserving or increasing tree species diversity might increase forest resilience to climate change

=> but effect on regeneration phase in plantation and natural regeneration?

=> How to manage regeneration to promote high diversity?



T2.3 Species diversity and mixed forests

Task Leader(s): Lisa Laurent (INRAE EFNO) & Xavier Morin (Cefe CNRS)

Partners: INRAE Biogeco (H. Jactel); Cirad Eco&Sol (J. Guillemot); LIF-IGN (L. Hertzog); INRAE EFNO (L. Laurent); CNRS Cefe (X. Morin); INRAE LESSEM (G. Kunstler V. Breton); ONF (M. Court)

Effects of species mixture on **natural regeneration**

T2.3.1 in triplets on two species mixture in 3 sites (GMAP, OPTMix, Lente) with or without browsing

T2.3.2 Effect of mixture on regeneration with IGN and OFS data

T2.3.3 Effect of mixture in **young tree plantations** in TreeDivNet (FORMIX, MataDIV, ORPHEE)

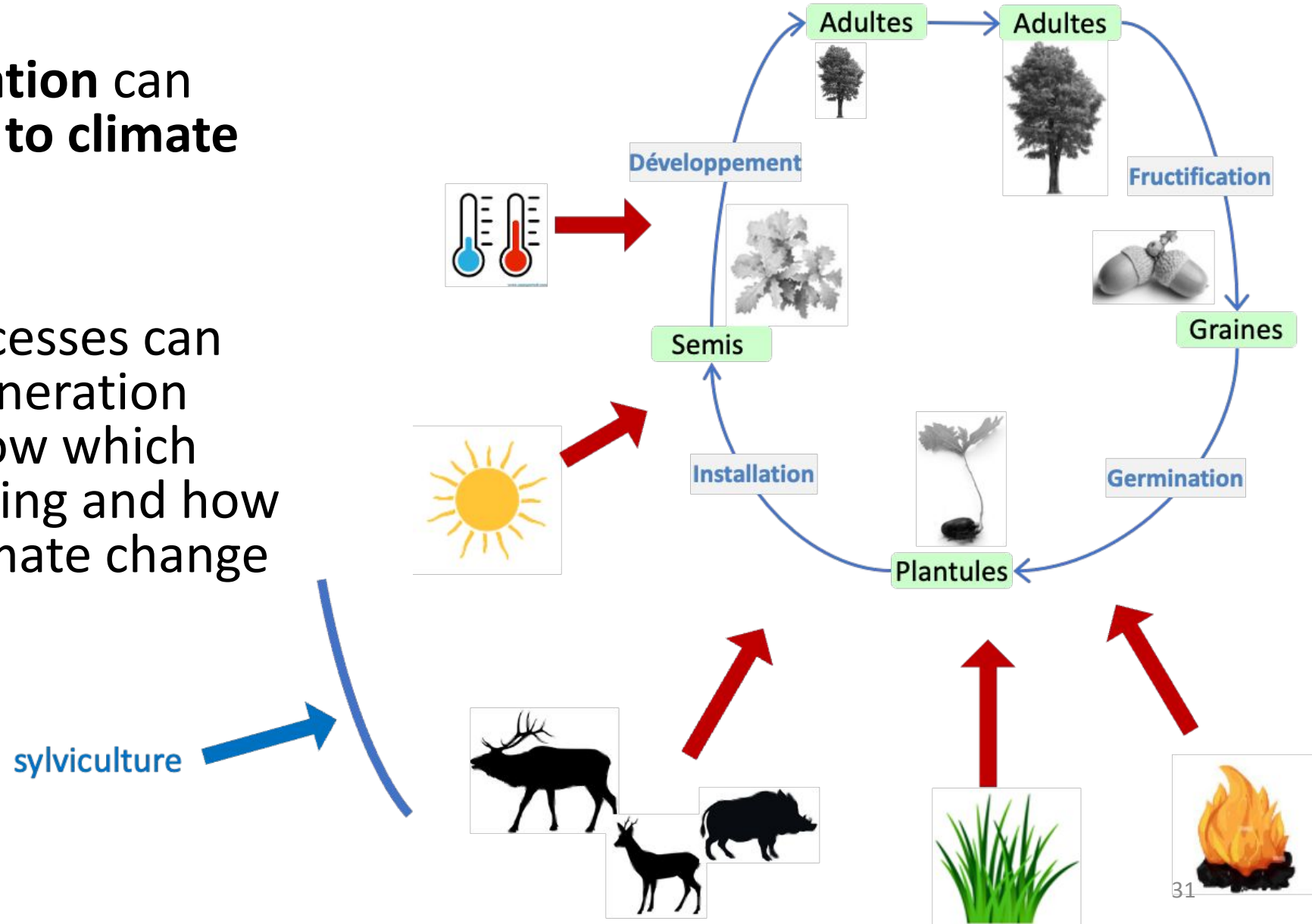


T2.3.4 Workshops to foster interactions between forest managers and researchers on the management of mixed-forest regeneration - **CALIFE - AFORCE**

T2.4 Barriers to natural regeneration

Lack of **natural regeneration** can impede **forest response to climate change**.

Multiple stages and processes can explain this natural regeneration failure, but we don't know which process is the most limiting and how this will change with climate change



T2.4 Barriers to natural regeneration

Task Leader(s): Catherine Collet (INRAE Silva) & Philippe Balandier (INRAE PIAF)

Partners: INRAE Silva (C. Collet); INRAE PIAF (P. Balandier); INRAE LESSEM (G. Kunstler B. Courbaud, V. Breton); INRAE Biogeco (C. Meredieu); INRAE Recover (B. Prevosto); EcoFoG (N. Tysklind); INRAE EFNO (A. Marell); INRAE Biofora (C. Teyssier); ONF (V. Boulanger, Y. Rousselle); OFB (S. Saïd)

- Network of experiments to manipulate factors controlling natural regeneration:

- Distance to seed trees
- Canopy cover
- Ground vegetation
- Browsing
- Seeds

Tronçais, Chantilly, Vaucluse,
Landes de Gascogne, Alpes,
Rambouillet, Orléans



- Analysis of regeneration demography and genetic diversity

- **Recommendation on silvicultural operations** : thinning, vegetation management, ungulate management, assisted migration, post-fire management

Experiments in connection with T1.3
for *Dicorynia guianensis* (Light,
browsing, ground vegetation)

Questions/commentaires sur WP2 ?



WP3
**Governance of regeneration in
socio-ecosystems**

**WP3:
Governance**

Task 3.1: Impacts on
biodiversity and NCPs

Task 3.2: Politics and
economics of forest
renewal

Task 3.3: Regeneration
in the making

Task 3.4:
Co-constructing
regeneration pathways

T3.1. Impacts on biodiversity and NCPs

- Regeneration pathways ranging from exotic species plantation to natural regeneration impacts on biodiversity conservation
- Analysis of short and long term effects of past regeneration decisions (historical ecology)
- Effect on NCPs (wood production, recreational value, etc.)



T3.1 Impacts on biodiversity and NCPs

Task Leader(s): Laurent Bergès (INRAE), Bruno Locatelli (CIRAD).

Partners: INRAE Lessem Grenoble, INRAE Efnogent, Edysan CNRS Amiens, Ecodiv Univ Rouen, P2E Univ Orléans, INRAE Beta Nancy, CIRAD Forêts et Sociétés (Amélie Robert, Antonello Lobianco, Arthur Perrotton, Aurélien Sallé, Bruno Locatelli, Guillaume Decocq, Hilaire Martin, Jérôme Buridant, Laurent Bergès, Lucie Vincenot, Marion Gosselin, Mathias Pires, Michael Aubert, Pierre Ganault, Yann Dumas).

3.1.1: **History** of forest regeneration in 2-3 large forest regions since 19th century, geo-historical approach

3.1.4: **Simulate** effects of regeneration choices on French forestry sector (FFSM model)

Compare how different plantation types and natural regeneration affect biodiversity and NCP

- 3.1.2: PhD on **long-term impacts** (up to 200 years)
- 3.1.3: PhD on **medium-term impacts** (up to 50 years)

3.1.5: Effect of plantation decisions made 40 years ago on biodiversity and NCP in Belterra, **Brazil**

T3.2. Politics and economics of forest renewal

- Forest regeneration is not only an ecological process guided by technical choices, but also a political and economical process
- Objective of this task :
 - Observe changes in the socio-technical regime(s) (systems linking production functions, exchange and regulation infrastructures and use functions) for forest renewal, using institutionalist lenses and a multi-level approach



T3.2. Politics and economics of forest renewal

Task Leader(s): Sandrine Allain (INRAE-LESSEM), Vincent Banos (INRAE-ETTIS)

Partners: INRAE LESSEM, INRAE ETTIS, with Arnaud Sergent, Philippe Deuffic, Sandrine Allain, Vincent Banos.

3.2.1: PhD on the policies and instruments that support investments in the forest sector in the French contemporary context

- political work that lead to policies;
- political capacity for forest strategy;
- conditions for hybrid policy framework (public/private)

3.2.2: Post-doc on the set up and rise in dominance of novel socio-technical regime(s) for forest renewal (e.g., silvicultural innovations vs. natural regeneration)

- power and ability of innovation promoters to frame and implement changes;
- competition, hybridization, coexistence of different innovations;
- socio-economic and technical-material factors put forward to justify adoption;
- alliances forged to overcome obstacles and conflict issues

T3.3. Regeneration in the making

- Forest regeneration takes place in a diversity of contexts that influence individual or collective decisions and their implementation on the ground
- This task will:
 - analyse how forest regeneration is deployed with what configurations of actors and what articulations of knowledge, representations, and values
 - explore the diversity of arrangements and practices of forest regeneration from the point of view of regeneration stakeholders (direct managers + those indirectly influencing decisions or being influenced by decisions)



T3.3. Regeneration in the making

Task Leader(s): Nelly Pares (CESCO MNHN), Bruno Locatelli (Cirad F&S)

Partners: MNHN CESCO, Cirad Forêts et Sociétés, AgroParisTech Nancy, INRAE BETA, with Bruno Locatelli, Jens Abildtrup, Manuel Boissière, Nelly Pares.

3.3.1. Postdoc on representations of forest regeneration

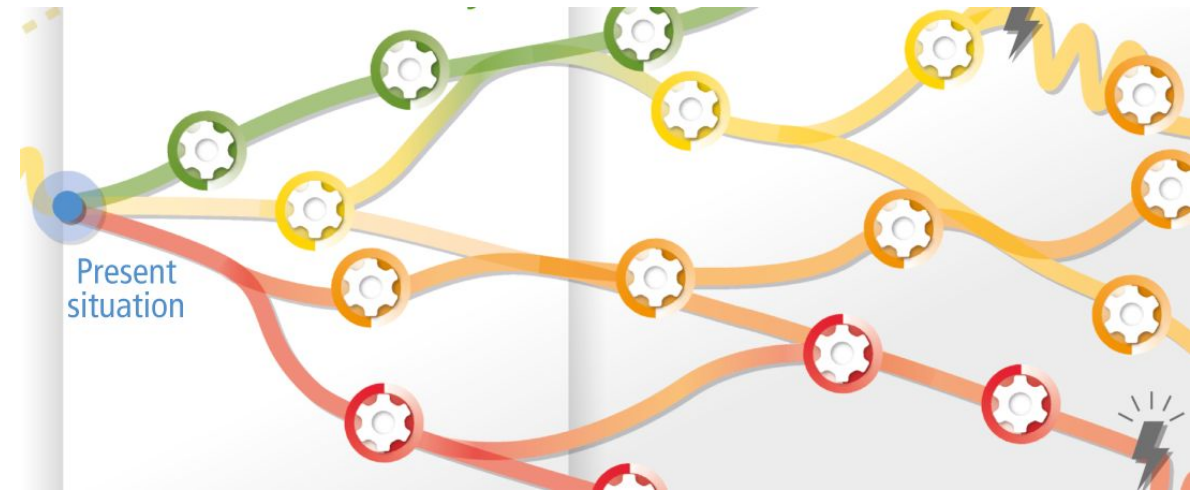
- notions, concepts and narratives mobilised by stakeholders for their communication on the subject (in link with social and political debates)
- differences in opinions and representations around regeneration dynamics and associated practices
- contrasts and potential divisions in the ways of thinking (representations, values) about forest regeneration

3.3.2. Articulations of actors and their values and representations in forest restoration initiatives in **Indonesia**

3.3.3. Behaviour of forest decision-makers regarding forest regeneration decisions (**large-scale survey**, in link with FFSM model)

T3.4. Co-constructing regeneration pathways

- Set-up multi-stakeholder processes to deliberate about alternative futures in various study sites, both in France and in Latin America, with the objective of supporting regenerative governance of forest territories
- Several methodological fields will be mobilised, including companion modelling (Etienne 2014) and foresight or prospective (e.g. Bourgeois 2017)



<https://www.ipcc.ch/report/ar6/wg2/chapter/chapter-18/>

T3.4. Co-constructing regeneration pathways

Task Leader(s): Arthur Perrotton (CIRAD-UFOPA, Santarém Brazil), Pascal Marty (CNRS Maison Française d'Oxford)

Partners: Embrapa and UFOPA (Brazil); ECOSUR, El Colegio de la Frontera Sur, Unidad de Campeche (Mexico), Cirad Forêts & Sociétés (and associated labs in Guatemala & Colombia), with Arthur Perrotton, Bruno Locatelli, Helene Dessard, Laurène Feintrenie, Marion Chesnes, Pascal Marty, Sandrine Allain.

3.4.1. PhD on the co-production and deliberative evaluation of forest regeneration scenarios at the scale of a Living Lab in France: Analyse forest regeneration as a situated practice of anticipatory governance

Develop and test a method;

Structure a universe of possible futures for forest regeneration in response to CC;

Explore complex socio-ecological trade-offs involving radical uncertainties;

Support collective choices within an expanded deliberative framework

3.4.2. Multi-actor arena to study and enable fair and inclusive governance of plantations (**Brazil**)

3.4.3. Deliberative process for forest restoration plan (**Colombia**)

3.4.4. Design of collective strategies to strategies to manage disservices from forest regeneration (**Mexico**)

Questions/commentaires sur WP3 ?



PEPR FORESTT

Forêts et changements globaux : systèmes socio-écologiques en transition

4



Logo of the French Republic (République Française) with the motto 'Liberté Égalité Fraternité'.

Logo for 'FRANCE 2030' with the text 'PROGRAMME DE RECHERCHE RÉSILIENCE DES FORÊTS'.

Logo of INRAE.

Logo of ANR (Agence Nationale de la Recherche).

À VOS AGENDAS !
Lancement Scientifique

Programme de Recherche
F O R E S T T

18 & 19 SEPTEMBRE 2024

Ouverture des inscriptions en avril 2024 sur <https://www.pepr-forestt.org/>

REGE-ADAPT

Forest regeneration and the adaptation of forest socio-ecosystems to climate change

