



### Engaging and working with stakeholders in the LinkTree and TipTree research projects (BiodivERsA 2008 and 2012 calls)

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#### LinkTree (2009-2013) and TipTree (2013-2016)

=> understanding how **genetic diversity** of forest trees is organized in **space** (LinkTree) and **time** (TipTree)

and why this confers adaptability and resilience to forests and forestry under climate change....

#### Linking genetic variability with ecological responses to environmental changes: forest trees as model systems (LinkTree) – BiodivERsA ERANET



Consortium of **7 partners** from **Spain** (CIFOR-INIA & CIDE-CSIC), **Italy** (CNR-Firenze), **France** (INRA-BIOGECO & INRA-URFM), **Germany** (Philipps-University of Marburg) and **Sweden** (Uppsala University), with 35 researchers and a total project cost of 1,956,790 €





# LinkTree: intraspecific genetic variation in model forests across Europe







# An enormous amount of diversity within population, a range-wide spatial structure



Figure 1: Map showing the distribution of different European Silver fir trees within and among four plots (N1, N2, N4 and N5) located along an elevation transect in Mont Ventoux, south eastern French Alps. The plots show the distribution of individuals with a particular genetic make-up at four different genes (one genotype per color, 47 genotypes in total) involved in resistance to environmental stress. Although differentiation among populations in frequencies of adaptive genes is significant at the landscape scale, genetic variability is at maximum at the micro-environmental scale, among individuals within the same population. This high genetic variability is crucial for local adaptation under climate change.



## Impact for different stakeholder groups



- *Management*: nature conservationists (e.g., WWF, IUCN) and national forest managers.
- *Policy*: National and European policy makers through MCPFE and National Ministries.
- General public and media.

### **Workshops and training courses**

**MSc and PhD programs in Universities from Spain,** France, Italy, Germany and Sweden

**Newsletter** (annual and special numbers)

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# In collaboration with international and national agencies

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European Forestry Institute

Second Evoltree Stakeholder Group Meeting  $\rightarrow$  September 16 - 17, 2009 Eisenstadt in Austria. EFIMED progress meeting and Scientific seminar on "Knowledge base management of Mediterranean forests under climate driven risks: the ways ahead"→ April 13 - 16, 2010 Antalya in Turkey.

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## In the long-term

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Scientific community  $\rightarrow$  a deeper understanding of the importance of tree genetic diversity for the sustainability of forest ecosystems and how this variation i) is structured in nature and ii) will respond to environmental change.

Forest managers, nature conservationists and policy makers  $\rightarrow$  indicators and/or guidelines to manage forest ecosystems and resources that are under pressure from global change and effective tools for adaptive diversity monitoring using high-throughput genotyping techniques.

Guidelines for the choice of appropriate 'minimum requirements' to select forest ecosystems and stands that will be recognized and managed as **conservation units** at the European scale

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#### LinkTree Biodiversa film http://www.biodiversa.org/190

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After analysis, we will be able to assess how the tree reacts to current climate change

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#### LinkTree publications

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### Forests and global change: what can genetics contribute to the major forest management and policy challenges of the twenty-first century?

Bruno Fady<sup>1</sup> · Joan Cottrell<sup>2</sup> · Lennart Ackzell<sup>3</sup> · Ricardo Alía<sup>4</sup> · Bart Muys<sup>5,6</sup> · Arantxa Prada<sup>7</sup> · Santiago C. González-Martínez<sup>4</sup>

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- <sup>3</sup> Federation of Swedish Family Forest Owners, Stockholm, Sweden
- <sup>4</sup> INIA, Forest Research Centre (CIFOR), Madrid, Spain
- <sup>5</sup> European Forest Institute, Barcelona, Spain
- <sup>6</sup> University of Leuven, Louvain, Belgium
- <sup>7</sup> General Directorate for Environment, Valencia, Spain

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#### LinkTree Biodiversa policy brief

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Adaptation of trees and forests to climate change: the importance of genetic variability European and national legislation:

- Biodiversity
- Forests
- Climate change

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Scenarios for forest biodiversity dynamics under global change in Europe: Identifying micro-evolutionary scale tipping points- TipTree

Consortium of **11 partners** from :

•France (5): INRA-URFM, ISEM-Montpellier II University, INRA-BIOGECO, INRA-ECOFOG, ONF

- •Germany (1): Philipps-University of Marburg
- •Sweden (2): Uppsala University, LRF Skogsägarna
- •Spain (2): CIFOR-INIA & EFI
- •Italy (1): CNR-Firenze

with 37 researchers, 2 forest managers, 1 forest agency.

Total project cost of 2,614,548 €

#### The people

![](_page_11_Picture_11.jpeg)

The forests

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### **TipTree Issues**

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Tree populations can adapt locally to climate change through plasticity/genetic adaptation

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- + High levels of genetic diversity
- + High levels of gene flow

# What is the amount of genetic variation available for key functional traits ?

Savolainen et al (AnRevEcolEvolSyst) 2007

#### But abundant genetic variation does not guarantee adaptation

![](_page_12_Figure_10.jpeg)

Conditions for "evolutionary rescue"

- Are there critical levels (tipping points) of genetic diversity below which populations collapse ?

- What are the traits limiting persistence at range limits when taking into account their genetic variability ?

# TipTree: Micro-evolutionary potential of forest tree populations in response to climate change

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How is variation transmitted, selected and expressed in present offspring ?

![](_page_13_Figure_3.jpeg)

#### Genomic tools to:

Sympatric tree species (for pines and oaks)

Hill top with wel

Experimental sites

Mediterranean pines

OaksSilver fir

Spruce

5-6 replicates per site

RP<sub>1</sub> RP<sub>2</sub> RP<sub>2</sub> RP

Temporarily waterlogged bottom-land

- $\checkmark\,$  Identify the loci under natural selection
- ✓ Genotype candidate gene

#### **Quantitative genetics to:**

- ✓ Validate phenotypic effects
- $\checkmark\,$  Estimate the genetic variance of the traits
- ✓ Estimate selection coefficients

#### Using :

- Common gardens
- Reciprocal Transplant Experiment
- In situ quantitative genetics

#### Realistic 'climate change' scenarios

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Realistic management scenarios for "stakeholders" and "scientists" needed:

=> Scientists – stakeholders conference, April 2014, Paris

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TipTree stakeholder partnership

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"From science to practice: the contribution of projects TipTree and AMTools to guiding better forest survival and regeneration under Global Change scenarios"

Paris, April 1-3, 2014 26 stakeholders (France, Canada, USA, International agencies) (forest managers, forest owners' representative, conservationists, policy makers, forest agencies and researchers )

=> Production of "realistic" management scenarios, including soft and hard options

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TipTree stakeholder partnership

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#### "From science to practice: the contribution of projects TipTree and AMTools to guiding better forest survival and regeneration under Global Change scenarios"

Figure 2: A scheme of possible adaptive management strategies for forest in face of CC/GC

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A typology of major challenges under climate change: genetic diversity ranked as severe at local scale

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# Raising awareness on the role of genetic diversity in adaptation to climate change in peripheral populations

Forest Ecology and Management 375 (2016) 66-75

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Review and synthesis

Evolution-based approach needed for the conservation and silviculture of peripheral forest tree populations

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Bruno Fady <sup>a,\*,1</sup>, Filippos A. Aravanopoulos <sup>b,1</sup>, Paraskevi Alizoti <sup>b,1</sup>, Csaba Mátyás <sup>c,1</sup>, Georg von Wühlisch <sup>d,1</sup>, Marjana Westergren <sup>e,1</sup>, Piero Belletti <sup>f</sup>, Branislav Cvjetkovic <sup>g</sup>, Fulvio Ducci <sup>h</sup>, Gerhard Huber <sup>i</sup>, Colin T. Kelleher <sup>j</sup>, Abdelhamid Khaldi <sup>k</sup>, Magda Bou Dagher Kharrat <sup>l</sup>, Hojka Kraigher <sup>e</sup>, Koen Kramer <sup>m</sup>, Urs Mühlethaler <sup>n</sup>, Sanja Peric <sup>o</sup>, Annika Perry <sup>p</sup>, Matti Rousi <sup>q</sup>, Hassan Sbay <sup>r</sup>, Srdjan Stojnic <sup>s</sup>, Martina Tijardovic <sup>o</sup>, Ivaylo Tsvetkov <sup>t</sup>, Maria Carolina Varela <sup>u</sup>, Giovanni G. Vendramin <sup>v</sup>, Tzvetan Zlatanov <sup>w</sup>

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## Federation of Swedish Farmers Federation of Swedish Family Forest Owners

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**International Family Forestry Alliance** 

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Members of:

Federation of Swedish Family Forest Owners

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## **Forest Ownership in Sweden**

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#### 60% of growth and harvest

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Federation of Swedish Family Forest Owners

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## Federation of Swedish Family Forest owners and its four Family Forest Associations

Industrial production

- 2 million tons of market pulp
- 5 million m3 of sawn goods

+ energy

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#### Why LRF decided to be part of TipTree

From LRF (Federation of Swedish Farmers and Federation of Swedish Family Forest Owners) we strongly welcome research efforts in the interface of genomics and climate change, exactly what TipTree aimed for. From the practical family forest point of view, the environmental changes (biotic as well as abiotic) due to climate change affect directly growth, survival, etc. of our forests. The forest's resilience depends on adaptation by human adjustment within the limits of adaptive variation and species plasticity. The TipTree project has provided knowledge on this matter that will enable forest management recommendations to mitigate negative climate change effects on our forests.

Lennart Ackzell (LRF) Senior Advisor International Affairs

# Thank you for your attention

Sierra Nevada National Park (Spain), home to the southernmost population of Scots pine