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ASSESS 4 EST

Seeing trees and forests for the future: assessment of trade-offs and potentials to breed and manage forests to meet sustainability goals, ASSESS4EST

Katri Kärkkäinen, LUKE, Finland

M Rosario García Gil, SLU, Sweden

Funded by the European Union

Grant agreement ID: 101094340

Overarching objective

SUSTAINABLE FORESTRY = ECONOMY + CLIMATE + LIFE ON LAND

EMPIRICAL SCIENCE

Assess the impact of BAU breeding ➔ Trade offs

New breeding and managemet practices

MODELLING

Model the impacts of management practices

SDGs

Bioeconomy: SDGs → 8, 9, 12

Need to replace oil-based products

Need for increased growth in forests

Climate: SDG → 13

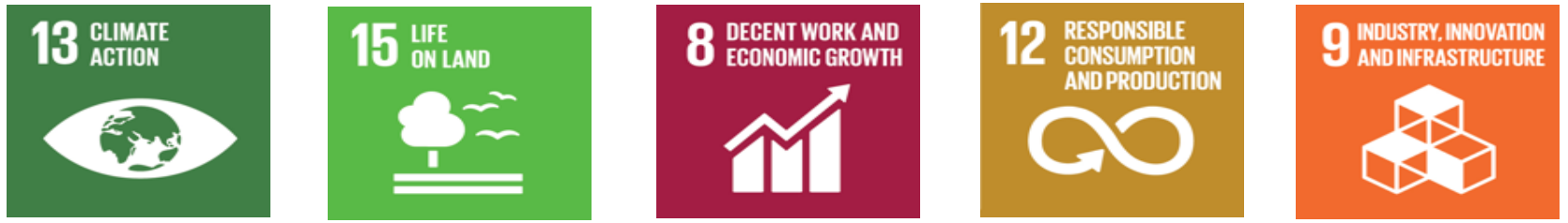
Above-ground C-storage

Need to use Wood for long-lasting carbon products – wood quality

Need to increase resilience: climatic adaptation, disease resistance

Life on land: SDG → 15

Biodiversity



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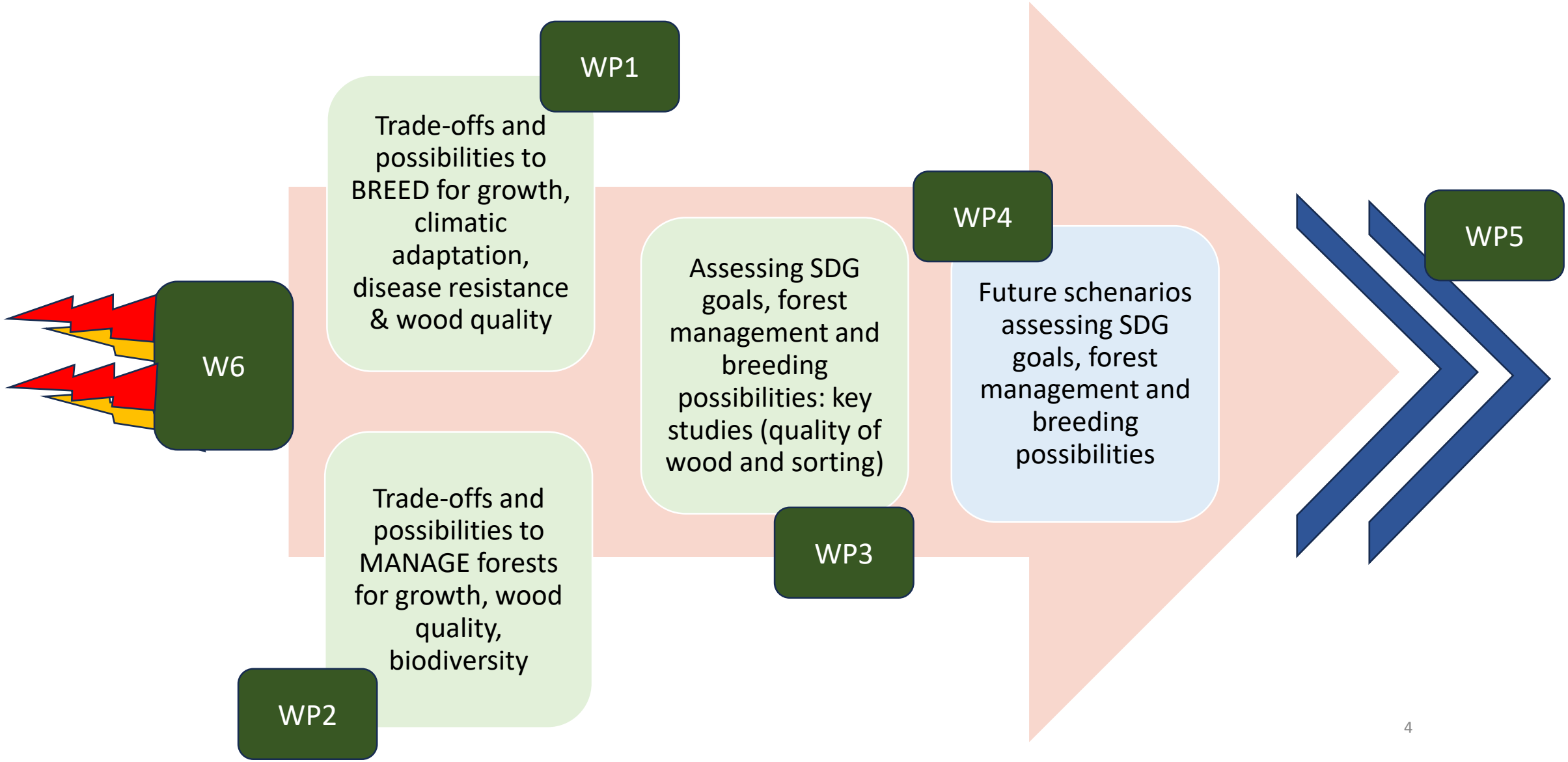
PROJECT WPs



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WP1

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Trade-offs and possibilities to combine different traits

:

Task 1.1: Aiming for volume and quality, how far can we get?

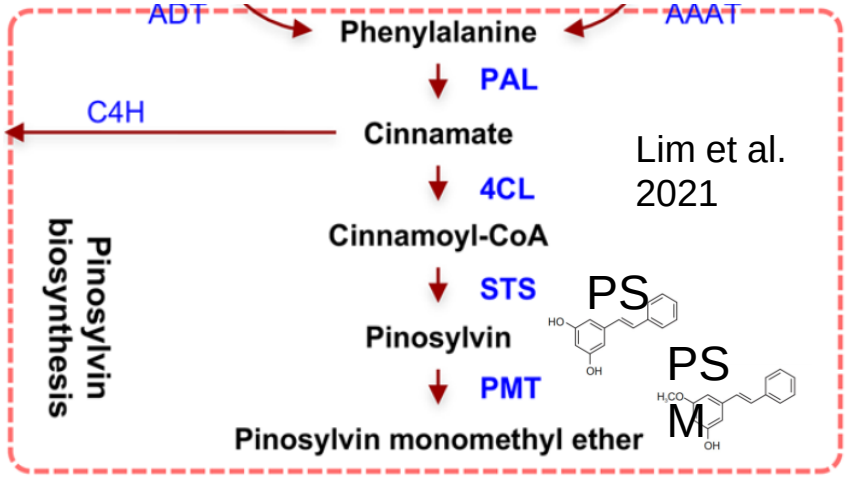
Task 1.2: Increasing forest growth in the context of climate warming: Mind the frost!

Task 1.3: Is phenotypic plasticity always for the good?

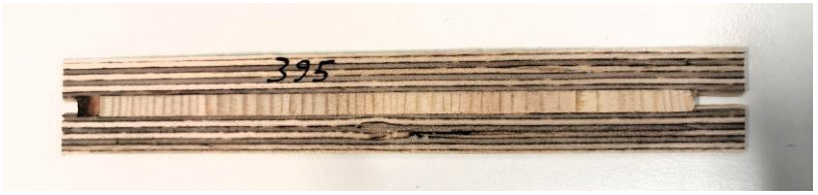
Task 1.4: Implementing of tradeoffs into Genomic Selection models

Task 1.1: Growth and Quality

GWAS for wood chemistry (stilbenes) and growth:



Lim et al. 2021



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Task 1.1: Growth and Quality

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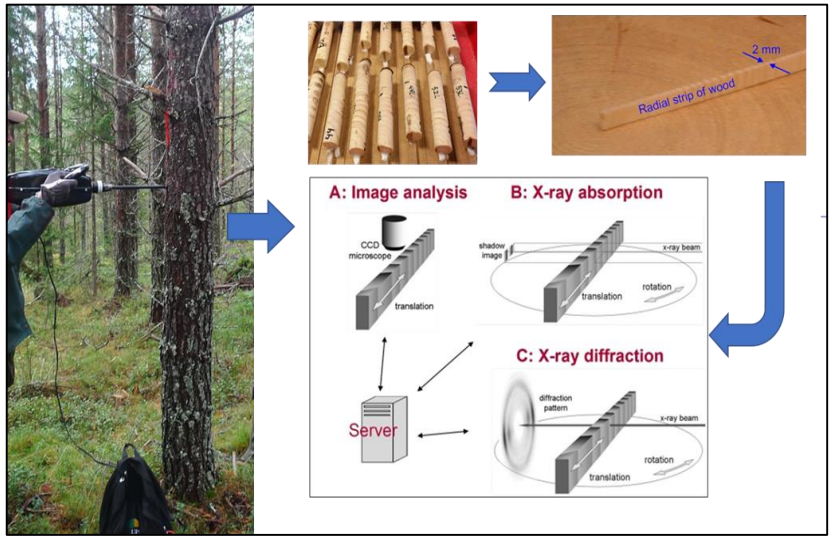

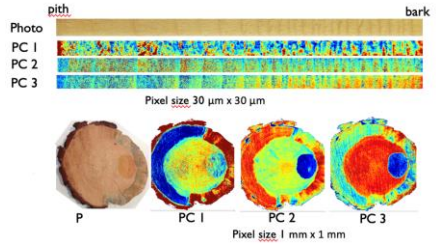

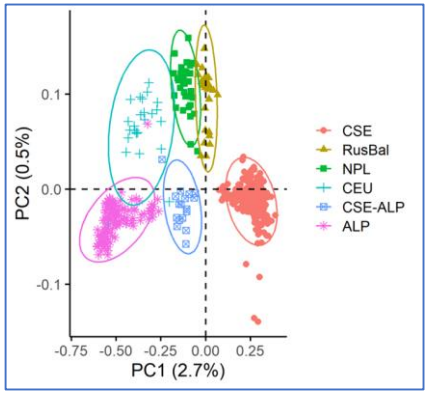

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RESEARCH Open Access

Implications of accounting for marker-based population structure in the quantitative genetic evaluation of genetic parameters related to growth and wood properties in Norway spruce

Haleh Hayatgheibi[1*], Henrik R. Hallingbäck[2], Sven-Olof Lundqvist[3], Thomas Grahn[4], Gerhard Scheepers[5], Peter Nordström[6], Zhi-Qiang Chen[1], Katri Kärkkäinen[7], Harry X. Wu[1,8,9] and M. Rosario García-Gil[1]

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Task 1.2 Frost

GWAS

- Genome Wide Association Study in a Southern Finnish natural population (Multi-Locus Mixed-Model; Segura et al. 2012)
- 390 trees with 77 432 SNPs (Kastally *et al.* 2022) and breeding values for 1st year seedling traits

➢ Trait associated SNPs not shared between traits

➢ Low frequency variants have the highest effect sizes

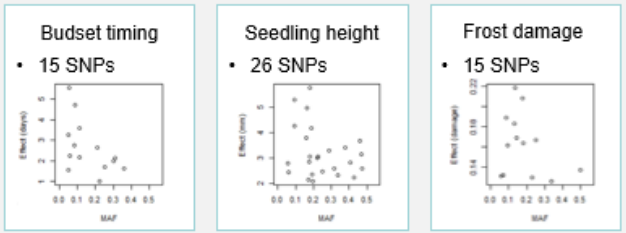

Figure 1. Trait associated SNPs. Effect size is the difference between the BLUEs of the two homotsygotes. MAF=minor allele frequency. Frost damage as scale from 0 (no damage) to 4 (dead)

Genomic Prediction

- Genomic predictions with Scots pine Southern Finnish breeding population for budset timing and 1st year seedling height
- 1021 progeny with 40 405 SNPs (Kastally *et al.* 2022) from 80 crosses between 110 plus trees

➢ Genomic prediction models work well

➢ Genetic correlation higher (0.37) than in the natural population sample (below)

Table 1. Prediction model statistics

	Heritability	Predictive ability*
Budset timing	0.46	0.44
Seedling height	0.68	0.57

*Pearson correlation of observed and genome predicted phenotypes. Validation (100X) by randomly selecting 90% of individuals in training set and 10% in validation set

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Evolution Letters, 2024, **8**(2), 231–242
https://doi.org/10.1093/evlett/qrad054
Advance access publication 27 November 2023
Letter

Within- and between-population comparisons suggest independently acting selection maintaining parallel clines in Scots pine (*Pinus sylvestris*)

Sonja T. Kujala[1], Komlan Avia[2,3], Timo A. Kumpula[2], Hanni Kärkkäinen[4], Juha Heikkinen[5], Katri Kärkkäinen[1], Outi Savolainen[2]

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Task 1.3 Plasticity

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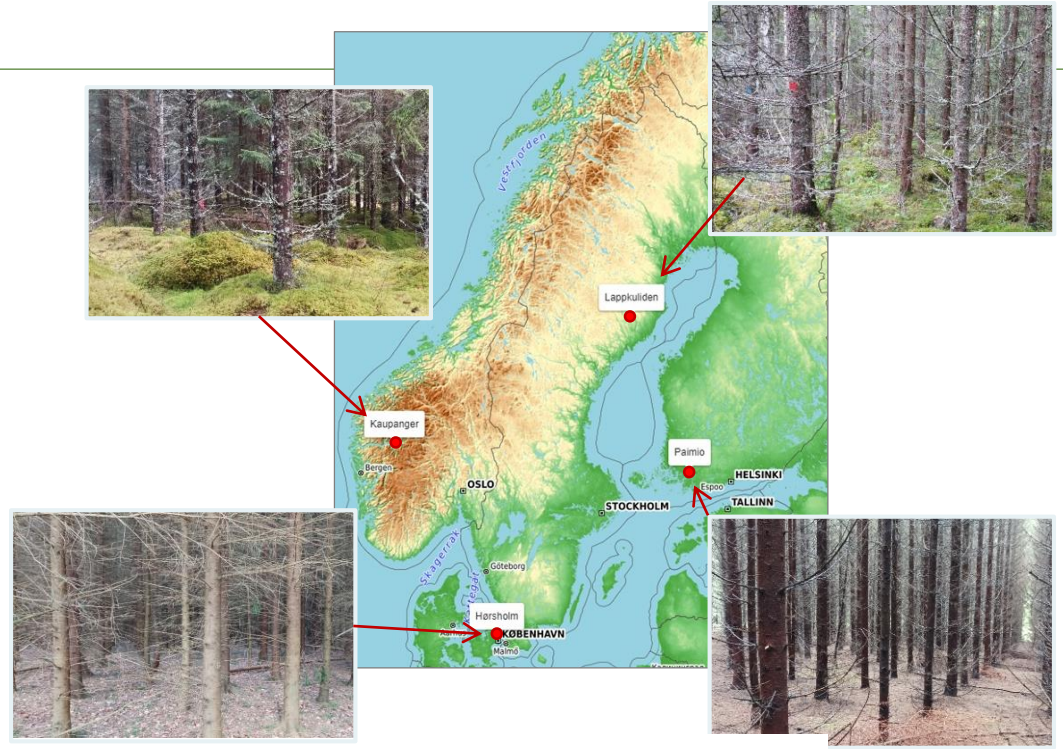
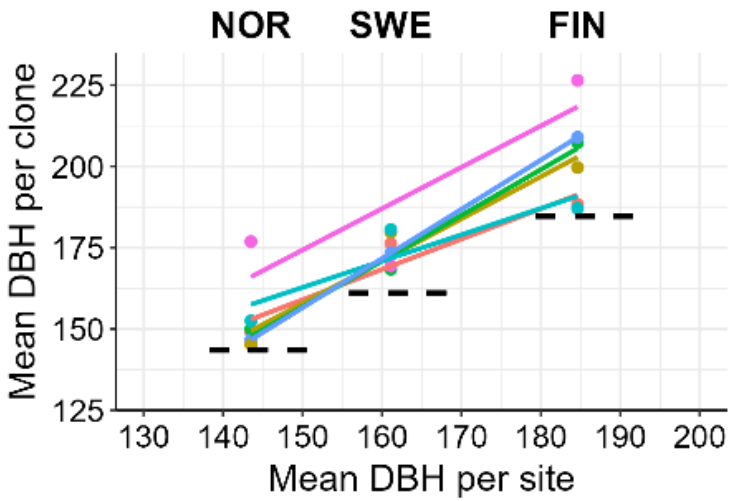
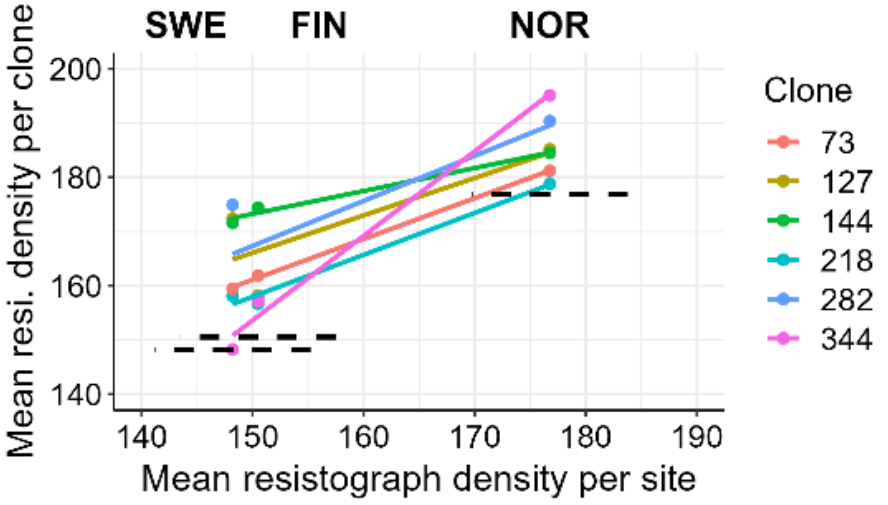
Norway spruce clonal trials

- Kaupanger (Norway)
- Lappkuliden (Sweden)
- Paimio (Finland)
- Hørsholm (Denmark)







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Task 1.4 Genomic selection

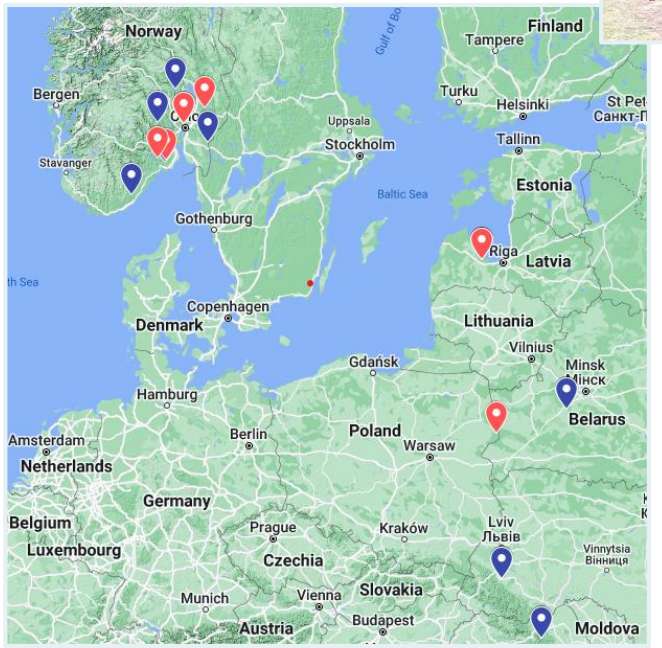
Norway spruce full-sib progeny test

10 x 10 factorial mating design

- 10 trees from Norway (5 ♀ and 5 ♂)
- 10 trees from eastern Europe (5 ♀ and 5 ♂)

	Trees
Planted (1988)	4,830
Alive (2023)	3,020
Genotyped	1,198

Trait	h^2 (SE)
Diameter	0.28 (0.07)
Height	0.28 (0.08)
Wood density	0.31 (0.07)
Grain angle	0.27 (0.07)



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Impact of regeneration method on trait variation

:

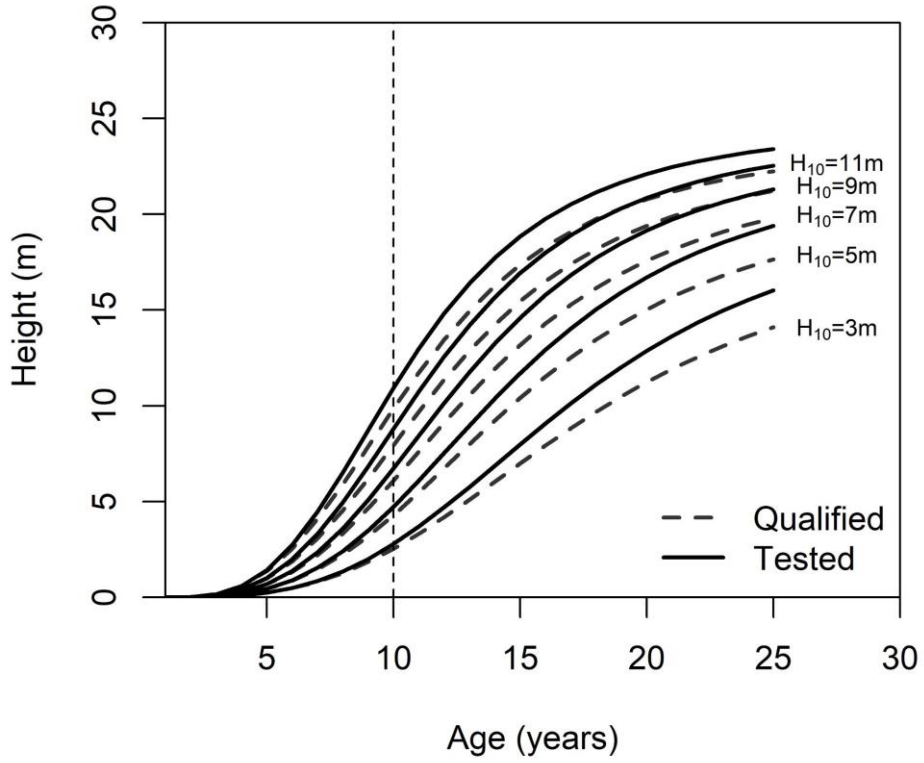
Task 2.1: Scots pine : Growth, wood quality, growth rhythm, cold tolerance, Heterobasidium

Task 2.2: Norway spruce

Task 2.3: Silver birch

ForestValue2 Task 2.1 Scots pine & 2.3 Silver birch

GADA - generalized algebraic difference approach



Objective → new growth functions for silver birch (*Betula pendula*) improved forest reproductive material (FRM) categories 'qualified' and 'tested' up to the midrotation (~ 25 years)

Volume 97, Issue 3
July 2024

JOURNAL ARTICLE

Height growth patterns of genetically improved Scots pine and silver birch Get access ›

Pauls Zeltiņš ✉, Āris Jansons, Virgilijus Baliuckas, Ahto Kangur

Forestry: An International Journal of Forest Research, Volume 97, Issue 3, July 2024, Pages 458–468, https://doi.org/10.1093/forestry/cpad057

Published: 20 November 2023 **Article history** ▾

WP3

Jari Hynynen

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Luke
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Assess Management: Forest management meeting the sustainability goals

:

Task 3.1: Performance of stand management alternatives: Case studies for Scots pine, Norway spruce and birch dominated stands (MOTTI software, Finland; Heureka, Sweden; SiTree, Norway and Latvian simulator)

Task 3.2: The effects of forest management and environmental changes on wood properties

Assess Future Forests: Future scenarios assessing SDG goals, forest management and breeding possibilities

:

Task 4.1: Novel Forest management regimes (breeding, management and stakeholder)

Task 4.2: Assess the sensibility of the models (gains and trade-offs)

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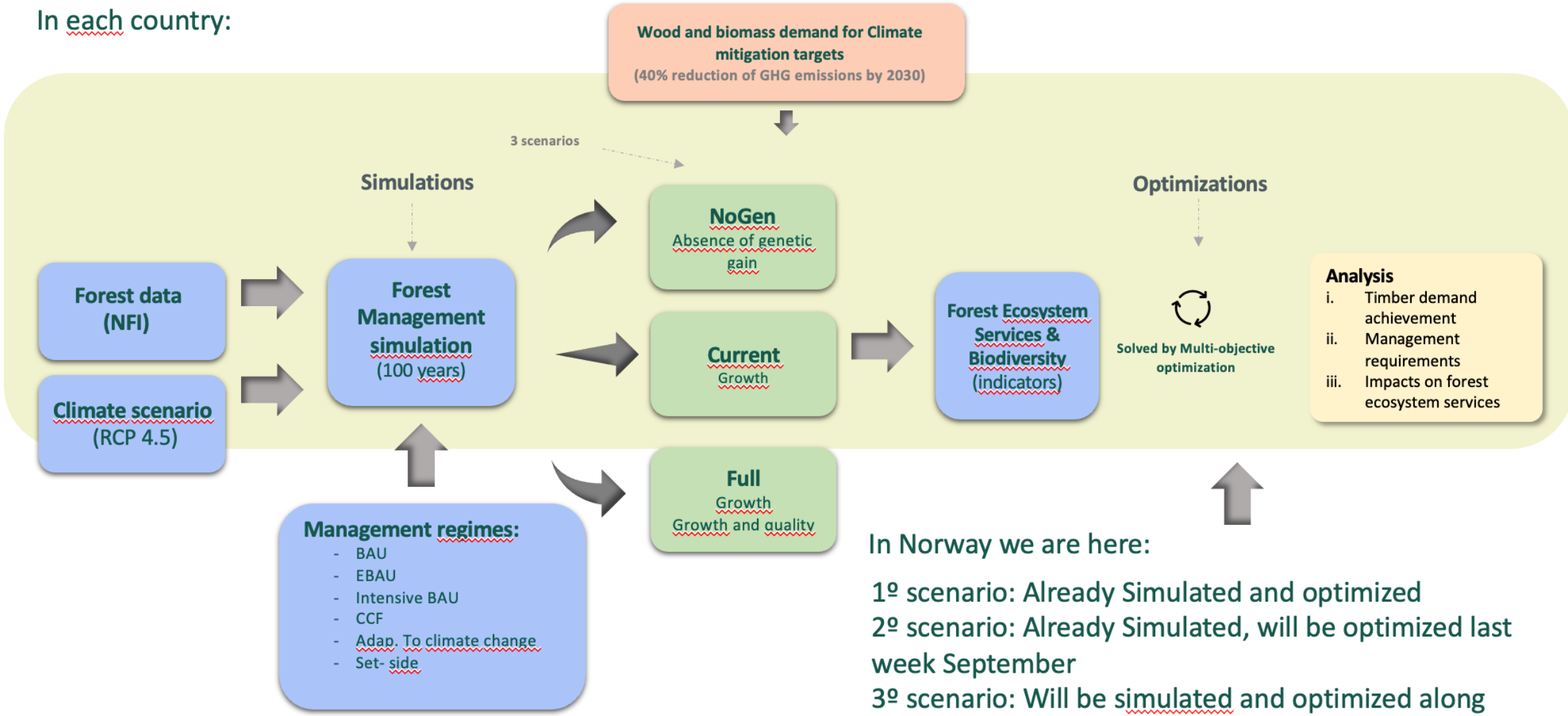
In each country:



In Norway we are here:

1º scenario: Already Simulated and optimized
2º scenario: Already Simulated, will be optimized last week September
3º scenario: Will be simulated and optimized along October

Impact of regeneration method on trait variation

:

Task 5.1: Interaction

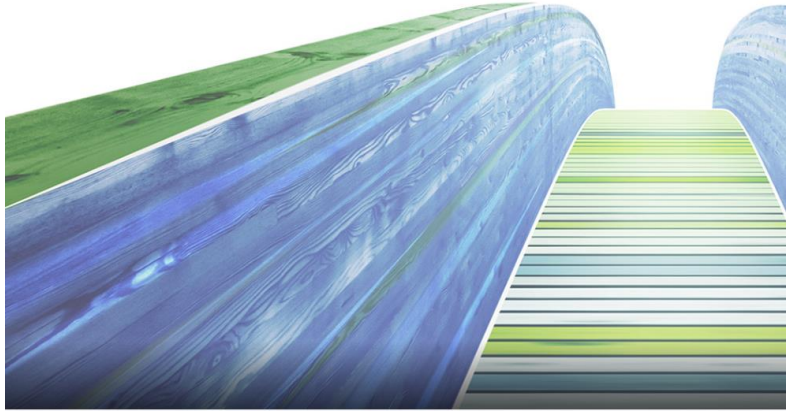
Task 5.2: Dissemination

Task 5.3: Exploitation

Stakeholder forums (WP5)

WOODWORKS! NORWEGIAN FOREST & WOOD CLUSTER

- Four national and international workshops
  - Future use of wood – and the quality needed
  - Scenarios for future forests management to fulfill the needs
  - Adaptation of forest management to climate change
  - The last workshop will be the 9th Oct. *in Nordic language* (sign on at https://woodworkscluster.no/)
- Aim: Match future **industrial needs** with **forest management**
- With introductions from
  - Rune Hedegart, Knut Magnar Sandland, Lars Johansson (**WoodWorks! Cluster**)
  - Magnus Petersson (**Sødra**)
  - Sverre Luktvasslimo (**InnTre Kjeldstad**)
  - Ola Kaaren (**SCA**)
  - Hallvard Olden, Knut J. Dreier (**Moelven**)
  - Joakim Dørum (**Green Advisers**)
  - Tuula Jyske (**Luke**)
  - Thomas Husum (**PEFC Norge**)
  - Trond Svanøe-Hafstad (**Landbruksdirektoratet**)
  - Paul McLean, Gro Hylen, Arne Steffenrem, Clara A. Fernández, Tor Myking (**NIBIO**)



Main results from the stakeholder forums

Industrial needs

- CO_2-neutral resource
- Limited resources today – more volume!
- Construction use of wood: will increase
  - Experiences: managed plantation forests are good
  - Preferred: Conifers of high stiffness and low weight
  - Explore: increased use of hardwoods
  - Limitations: Juvenile wood under shorter rotations
- Fiber use is under development, innovations!
  - High interest in birch fibre
  - Softwood from spruce will be more important
- Innovation and flexibility: The most adaptable industry will survive

Forest management scenarios

- Adaptation and risks – climate change
  - Adapted and healthy forests are most important!
- Differentiate forest production more to achieve
  - High volumes under intensive short rotation production
  - Mixed species forests
  - Longer rotations and CCF
  - Varied and site specific: the best use of species
- Silviculture and tree breeding important to increase productivity and reduce risks from climate change
- Wood of good quality will always be most useful in competition with steel and concrete
  - Strength - weight ratio, knot size, long fibres, reduced fiber angle, improve juvenile wood properties
- In the long run: No need to tailor the timber resource to a specific industry – industry will adapt

Thank you!

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