Bio4Energy Feedstock Spruce data

and its use within Bio4Energy and beyond

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Johan Westin

Presentation at Bio4Energy Researchers' Meeting, Piteå, 22 May 2018

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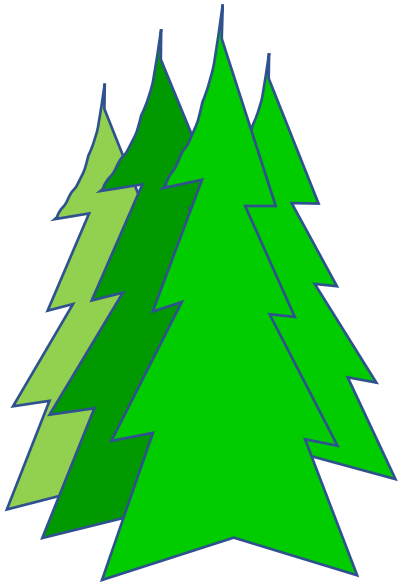
Outline

- Unique data on Norway spruce built by SLU, RISE Bioeconomy and Skogforsk for research collaboration outlined in the Bio4Energy application
- The data are used also in collaborations with other researchers
- The data, current and added
- Examples of results and publications
- Discussion

Aim of presentation

- Wider knowledge about the potential of data for further collaborations



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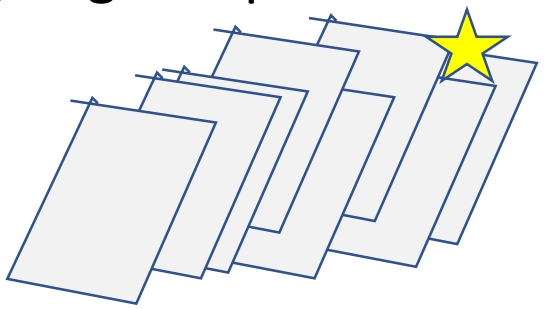
Collaboration

- At the start of Bio4Energy,
  a team was built of researchers from SLU and Innventia, now RISE Bioeconomy,
  supported also by Skogforsk, in order to create an internationally unique
  research environment of wide competence, capabilities and experiences,
  in accordance with the application.
- This has resulted in much cited articles and submitted manuscripts, 2 PhDs,
  and much ongoing and planned research.



- Main track:
  To match properties and genes for Norway spruce,
  to create new efficient tools for tree improvement towards specific properties.

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Research based on unique data

- Research based on unique data, built for the purpose
- Data on further properties successively added , to fulfil more of the tasks.
- Many researchers and students are involved in ongoing and planned research based on the data.
- New possibilities emerge on evaluations an when new data are added. The groups will most likely exploit the data for research also beyond Bio4Energy phase II.
- Also, several collaborations with other researchers are running based on agreements securing ongoing and planned work. We aim for more of this.

Almost 6000 trees of 524 families sampled for increment cores on 2 sites at age 21 years

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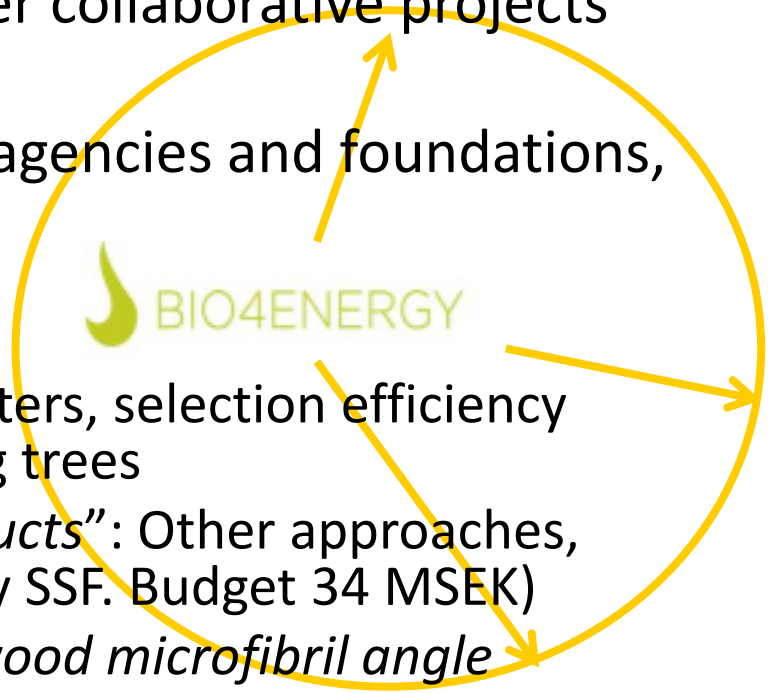
Examples of collaborations based on the data

- Since the start, the data have been used also in further collaborative projects with other researchers, based on agreements
- This way, additional funding has been obtained from agencies and foundations, widening the research within the Bio4Energy sphere.



Examples:

- *Traditional tree breeding approaches*: Genetic parameters, selection efficiency at different ages; new tools for assessment of standing trees
- "*Genomic breeding of Norway spruce for new bioproducts*": Other approaches, resistance to *Heterobasidion*, phenology, … (Funded by SSF. Budget 34 MSEK)
- *Genetic control of transition from juvenile to mature wood microfibril angle* (funded by 3 foundations)
- *Exploration of machine learning as a tool to phenotype standing trees* (Funded by Bio4Energy strategic pot)
- VR Interdisciplinary application just submitted: *Implementation of novel techniques into next-generation forest tree breeding*: Remote sensing, imaging technologies, artificial intelligence, … (Budget 20 MSEK)

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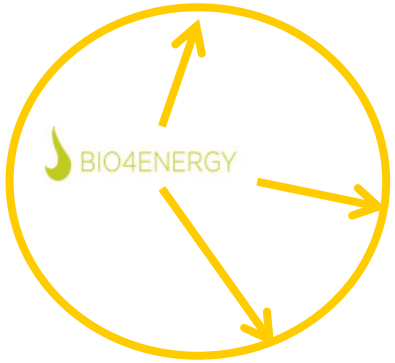
Use of data by other groups within Bio4Energy and beyond



- Such ideas on new collaborations, use of data and terms of use are discussed with a group representing the researchers involved at SLU, RISE Bioeconomy and Skogforsk, which judge on how suggested collaborations relate to ongoing and planned research to avoid conflicts of interest. Contact: Rosario Garcìa Gil.

- The basis for discussion is a description of the suggested collaboration: Aims, approach, data to be used, results and publications foreseen, etc.
- We want such collaboration to increase, giving priority to:
  - Joint efforts with other researchers within Bio4Energy, as now
  - Collaborations of strategic importance with internationally leading groups, which will be sought for

Ongoing and planned research will be secured with agreements to avoid conflicts of interests

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Publication of the data

- The ambition is that all these data will become public.
- The research based on the data will be planned to allow this without problems at the end of Bio4Energy phase II.
  The group representing SLU, RISE Bioeconomy and Skogforsk will manage the data and suggest how to do it, for decision on higher level.
- Until then, access to data can be discussed and agreed according to above.

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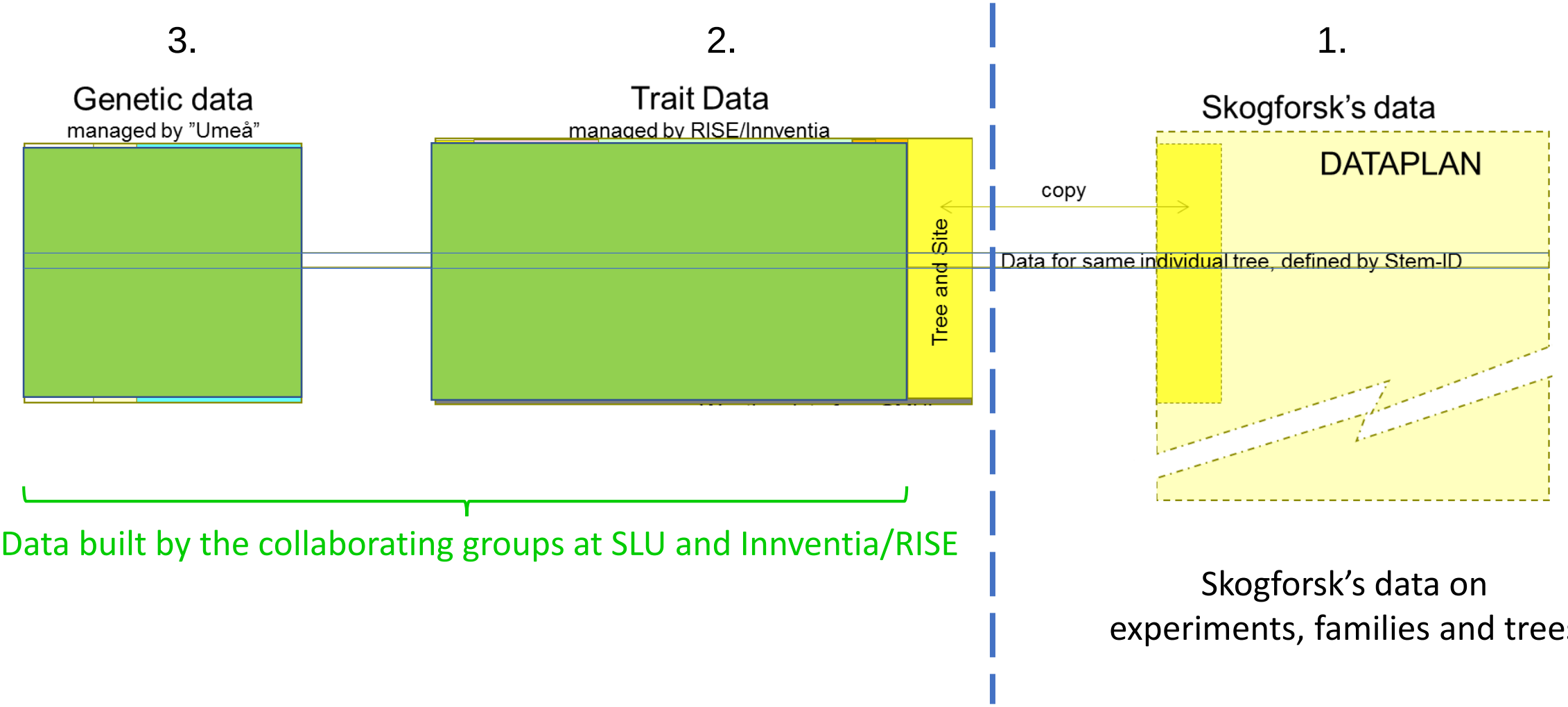
Overall structure of data



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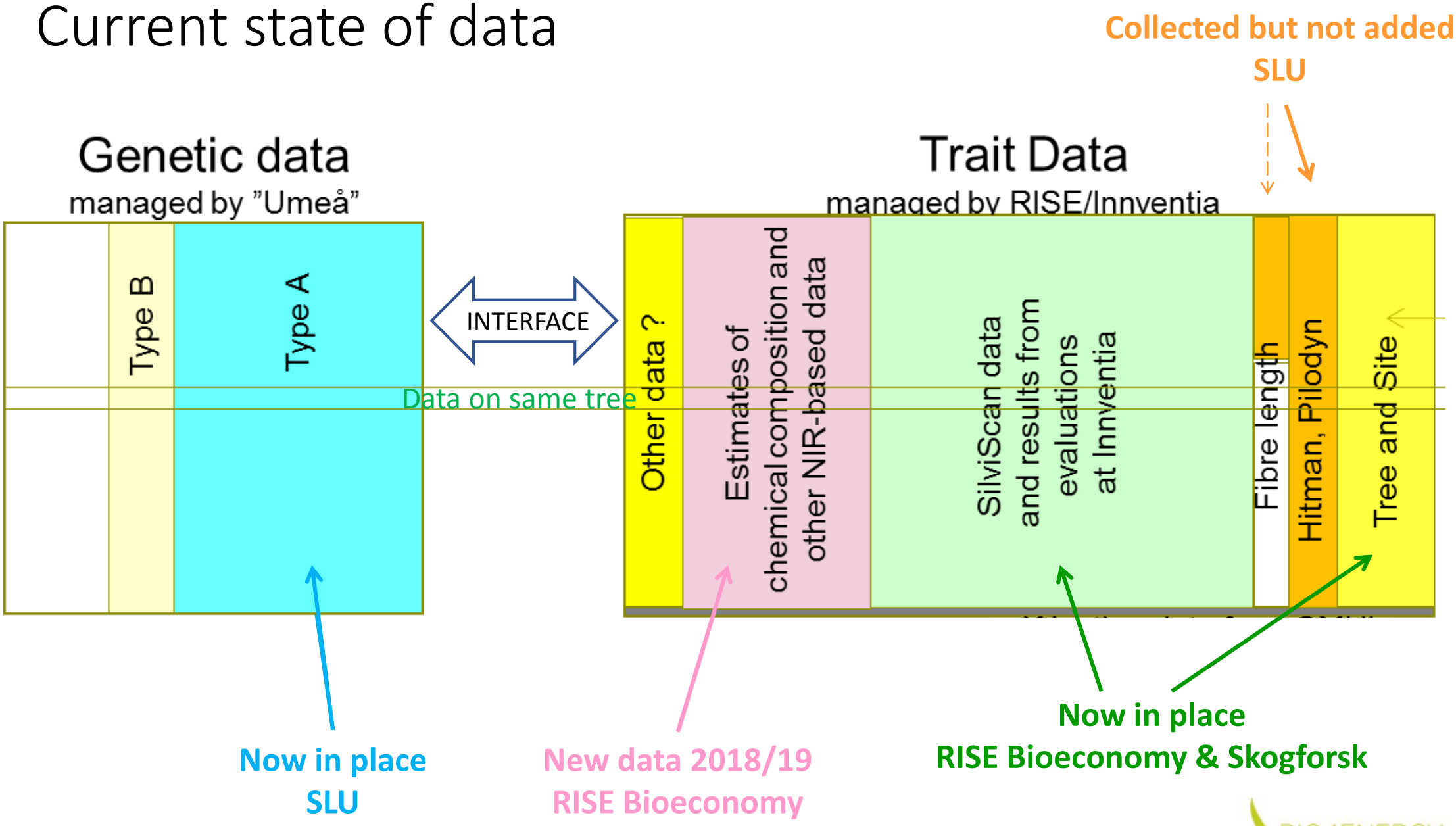
Current state of data



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Some numbers

- Almost 6000 trees of known background
- Representing 524 families, grown on 2 sites
- Sampled at age 21 years
- Data on radial variations from pith to bark, in most cases radial resolution 25 µm
- All rings identified and averages calculated for 71000 growth rings and 212000 ring compartments (earlywood, transitionwood and latewood) …
- … on a large number of growth, wood and fibre traits for
  - detailed studies of wood formation
  - industrial uses
  - product quality (stability of wood constructions, …)

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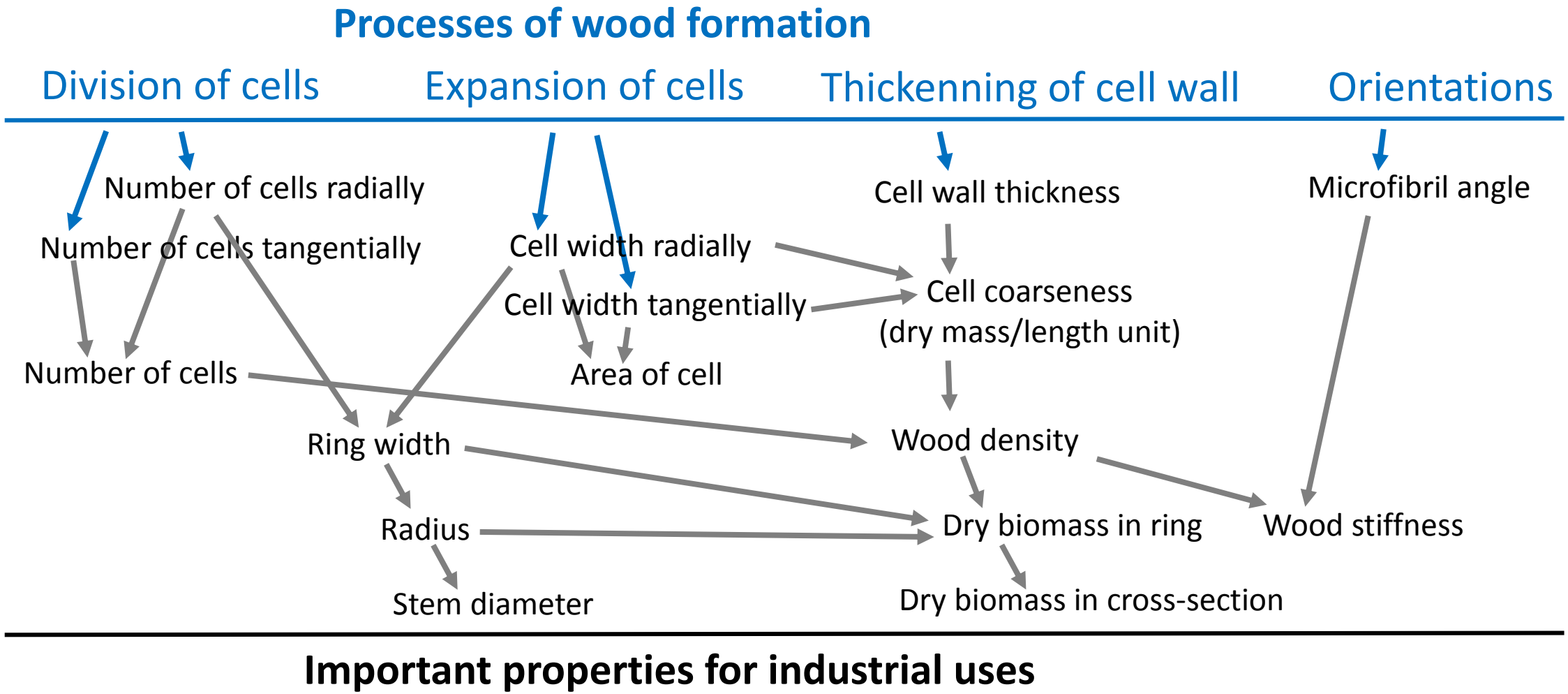
Roadmap from wood formation to growth and properties

built through refinement of SilviScan data at Innventia



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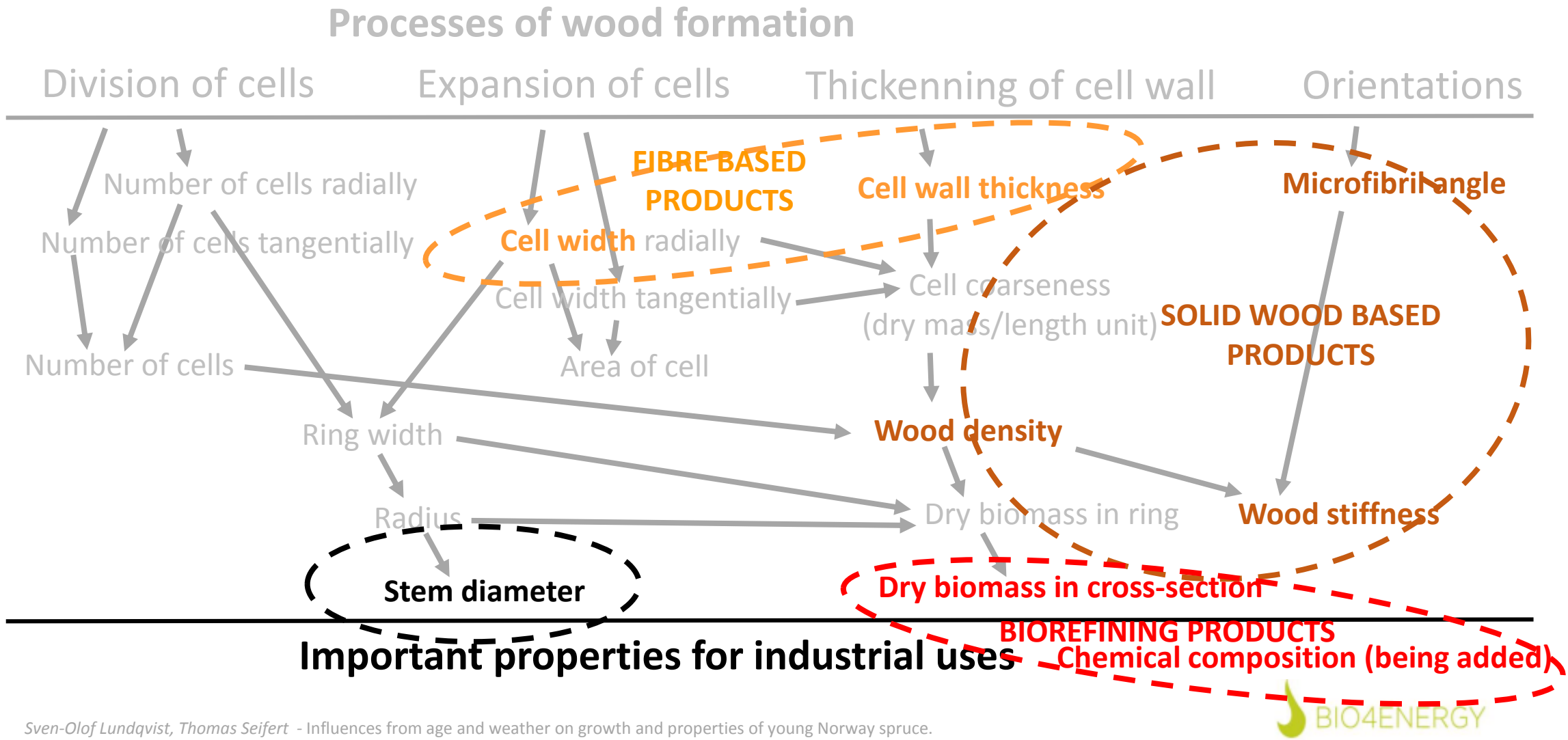

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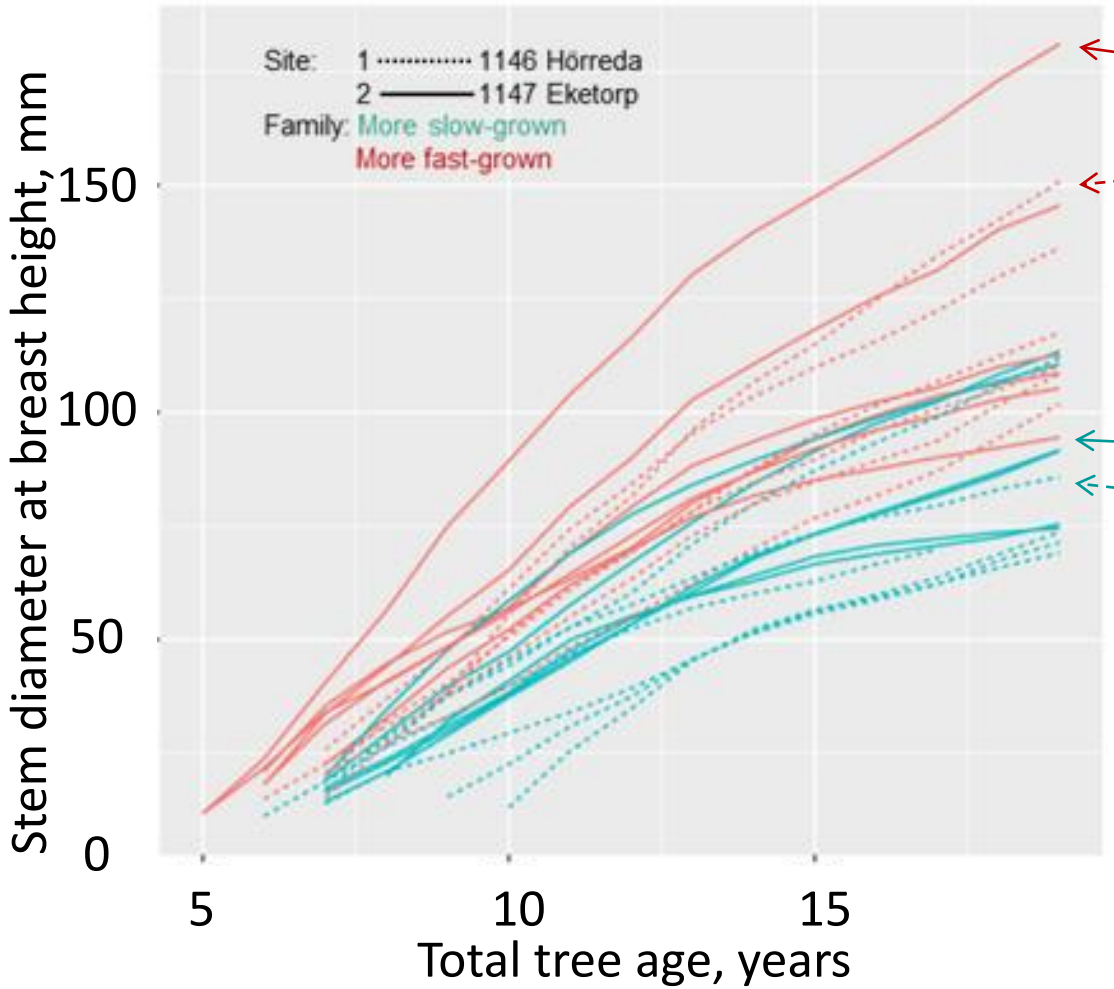
Large differences between and within families and sites

Stem diameter of trees at breast height



Fast-grown family
Site 2
Site 1

Slow-grown family
Site 2
Site 1

Sven-Olof Lundqvist, Thomas Seifert - Influences from age and weather on growth and properties of young Norway spruce.

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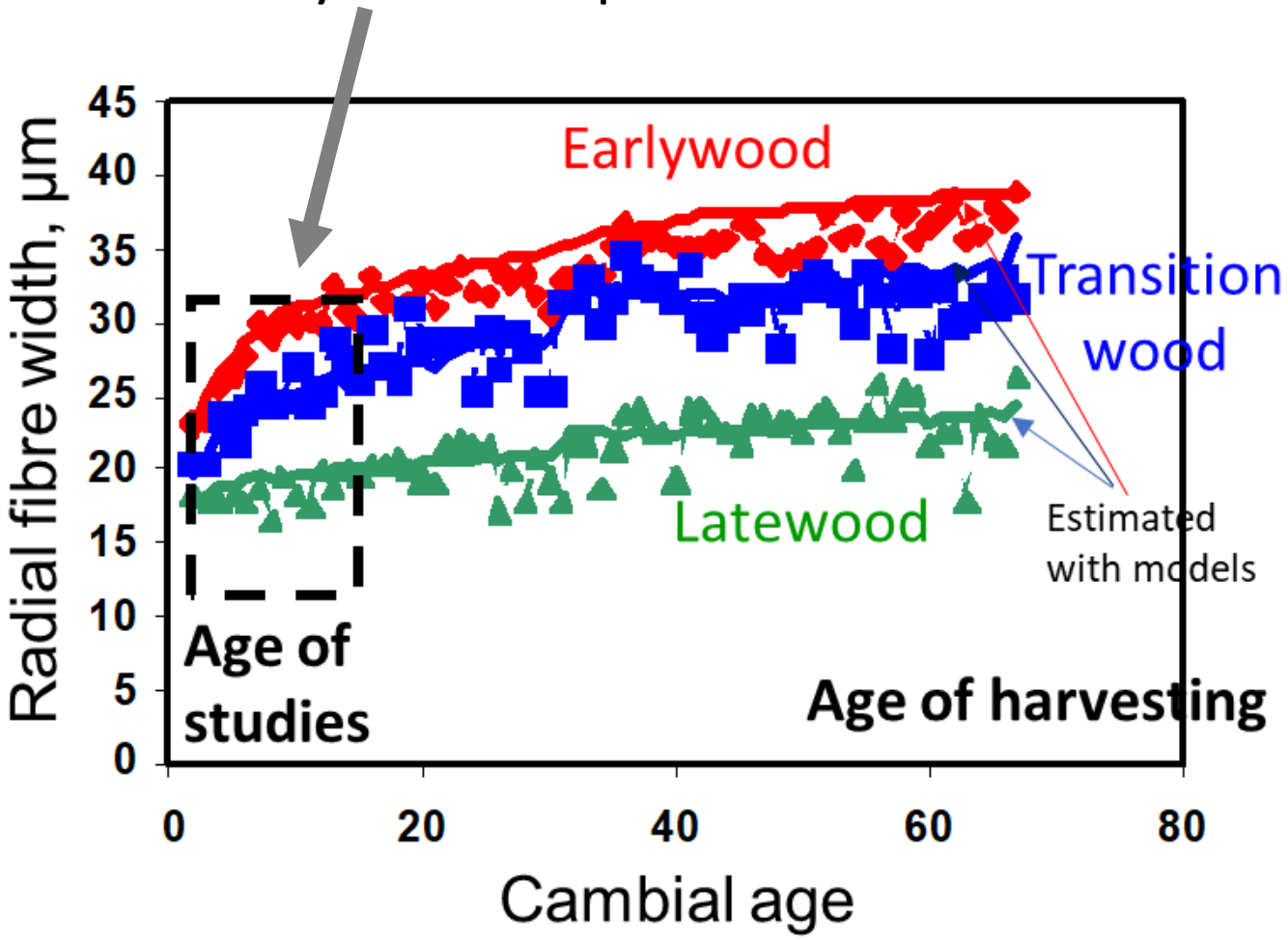
High resolution data
for the most dynamic phase of the trees´ lives



Illustrated with data and models from previous research at Innventia (Lundqvist et al 2008)

PhD theses, published and submitted articles based on the data

PhD Theses by + Zhi-Qiang Chen
+ Haleh Hayatgheibi

Published/Accepted

Zhi-Qiang Chen*, Karl Lundén*, Bo Karlsson, Ingrid Vos, Åke Olson, Sven-Olof Lundqvist, Jan Stenlid, Harry X. Wu, M Rosario García-Gil and Malin Elfstrand (2018) Early selection for resistance to *Heterobasidion parviporum* in Norway spruce is not likely to affect growth and wood quality traits in late-age performance. European Journal of Forest Research

Chen ZQ, Karlsson B, Mörling T, Olsson L. Mellerowicz, Wu HX, Lundqvist SO, García-Gil MR (2016) Genetic analysis of fiber dimensions and their correlation with stem diameter and solid-wood properties in Norway spruce. Tree Genetics and Genomics. 12: 123-135

Chen ZQ, Abramowicz K, Raczkowski R, Ganea LS, Mörling T, Wu HX, Lundqvist SO, Sjöstedt-De Luna S, García-Gil MR and Mellerowicz EJ (2015) Methodology of Fiber length determination for large-scale population analyses in Norway Spruce. Holzforschung: International Journal of Biology, Chemistry, Physics and Technology of wood, Germany. 79 DOI 10.1515/hf-2015-0138

Chen ZQ, Karlsson B, Lundqvist SO, García-Gil MR, Olsson L and Wu HX (2015) Estimating solid wood properties using Pilodyn and acoustic velocity on standing trees of Norway spruce. Annals of Forest Science. Volume 72, Issue 4, pp 499-508

Chen Zhi-Qiang, García Gil MR, Karlsson B, Lundqvist SO, Olsson L, Wu HX (2014) Inheritance of growth solid wood quality traits in a large Norway spruce population tested at two locations in southern Sweden. Tree Genetics and Genomes, 10: 1291-1302

Submitted (BioRxiv and under revision)

Zhi-qiang Chen, John Baison, Jin Pan, Bo Karlsson, Bengt Gull Andersson, Johan Westin, Maria Rosario Garcia-Gil, Harry Xiaming Wu (2018) Accuracy of genomic selection for growth and wood quality traits in two control-pollinated progeny trials using exome capture as genotyping platform in Norway spruce (BioRxiv reprint https://www.biorxiv.org/content/early/2018/04/03/293696?rss=1, under revision at Candian Journal of Forest Research)

John Baison J, Vidalis A, Zhou Linghua, Chen Zhi-Qiang, Li Zitong, Sillanpää Mikko J, Bernhardsson Carolina, Scofield Douglas G, Forsberg N, Olsson Lars, Karlsson Bo, Wu Harry, Ingvarsson Pär K, Lundqvist Sven-Olof, Niittylä Totte, García-Gil Rosario M (2018) Association mapping identified novel candidate loci affecting wood formation in Norway spruce BioRxiv reprint https://doi.org/10.1101/292847 (under revision New Phytologist)

Haleh Hayatgheibi, Nils Forsberg, Sven-Olof Lundqvist, Tommy Mörling, Ewa J. Mellerowicz, Bo Karlsson, Harry Wu, M Rosario García-Gil (2018) Genetic control of transition from juvenile to mature wood with respect to microfibril angle (MFA) in Norway spruce (*Picea abies*) and lodgepole pine (*Pinus contorta*) BioRxiv repring http://biorxiv.org/cgi/content/short/298117v1 (under revision Canadian Journal of Forest Research)

Linghua Zhou, Zhiqiang Chen, Sven-Olof Lindqvist, Lars Olsson, Thomas Grahn, Bo Karlsson, Harry X. Wu, María Rosario García-Gil (2018) Correlation analysis between maternal and open-pollinated progenies for wood quality in Norway spruce. BioRxiv repring http://biorxiv.org/cgi/content/short/293969v1 (under revision Canadian Journal of Forest Research)

Sven-Olof Lundqvist, Stefan Seifert, Thomas Grahn, Lars Olsson, María Rosario García-Gil, Bo Karlsson, Thomas Seifert (2018) Age and weather effects on between and within ring variations of number, width and coarseness of tracheids and radial growth of young Norway spruce. European Journal of Forest Research (submitted)

And more manuscripts in progress

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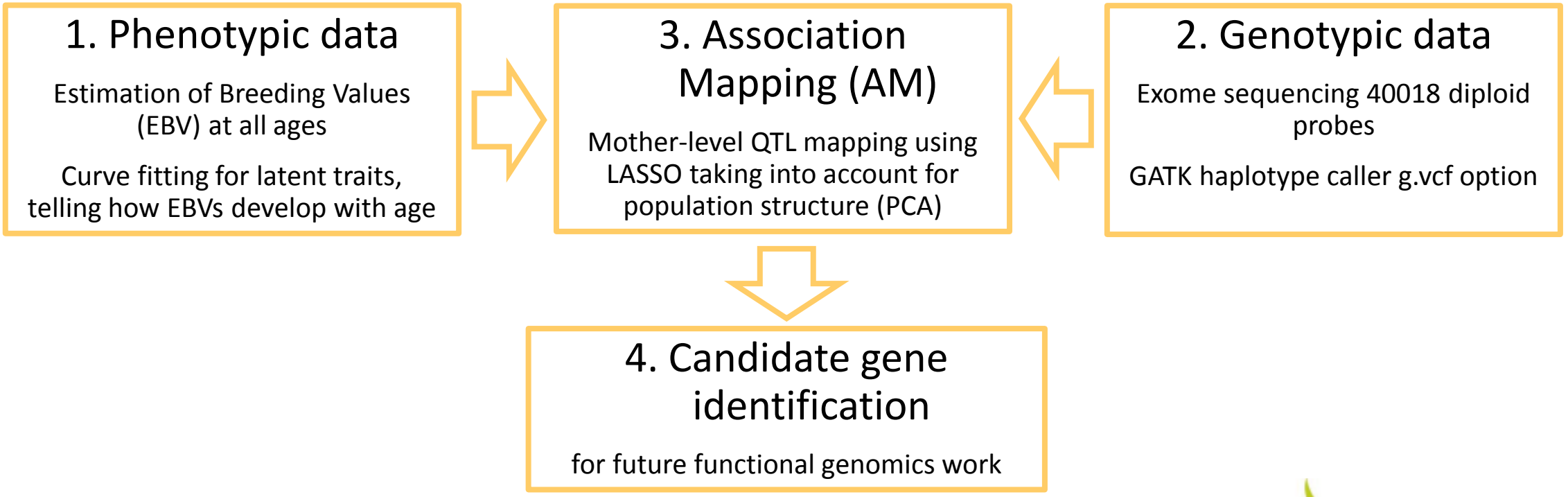
Association mapping identified novel candidate loci affecting wood formation in Norway spruce

John Baison et al

The first genome-wide association mapping study presented for traits of tracheids in Norway spruce



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Association mapping identified novel candidate loci affecting wood formation in Norway spruce

- An exome capture genotyping approach was used, generating 178 101 high quality Single Nucleotide Polymorphisms (SNPs) from 40 018 probes within a population of 517 Norway spruce mother trees
- A LASSO based association mapping method was applied, using a functional multi-locus mapping approach that utilizes latent traits
  - 17 original traits under investigation + latent traits related to these
  - 178 101 SNPs
  - 51 significant SNPs
  - 39 candidate genes
- Genome-wide association (GWAS) mapping made possible the establishment of the genetic basis of phenotypic trait variation for
  - 19 traits
  - 21 significant SNPs
  - 19 candidate genes
- among them loci for trees with both high growth and density = more biomass!

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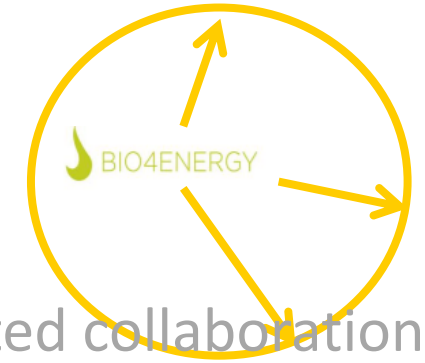
Discussion



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