A Roadmap for Europe-wide Forest Estimates from Airborne LiDAR

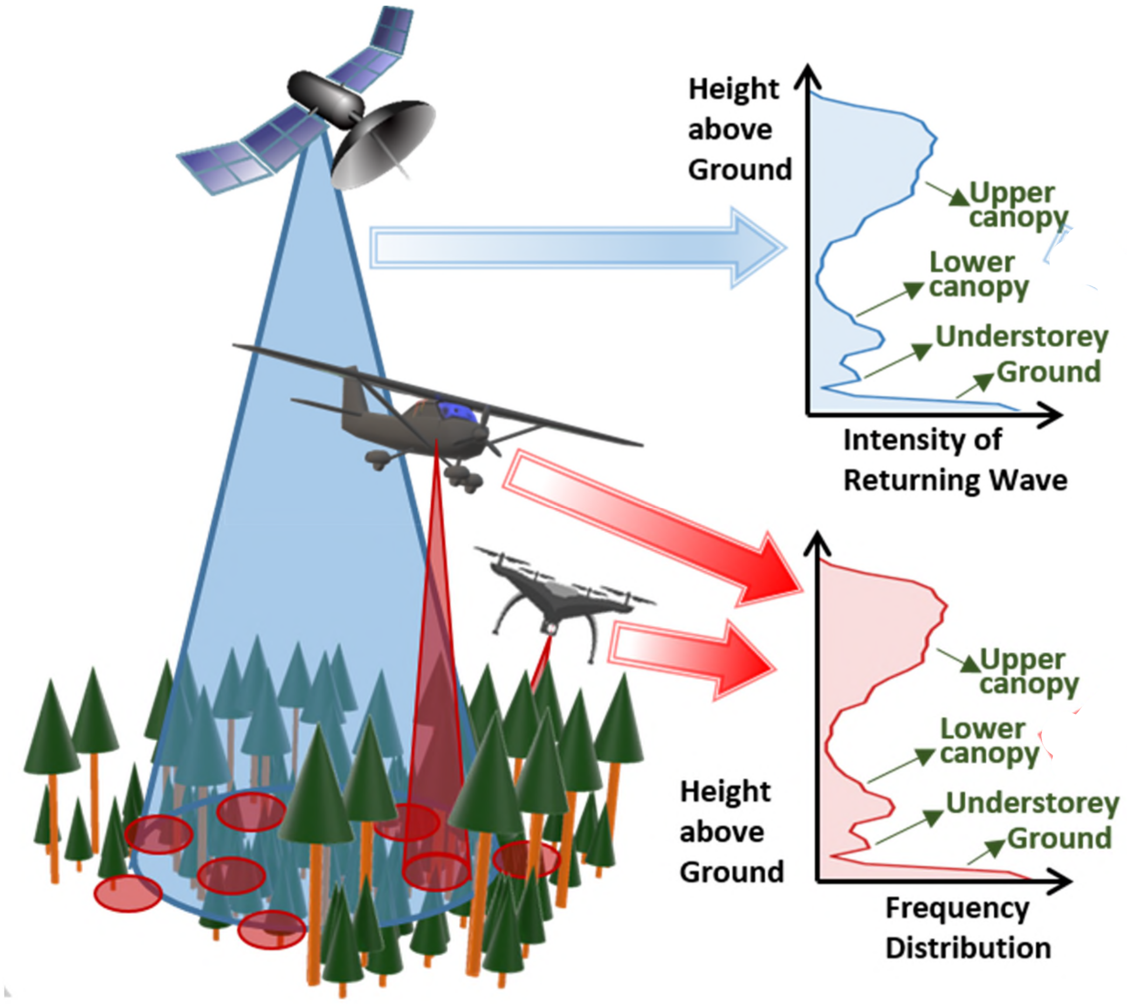
Reunión EIKOS: Las Nuevas Tecnologías Aplicadas al Conocimiento de los Ecosistemas

Rubén Valbuena
Professor of Remote Sensing of Forests

Mats Nilsson
Researcher at the Division of Forest Remote Sensing

SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES

Ecosystem Structure Essential Biodiversity Variables - Ecosystem Vertical Profile



Science

GEO BON
Group on Earth Observations
Biodiversity Observation Network

HOME > SCIENCE > VOL. 339, NO. 6117 > ESSENTIAL BIODIVERSITY VARIABLES

POLICY FORUM | ECOLOGY

Essential Biodiversity Variables

A global system of harmonized observations is needed to inform scientists and policy-makers.

H. M. PEREIRA, S. FERRIER, M. WALTERS, G. N. GELLER, R. H. G. JONGMAN, R. J. SCHOLES, M. W. BRUFORD, N. BRUMMITT, S. H. M. BUTCHART, [...] M. WEGMANN

Community composition	Community abundance
	Taxonomic/phylogenetic diversity
	Trait diversity
	Interaction diversity
Ecosystem functioning	Primary productivity
	Ecosystem phenology
	Ecosystem disturbances
Ecosystem structure	Live cover fraction
	Ecosystem distribution
	Ecosystem Vertical Profile

UN environment WCMC

UNIVERSITY OF CAMBRIDGE

Trends in Ecology & Evolution

CellPress REVIEWS

Opinion

Standardizing Ecosystem Morphological Traits from 3D Information Sources

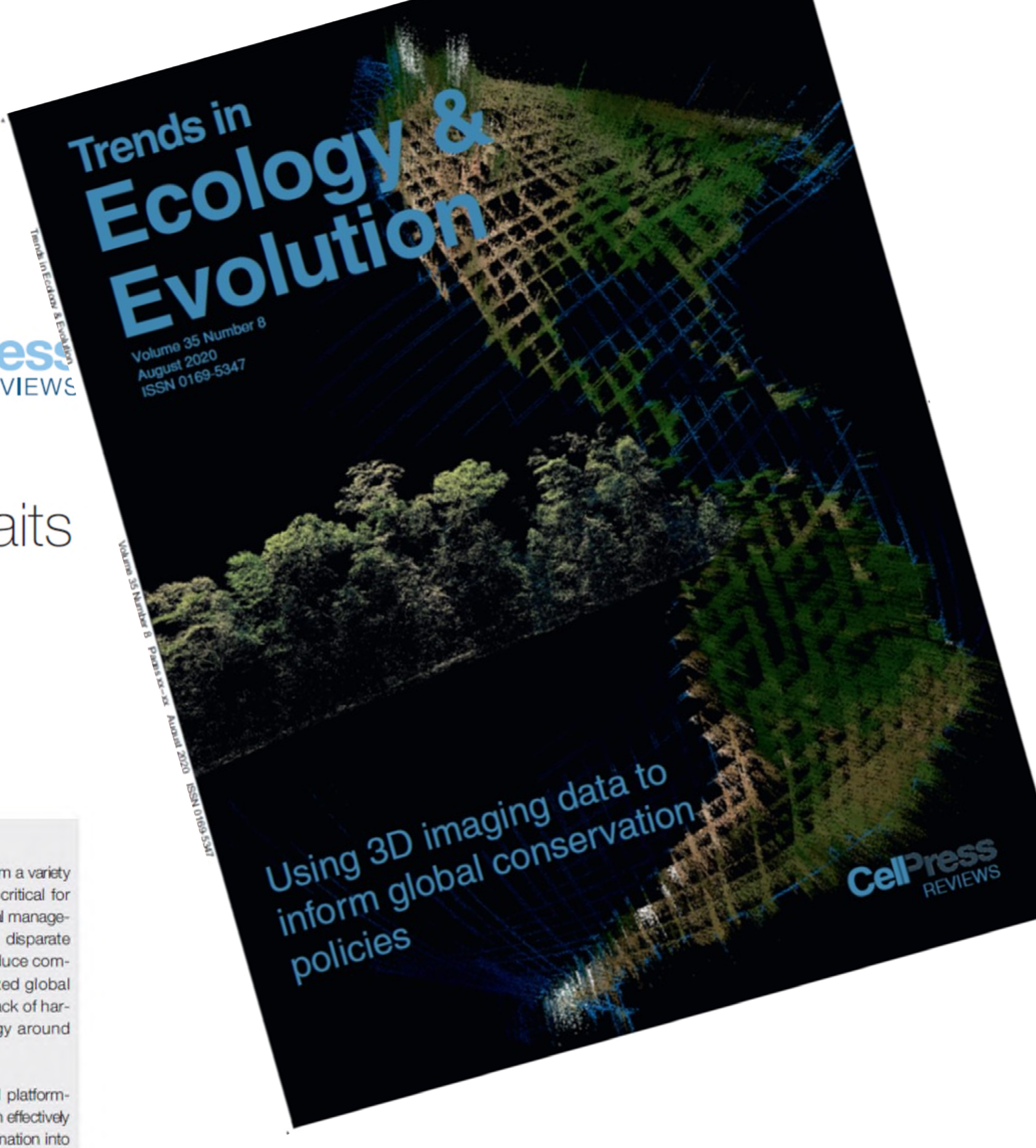
R. Valbuena,[1,2,3,14,*,@] B. O'Connor,[1] F. Zellweger,[2,4] W. Simonson,[1] P. Vihervaara,[5] M. Maltamo,[6] C.A. Silva,[7,8] D.R.A. Almeida,[9] F. Danks,[1] F. Morsdorf,[10] G. Chirici,[11] R. Lucas,[12] D.A. Coomes,[2] and N.C. Coops[13]

3D-imaging technologies provide measurements of terrestrial and aquatic ecosystems' structure, key for biodiversity studies. However, the practical use of these observations globally faces practical challenges. First, available 3D data are geographically biased, with significant gaps in the tropics. Second, no data source provides, by itself, global coverage at a suitable temporal recurrence. Thus, global monitoring initiatives, such as assessment of essential biodiversity variables (EBVs), will necessarily have to involve the combination of disparate data sets. We propose a standardized framework of ecosystem morphological traits – height, cover, and structural complexity – that could enable monitoring of globally consistent EBVs at regional scales, by flexibly integrating different information sources – satellites, aircrafts, drones, or ground data – allowing global biodiversity targets relating to ecosystem structure to be monitored and regularly reported.

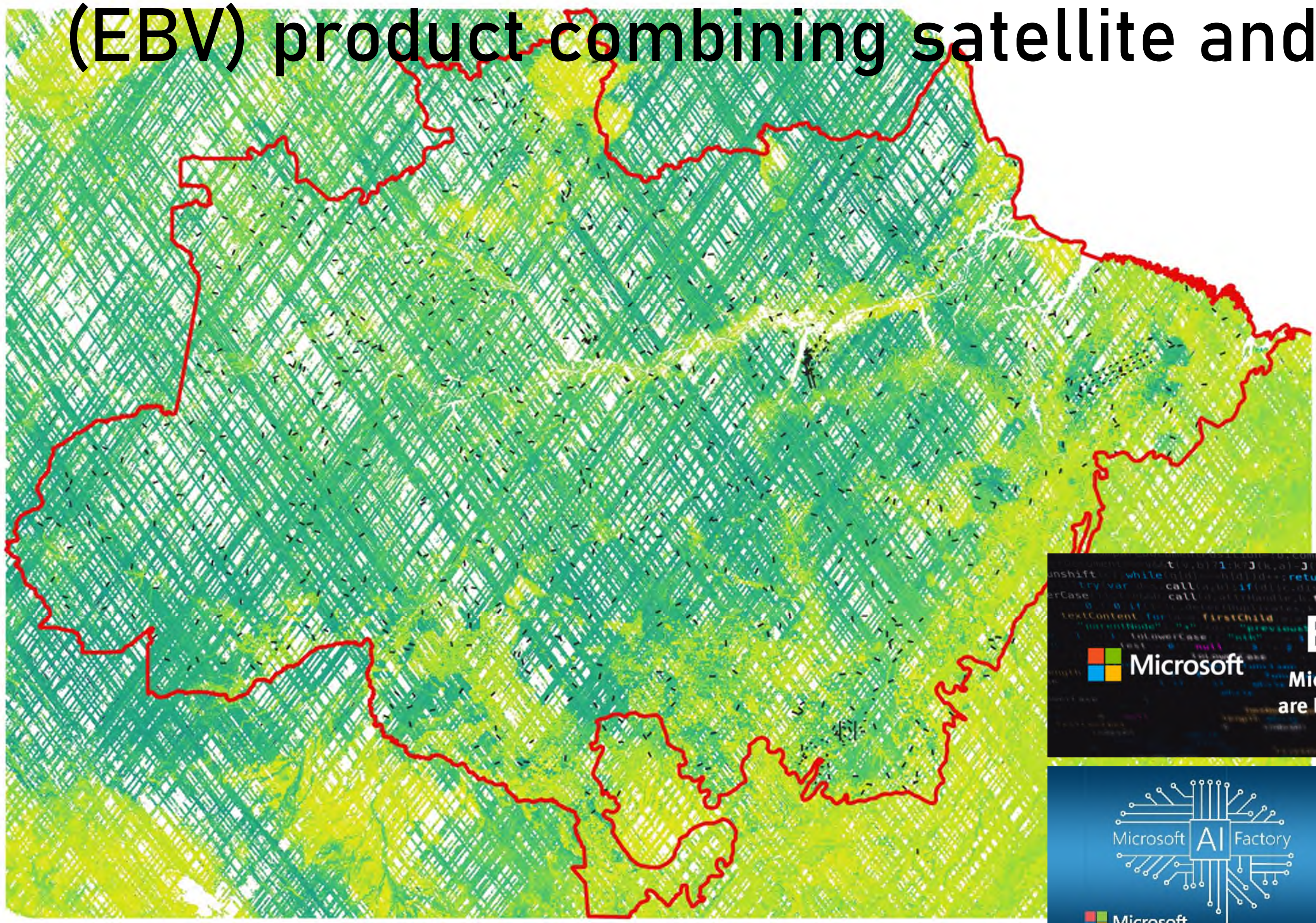
Highlights

3D-imaging data acquired from a variety of platforms have become critical for ecological and environmental management. However, the use of disparate information sources to produce comprehensive and standardized global products is hindered by a lack of harmonization and terminology around ecosystem structure.

We propose a sensor- and platform-independent framework which effectively distils the wealth of 3D information into concise ecosystem morphological traits – height, cover, and structural complexity –



Project AMAZECO: Covering the Amazon with an Ecosystem Structure Essential Biodiversity Variable (EBV) product combining satellite and airborne LIDAR

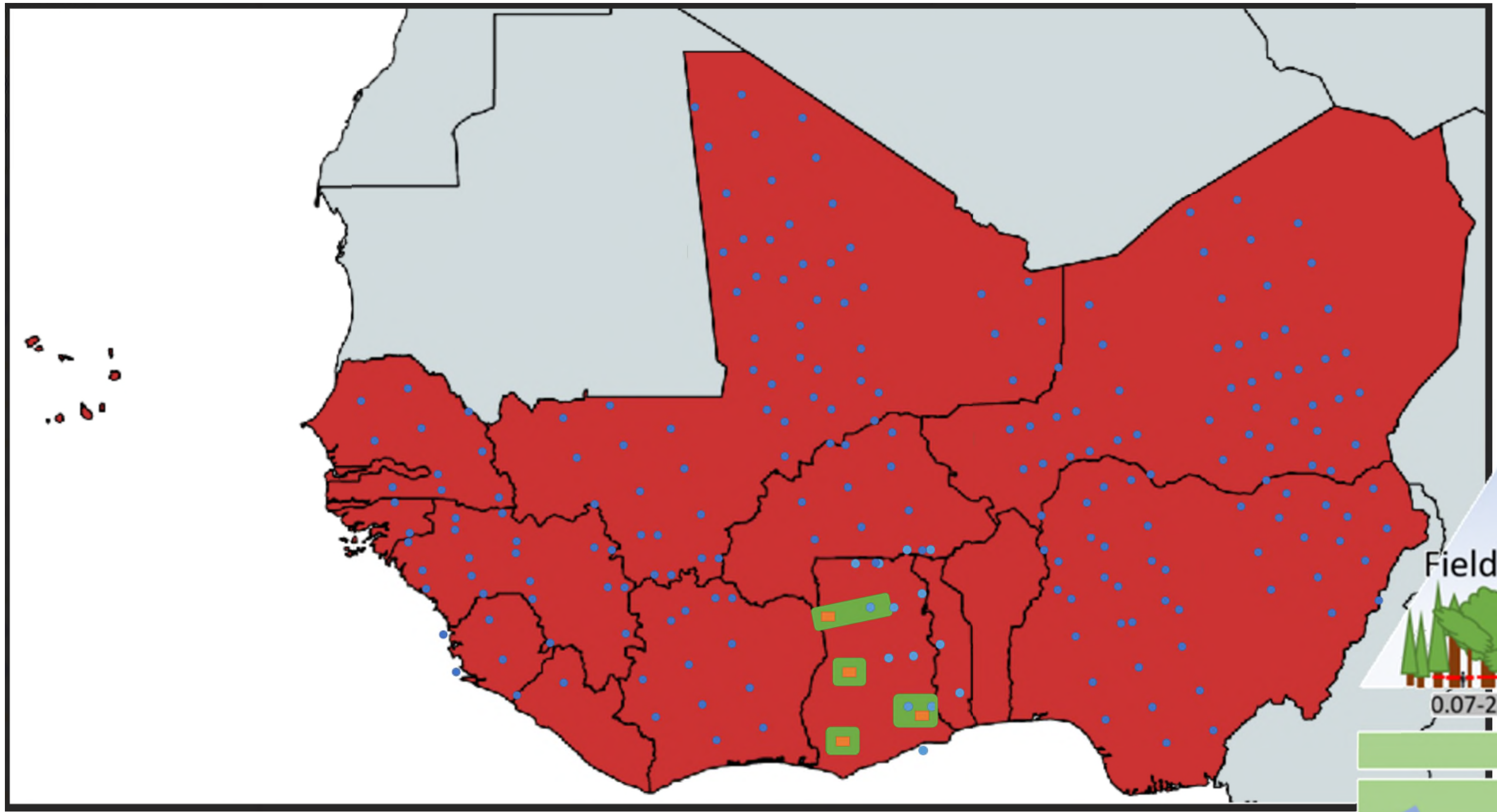


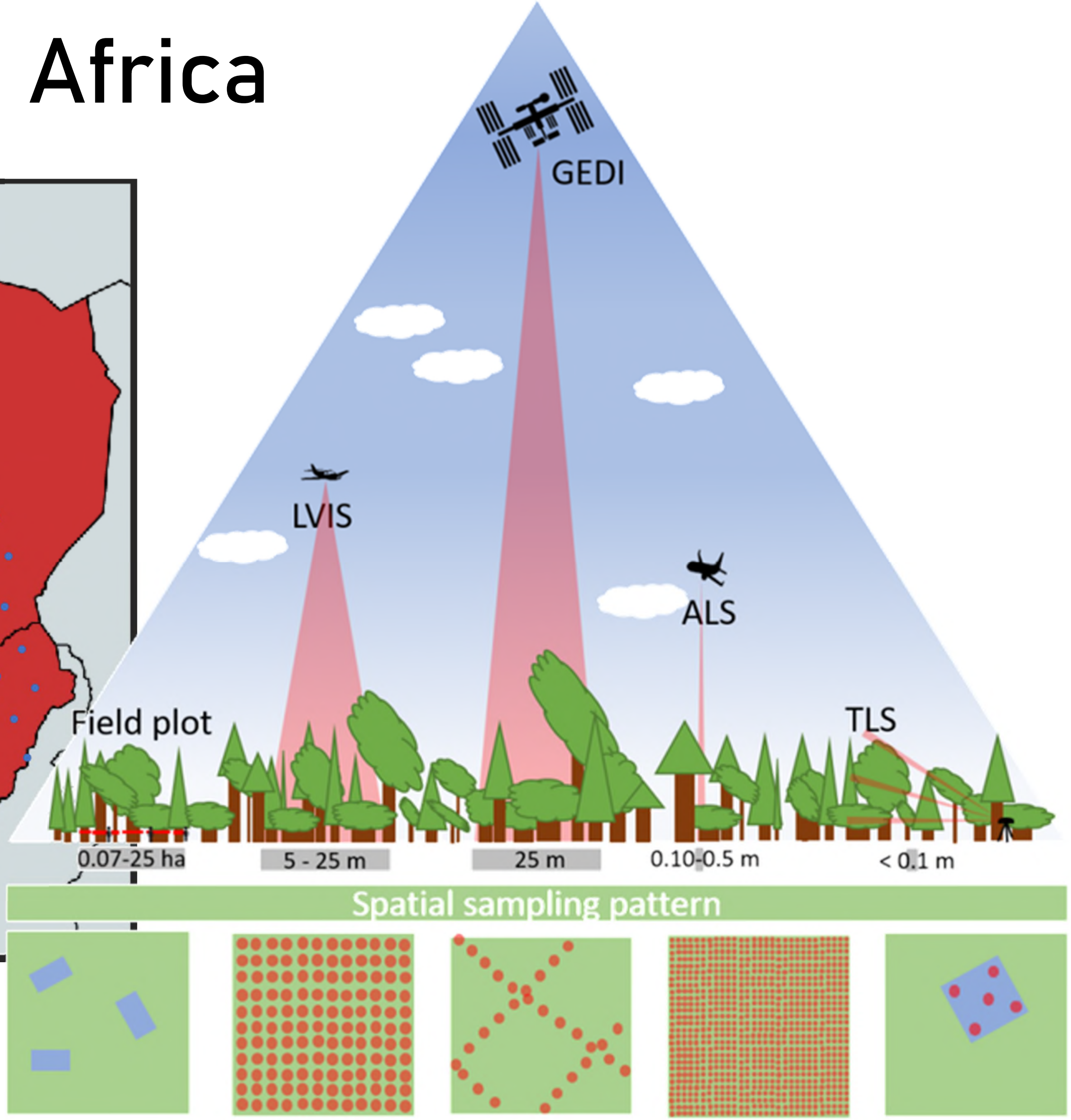
Microsoft AI Factory
Microsoft

GEO BON
Group on Earth Observations
Biodiversity Observation Network

Microsoft Azure

FAO national estimates in West Africa





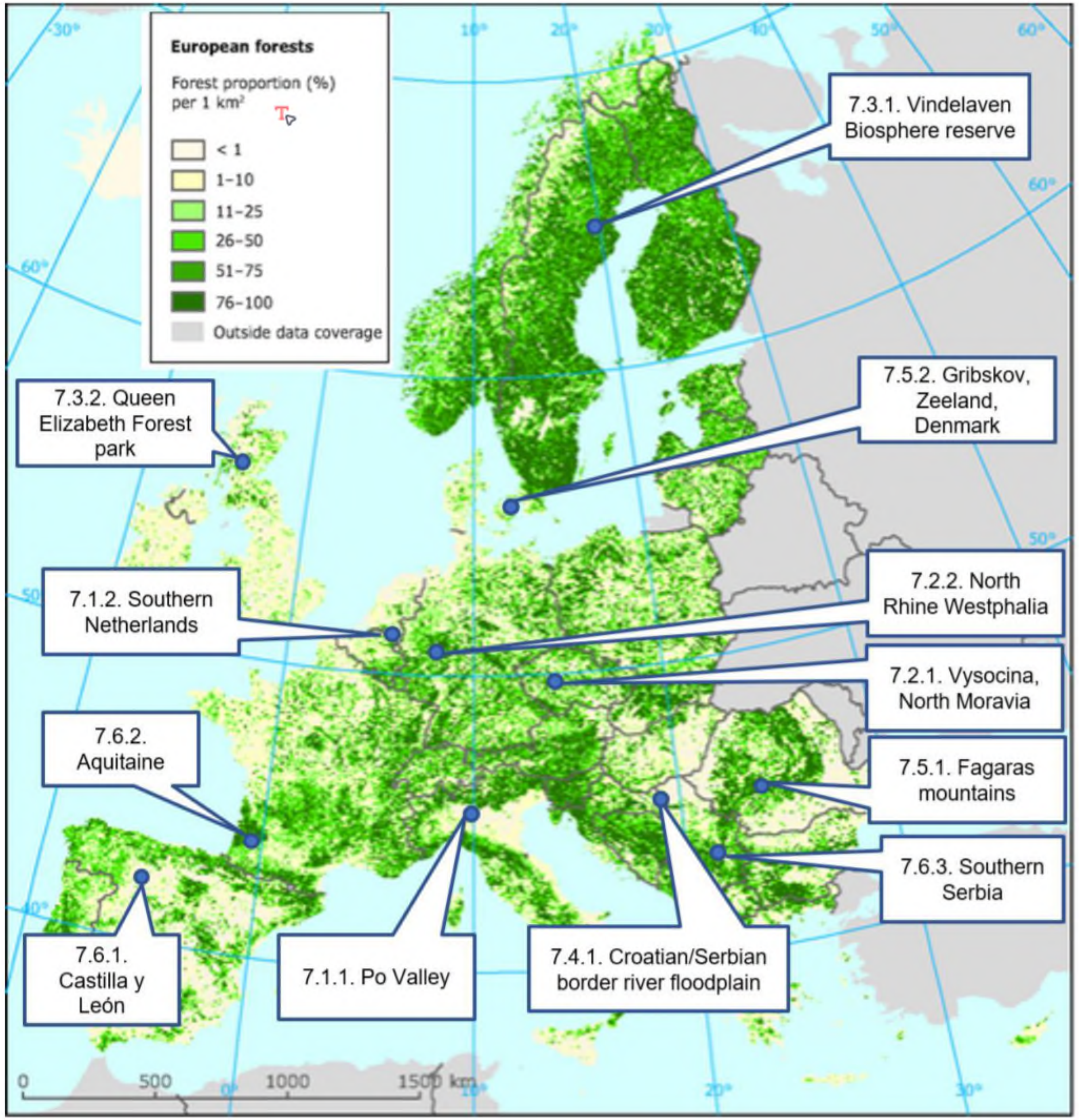
FORIG

Oxford

Maryland

UPSCALING FROM FIELD PLOTS (GHANA) TO SATELLITE LIDAR (W. AFRICA)

Biodiversity Assessments



SUPERB
Upscaling Forest Restoration

Biodiversity Assessments

SUPERB
Upscaling Forest Restoration

Remote Sensing

Bioacoustics

DNA metabarcoding

Biodiversity Assessments

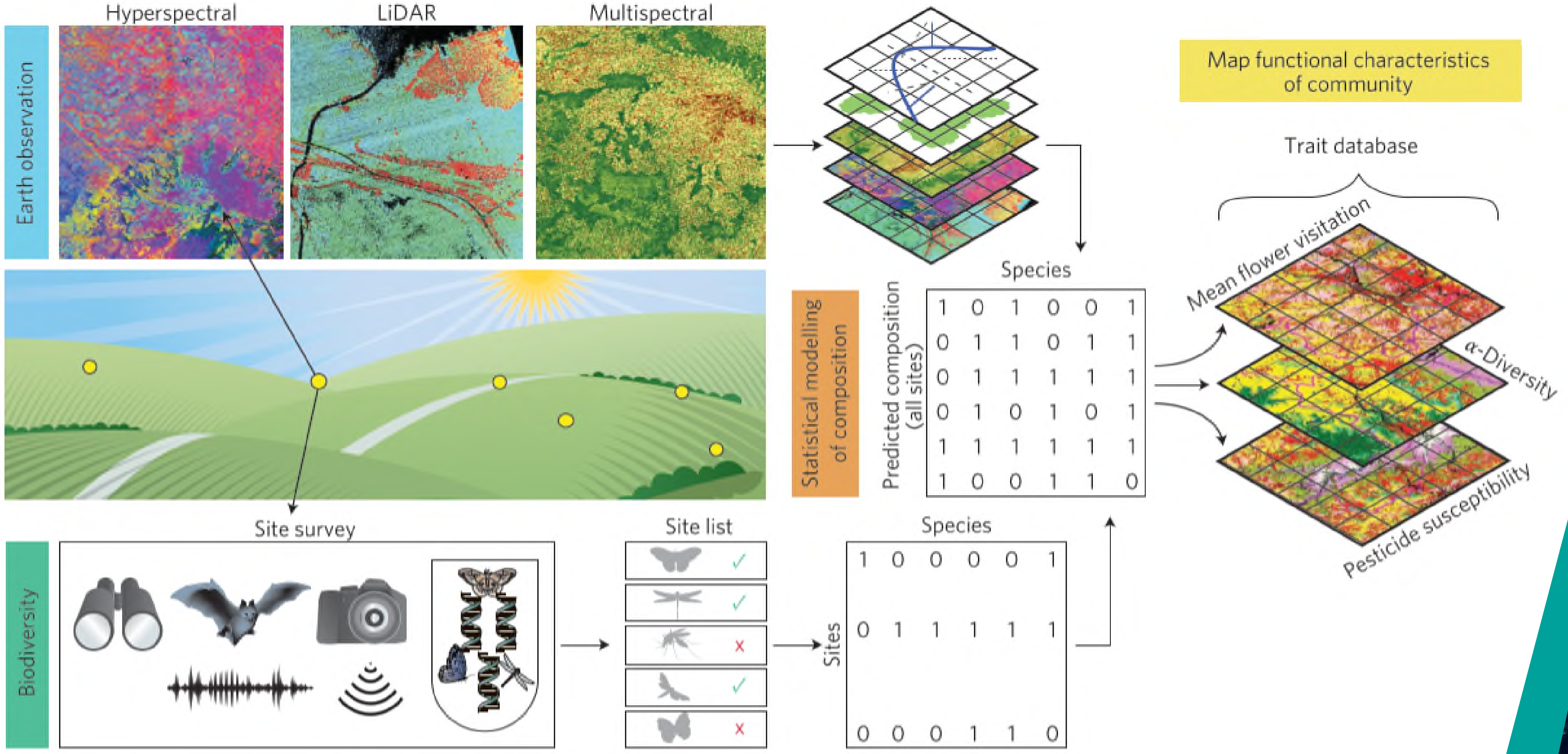
SUPERB
Upscaling Forest Restoration

nature ecology & evolution

PERSPECTIVE
PUBLISHED: 22 JUNE 2017 | VOLUME: 1 | ARTICLE NUMBER: 0176

Connecting Earth observation to high-throughput biodiversity data

Alex Bush[1,2,3], Rahel Sollmann[4], And



Policy Relevance

The New York Times

Policy Relevance

nature

Article | Published: 01 July 2020

Abrupt increase in harvested forest area over Europe after 2015

Guido Ceccherini, Gregory Duveiller, Giacomo Grassi, Guido Lemoine, Valerio Avitabile, Roberto Pilli & Alessandro Cescatti

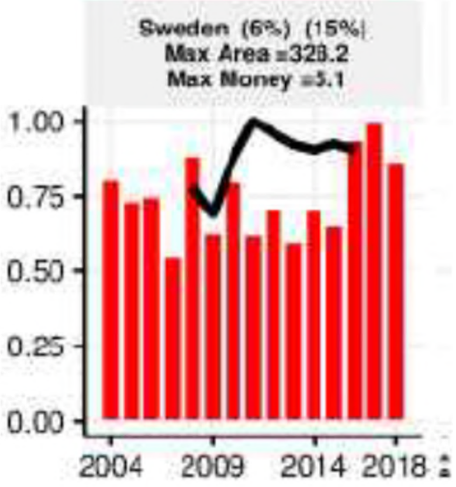
Nature **583**, 72–77 (2020) | Cite this article

Matters Arising | Published: 28 April 2021

Concerns about reported harvests in European forests

Marc Palahí, Rubén Valbuena, Cornelius Senf, Nezha Acil, Thomas A. M. Pugh, Jonathan Sadler, Rupert Seidl, Peter Potapov, Barry Gardiner, Lauri Hetemäki, Gherardo Chirici, Saverio Francini, Tomáš Hlásny, Bas Jan Willem Lerink, Håkan Olsson, José Ramón González Olabarria, Davide Ascoli, Antti Asikainen, Jürgen Bauhus, Göran Berndes, Janis Donis, Jonas Fridman, Marc Hanewinkel, Hervé Jactel, … Gert-Jan Nabuurs + Show authors

Nature **592**, E15–E17 (2021) | Cite this article

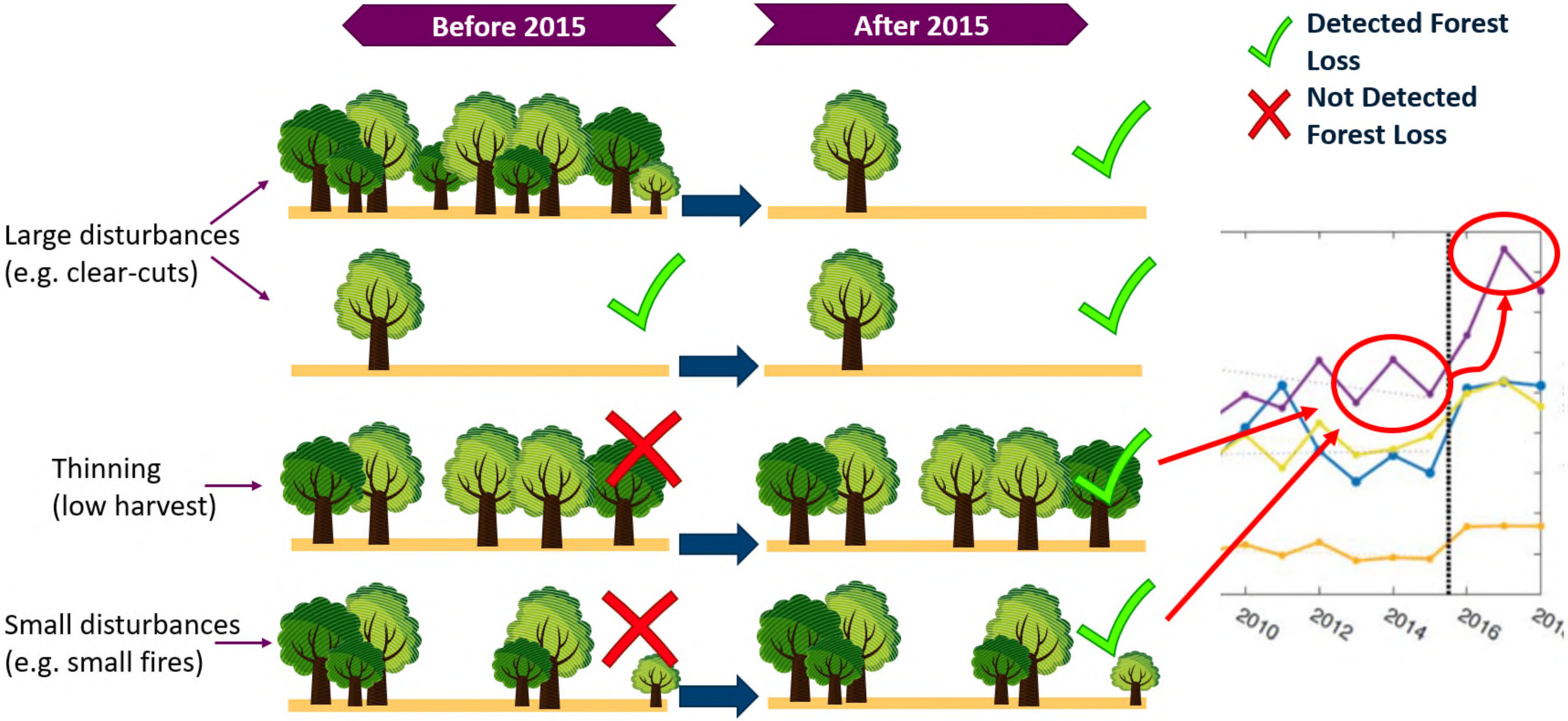


Sweden

Finland

Policy Relevance

Omission of small forest disturbances in earlier years

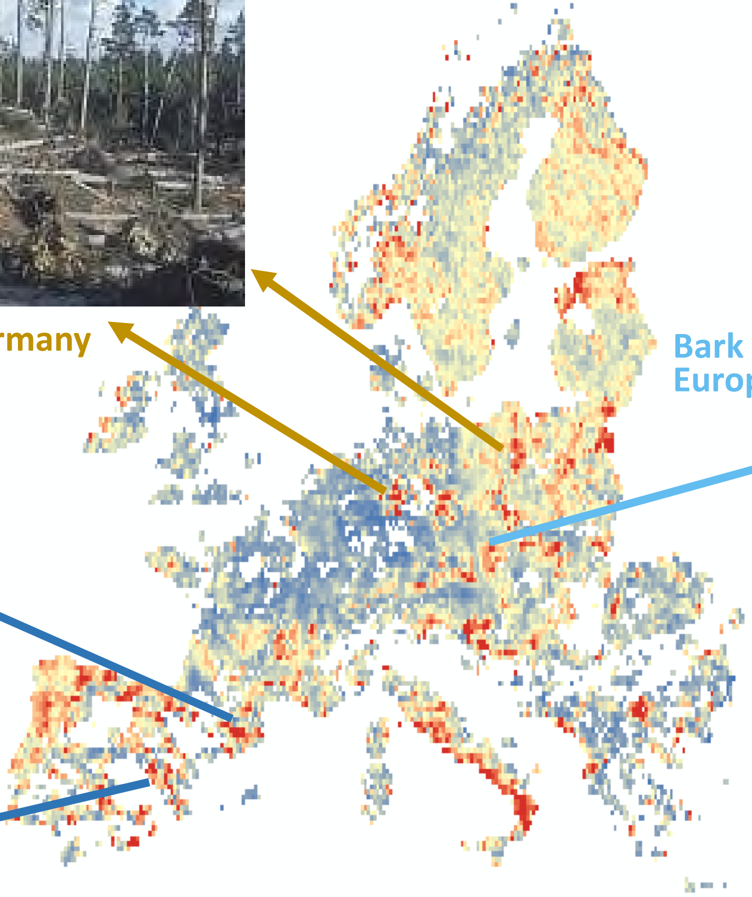


Policy Relevance

Misattribution of natural disturbances as being harvest

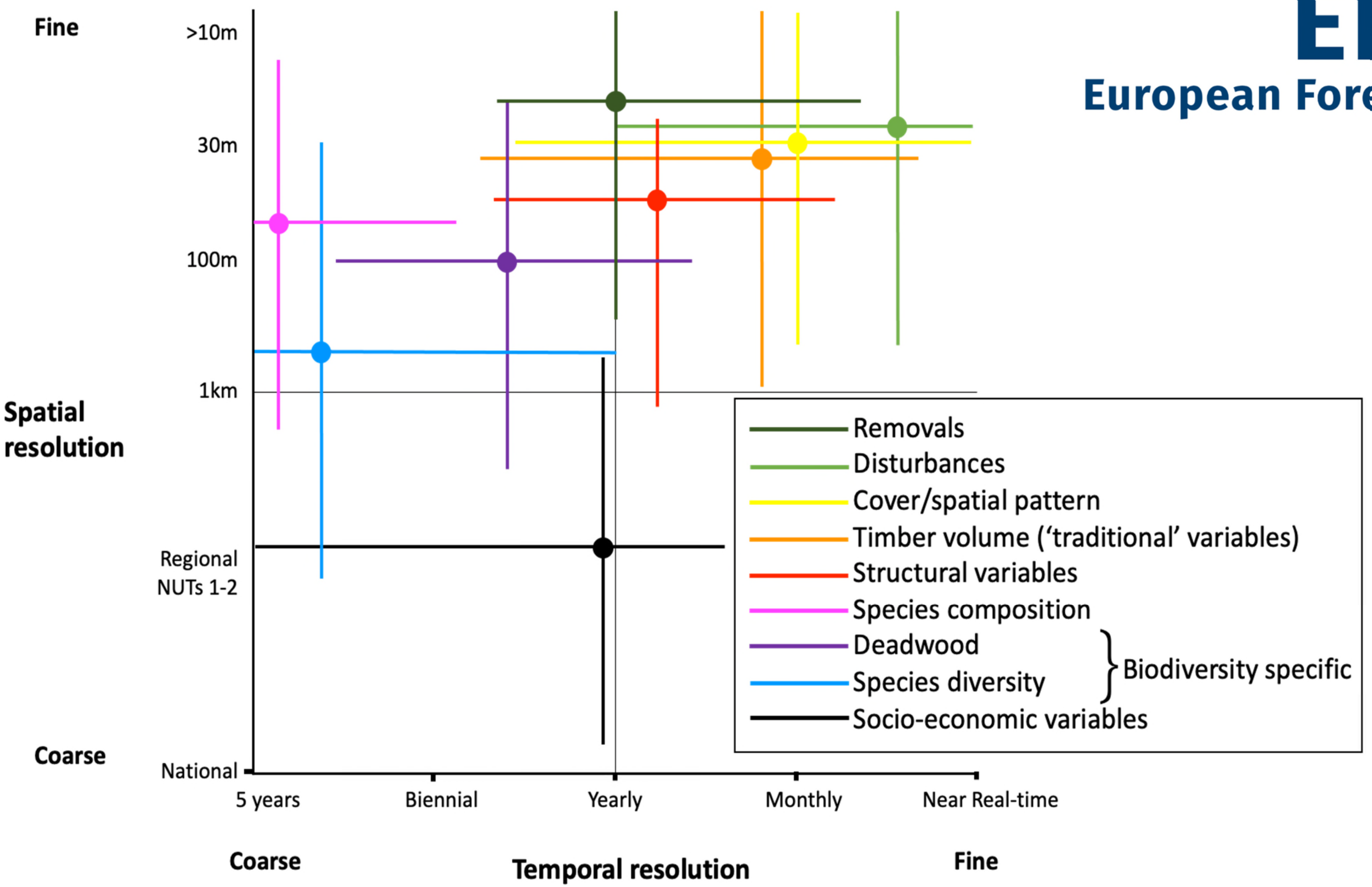
Windthrow in Germany and Poland

Processionary moth in Spain



Bark Beetle in Central Europe

What should be the Main Objectives in Forest Monitoring?



EFINET
European Forest Information Network

The ForestWard Observatory to Secure Resilience of European Forests

Rubén Valbuena, Swedish University of Agricultural Sciences

Policy Session - Forest resilience, Genetic resources and Climate change mitigation
European Commission

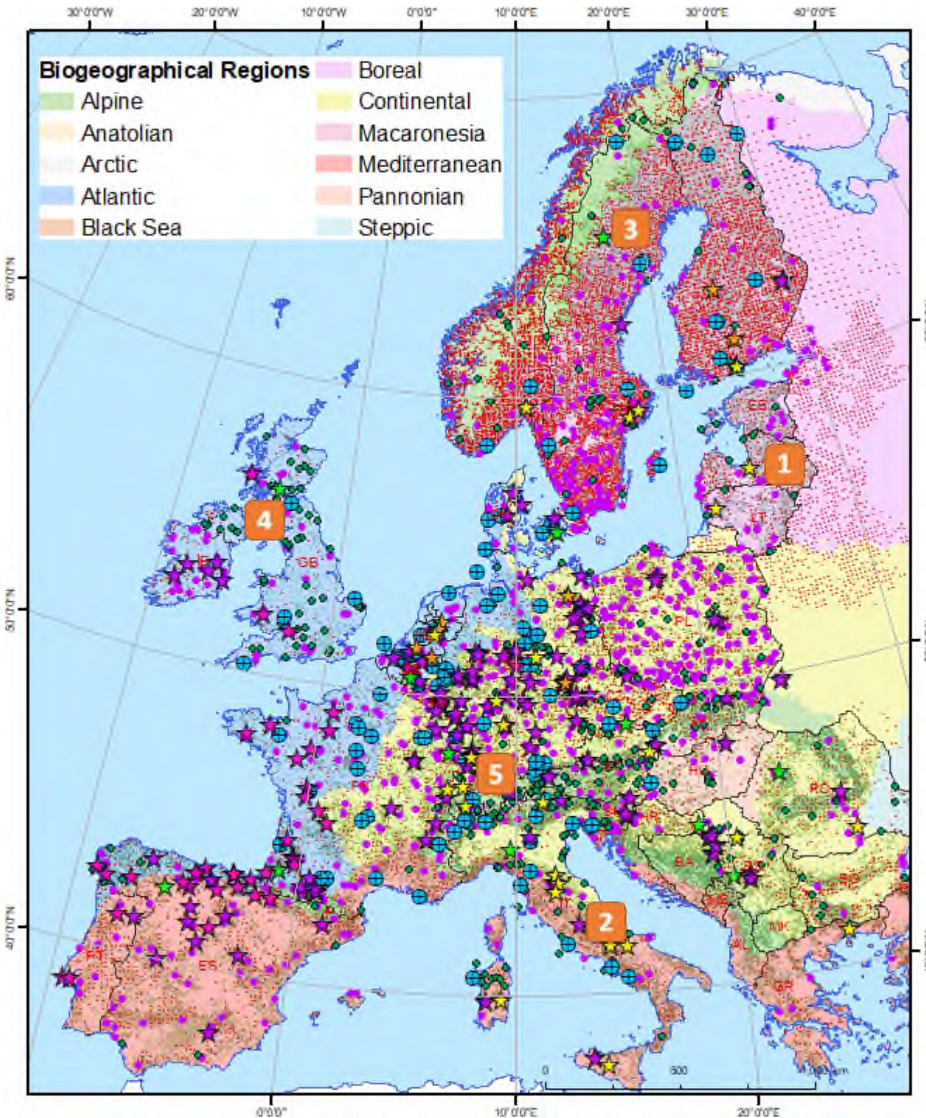
FORWARDS

Funded by
The European Union

FORWARDS PROJECT

FORWARDS: The ForestWard Observatory to Secure Resilience of European Forests

FORESTWARD OBSERVATORY



Existing Established Monitoring Networks

- ICP Forest level I & NFI
- ICP Forest level II
- LTER
- ICOS

Existing Established CSF & Restoration Networks

- EFI CSF Network
- SUPERB
- HOLISOILS
- INTEGRATE
- REINFFORCE

Network of FORWARDS Demo-sites

1. Peatland restoration and wind resistance in hemiboreal forests
2. Balancing Carbon & Biodiversity targets in mixed mediterranean forests
3. Landscape diversification & riparian boreal forests
4. Natural flood management & diversification of plantations in atlantic forests
5. Treeline ecotone restoration in alpine forests

SLU SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES

EUROPEAN FOREST INSTITUTE

WAGENINGEN UNIVERSITY & RESEARCH

PRIFYSGOL BANGOR UNIVERSITY

Forest Research

WSL Swiss Federal Institute for Forest, Snow and Landscape Research WSL

THÜNEN

SILAVA

Luke NATURAL RESOURCES INSTITUTE FINLAND

ESSRG Environmental Social Science Research Group

prospex institute

Università degli Studi del Molise

BOKU

Università degli Studi Firenze

GFZ Helmholtz-Zentrum Potsdam

ICONS

Instituut Natuur- en Bosonderzoek

Lunds Universitet

FORWARDS components

Environmental Monitoring of Forests

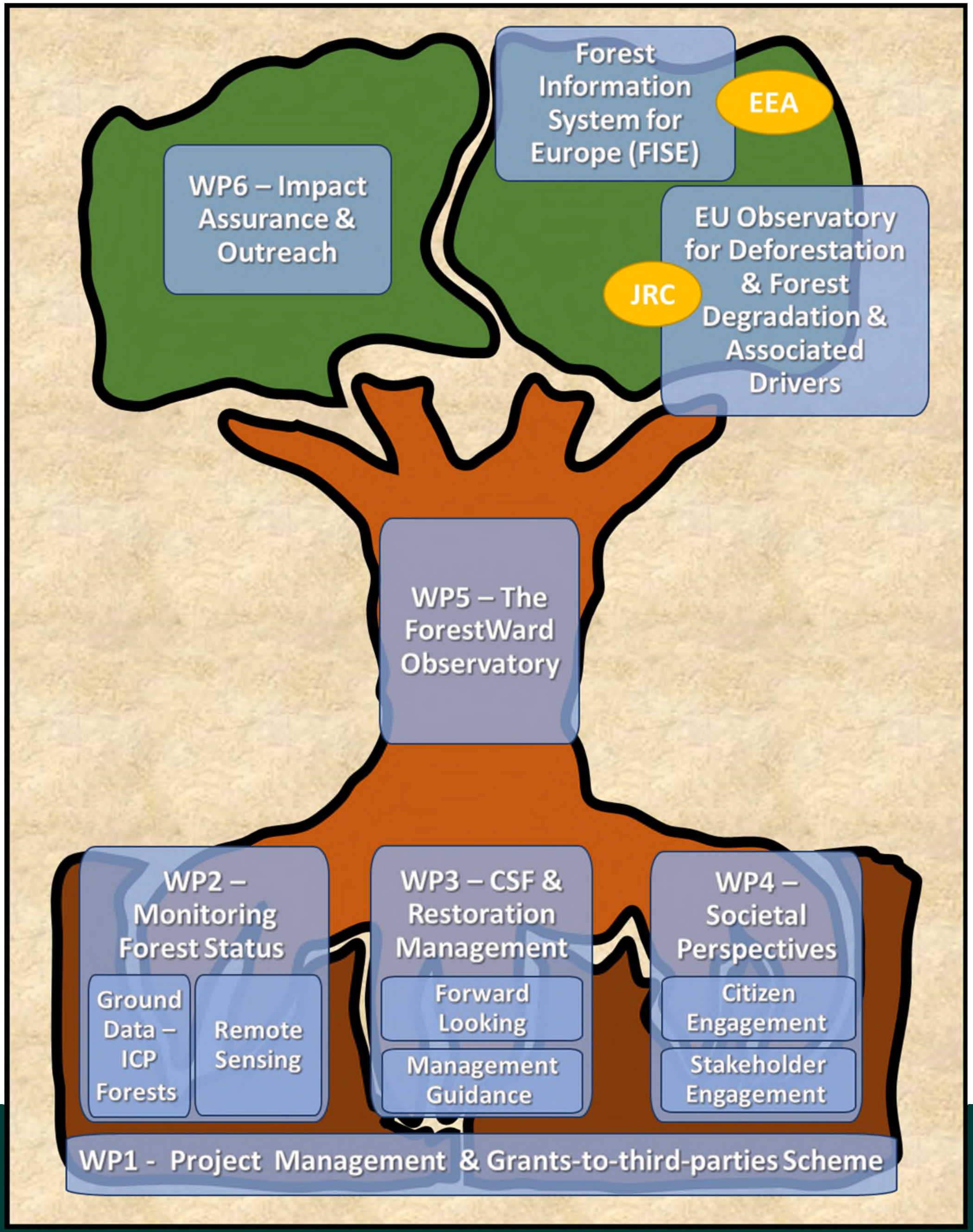
Developing a network of SUPERSITES to adapt ICP FORESTS to make it compatible for using along remote sensing data sources.

Guidance in Forest Management

Developing a network of pilots testing management alternatives for CLIMATE-SMART FORESTRY, ECOSYSTEM RESTORATION and BIODIVERSITY PRESERVATION.

Considerations of Social Perspectives

The ForestWard Observatory will be constructed under the principle of CO-DESIGN, engaging both forest stakeholders and the public in decision-making.



Environmental Monitoring of Forests

- Network of Supersites
- Novel methods for forest disturbance characterization

Climate-Smart Forestry

- Spatially explicit projections on forests
- Evaluate synergies and trade-offs of conversion and restoration activities
- Good practice guidance on effective CSF & Restoration management

EFI

Research Network

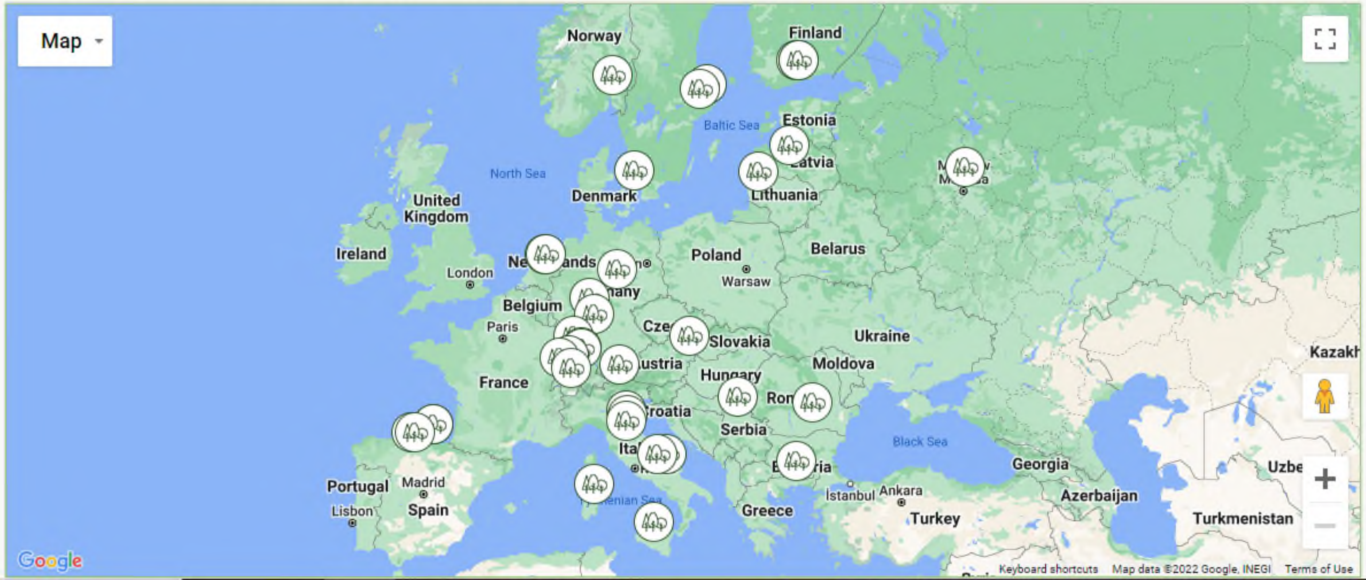
Climate Smart Forestry

WAGENINGEN
UNIVERSITY & RESEARCH

Europe's forests are being hit hard by climate change. At the same time we expect forests to fulfil their carbon sink function and maintain and provide many other functions. This is not only vital for the big forest countries, but also for the wood importing countries in Europe. Europe needs coordinated actions in this field. Climate-Smart Forestry (CSF) is a prominent way to deal with this and is urgently needed to connect mitigation with adaption measures, enhancing the resilience of forest resources and ecosystem services, and meet the needs of a growing population. The Netherlands has been the first country in Europe to establish CSF pilots to connect science to action and to demonstrate its potential. Several other countries have also started actions in recent years.

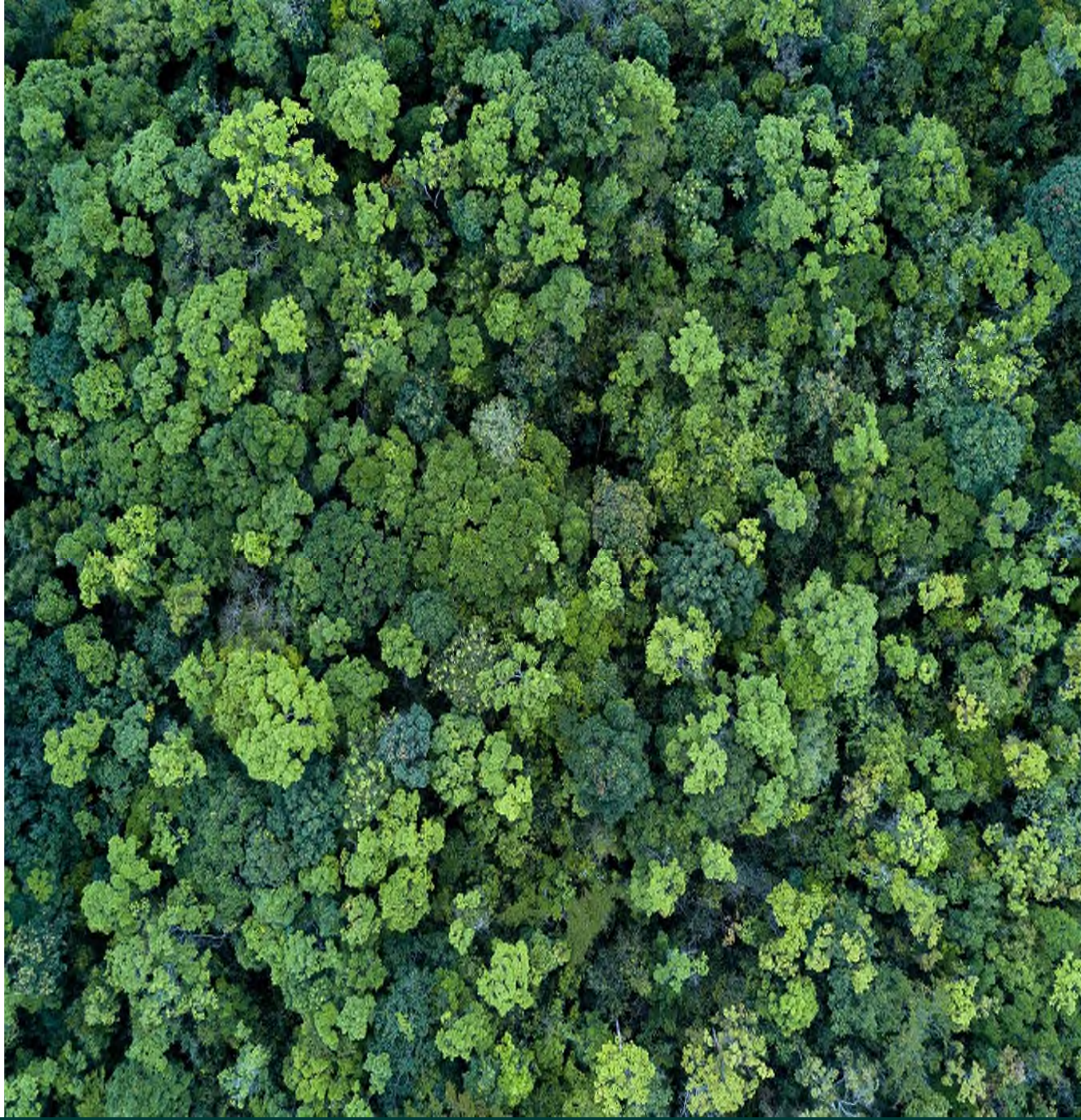
We believe that it is time to upscale the actions based on the experiences from CSF projects. In 2020, a European Network on Climate-Smart Forestry has started, with representatives from more than ten European countries (listed below). The network gathers information on CSF projects. The gathered information is presented on the interactive map on this webpage. In 2021, more information on projects will be added.

Overview of climate-smart forestry projects in Europe:



Societal Perspectives

- Stakeholder forum for co-design and citizen engagement
- Forest owner societal attitudes across Europe
- Governance for the delivery of climate-smart forestry and pan-european integration of forest information



Grants to Third Parties

- 50 grants of €150k each
- Non-FORWARDS partners are eligible

Grant Theme	Supported activities	Approx. duration	Approx. launch
Pilot network of long-term climate impact forest monitoring sites	– Install new measurement equipment in existing monitoring plots. – Perform measurements and maintain equipment.	2 years	Month 12
Disturbance characterization	– Provide a Europe-wide, consistent, and statistically robust disturbance assessment for different project years (lot 1). – Provide detailed characterization of cause-effect relationships for disturbances in and around the CSF and restoration priority areas (lot 2).	3 years	Months 12, 24, 36
CSF and forest restoration pilots	– Establish new CSF and forest restoration trials. – Field measurements on newly established or already existing CSF and forest restoration trials. – Analyse the effectiveness of the practises considering indicators developed in FORWARDS.	2 years	Month 9
Citizen and stakeholder engagement in CSF and forest restoration	– Implement innovative social engagement activities. – Stakeholder surveys, workshops, or other interactive formats for knowledge exchange, joint vision development, collective learning, collaborative planning or co-creating solutions.	1 year	Month 18
Knowledge to practice	– Develop web applications that link to the ForestWard Observatory and rely on its datasets.	1 year	Month 36

E F I

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Swedish University of Agricultural Sciences

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Startpage for Department of Forest Resource Management

About us Education Research Environmental monitoring Programmes & projects Publications

startpage slu / departments / department of forest resource management / research / Forest Remote Sensing

Forest Remote Sensing

In the Forest remote sensing field, we work with all sensors and sensor platforms that are of relevance to forestry and assessment of vegetation. Common sensors are digital cameras, laser scanners and imaging radar. Platforms include aircraft and satellites, but also photos from drones or from sensors that view the forest from the ground that might be stationary, or manually carried or carried by vehicles.

More about remote sensing | Workareas | Staff | Publications

Undergraduate and Master Studies

We conduct teaching in Geographical Information Technology (GIT) and Remote Sensing.

Remote Sensing Laboratory

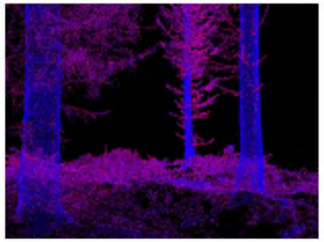
A resource for collection and processing of remote sensing data. A meeting place for students, researchers and companies.

National Forest Estimates

An important part of remote sensing is to continuously develop methods for producing national raster databases with estimated variables.

GIS Support

Support to users of GIS software and spatial information (geodata). Internally within SLU.

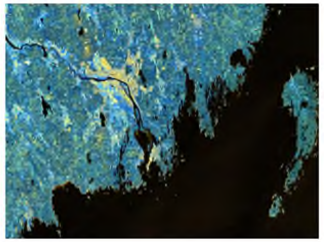


Laser Scanning

Laser scanning measures positions on objects using light pulses. Measurement coordinates are used to calculate forest area statistics and estimate different forest parameters.

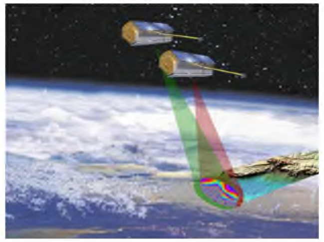
Digital Photogrammetry

Digital photogrammetry is the creation of three dimensional (3D) point cloud data by applying image matching to overlapping digital images.



Optical Satellite Images

Satellites with optical sensors generate images of the Earth over relatively large areas and are useful in the production of vegetation maps or to estimate specific vegetation parameters.



Radar

Radar using satellites as a platform can be used for mapping forests across large areas. The technology is similar to lidar (laser scanning) using electromagnetic waves but is less affected by e.g. cloud coverage.

Forest Remote Sensing, Department of Forest Resource Management

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Section Manager: Jonas Bohlin, jonas.bohlin@slu.se, +46907868640

Postal address: Department of forest resource management, SLU, S-901 83 Umeå
Visiting address: Skogsmarksgränd, Umeå, Sweden

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Nationwide area based lidar estimates of Swedish forests

Mats Nilsson
Swedish University of Agricultural Sciences

ELSEVIER

Remote Sensing of Environment

Volume 56, Issue 1, April 1996, Pages 1-7

Estimation of tree heights and stand volume using an airborne lidar system

Mats Nilsson *

[a] Swedish University of Agricultural Sciences, Department of Forest Resource Management and Geomatics, Umeå, Sweden

Received 22 September 1994, Revised 15 September 1995, Available online 22 February 1999.

ELSEVIER

Remote Sensing of Environment

Volume 194, 1 June 2017, Pages 447-454

A nationwide forest attribute map of Sweden predicted using airborne laser scanning data and field data from the National Forest Inventory

Mats Nilsson [a], Karin Nordkvist [a], Jonas Jonzén [a], Nils Lindgren [a], Peder Axensten [a], Jörgen Wallerman [a], Mikael Egberth [a], Svante Larsson [b], Liselott Nilsson [b], Johan Eriksson [b], Håkan Olsson [a]

[a] Department of Forest Resource Management, Swedish University of Agricultural Sciences, Umeå, Sweden

[b] Swedish Forest Agency, Jönköping, Sweden

Received 3 March 2016, Revised 31 August 2016, Accepted 11 October 2016, Available online 22 October 2016, Version of Record 9 May 2017.

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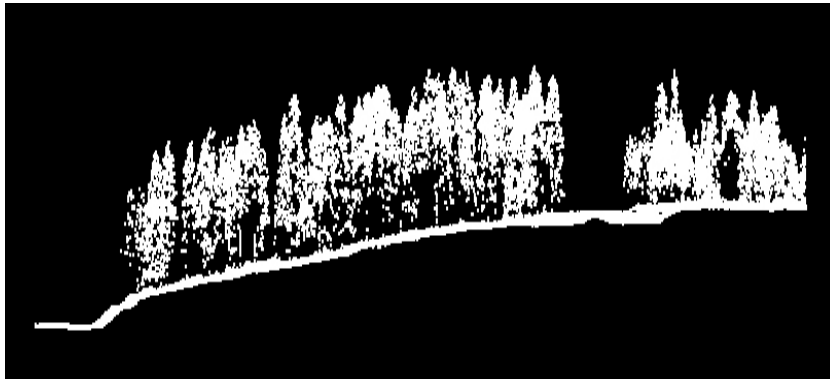
Nation-Wide Mapping of Tree Growth using Repeated Airborne Laser Scanning

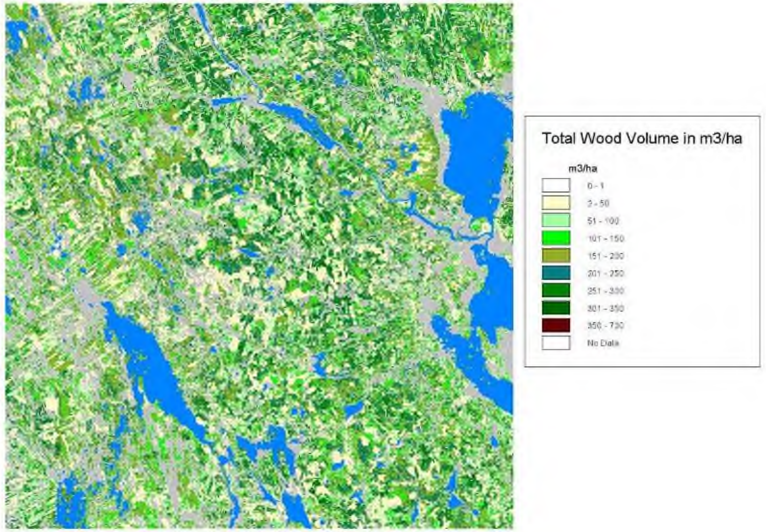
Publisher: IEEE Cite This PDF

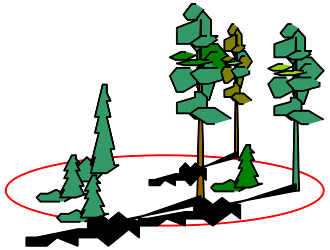
Jörgen Wallerman ; Kenneth Nyström ; Mats Nilsson ; Peder Axensten ; Mikael Egberth ; Jonas Jonzén ; Emma Sandström ; Johan E.S. Franss...

Estimation of forest variables

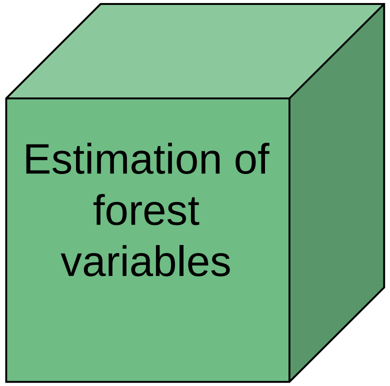


Laserdata från the National Land Survey





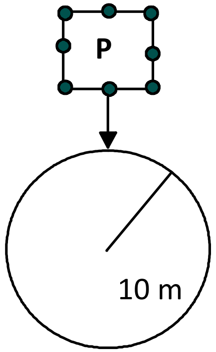
Field surveyed plots from the National Forest Inventory



Raster databases with estimated forest variables

Reference data from the National Forest Inventory (NFI)

- 11 500 permanent, undivided NFI plots, in productive forest land, max 4 years old
- Blue = clusters with 5 m position accuracy
- Yellow = plots with 1 m position accuracy



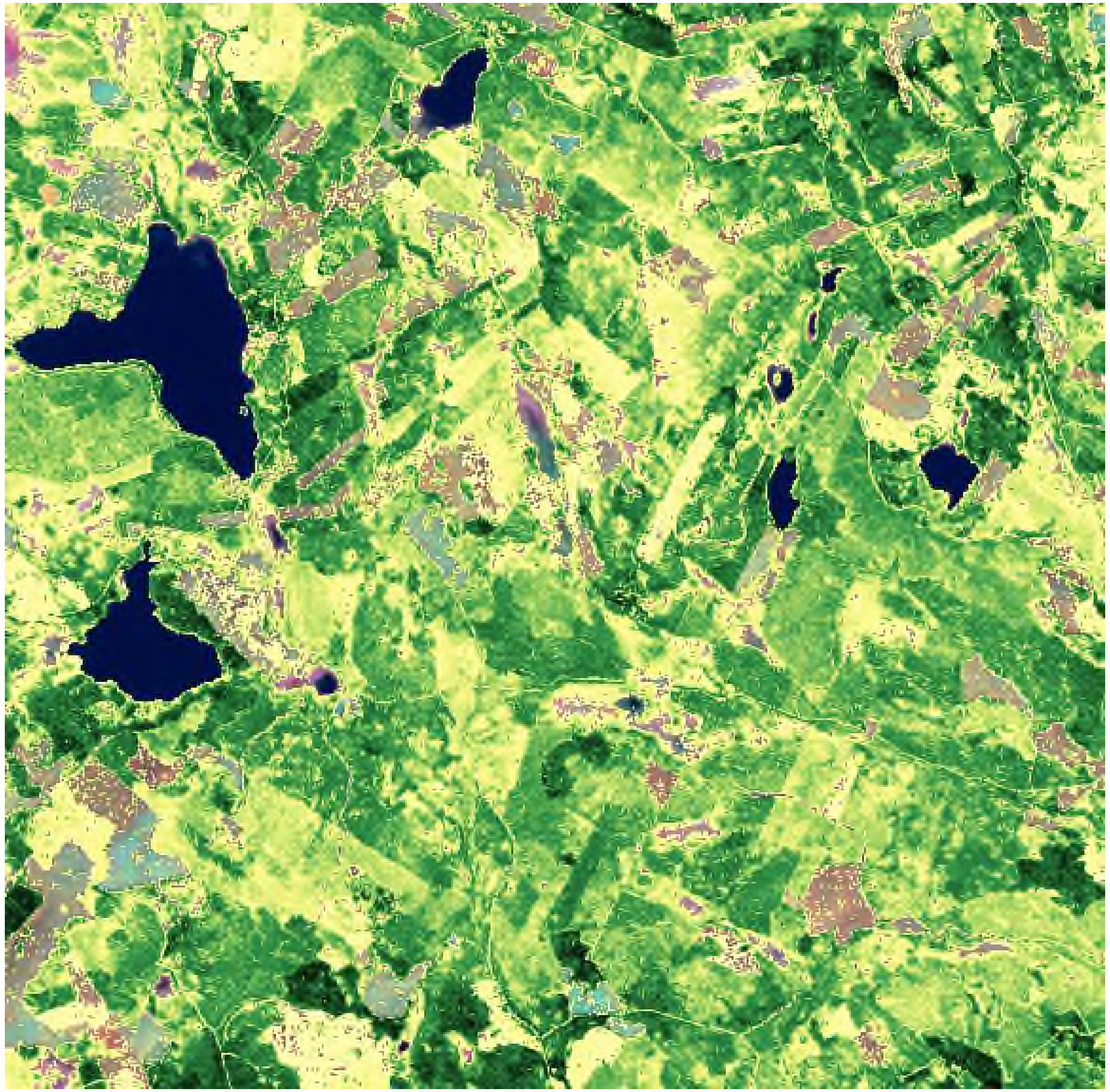
Permanent plots

Forest maps from laser data

Estimated variables

- Mean height
- Mean stem diameter
- Basal area
- Stem volume
- Biomass

- Representing forest conditions in 2009-2015-2019
- Presented for 12.5 × 12.5 m grid cells for all land



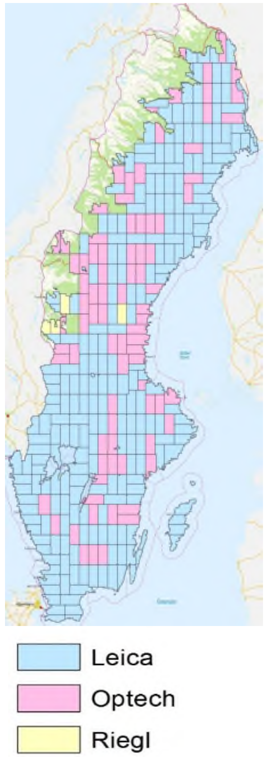
Laser data from the Swedish Mapping Agency

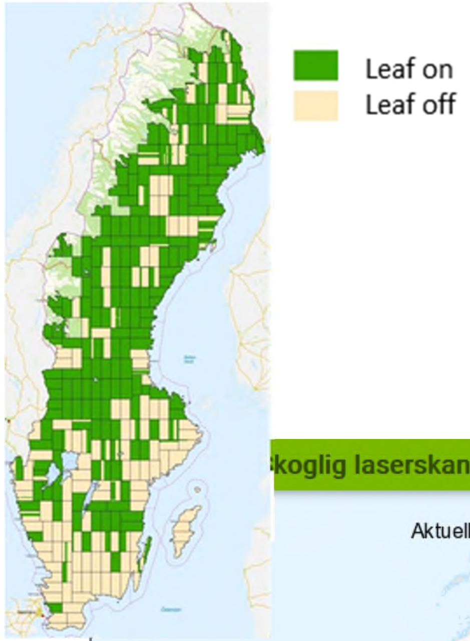
Laser data NH (2009 – 2019)

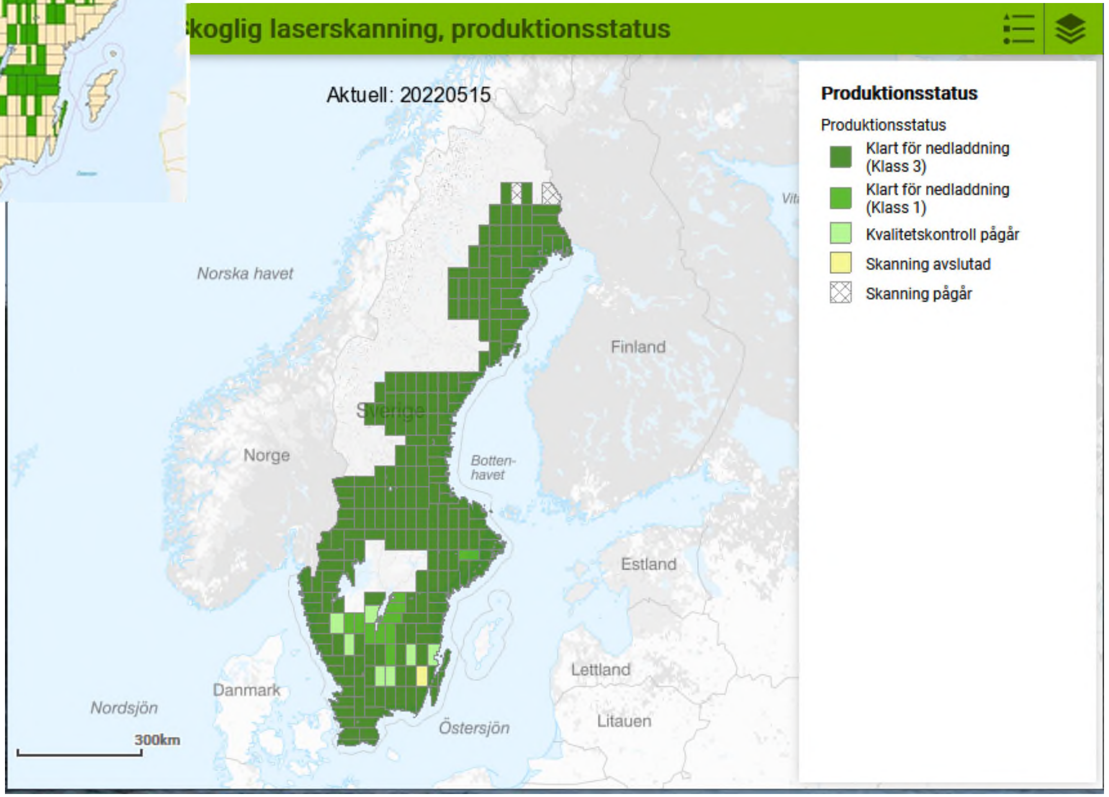
- Point density: 0.5-1 pts/m^2
- Flying altitude: 1,700-2,300 m
- Max scan angle : ± 20º
- Footprint: 0.4-0.9 m

Laser data, forest (2019 -)

- Point density : 1-2 pts/m^2
- Flying altitude: 3,000 m
- Max scan angle: ± 20º
- Footprint: < 0.75 m



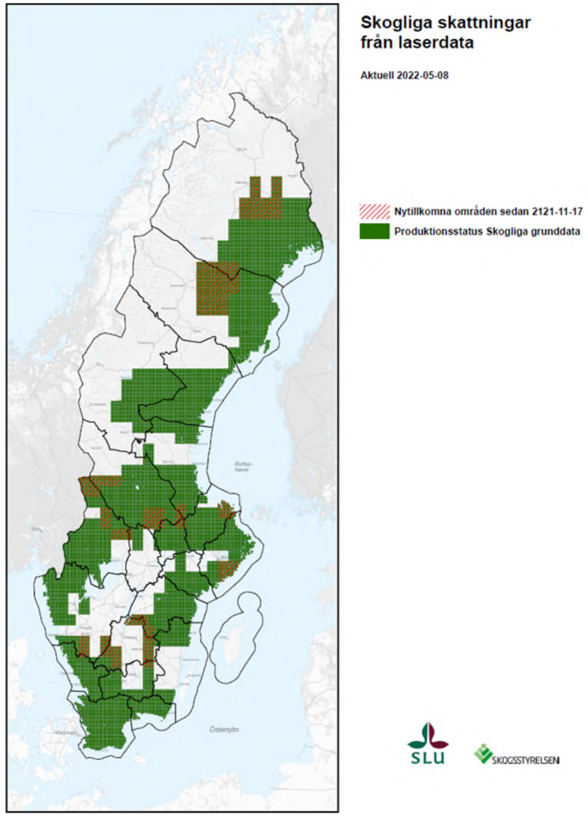




Forest maps from laser data

Version 1
2009-2019

Version 2
2021-11-17



Produced by combining laser data from the Swedish Mapping Agency and field data from the Swedish NFI.

Provided as open data by the Forest Agency (https://www.skogsstyrelsen.se/skogligagrunddata)

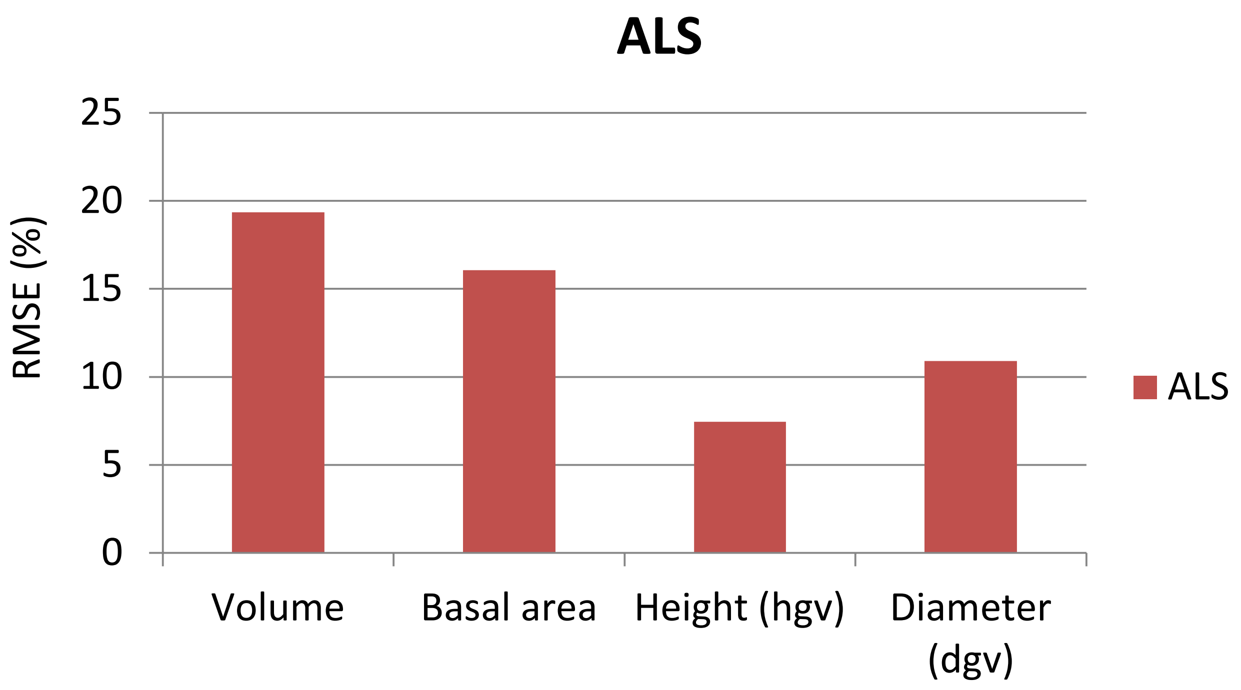
Variables
- Standing volume
- Mean tree height
- Mean diameter
- Basal area
- Tree biomass

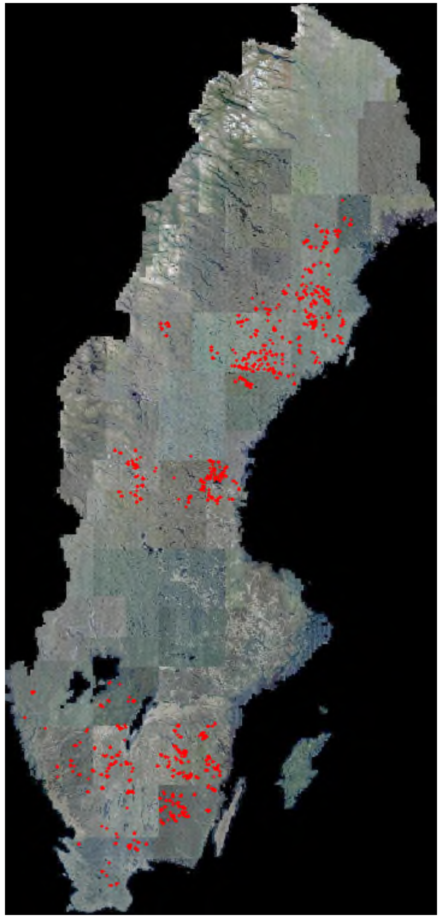
Cell size
- 12.5 x 12.5 m

SKOGSSTYRELSEN

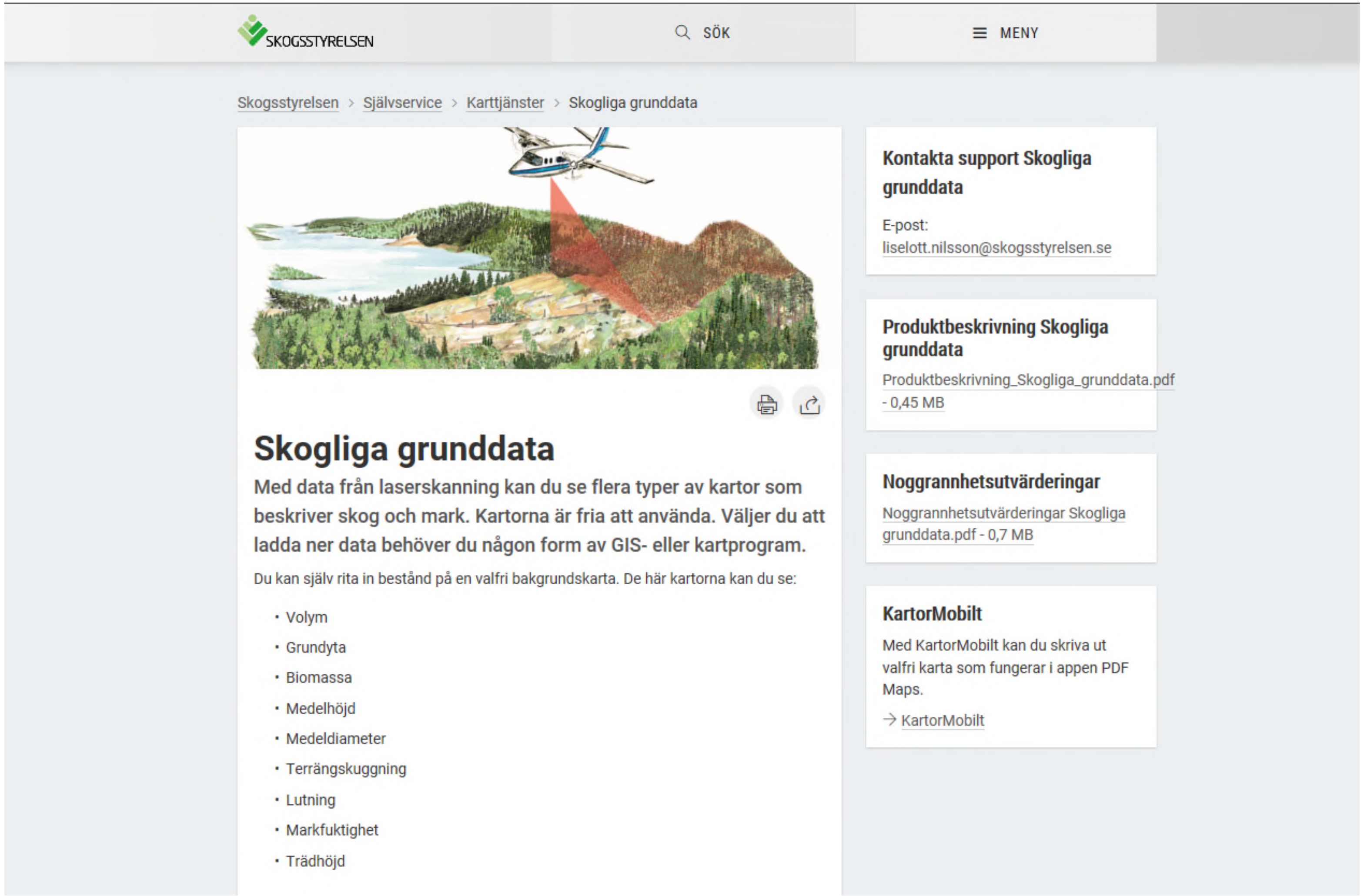
Estimation accuracy

(543 stands)





Data are distributed freely over internet



SKOGSSTYRELSEN SÖK MENY

Skogsstyrelsen > Självservice > Karttjänster > Skogliga grunddata

Skogliga grunddata

Med data från laserskanning kan du se flera typer av kartor som beskriver skog och mark. Kartorna är fria att använda. Väljer du att ladda ner data behöver du någon form av GIS- eller kartprogram.

Du kan själv rita in bestånd på en valfri bakgrundskarta. De här kartorna kan du se:

- Volym
- Grundyta
- Biomassa
- Medelhöjd
- Medeldiameter
- Terrängskuggning
- Lutning
- Markfuktighet
- Trädhöjd

Kontakta support Skogliga grunddata

E-post:
liselott.nilsson@skogsstyrelsen.se

Produktbeskrivning Skogliga grunddata

Produktbeskrivning_Skogliga_grunddata.pdf - 0,45 MB

Noggrannhetsutvärderingar

Noggrannhetsutvärderingar Skogliga grunddata.pdf - 0,7 MB

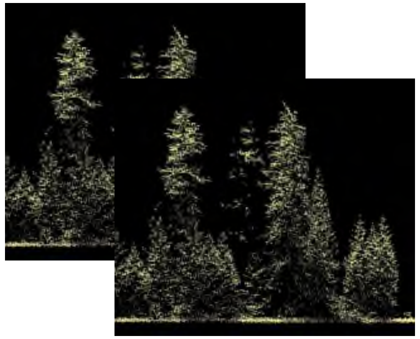
KartorMobilt

Med KartorMobilt kan du skriva ut valfri karta som fungerar i appen PDF Maps.

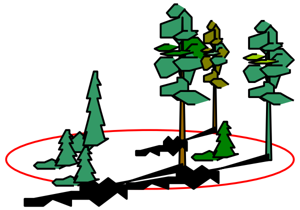
→ KartorMobilt

Interface only in Swedish

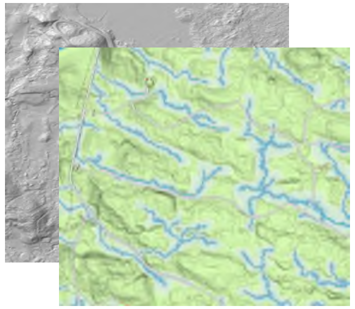
Site Index



Laser data from two time points



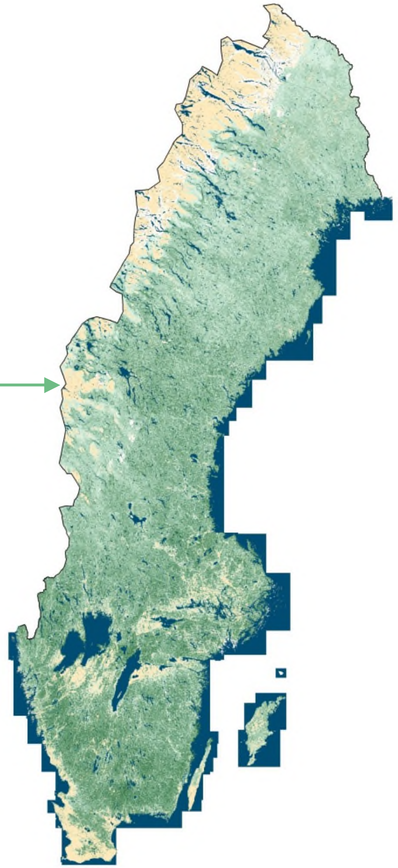
NFI data



Altitude, Latitude, soil moisture, …

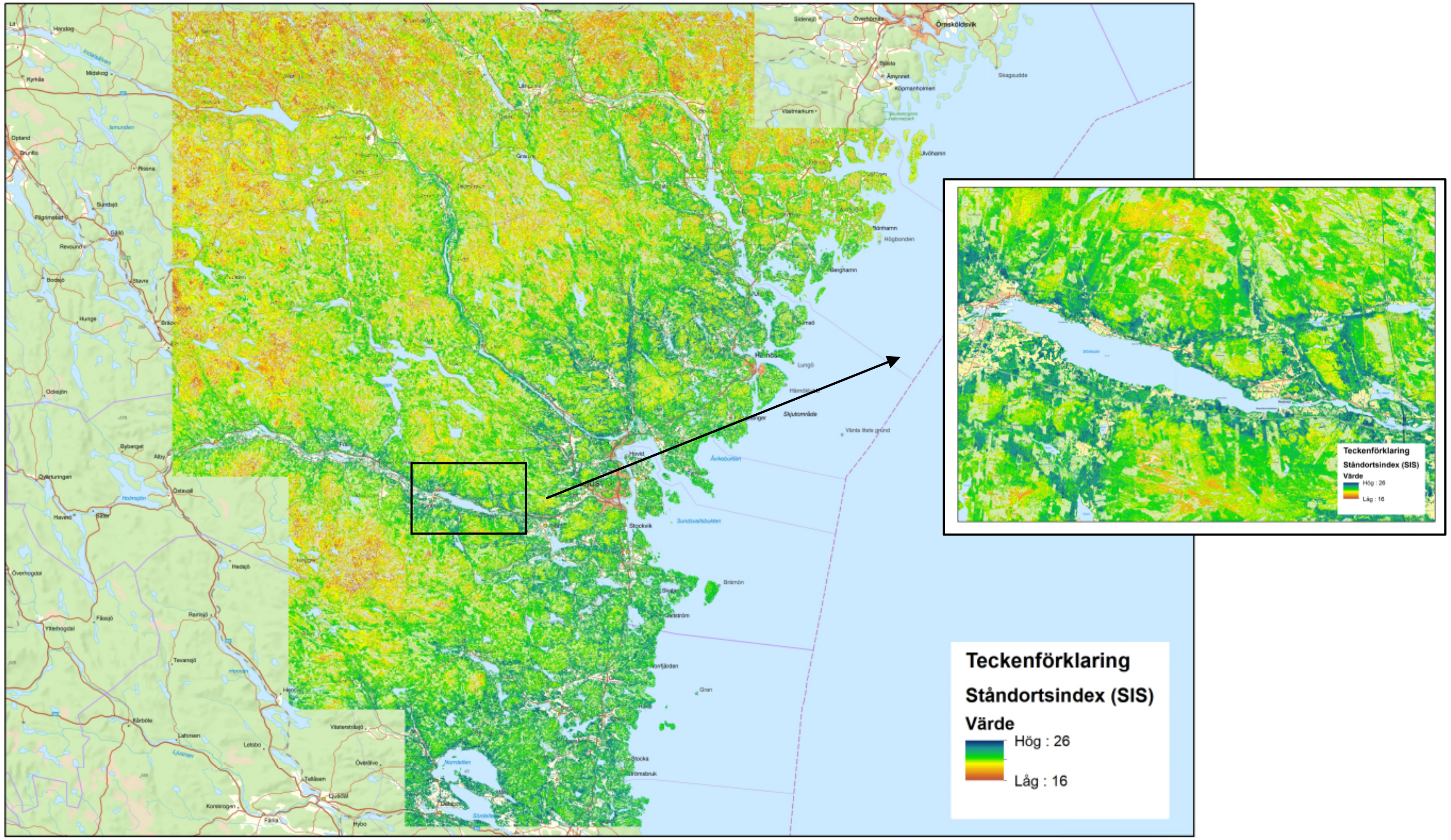
SIS = f(height growth, height , …)

- Regression
- Random Forest
- k Nearest Neighbours (kNN)



Raster maps with site index for pine and spruce

Site index (SIS) spruce



Data for SI estimation

- National Forest Inventory data
- Pine or Spruce (basal area >65%)
- Permanent plots: for model calibration
- Temporary plots: for model validation
- Stands with thinnings (or clear cuts) were removed.
- Combined leaf-on and leaf-off seasons
- Model height above 5m

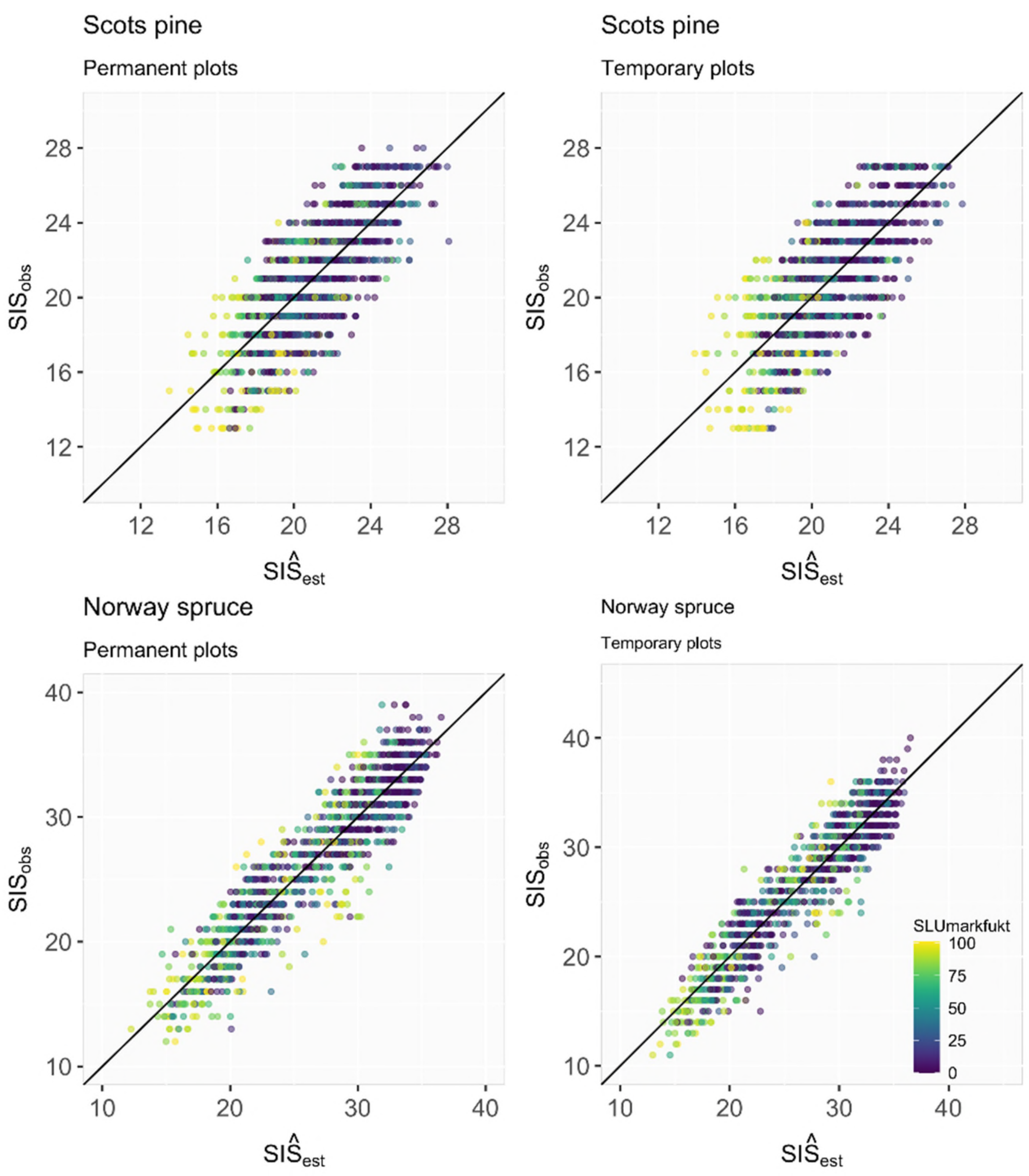
Final predictor variables:

- Height at the second scanning (p90_t2)
- Annual height growth (p95)
- Latitude
- Altitude
- Distance to coast
- Probability of Soil wetness (SLU soil moisture map)

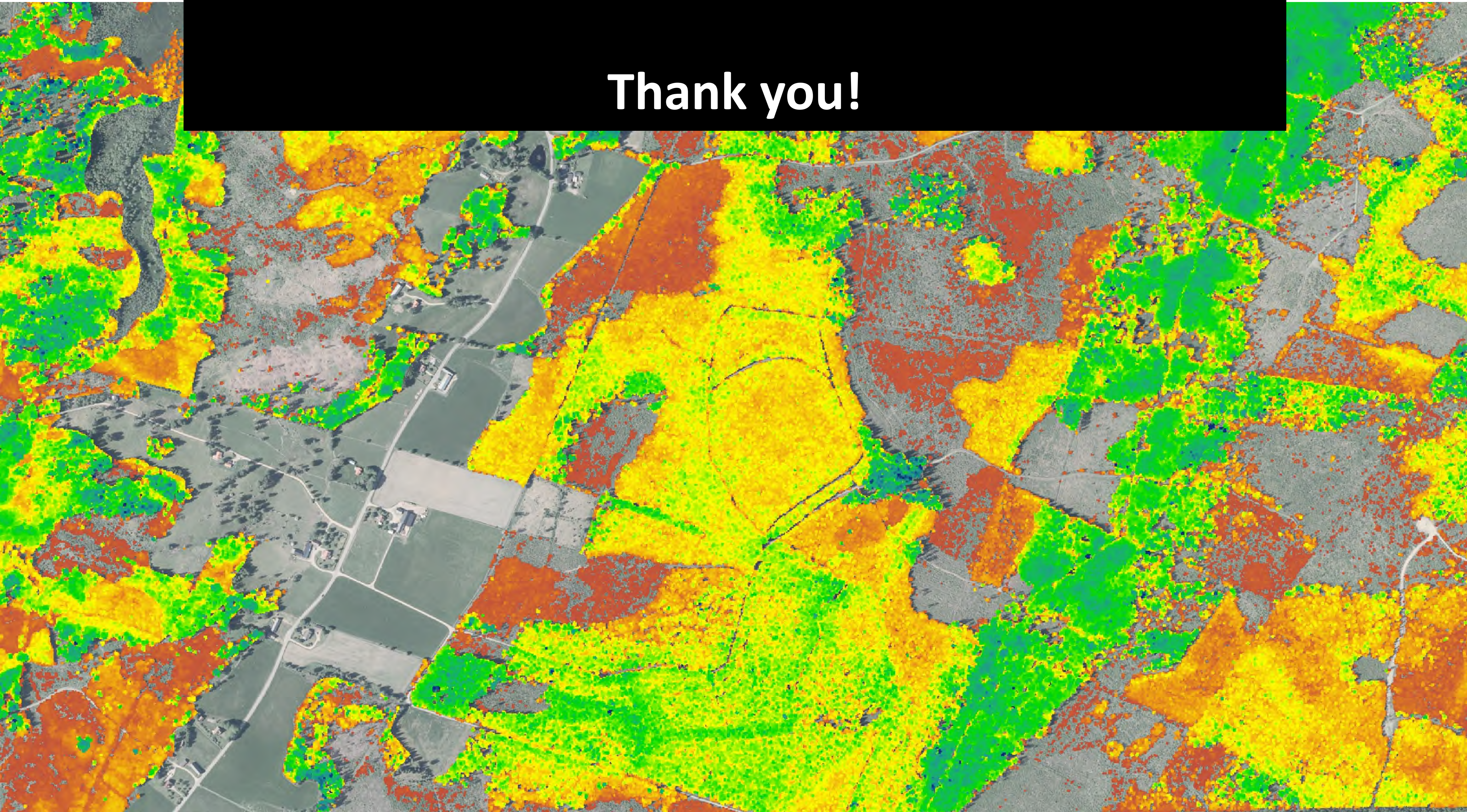
Accuracy of the models

Scots pine: **2.02 m** (9.7 %)

Norway spruce: **2.00 m** (7.5 %)



Thank you!



A Roadmap for Europe-wide Forest Disturbance Detection & Characterization

- Disturbance detection needs satellite data
- Disturbance charachterization needs local knowledge

- Two-phase Disturbance characterization based on:
  - Copernicus prompt forest detection system
  - A Europe-wide network for characterization, validation (or deep learning?)

A Roadmap for Europe-wide Forest Estimates from Airborne LiDAR

- Two different approaches:
  - Wall-to-wall mapping
  - Lidar sampling

- Roadmap for Wall to wall mapping:
  - In the short term: let's make a 'bad map' with what we got
  - In the long term: NFI's optimised for use in lidar mapping

- Roadmap for lidar sampling:
  - A EU-wide tender for homogeneous airborne lidar transect sampling

Thank you!

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FORWARDS

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