Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

# Forest remote sensing in Sweden

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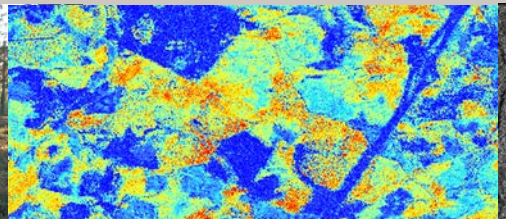
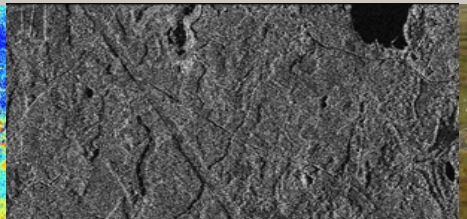
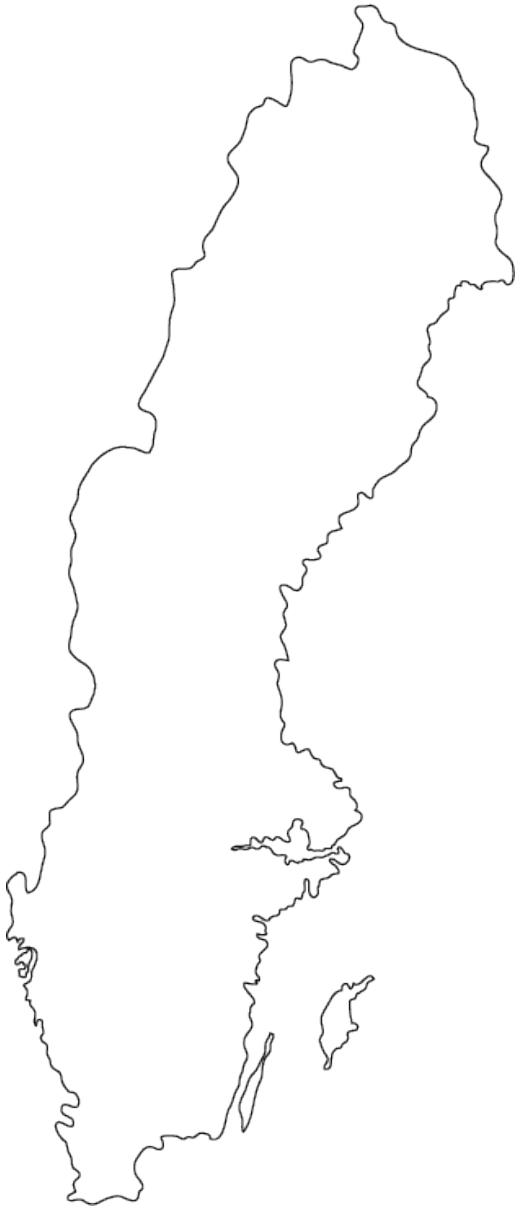
SLU, Umeå, Sweden


# Background

- Sweden covers 40.7 millions ha land
- 69% consists of forest, of which 84% is productive
- 50% of the forest is privately owned
- Forest industry constitutes 10% of national GDP

**Conclusion: Forest is a BIG deal in Sweden**



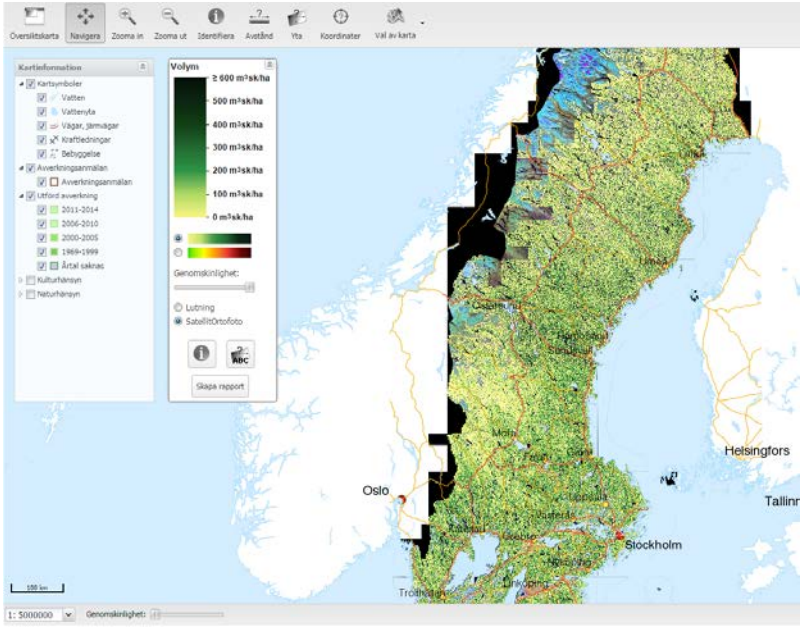
# National RS forest mapping in Sweden

- Airborne photographs, 1/3rd of the land annually, 2y in populated regions
- Airborne laser scanning (first rotation 2009 to 2015, second ongoing since 2018)
- National field inventory (NFI) ~5,000 forest field plots annually, 11,000 in total
- Satellite based SAR, optical…

➔ SLU forest map, 5y interval based on optical satellite images and NFI, 25m

➔ SAR based products – PALSAR (25m), Envisat ASAR, TanDEM-X (10m)

➔ National forest base maps (SGD) based on laser scanning and NFI 12.5m



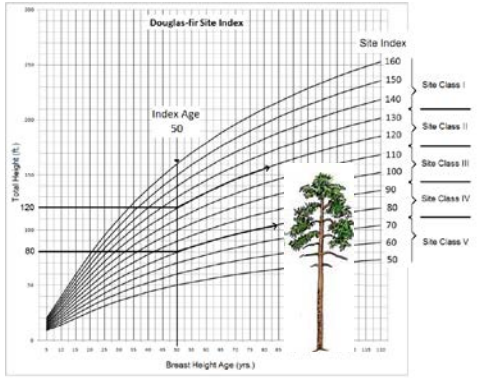
# More on RS in Swedish Forestry

- Many technical platforms researched in parallel
  -aerial methods – photographs & laser scanning
  -satellite methods – photographs & SAR
  -terrestrial methods – laser scanning, back pack scanners, harvester data
  -drones

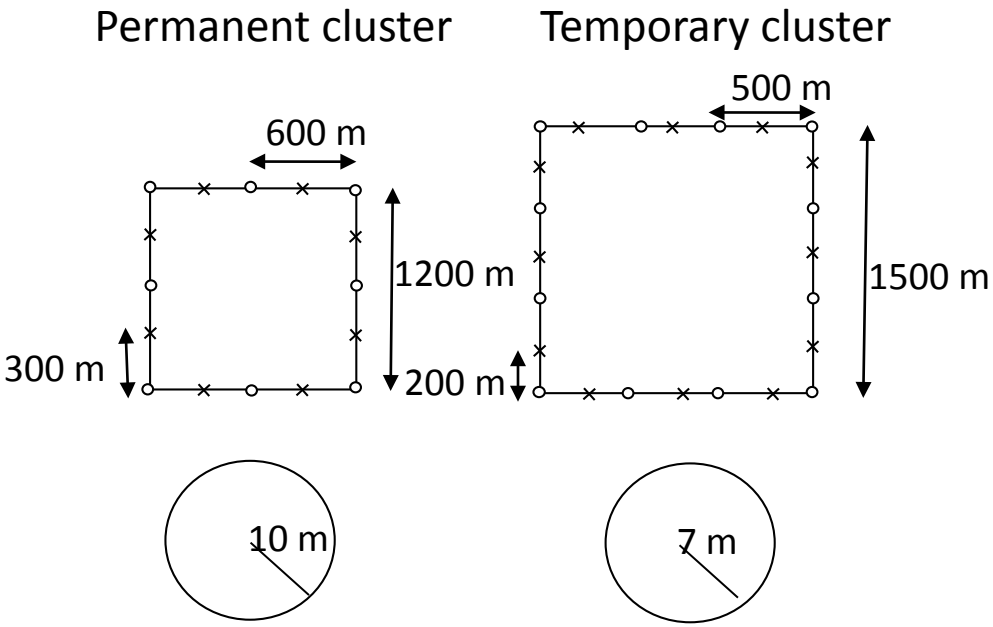
Current two variables of holy grail:

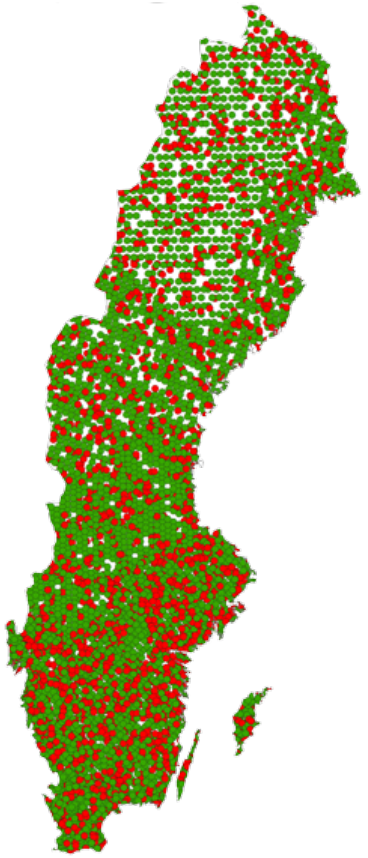
- Tree species decomposition
- Age

- Forest Change
- Site Index



# Field data – 11,000 NFI plots/year

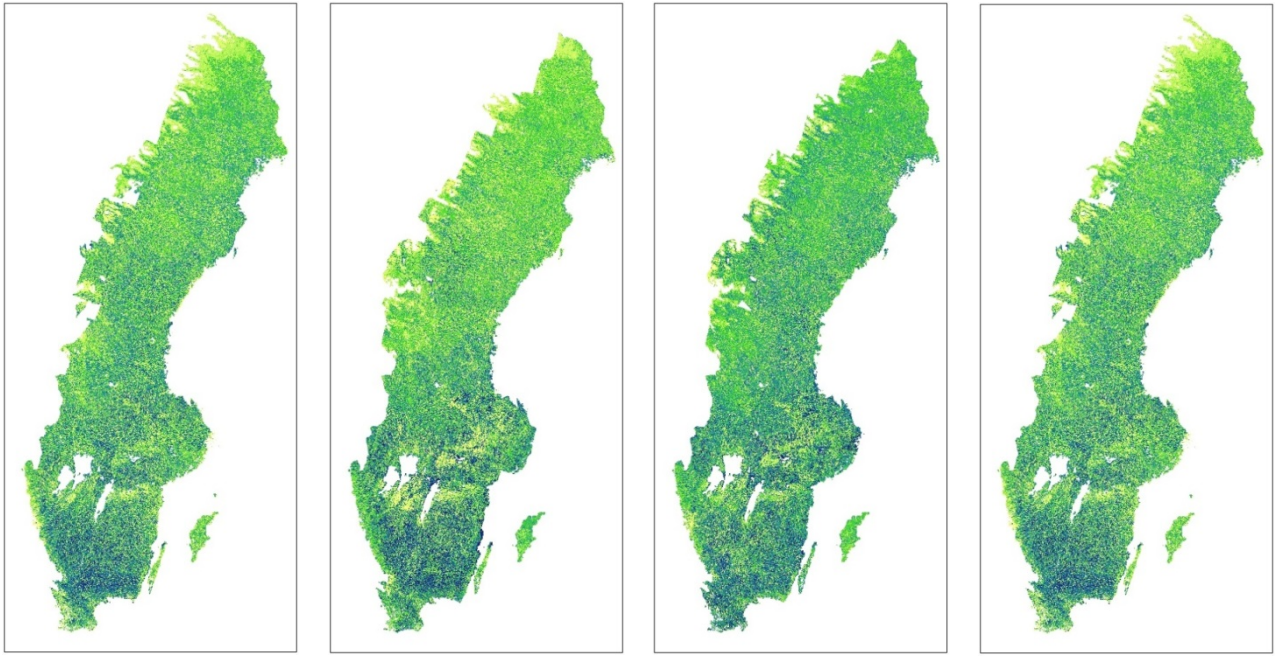


# SLU-skogskarta – national forest map

**2000** **2005** **2010** **2015**

NFI-plots +



Estimates of
- Volume
- Biomass
- Lorey's height
- Age
- Tree species

Resolution: 25 x 25m

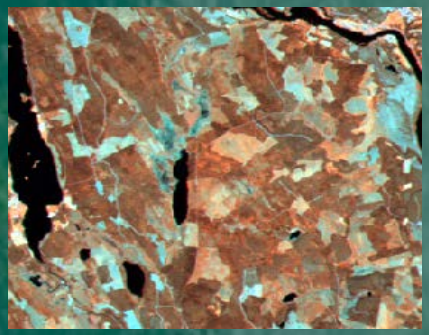
Landsat, 1997-2001

SPOT, 2005-2006

SPOT, 2008-2010

Sentinel-2 + aerial heights, 2015-2017

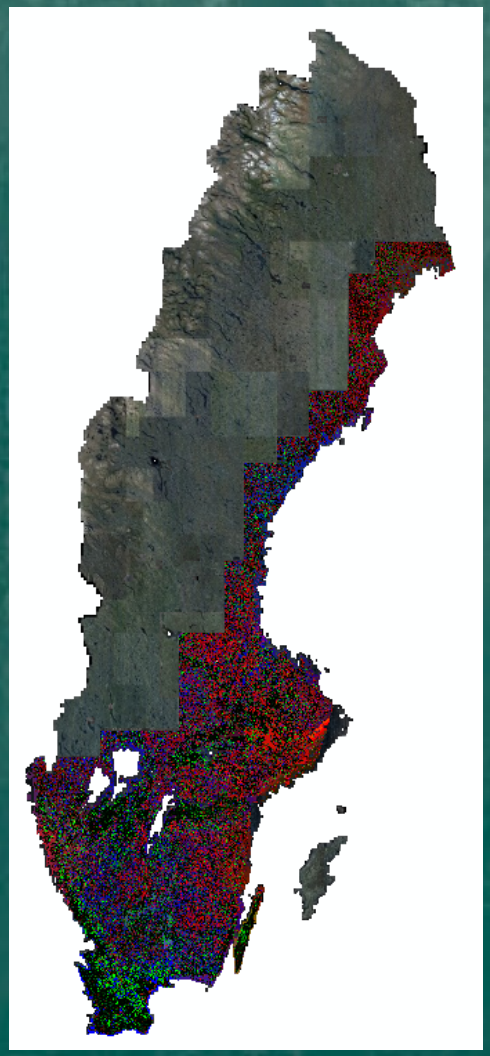
# SLU Forest Map 2015



Sentinel-2 data

Surface models from aerial photogrammetry

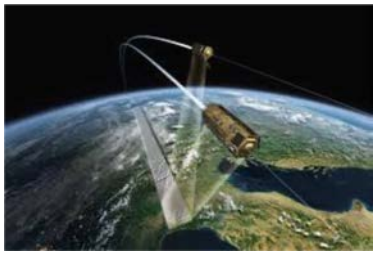
Field plots from the NFI

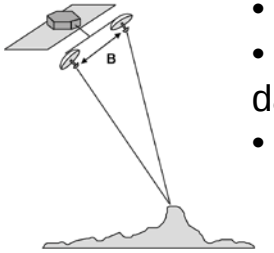


12.5 m pixel size

# TanDEM-X based maps

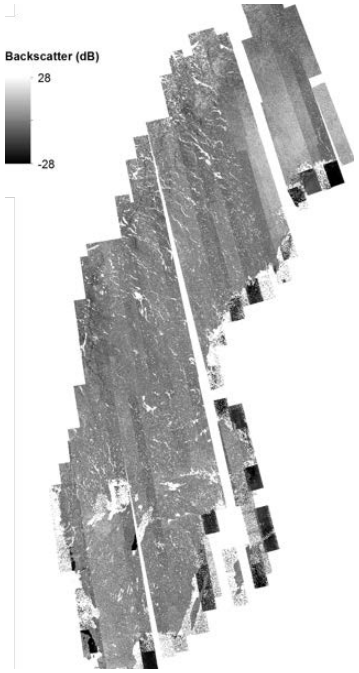
## (Persson et al. 2017)



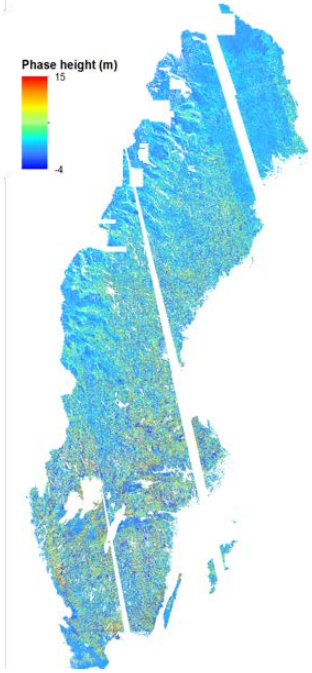



Input data:

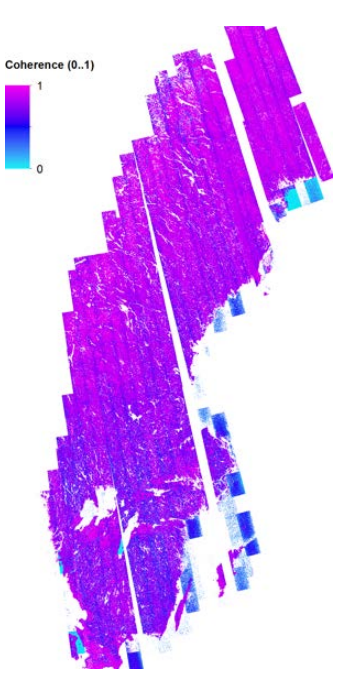
- SAR data - 518 TanDEM-X pairs
- Air temperature from meteorological data (SMHI)
- National laser scanning terrain model

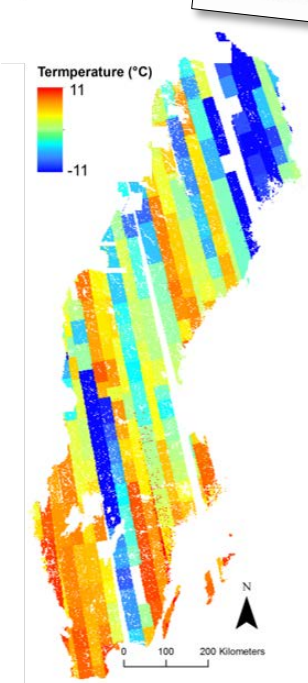

backscatter




phase height

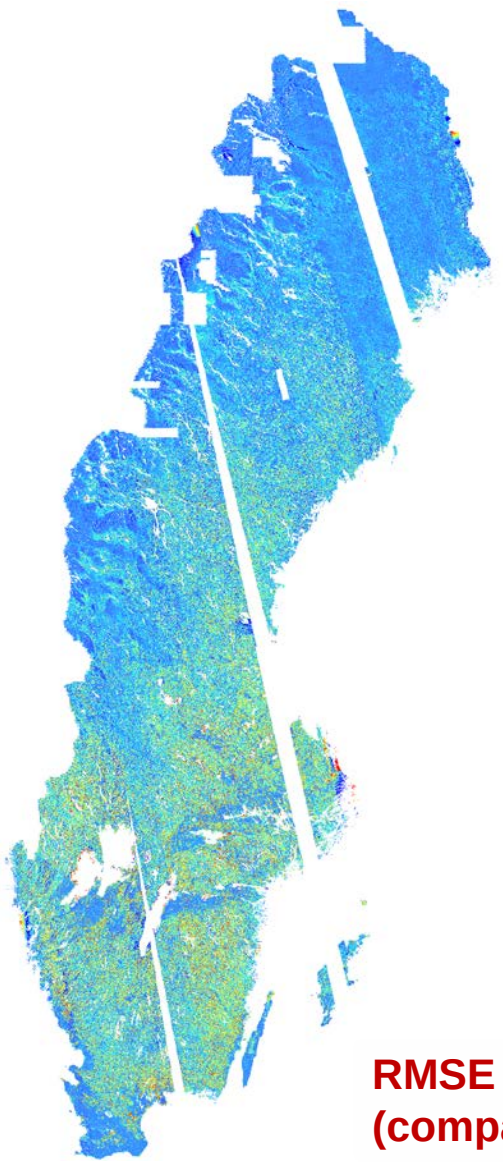


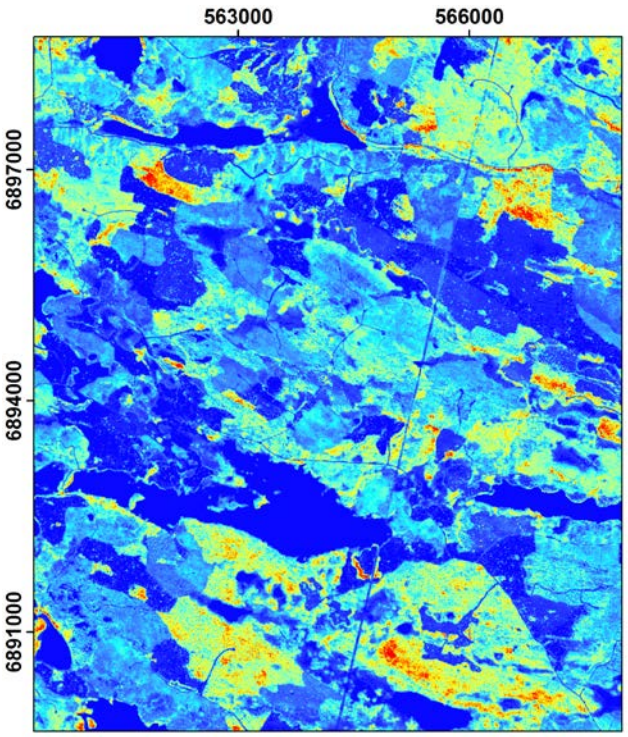

coherence

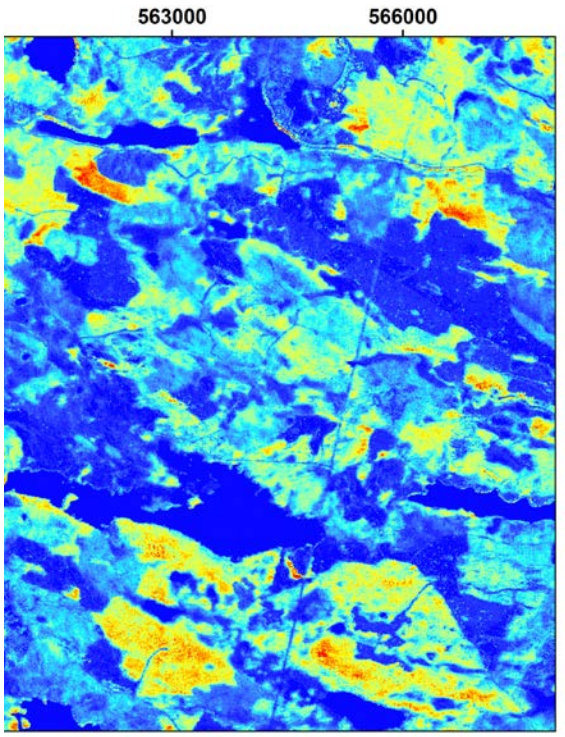



air temperature

# Comparison TanDEM-X vs. ALS AGB maps






***Skogliga Grunddata (airborne laser based)***

***TanDEM-X based***

**RMSE at stand-level: ~19-22% ~21-25%**
**(compared to objective field inventory)**

# Forest Base Maps

- Tree height (max $h_{perc}$ ALS)
- Lorey's height
- Mean diameter
- Basal area
- Volume
- Biomass

ALS data,
12.5 m pixels

**No age or tree species!**

**but freely available**

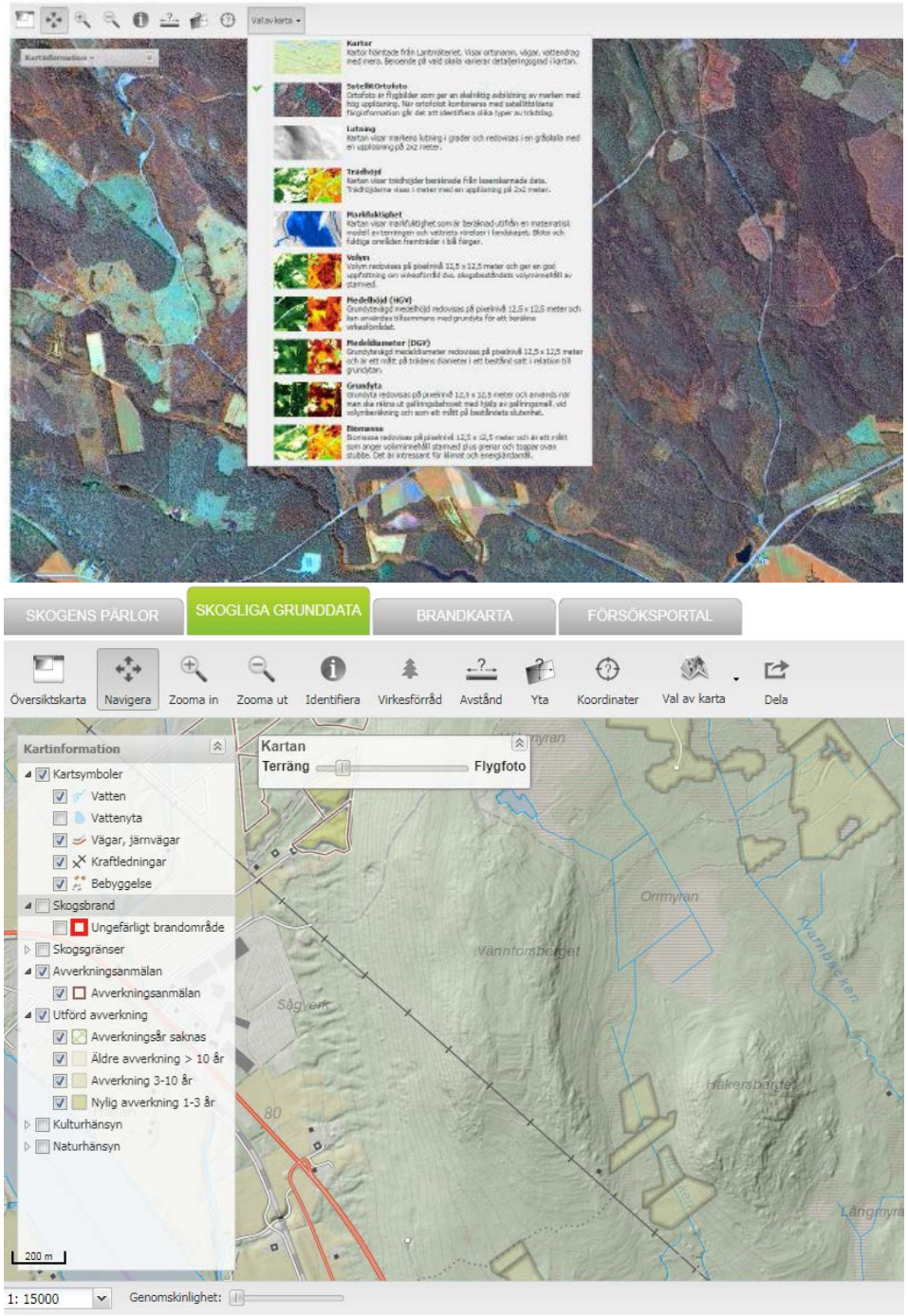
# Forest Base Maps

## a forest RS portal

Additional value maps added as they become available, e.g.

- Fire risk maps
- Automatically detected clear cuts
- Soil moisture maps
- Protected biotope segments
- Aerial photos
- Satellite images
- Thinning templates…

**If the global land mass was to be ALS scanned, it corresponds to 328 times Sweden.**
**~33 billion €**



# Current research


Skogsvårdsstyrelsen
VÄRMLAND–ÖREBRO

2005-09-25

INSTRÖM JONAS
KOJGRÄND 1
123 45 Skogen

**Information om röjningsbehov**

**Fastighet: LILLSKOGEN 1:33** **Kommun: KARLSTAD**

**Areal: ca 8 ha**

**På kartans markerade område kan röjningsbehov finnas.**

Röjningsinsatserna under senare år har sjunkit eroväckande vilket tyvärr kan leda till stora ekonomiska förluster för dig som skogsägare. Röja bör du göra för att skapa

## Tree species

- Sufficient with Sentinel-2 based maps?
- Multispectral laser scanning

## Age

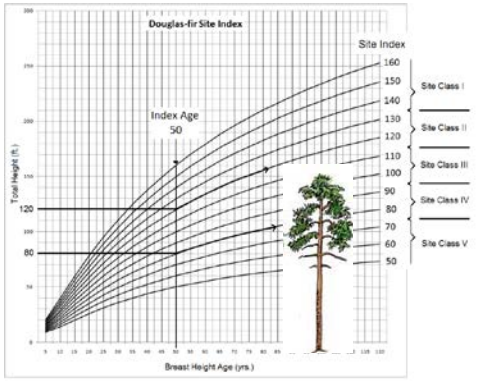
- Site index (SI) can be estimated from height changes if species is known, using SI curves
- Then age can be derived, since SI and tree height is available

The Swedish Forest Agency use NDVI from satellite data to detect young stands with shrubs.

Letters about need for thinning are sent to the forest owners.

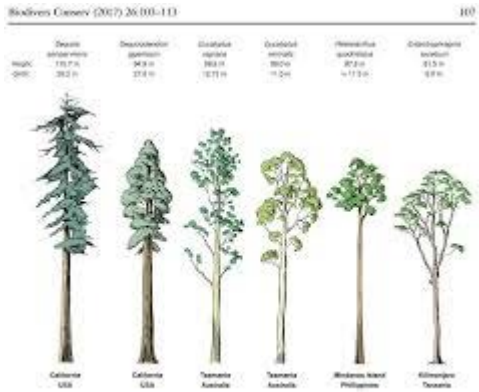
## Forest change

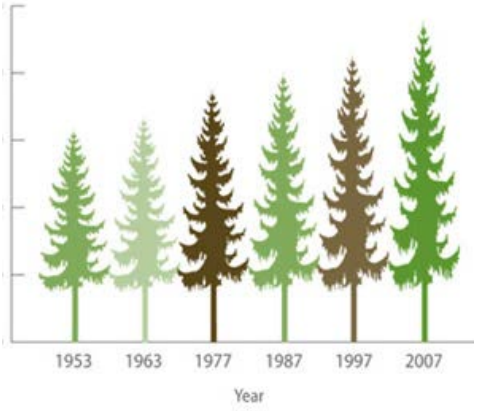
- Thinning needs and clear cuts detected operationally
- Forest growth – airborne laser scanning and aerial image matchings every 7 respective 3 years



# More on forest mapping

- Storm damages, fires, fast changes – Sentinel-1, helicopters and UAVs. Days to weeks.
- Tree species, slow changes - Sentinel-2 (years)
- Forest growth (years)
- Standing volume – laser based methods, TLS, MLS, ALS. Continuously
- Single-photon counting laser scanners enables ALS data acquisition more frequently
- (Near) Real-time monitoring of forest stock – evaluated with harvester data. Does SAR have a role?

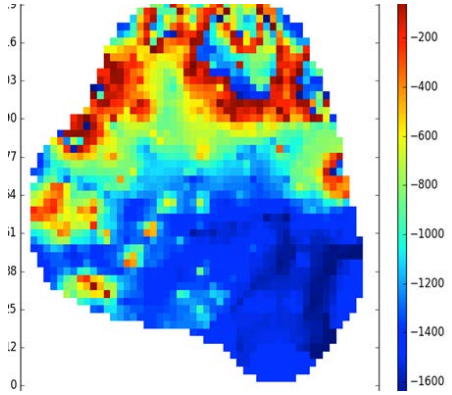




# CT scanning of trunks

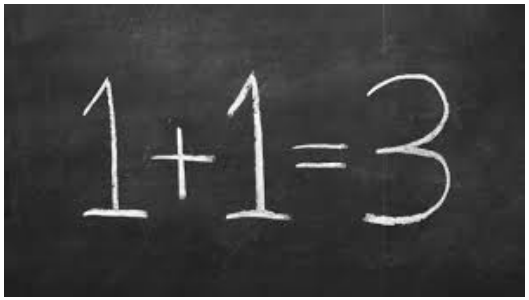
Wood quality already of standing trees in the forest...

- A wet dream or soon reality?
- Already reality in the saw mills
- Could next generation SARs be brought to such levels, that we have many pixels/tree instead of many trees/pixel?




# Conclusions

- **Airborne laser scanning products and aerial photos have become the baseline for Swedish forest owners and industry**
- **Other RS based methodologies most be at least as ‘good’ and cheap to be considered**



# Thank you!