Mapping of mountain birch in the sub-arctic area using airborne laser scanning and SPOT data

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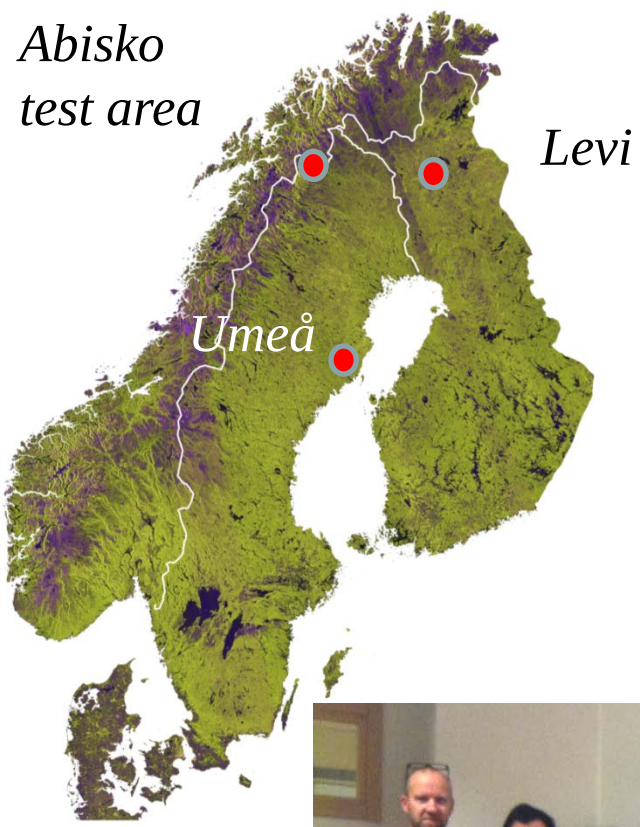


SLU, Umeå

Remote sensing section

Studies

1. Mountain birch biomass change from re-surveyed field plots (*Hedenås et al. 2011 Ambio 40:672-682)*

2. Prediction of biomass, tree height, and canopy closure of mountain birch using high and low density LiDAR data (*Nyström et al. 2012 RSE 123:271-279)*

3. Classification of forest areas according to FAO using LiDAR (*N. Lindgren 2012 MSc thesis at SLU)*

4. Change detection experiment using LiDAR *(Submitted)*

5. Classification of mountain vegetation using LiDAR and SPOT satellite data *(ongoing work*)

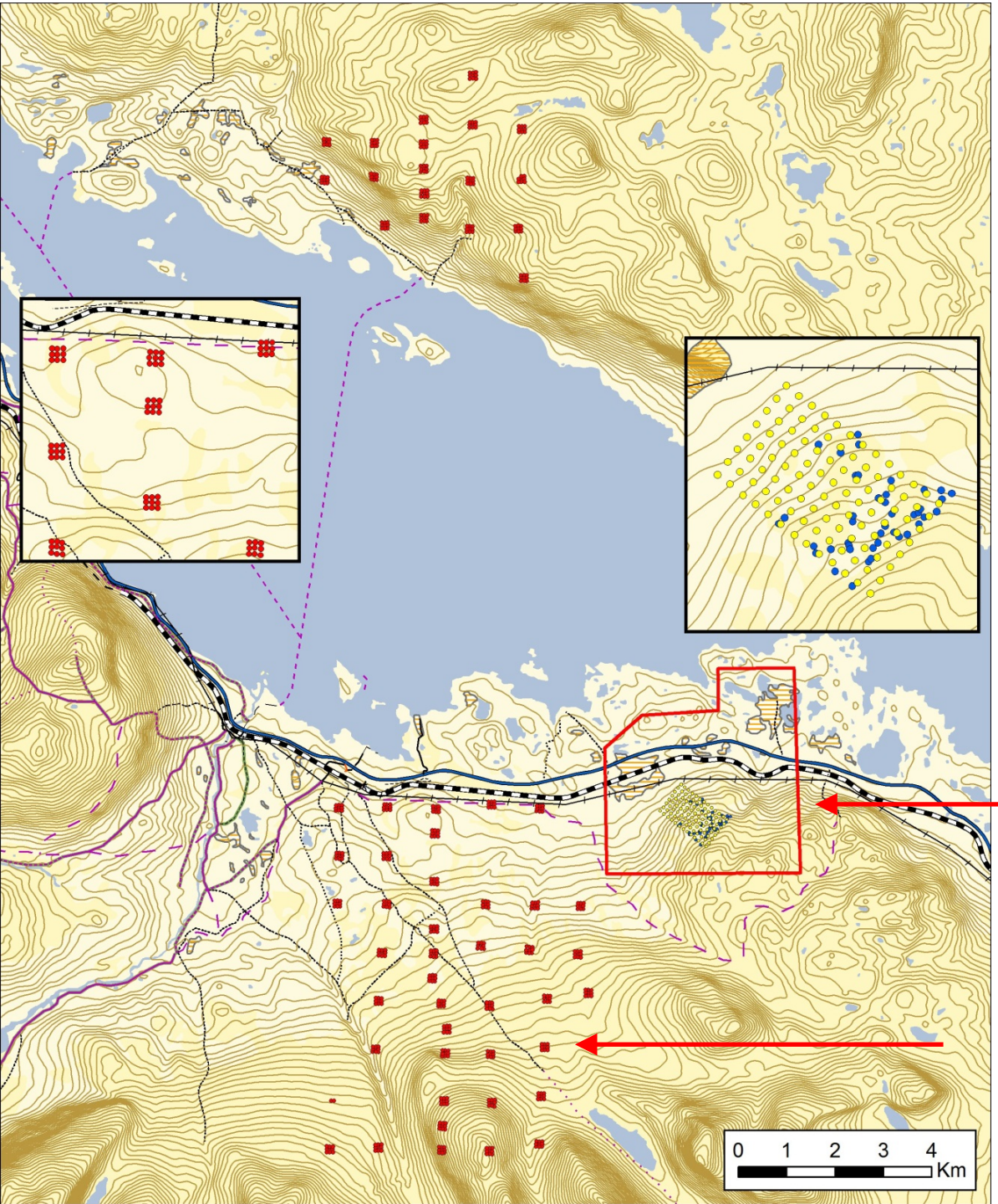
Mountain birch, *Betula pubescense ssp. czerepanovii*

crooked, umbrella-like canopies

Shrub expansion in the Abisko area

Fig. 2 Photography **a** was taken in 1977, by N.-Å. Andersson, and photo **b** was taken in 2009 by H. Hedenås. They are taken from approximately the same location, uphill from plot A2, looking towards plots A3 and A4.

Rundqvist et al. 2011
Ambio 40:683–692

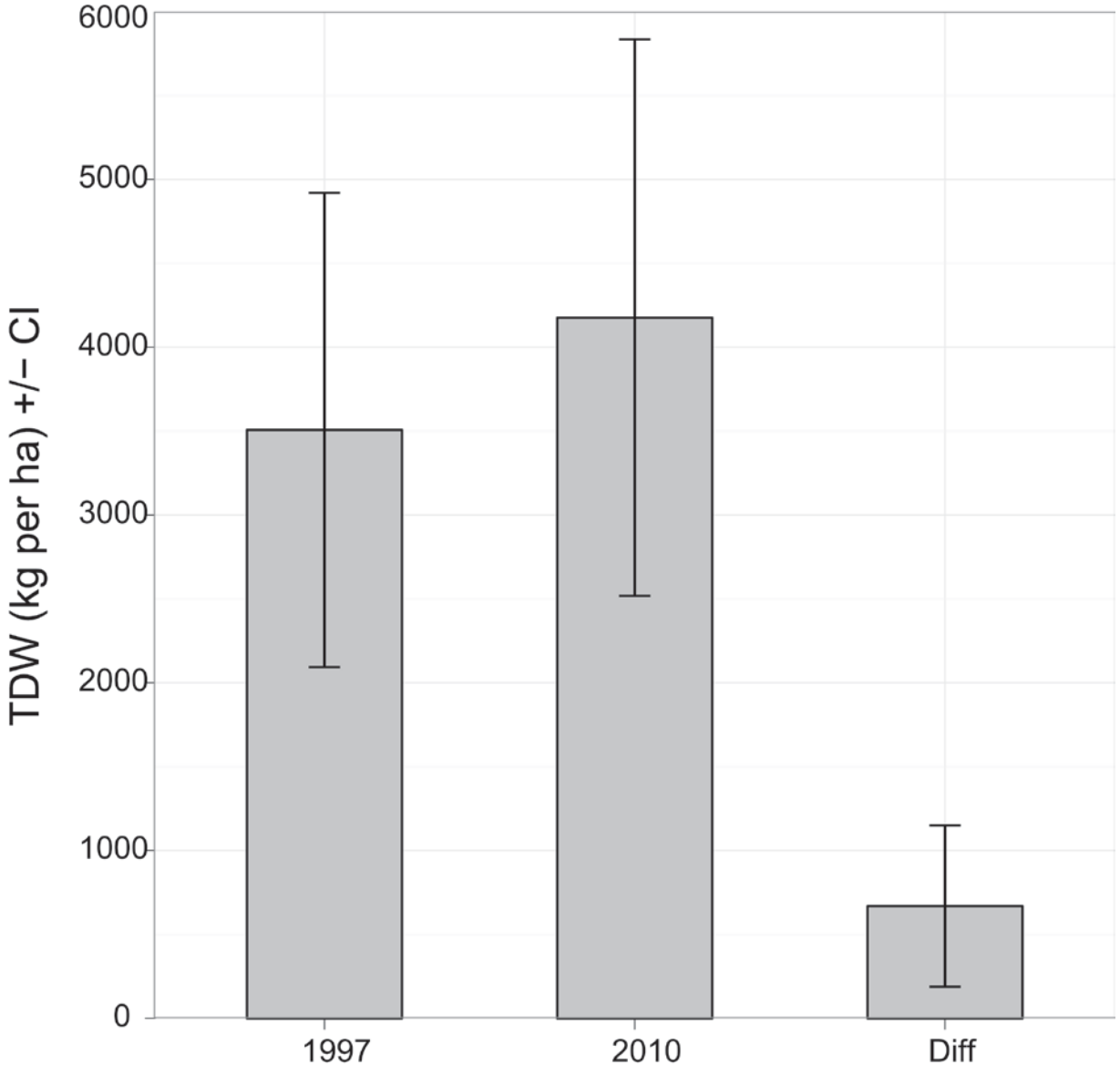


Swedish national laser scanning (NNH) mountain test area in Abisko
1.4 LiDAR returns / m2

Helicopter scanning
6.1 LiDAR returns / m2
104 field plots +
change experiment

550 field plots
surveyed 1997 & 2010

Study 1, Re-survey of field plots
19% increase in mountain birch biomass 1997-2010



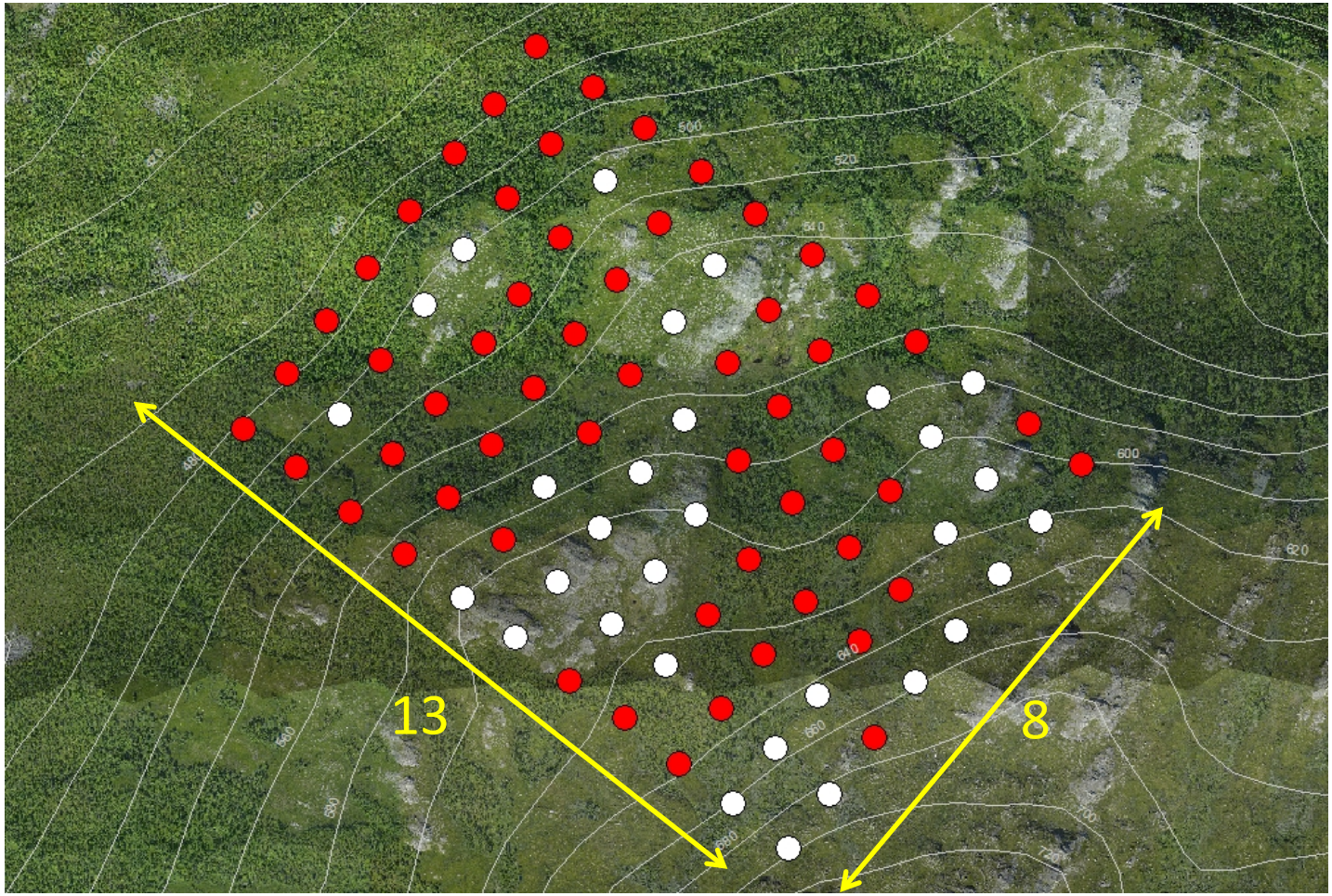
The figure shows a significant difference in tree biomass between years (paired t-test; T-value=2.78, p-value= 0.007).

The biomass increased on average 1.5% per year from 3.5 t ha^{-1} in 1997 to 4.2 t ha^{-1} in 2010.

Hedenås et al. 2011
Ambio 40:672–682

Study 2, Prediction of biomass using LiDAR data

- 104 sample plots, radius 10 m, 100 meters grid (8x13)
- 31 plots without trees taller than 2 meters (white dots)



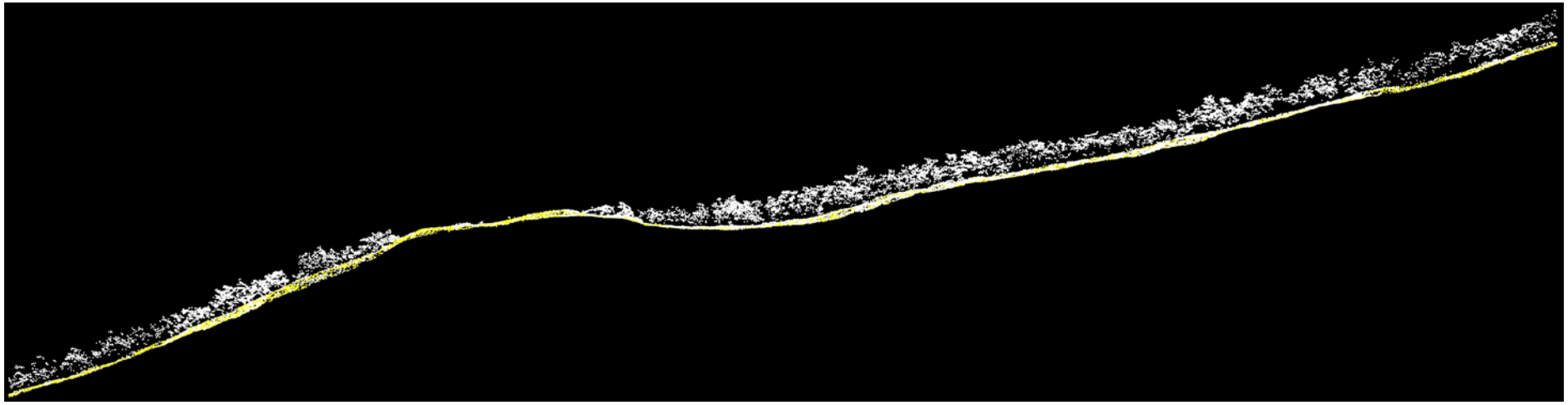
Airborne Laser Scanning (ALS) data used

TopEye MkII

- 2008
- ~6.1 pts/m^2
- 500 m a.g.l.

Optech ALTM Gemini (NNH)

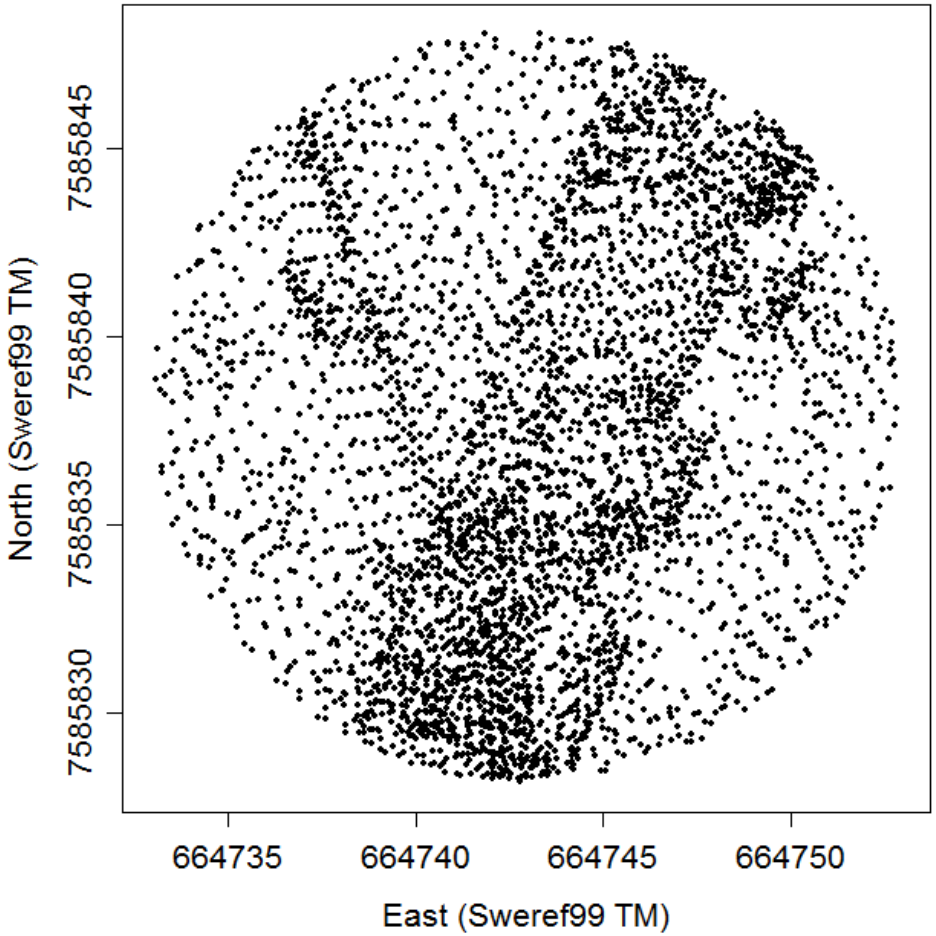
- 2010
- ~1.4 pts/m^2
- 1740 m a.g.l.

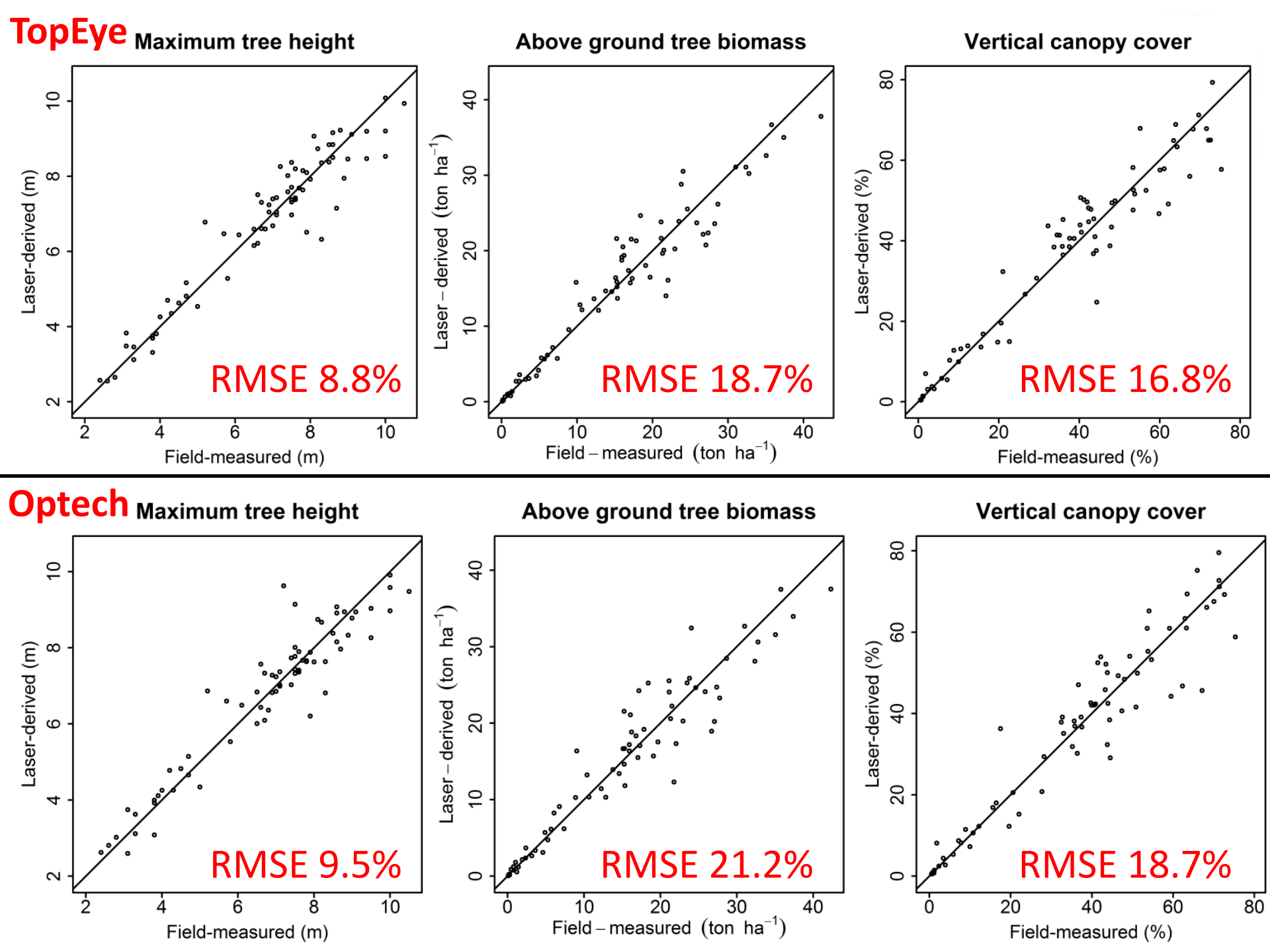


Profile of a 10 meter wide and 500 meter long transect

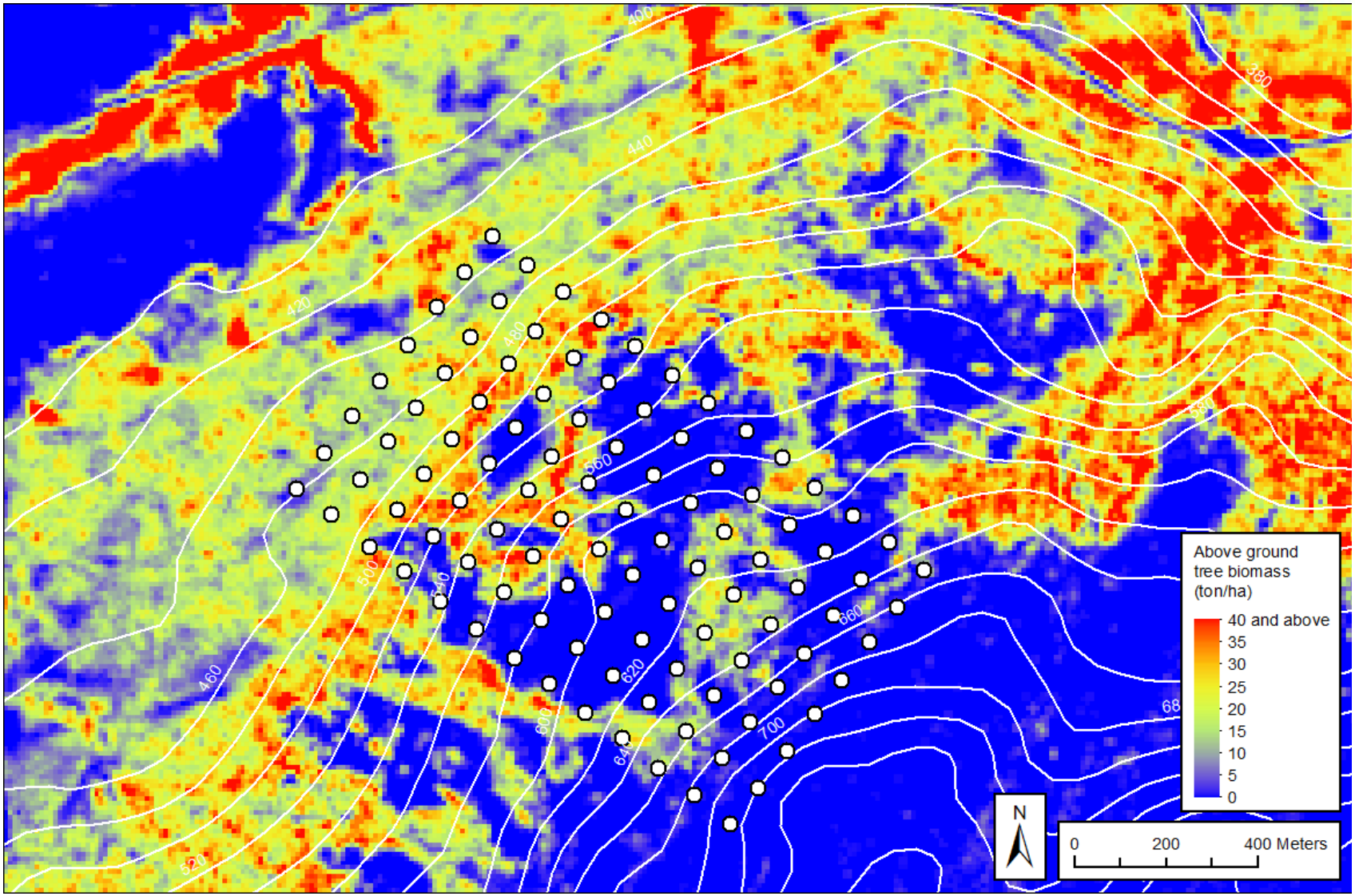
Correction for uneven distribution of points

- Uneven distribution of points causes problem when estimating especially density measures from the points
- Solution: Each point is weighted based on the density of the surrounding points




TopEye
Maximum tree height
Above ground tree biomass
Vertical canopy cover
Laser-derived (m)
Field-measured (m)
RMSE 8.8%
Laser – derived (ton ha^{-1})
Field – measured (ton ha^{-1})
RMSE 18.7%
Laser-derived (%)
Field-measured (%)
RMSE 16.8%
Optech
Maximum tree height
Above ground tree biomass
Vertical canopy cover
Laser-derived (m)
Field-measured (m)
RMSE 9.5%
Laser – derived (ton ha^{-1})
Field – measured (ton ha^{-1})
RMSE 21.2%
Laser-derived (%)
Field-measured (%)
RMSE 18.7%

Birch biomass from ALS , 10x10 meter pixels



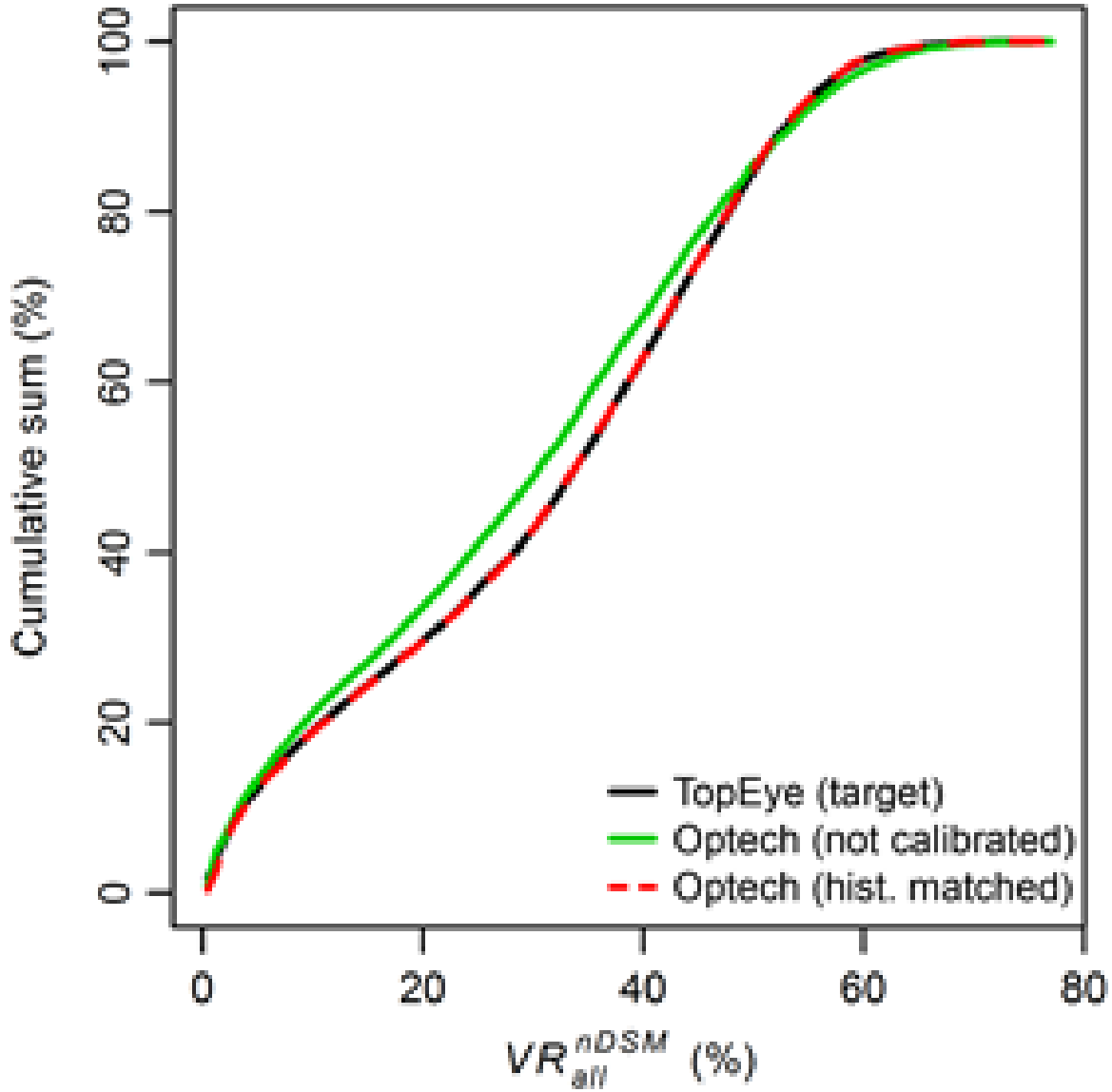
Study 3,
Classification of forest areas according to FAO using ALS

Dark green = forest fulfilling the FAO criterias:
> 5 m
> 10 % canopy cover
classified from ALS with 92% overall accuracy

Study 4 ALS change detection in the treeline

1.5-2.5 m tall birches were cut in 6 m radius circles, 96 plots, 3 treatments:

- 100 % of the trees cut
- 50 % of the trees cut
- 0 % cut = reference
- -
- -



Historgram-matching was successfully used for relative calibration of laser metrics from different sensors and years

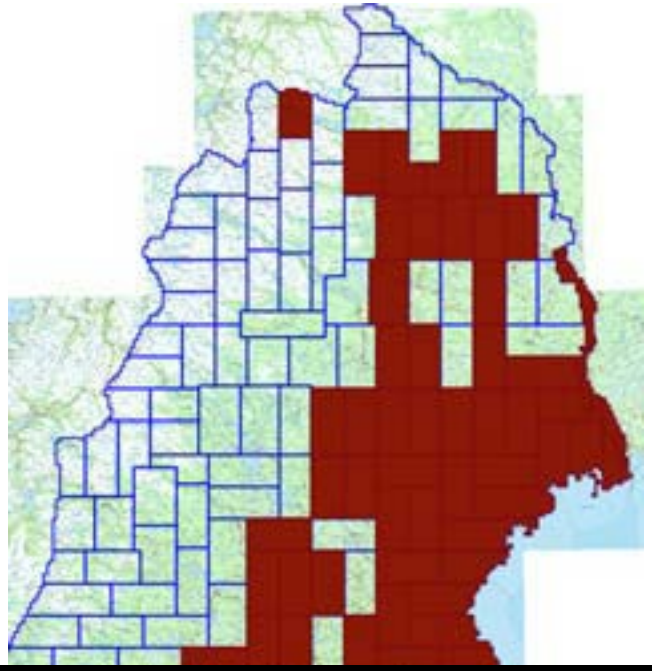
Results classification, error matrix

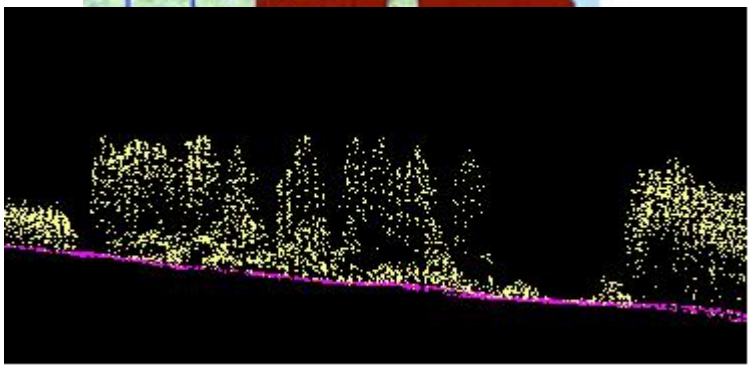
		True								
		H_{95}^{nDSM}			D_1^{nDSM}			H_{95}^{CH} and D_1^{nDSM}		
		Ref.	50%	100%	Ref.	50%	100%	Ref.	50%	100%
Predicted	Ref.	65	8	3	64	3	0	66	3	0
	50 %	3	3	2	3	8	3	1	9	5
	100%	0	2	10	1	2	12	1	1	10
			81%			88%			89%	

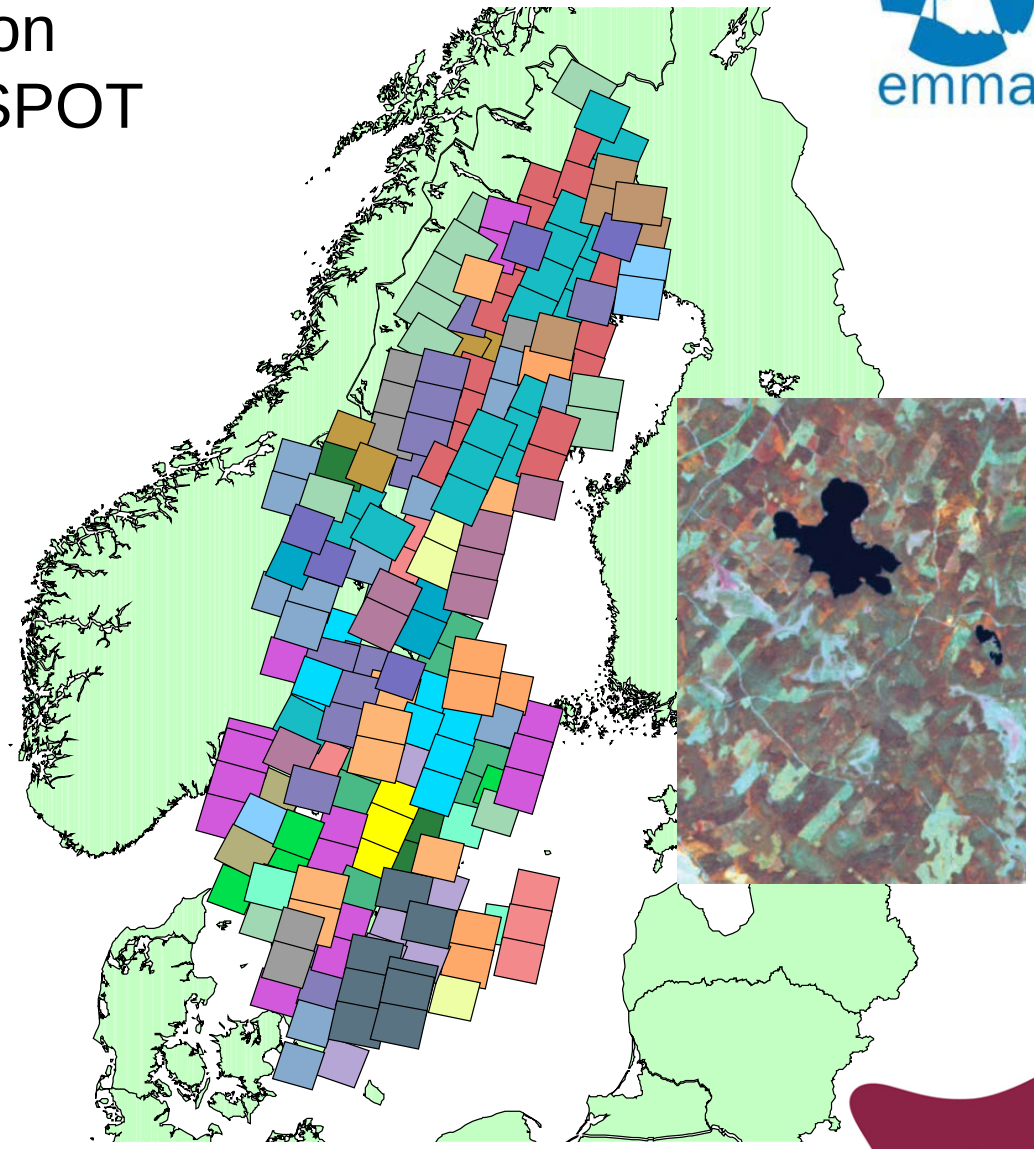
Yearly SPOT data base

Study 5, Mountain vegetation classification using ALS + SPOT

Ongoing national laser scanning







http://saccess.lantmateriet.se

Over-all accuracy and class-wise producer's accuracies for different combinations of SPOT band 1-4 and metrics from laser scanner data

Bands:	Blocks, bedrock	Grass heath	Heath	Meadow	Moderate snow-bed	Birch forest	Sparse birch forest	Over-all
S1-S4 (=SPOT only)	93.3	73.1	79.1	72.7	83.3	85.7	28.0	75.6
S1,S2,S4,NDVI	93.3	76.9	77.7	81.8	83.3	83.3	28.0	75.3
S1-S4, H_{10}	93.3	73.1	81.1	72.7	75.0	88.1	28.0	76.7
S1-S4, H_{95}	86.7	69.2	79.7	72.7	75.0	81.0	36.0	74.9
S1-S4, V	93.3	65.4	86.5	72.7	58.3	83.3	52.0	79.6
S1-S4, $h_{,all}$ (=SPOT + ALS)	93.3	80.8	85.1	72.7	83.3	88.1	44.0	81.4
S1-S4, $\sigma_{h,all}$	86.7	76.9	85.1	72.7	91.7	83.3	48.0	80.7

Summary of results

1) The birch Biomass in the established forest increased significantly over 13 years, several reasons are possible.

2) ALS is excellent for prediction of biomass, tree height, and canopy closure of mountain birch, low density ALS is nearly as good as high density

3) ALS functions well for classification of forest areas according to FAO

4) Histogram matching facilitates ALS change detection, density metrics are best for them partial changes

5) ALS only improved a SPOT classification of mountain vegetation types (+ 5 % overall accuracy).

Acknowledgements:
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