

# EO-assisted estimation enhances the precision of National Forest Inventory variables, also in a data-poor context



Let's connect!



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## 1. Official forest data: accurate, but imprecise

### National Forest Inventories (NFIs):

- Europe's official source of forest data for **national & international reporting** (UNFCCC, FAO)
- NFIs are **plot-based** and **systematic field measurements** collected every 5-10 years

### The precision problem:

- NFIs are **expensive** and have limited **sample sizes**, this limits **precision of its forest estimates**
- Key forest variables (e.g., growing stock volume, aboveground biomass) change slowly → imprecise estimates can hide real trends
- Recent EU-level discussions on a pan-European forest monitoring system highlight **the need for more precise NFI estimates**

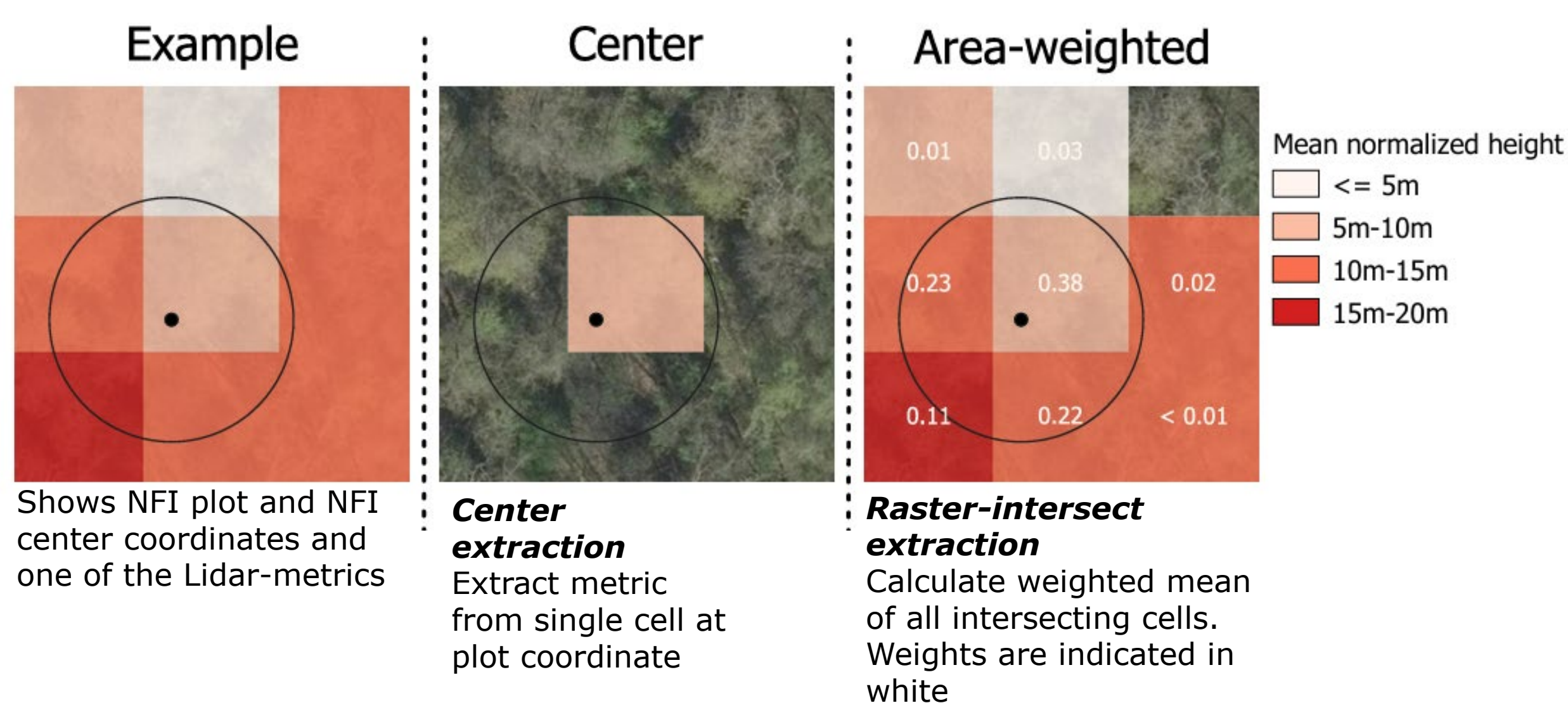
### A potential solution:

- Integrating** wall-to-wall EO data with NFI field plots to improve precision is a promising way forward. But sampling density varies among EU countries.
- The Netherlands is a suitable case study:** National airborne lidar data is available, but its potential to enhance precision is unexamined

## \* 4. Extraction method: does it affect precision gains?

### Perform analysis testing two different extraction methods:

The **Lidar-based metrics** are gridded at 10x10m, while the NFI plots have a **varying radius of 5-20m**. Therefore, the plot footprints rarely align with the raster cells. *How to extract the metrics at plot locations?*

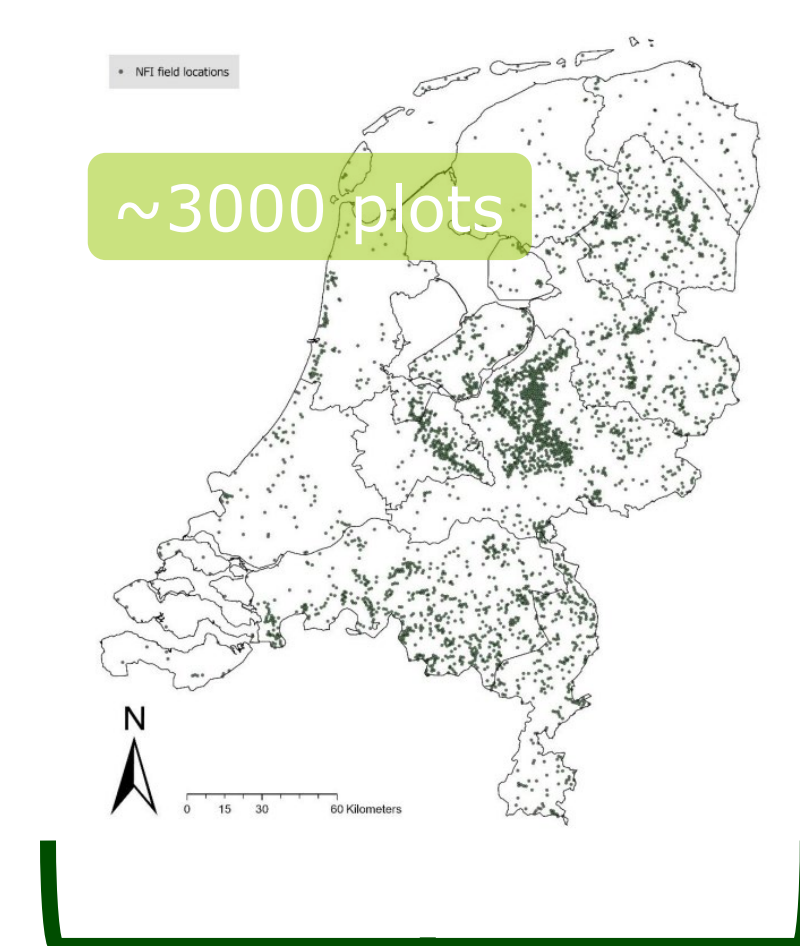


## 2. The main objective

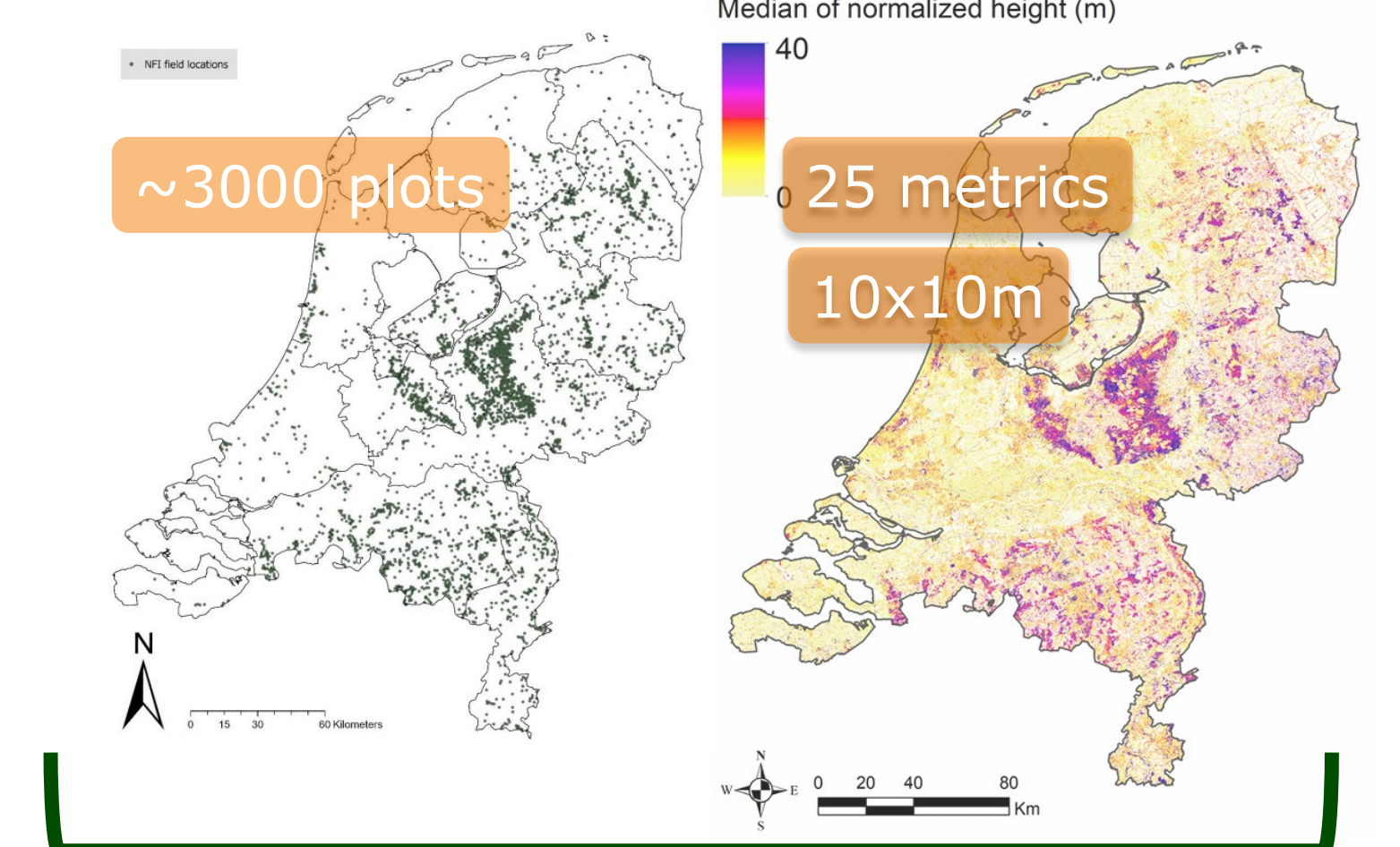
? **Can lidar-based structure metrics improve the precision of NFI estimates – and does it still work with fewer plots?** ?

## 3. Model-assisted estimation to enhance precision

### Plot-based estimation [NFI only]



### Model-assisted estimation [NFI + LiDAR-metrics]



Plot-based estimation of mean and variance (precision baseline)

Use **Random Forest** as assisting model for model-assisted estimation of mean and variance

Quantify **precision enhancement** of using LiDAR-metrics as **auxiliary information** by **Relative Efficiency (RE)**:

$$RE = \frac{VAR(\hat{\mu}_{plot})}{VAR(\hat{\mu}_{MA})}$$

For three key NFI variables:

**GSV** **AGB** **BA**

X 100%-10% of sample size

## 5. Results: Enhanced precision for forest variables

**Table 1.** Sample size (n), means, and variances of growing stock volume (GSV, m<sup>3</sup> ha<sup>-1</sup>), aboveground biomass (AGB, Mg ha<sup>-1</sup>), and basal area (BA, m<sup>2</sup> ha<sup>-1</sup>), and relative efficiency (RE) indicator. Means and variances are reported for both plot-based and model-assisted estimates.

Variable	Extraction method	n	Plot-based		Model-assisted		RE
			Mean	Variance	Mean	Variance	
GSV	center	2997	224.16	5.35	216.03	3.81	1.40
GSV	area-weighted	2997	224.16	5.35	222.30	3.65	1.48
AGB	center	2953	175.61	5.71	167.52	4.24	1.35
AGB	area-weighted	2953	175.61	5.71	175.62	4.16	1.37
BA	center	2939	26.65	0.06	25.77	0.04	1.50
BA	area-weighted	2939	26.65	0.06	26.82	0.04	1.50

**Table 2.** Sample size (n), means, and variances of GSV (m<sup>3</sup> ha<sup>-1</sup>) and relative efficiency (RE) indicator for reduced sample size scenarios. Means and variances are reported for both plot-based and model-assisted estimates.

Percentage	n	Plot-based		Model-assisted		RE
		Mean	Variance	Mean	Variance	
100%	2832	222.7	5.49	219.8	3.72	1.48
90%	2549	221.9	6.12	220.3	4.10	1.49
80%	2266	223.6	7.06	220.6	4.88	1.45
70%	1983	224.5	8.09	221.2	5.62	1.44
60%	1700	224.7	9.53	223.6	6.67	1.43
50%	1416	226.5	11.49	222.9	7.83	1.47
40%	1133	228.9	14.17	227.2	9.46	1.50
30%	850	229.5	18.54	228.1	12.22	1.52
20%	567	227.6	28.21	227	19.23	1.50
10%	284	229.2	54.45	228.8	34.24	1.59

## 6. Conclusion

### 1. Lidar-based metrics improved precision for all three variables:

Up to 50% fewer plots needed to achieve the same precision as plot-based estimation (RE up to 1.50).

### 2. Area-weighted extraction consistently outperformed center extraction:

Mean estimates of center extraction introduced fell outside the 95% confidence interval of plot-based estimates.

### 3. Precision gains remained high, even in a data-poor scenario (RE 1.43–1.59):

At just 70% of plots, model-assisted precision ~matched full-sample plot-based estimation.