Carbon stock changes in forests and soils across Sweden: the national inventories

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SLU
Or, alternatively…. 

Elephant measurements in Sweden during the past 90 years!

How large has it become?
Outline

- The national forest inventories in Sweden
- Measure or model carbon stock change?
- Carbon stock changes since 1990
- Forecasts
- Conclusions
The national forest inventories (NFIs)

- ... have been conducted since 1923 in Sweden
Areal produktiv skogsmark¹ fördelad på åldersklass. 1923-2012.
Area productive forest land¹ by age class. 1923-2012.

Areal (milj. ha.) Area (milj. ha.)
Important to note

- The basic measurements of the NFI are very relevant for quantifying biomass and biomass change.
- A specific inventory of forest soils was initiated in the 1960s.
- Land use and land-use transfers are easily identified.
The NFI: a large number of sample plots allocated in clusters across Sweden
Above- and belowground biomass

- Measurements of diameters and heights
- Application of biomass models
Litter and soil organic carbon

- Measurements on mineral soils
- Modeling on peatlands
Repeated measurements

- Every 5-10 years
- Change estimation
- Annual figures by interpolation
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National forest carbon budgets – measure or model?

- Some countries are largely model-based (e.g. Australia)
- Some countries are largely measurement-based (e.g. Sweden)

But:
- Models need to be calibrated through measurements
- No national carbon budgeting systems can be based entirely on measurements
- "Best" choice depends on national conditions
Area-based sampling (measurements)

- 30,000 sample plots across Swedish forests
- Permanent plots; efficient for change estimation
- Unbiased estimates
- Uncertainty can be quantified
- Possible to match carbon pools to land use

The estimator

\[ \hat{\Delta B}_i = A_i \cdot \frac{\sum_{j=1}^{n_i} \Delta b_{ij}}{\sum_{j=1}^{n_i} a_{ij}} = A_i \cdot R_i \]

The variance estimator

\[ \text{Var}(\hat{\Delta B}_i) \approx \frac{A_i^2}{\left(\sum_{j=1}^{n_i} a_{ij}\right)^2} \cdot n_i \cdot S_{\Delta b_{ij} - R_i \cdot a_{ij}}^2 \]
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About uncertainties

- Small (relative) sampling errors at national level
- Larger (relative) sampling errors for small domains
- Modeling errors may be influential (but are difficult to quantify)
- Checks for measurement errors are made in the NFI
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Forest definition
(at maturity *in situ*)

- Area at least 0.5 ha
- Minimum 10% canopy closure
- Minimum height 5 m
- No other predominant land use
- ~ 28 Mha in Sweden
Emissions/Removals from the LULUCF sector
Total emissions

M ton CO$_2$-eq

-60
-40
-20
0
20
40
60
80
100
120


- LULUCF
- Emissions from biomass
- Total wo LULUCF
What pools are influential?

- Biomass accumulates very large amounts of carbon
- Mineral soils (and HWP) accumulate large amounts of carbon
- Organic soils release fairly large amounts of carbon
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Forecasts

- Based on NFI plots and the Heureka RegVis system
Ecosystem processes and forestry management operations

Description of the initial status

Period \( t \)

Future status and production of products and ecosystem services

Period \( t + 1 \)

Period \( t + 2 \)
Forecasted accumulated net emissions (four scenarios)
Conclusions

- Overall, the Swedish forests have been substantial carbon sinks over a long period of time.
- The increase of carbon in biomass, soils and HWP is about 10 Mton annually (about 40 CO$_2$-eq); this is a large portion of the total emissions in the other GHG sectors.
- (However, the removals in the LULUCF sector only to a small extent are accounted for under the current reporting agreements.)