METLA

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Biomass estimates in national carbon inventories

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Research seminar on

Carbon budget of Finnish forests 1920-2000

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Introduction

Forest biomass and carbon assessments – current information needs

Scientific

- to increase understanding on C fluxes
  - within ecosystems
  - between terrestrial ecosystems and atmosphere

Climate policy

- **Climate Convention** (UNFCCC) -> forest carbon stock and stock changes to be reported
- **Kyoto Protocol** -> national greenhouse gas inventories, including forest carbon sink (LULUCF)
- **IPCC good practice guidance** for national inventories -> 5 pools to be included **above-** and **below ground biomass**, **dead wood**, **litter** and **soil organic matter**

Needs

Introduction

Forest biomass – Available information

- element budgets of forest ecosystem
- studies on nutrient cycling
- NPP of forest ecosystem
- biomass equations developed by bioenergy studies

…but how to assess biomass at national scale?

Needs

Options for national inventories

- To apply biomass equations directly on tree-wise data
  - access on NFI sample plot data (tree-wise measurements of DBH and height)
  - **biomass equations**
- To convert stem volume to biomass estimates with BEFs
  - national estimates of stem volumes according to tree species (and age classes) provided by NFI
  - relevant **Biomass expansion factors**
  - Biomass (Mg/ha) = BEF (Mg/m^3) *Stem volume(m^3/ha)
- Methods based on remote sensing data
  - ground truth data on volume or **biomass estimates**
  - interpretation of change with RS-data

Options

Applicable information

At tree level

- biomass equations for stump, branch and/or crown biomasses developed by bioenergy studies

Problems

- representativeness
- biomass eq. are not applicable at stand level without tree-level information on dimensions

At stand level

- Biomass Expansion factors (BEFs) based on selected ecosystem studies

Problems

- no representative sampling over all site conditions and over large geographical area
- may introduce bias on biomass estimates
- uncertainty not known

Options

In this project

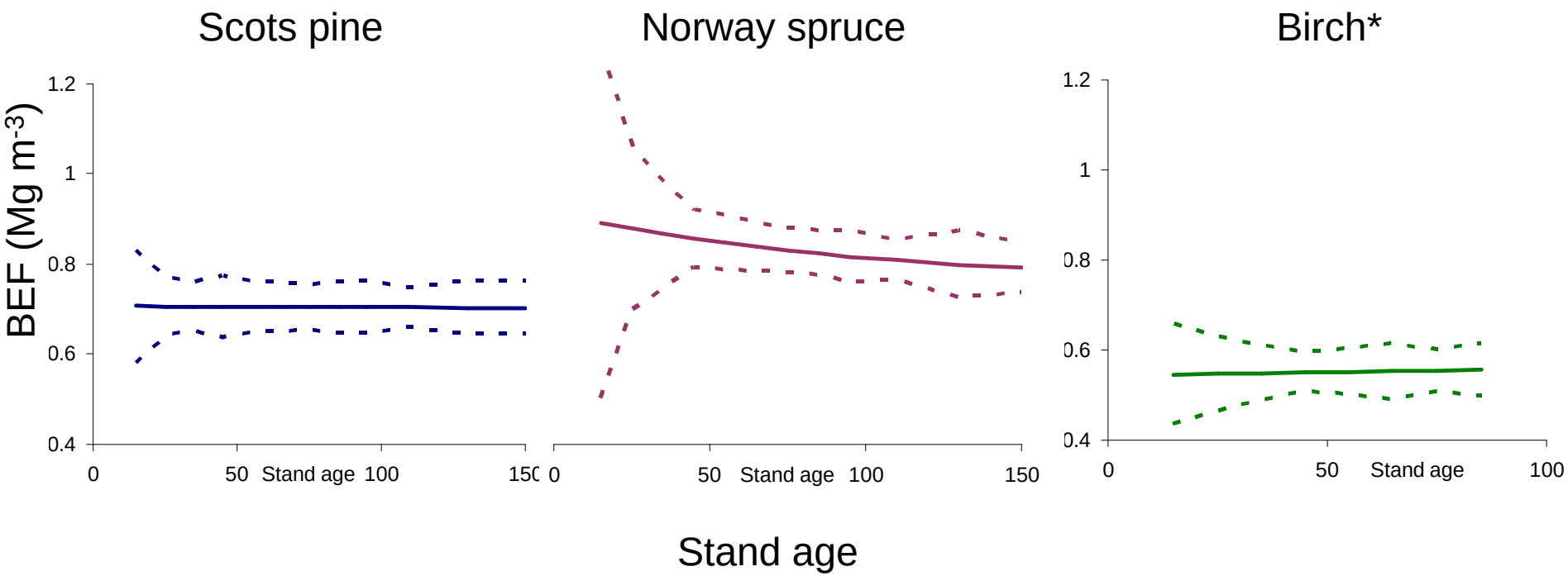
New tools developed for estimation of biomass

- Biomass expansion factors (BEFs) with uncertainty estimates
- Database on biomass equations
- Generalized biomass equations
- Biomass equations for understorey vegetation according to stand age and dominant tree species

New tools

Biomass expansion factors

Age-dependent biomass expansion factors (BEFs) with 95% confidence limits for total biomass of Scots pine, Norway spruce and birch* *(Lehtonen et al. 2004)*



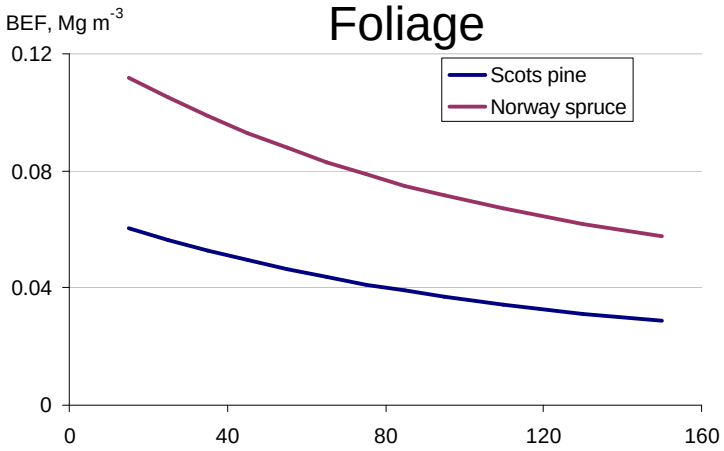
* for birch aboveground biomass only

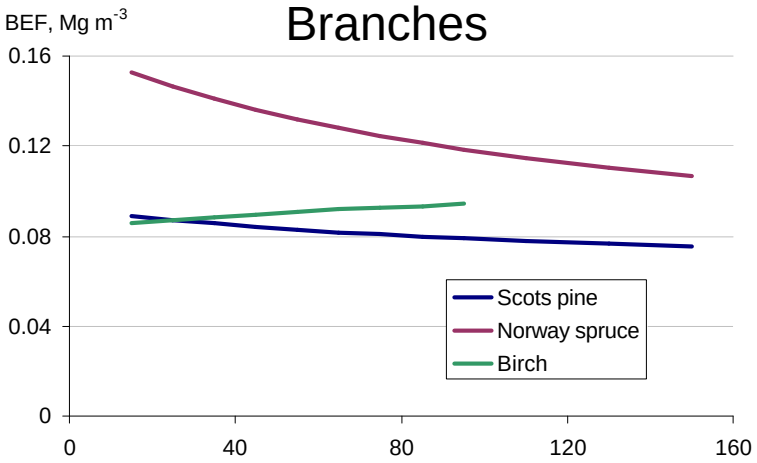
New tools

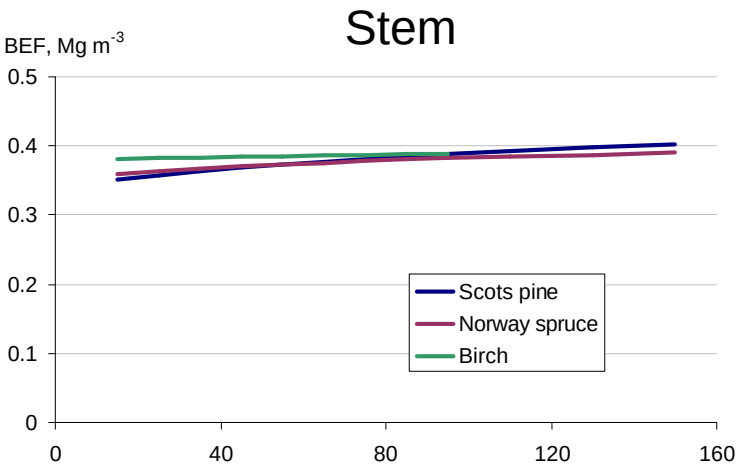
Biomass expansion factors

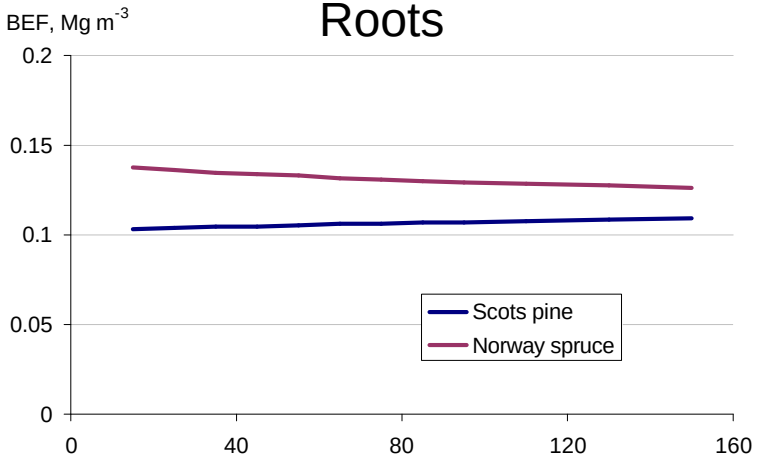
Tree species specific BEFs for different biomass components

(Lehtonen et al. 2004)







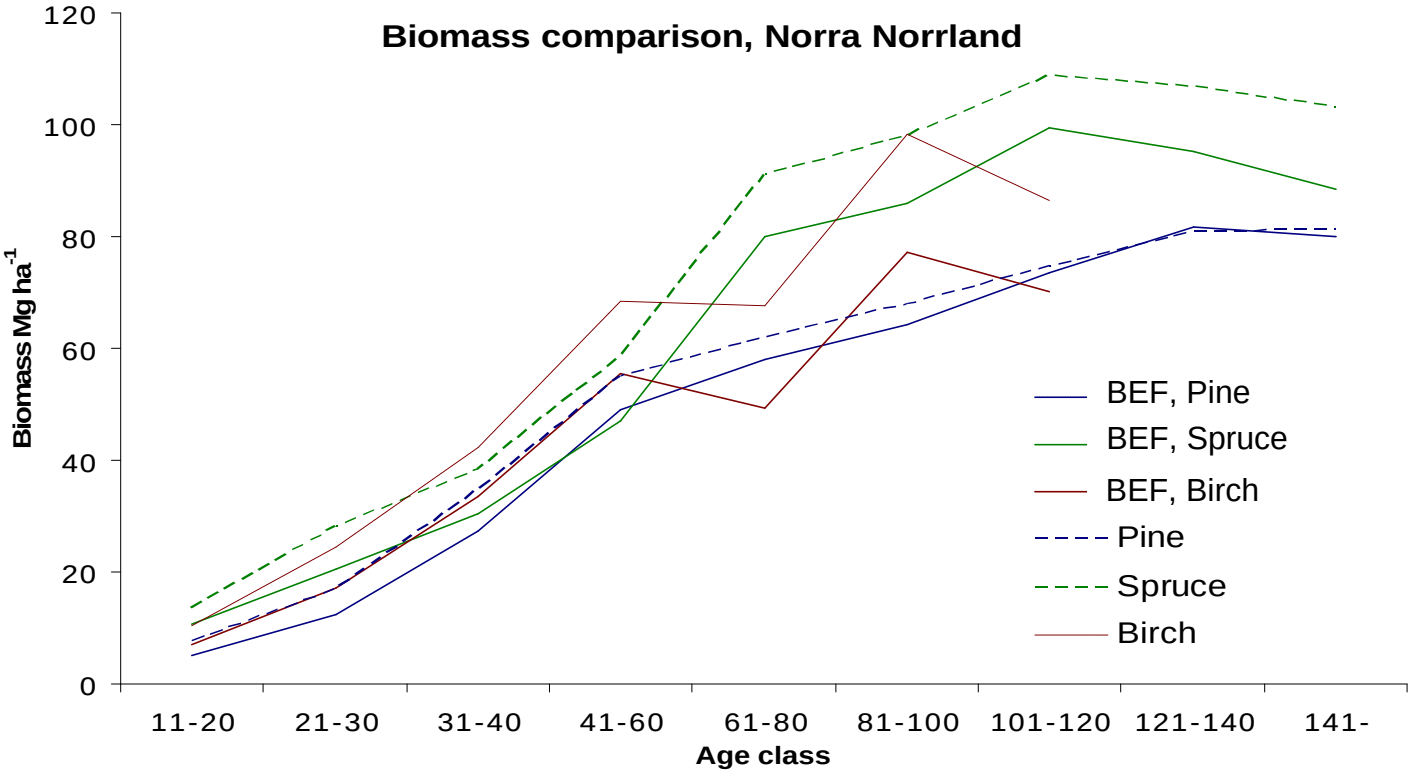


Stand age

New tools

BEFs – test of applicability

Age-dependent BEFs in large scale inventories *(Jalkanen, A., Mäkipää, R., Ståhl, G., Lehtonen, A. & Petersson, H. Submitted manuscript)*



Biomass estimates calculated with BEFs were slightly lower than those calculated with Marklund's biomass equations (broken line)

New tools

Database on biomass equations

- Tree-wise equations for whole tree biomass and biomass compartments f(dbh,h) of common European tree species *(Zianis, D., Muukkonen, P., Mäkipää, R. & Mencuccini, M. Submitted manuscript)*
- more than 500 equations from 16 countries
- Example; equations for different biomass compartments (AB= total aboveground, SB= stem bark, FL=foliage, BR=branch, ST=stem,…)

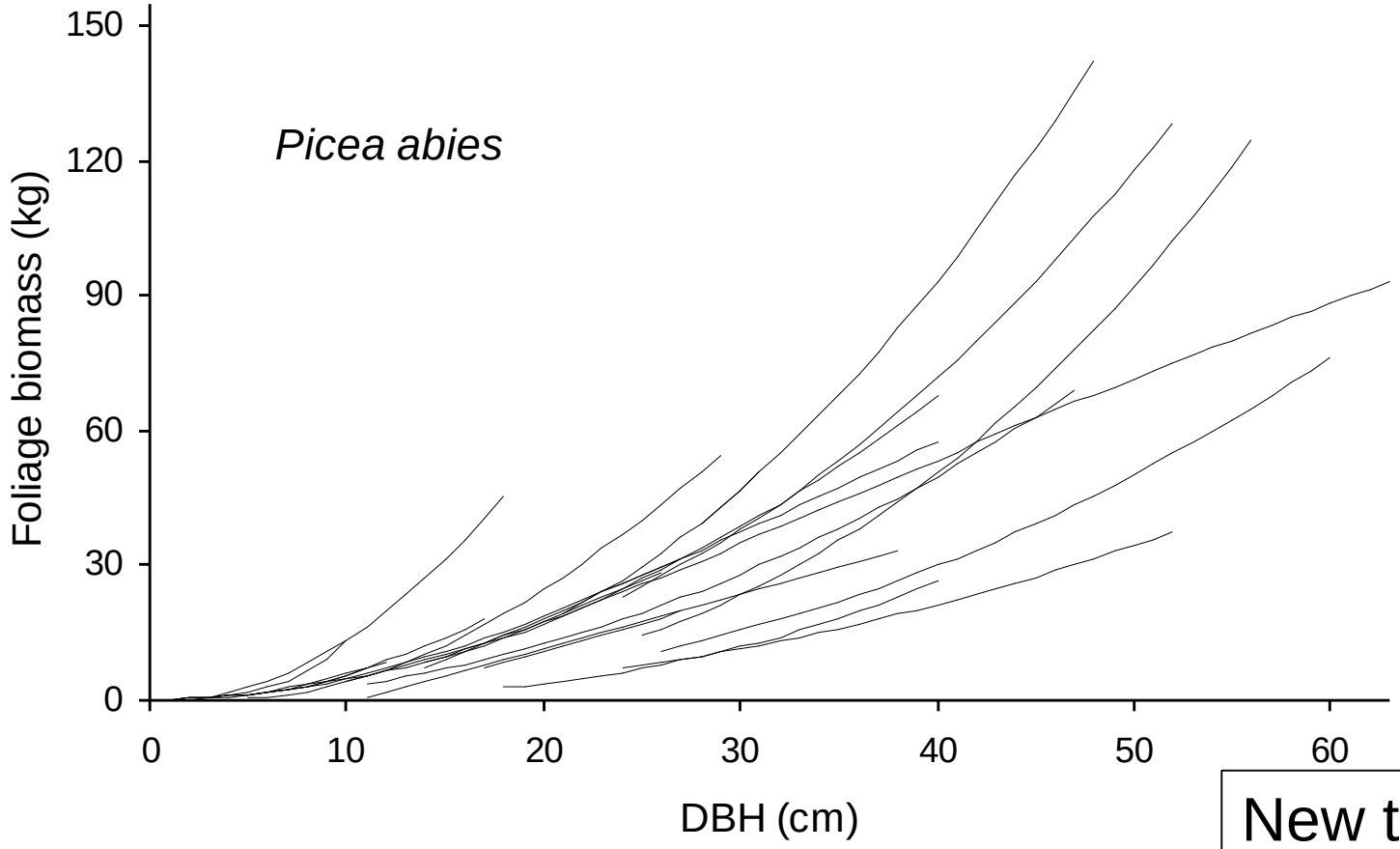
Scientific name	Location	Depende	Format of equation	a	b	c
Picea abies	Germany, Saxonia, Tha	AB	a+b*D+c*D^2	-142,6088	13,63896	0,12593
Picea abies	Germany, Saxonia, Tha	SB	a+b*D+c*D^2	-6,55127	0,75517	0,02156
Picea abies	Austria, Carinthia, contr	FL	a+b*D+c*D^2	-1.9745	0,039	0.00382
Picea abies	Austria, Carinthia, fertili	FL	a+b*D+c*D^2	-0.7095	0,0011	0.00142
Picea abies	Austria, Carinthia, contr	BR	a*exp(b*D)	5.3727	0.00876	n/a
Picea abies	Austria, Carinthia, fertili	BR	a*exp(b*D)	1,325	0.0135	n/a
Picea abies	Finland	ST	a*D^b	0,12269	2,3272	n/a
Picea abies	Finland	BR	a*D^b	0,0022	2,9122	n/a
Picea abies	Finland	FL	a*D^b	0,00445	2,2371	n/a
Picea abies	Finland	FL(1)	a*D^b	0,00394	2,1534	n/a
Picea abies	Finland	FL(2)	a*D^b	0,00083	2,4074	n/a
Picea abies	Finland	RC	a*D^b	0,33989	1,4728	n/a
Picea abies	Denmark, Klosterheden	ln(FL)	a+b*LOG(D²*H)	-4.24	0.67	n/a
Picea abies	Denmark, Klosterheden	ln(FL)	a+b*LOG(D²*H)	-4.85	0.81	n/a
Picea abies	Denmark, Klosterheden	ln(BR)	a+b*LOG(D²*H)	-5.88	1.02	n/a

Database available from Petteri.Muukkonen@metla.fi

New tools

Database on biomass equations

Compiled biomass equations for foliage biomass of Norway spruce *(Zianis, D., Muukkonen, P., Mäkipää, R. & Mencuccini, M. Submitted manuscript)*



New tools

Database on biomass equations

How to use compiled biomass equations in a national inventory?

With tree-wise data

- Evaluate equations and select one developed in closest (or most alike) region
- Estimate range of biomass
- Compile meta-data of reported biomass values and develop a new equation
- Generalize equations *(Muukkonen & Lehtonen)*

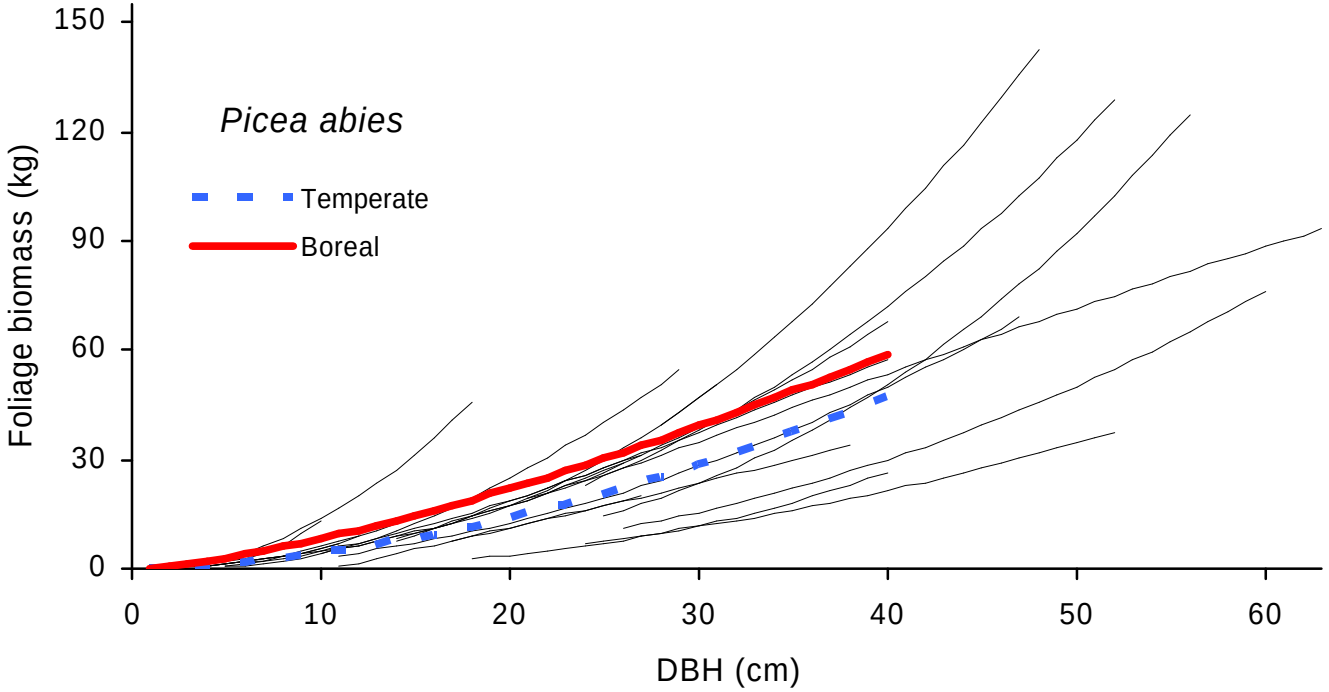
With stand level data

- formulate BEFs or apply on median tree

New tools

Generalized equations

Generalized biomass equations developed for different biomass components of major tree species in Europe *(Muukkonen, P. & Lehtonen, A. Manuscript in preparation)*

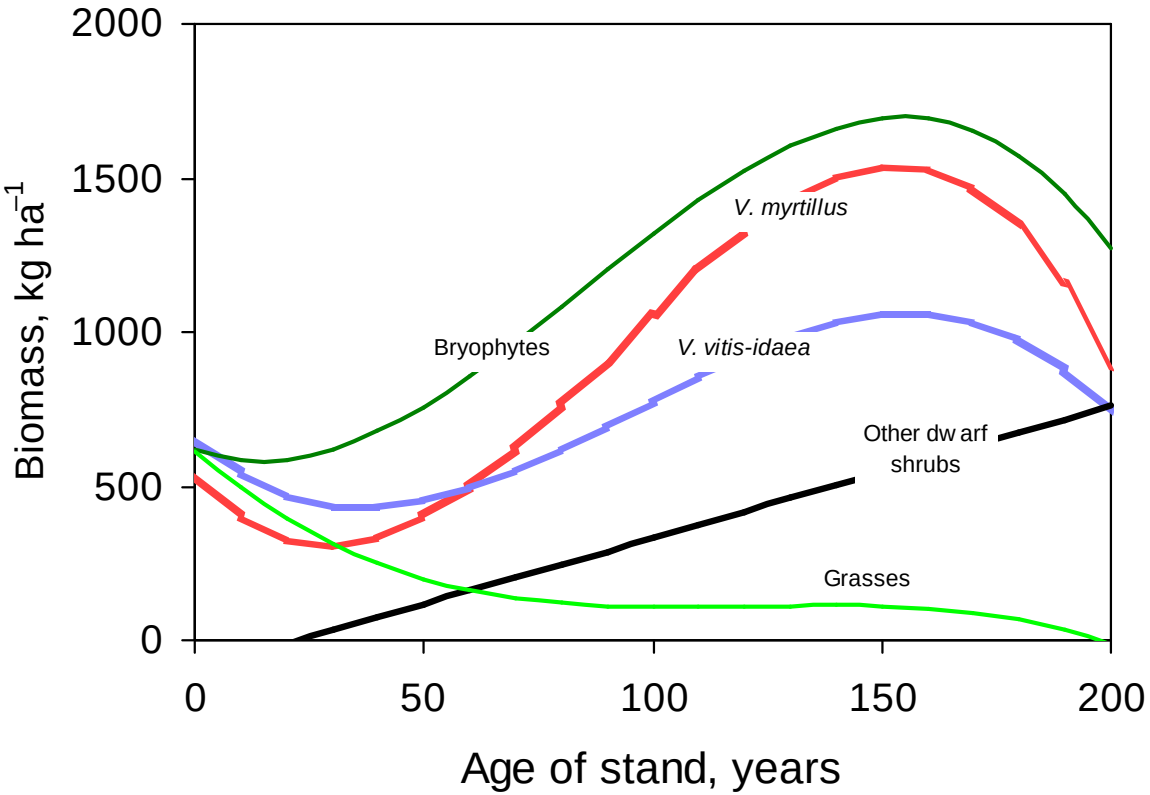


Generalised biomass equations for foliage biomass of Norway spruce in temperate and boreal conditions

New tools

Biomass of understorey

Biomass of understorey vegetation modelled according to stand age in pine and spruce dominated stands *(Muukkonen, P. & Mäkipää, R. Submitted manuscript)*



Biomass of understorey vegetation in Norway spruce stands according to stand age

New tools

Major uncertainties

Biomass of roots

- existing information is based on relatively small number of sampled trees
- sampling methods underestimate biomass of small roots
- fine roots, stand level estimates from a few sites

Foliage

- information on foliage biomass of deciduous trees from few sites, difficulties in sampling

Shrub layer not included

Biomass of mycorrhizas

Conclusions

Conclusions

- BEFs with uncertainty estimates are available and applicable for national inventory
- Various biomass equations are available and –after evaluation or gereralization – applicable for national inventories
- Biomass component (foliage, branches,…) specific BEFs and biomass equations are available and biomass by components can be estimated
- Biomass of understorey vegetation can be estimates as a function of stand age, but high uncertainty
- High uncertainties in the estimation of below ground biomass and foliage biomass of broadleaved trees

Conclusions

References

Lehtonen, A., Mäkipää, R., Heikkinen, J., Sievänen, R. & Liski, J. 2004. Biomass expansion factors (BEFs) for Scots pine, Norway spruce and birch according to stand age for boreal forests. Forest Ecology and Management 188(1-3): 211-224.

Muukkonen, P. & Mäkipää, R. Biomass models of understorey vegetation according to stand age and site quality in coniferous forests. Submitted manuscript.

Jalkanen, A., Mäkipää, R., Ståhl, G., Lehtonen, A. & Petersson, H. Estimation of biomass stock of trees in Sweden: comparison of biomass equations and age-dependent biomass expansion factors. Submitted manuscript.

Zianis, D., Muukkonen, P., Mäkipää, R. & Mencuccini, M. Biomass and stem volume equations for tree species in Europe. Submitted manuscript.

Muukkonen, P. & Lehtonen, A. Generalized allometric volume and biomass functions for some European tree species. Manuscript in preparation.

Further information

http://www.efi.fi/projects/integrated/

http://www.metla.fi/hanke/3306/index-en.htm

Conclusions