UNIVERSITY OF EASTERN FINLAND

Modelling wood biomass production for energy

Blas Mola-Yudego

Técnicas Modernas para la Planificación de Paisajes Forestales ante Escenarios de Fuego

Temuco, Chile

blas.mola@uef.fi

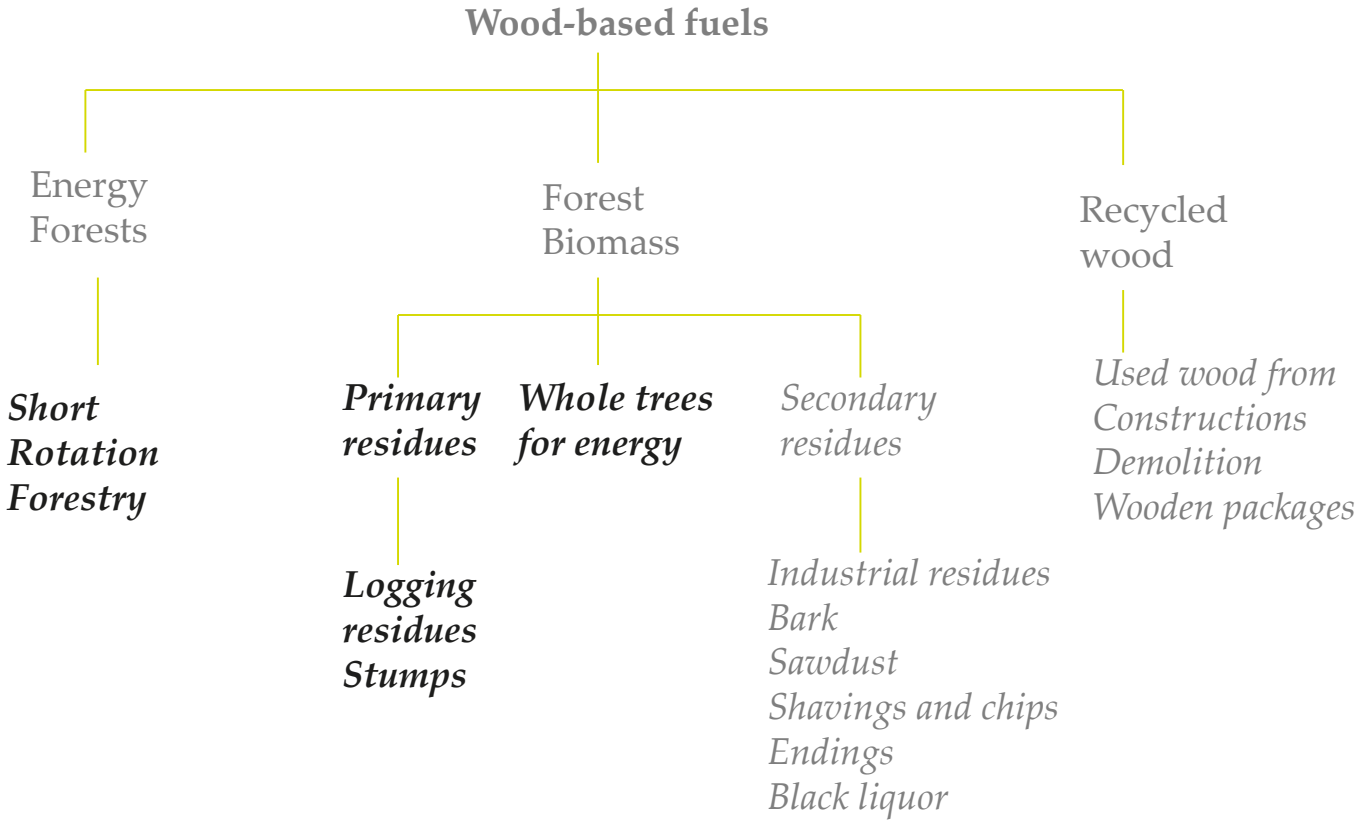
SuFoRun

Models and decision SUpport tools for integrated FOrest policy development underglobal change and associated Risk and UNcertainty

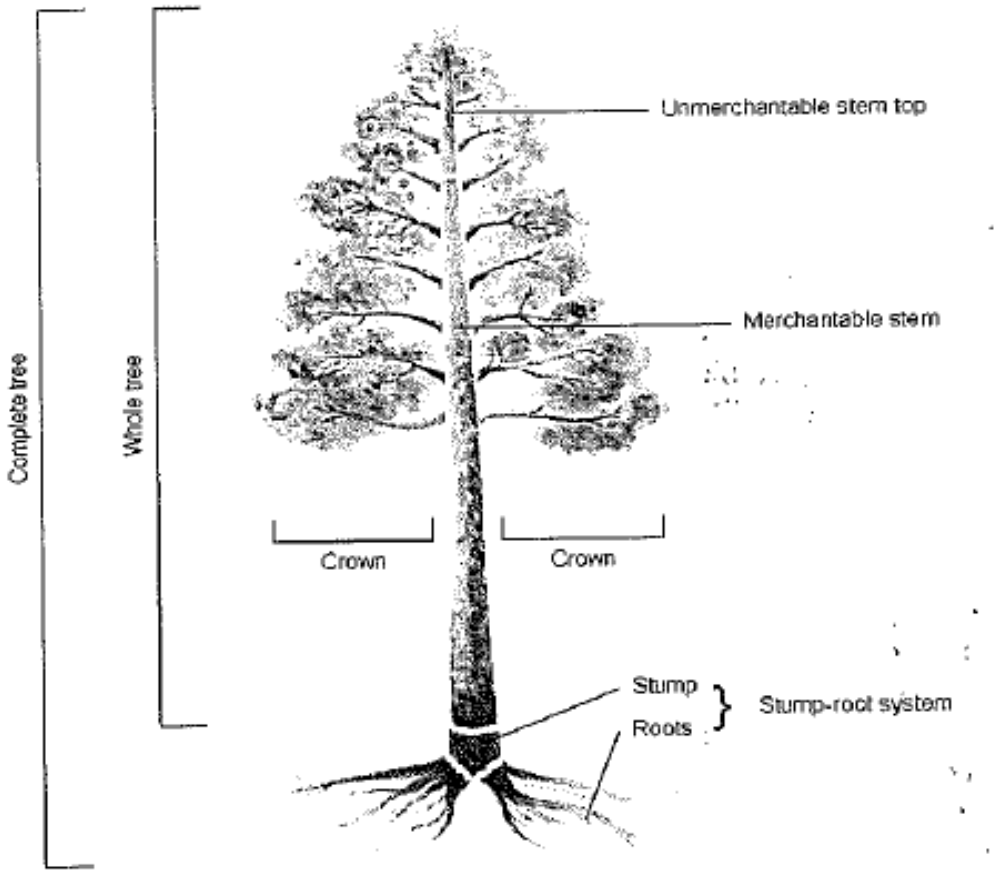
Marie Sklodowska-Curie
H2020

Biomass

Wood sources for energy



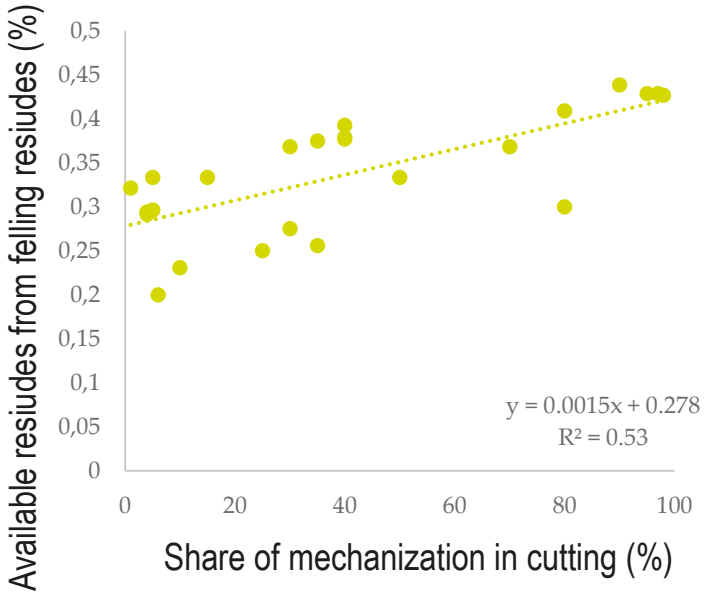
Tree biomass



Hakkila, P., & Parikka, M. (2002). Fuel resources from the forest. In Bioenergy from Sustainable Forestry (pp. 19-48). Springer Netherlands.

How?

Mechanization



	Share of timber from clearcuts %	Share of mechanization in cutting %	Share of spruce-group %	Total felling residues (mill. m³ /a)	Available vol. of felling residues (mill. m³ /a)	Available vol. of residues from annual change rate surplus (mill. m³ /a)	Total vol. of stumps from fellings (mill. m³ /a)	Available vol. of stumps from fellings (mill. m³ /a)	Available vol. of stumps from annual change rate surplus (mill. m³ /a)
Austria	18	30	69	10.9	3.0	5.5	4.97	0.05	0.04
Belgium	70	80	40	2.2	0.9	1.1	1.06	0.11	0.02
Bulgaria	70	5	11	1.2	0.4	2.3	0.69	0.01	0.004
Cyprus	-	-	-	-	-	-	-	-	-
Czech Republic	83	40	65	11.2	4.4	3	5.17	0.66	0.05
Denmark	70	50	54	0.6	0.2	0.2	0.32	0.05	0.01
Estonia	73	70	25	3.8	1.4	0	2.42	0.18	0
Finland	71	97	45	35.7	15.3	6.3	20.04	2.11	0.14
France	76	40	19	16.9	6.4	14.2	8.93	0.54	0.15
Germany	5	35	45	32.8	8.4	22	16.02	0.11	0.39
Greece	-	-	-	-	-	-	-	-	-
Hungary	72	15	0	1.2	0.4	0.6	0.76	-	-
Ireland	82	95	74	2.1	0.9	0.4	0.93	0.17	0.01
Italy	20	10	19	1.3	0.3	9.5	0.80	0.002	0.01
Latvia	76	35	17	4.8	1.8	3.4	3.26	0.14	0.03
Lithuania	50	5	23	2.7	0.8	1.7	1.82	0.06	0.02
Luxembourg	70	80	27	0.1	0.03	0.2	0.03	0.003	0.002
Malta	-	-	-	-	-	-	-	-	-
The Netherlands	80	25	13	0.4	0.1	0.3	0.22	0.01	0.001
Poland	44	4	9	14.4	4.2	8.3	8.36	0.10	0.03
Portugal	70	30	0	3.8	1.4	2.2	2.37	-	0.31
Romania	70	1	44	5.6	1.8	0.1	2.85	0.16	0.001
Slovakia	40	4	39	3.4	1.0	2.1	1.69	0.04	0.01
Slovenia	0	6	44	1.5	0.3	1.5	0.72	-	0.01
Spain	70	40	0	6.1	2.3	6	3.81	-	-
Sweden	70	98	43	42.4	18.1	8.4	23.46	2.55	0.2
United Kingdom	80	90	46	5.7	2.5	2.3	2.71	0.31	0.04
Total				**210.8**	**76.5**	**101.6**	**113.4**	**7.4**	**1.2**

Asikainen, A., Liiri, H., Peltola, S., Karjalainen, T., & Laitila, J. (2008). Forest energy potential in Europe (EU27). Finnish Forest Research Institute, Vantaa.


PONSSE

Felling residues

Assortments

Resiudes

Whole tree

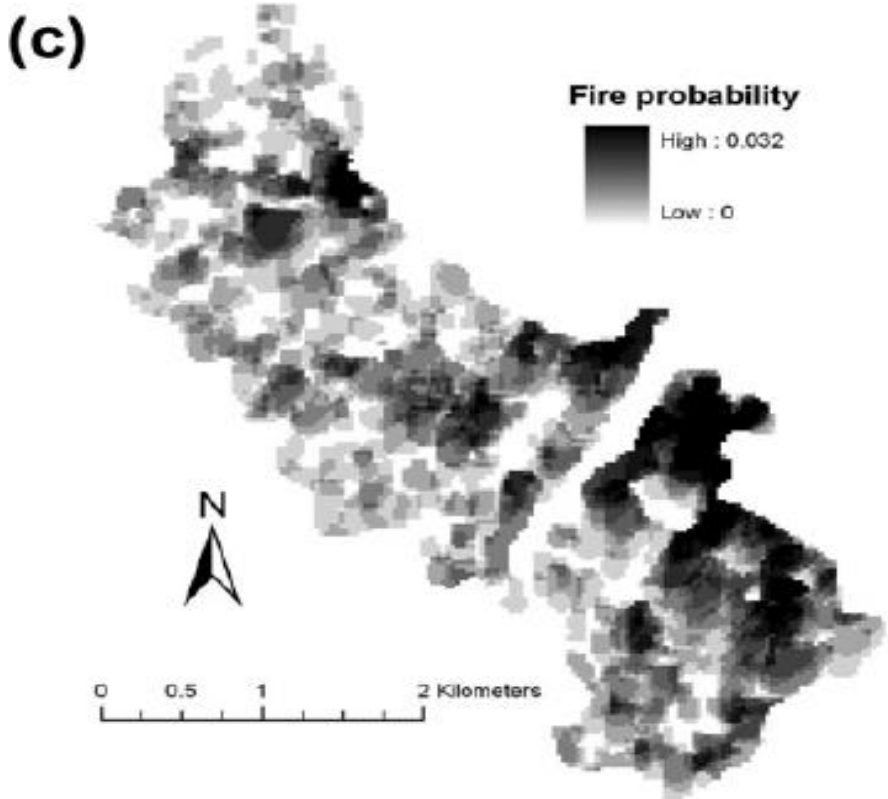
Stems, small diameter

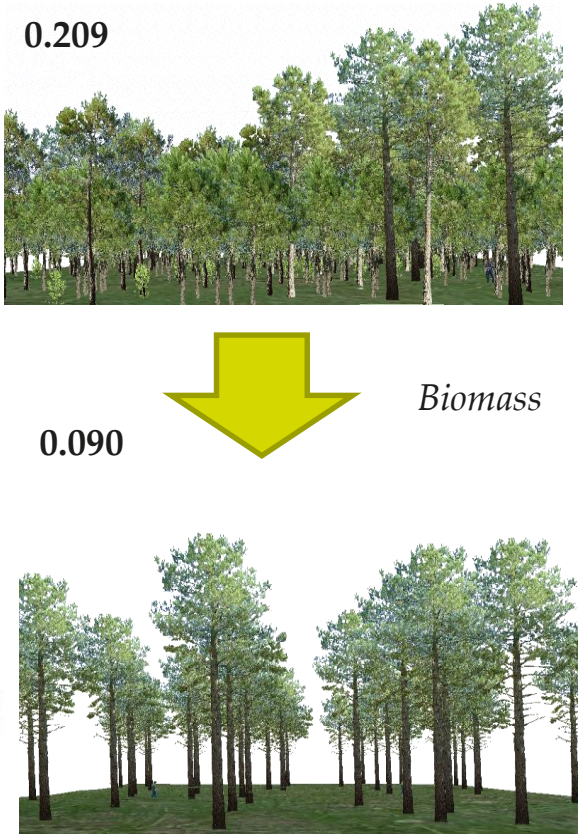
Small diameter trees

Logging residues

Stumps

Biomass and fire prevention





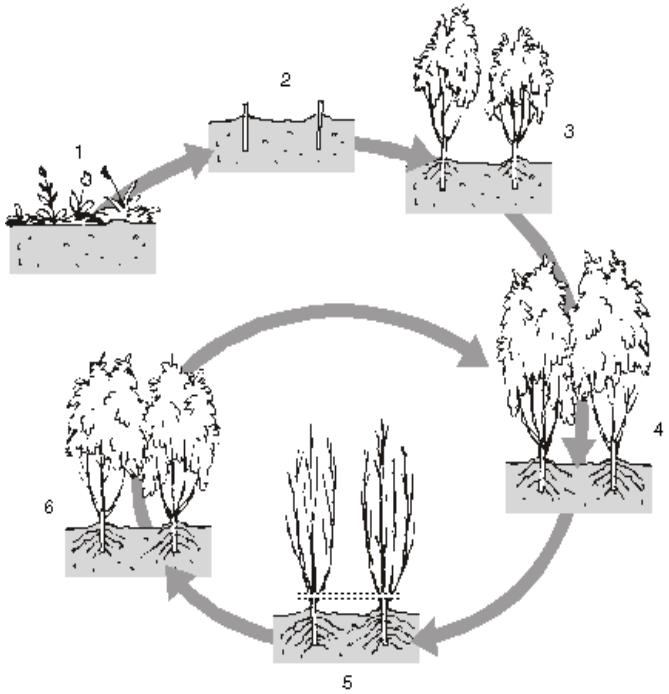
González-Olabarria, J. R., Rodríguez, F., Fernández-Landa, A., & Mola-Yudego, B. (2012). Mapping fire risk in the Model Forest of Urbión (Spain) based on airborne LiDAR measurements. Forest Ecology and Management, 282, 149-156.

Agriculture and wood valorization

Plantations on agricultural land

Plantations on agricultural land

Production cycle



Cutting cycle for a salix plantation

Source: NE Nordth

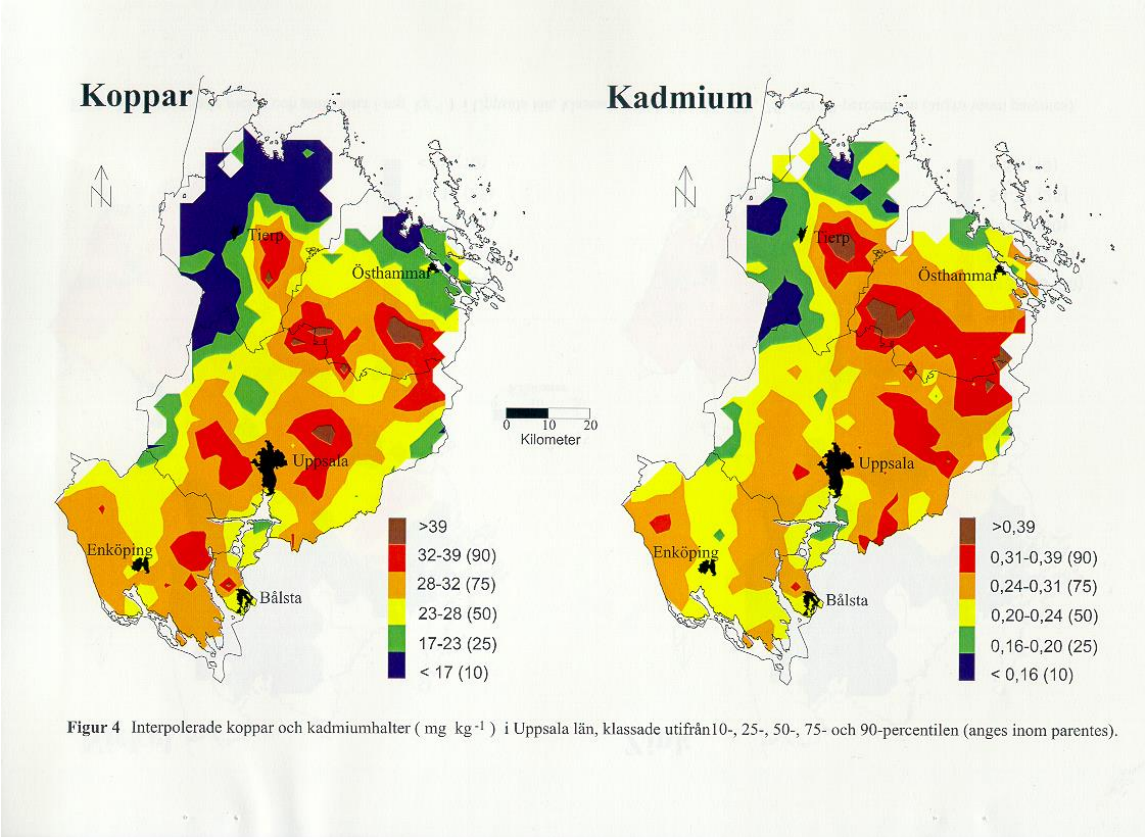
Agroforestry

Simultaneous cultivation of plantations and annual crops on the same area

Picture sources: © Dominik Rutz

Impact on groundwater

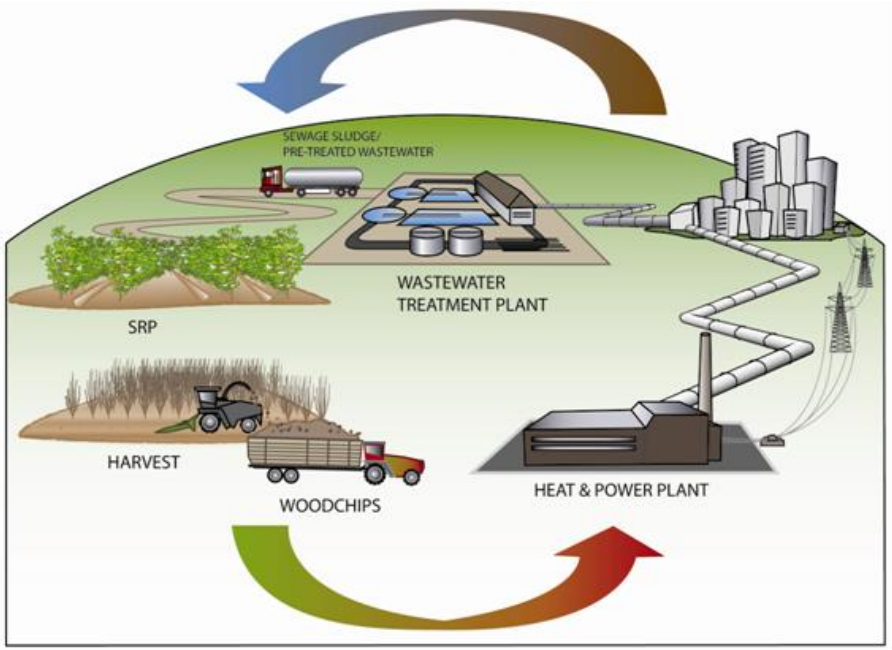
Soil remediation



Figur 4 Interpolerade koppar och kadmiumhalter (mg kg^{-1}) i Uppsala län, klassade utifrån10-, 25-, 50-, 75- och 90-percentilen (anges inom parentes).

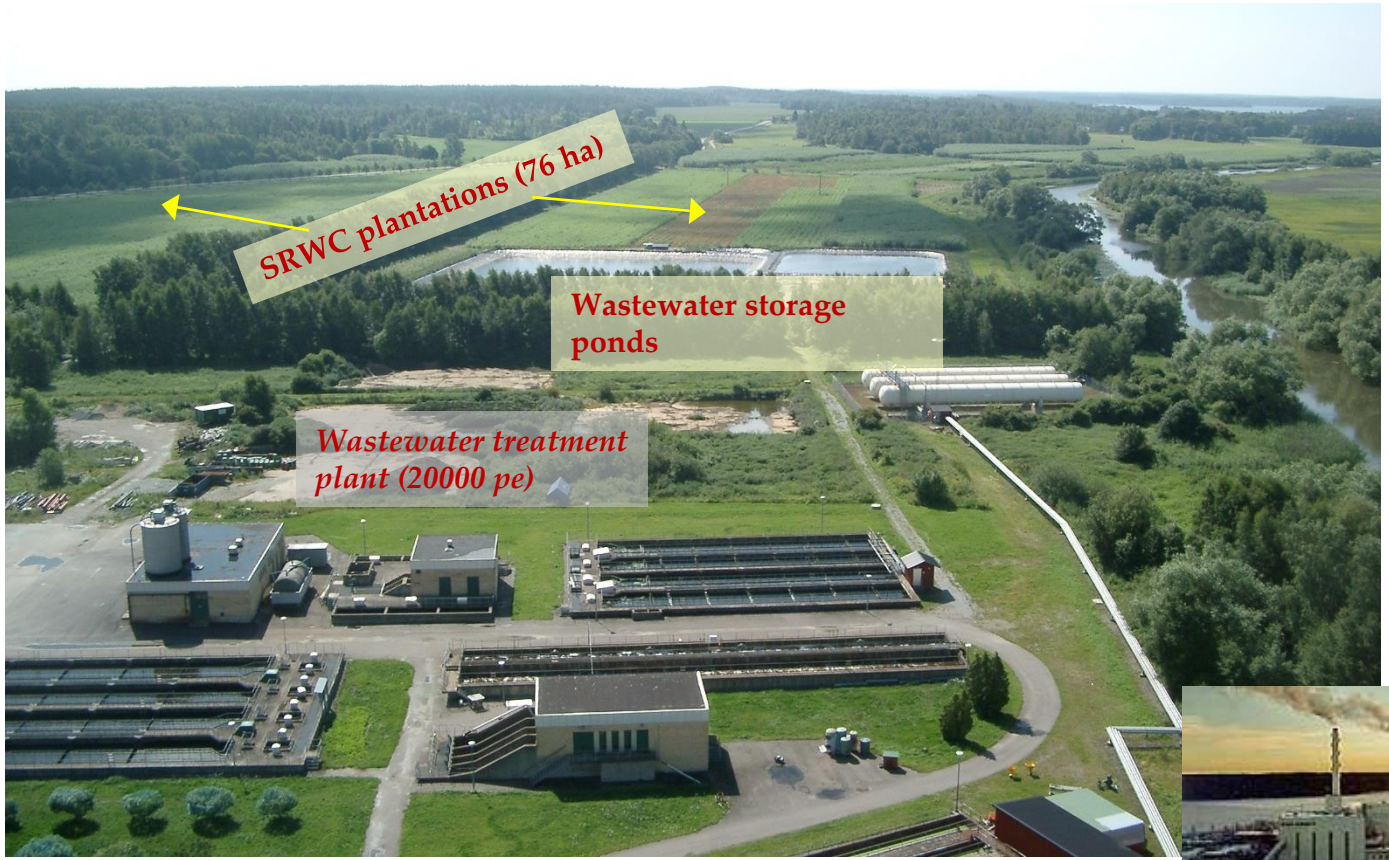
Biodiversity

Multifunctional uses



The safe use of nutrient-rich residues of society (as municipal wastewater and sludge) to fertilise fast-growing tree species (willows and poplars) to produce biomass for energy

Multifunctional uses: Enköping



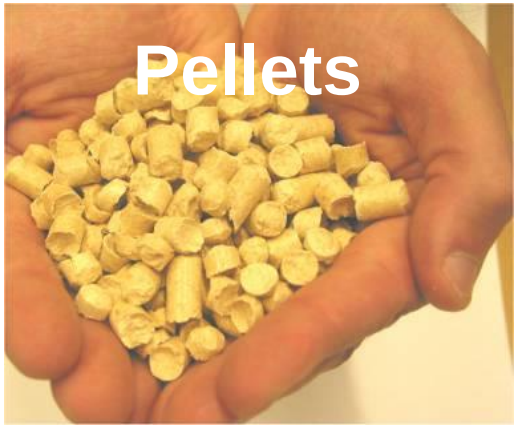

BEVATTNING!
Ej dricksvatten

Multifunctional uses: Anywhere

Spreading of sewage sludge and wood-ash (when available)

Logistics

Storage and logistics



Pellets and boilers

Pellets and boilers


VOLVO


Kohisevan Kuljetus Oy
Kohisevan Kuljetus Oy
Kuopio


SCANIA
SCANIA


www.korsu.fi
SCANIA
KORSU OY
RAAHE
VAPO
Pelletti
VAPO
Pelletti
VAPO
Pelletti


UPIV
Säätötuli
20

Storage and logistics

Storage and logistics

Figure 16. Pile of bundles in Rautalampi included in the seasoning trial. Monitoring bundles in the middle part of the pile. © Ari Erkkilä.

Röser, D., Erkkilä, A., Mola-Yudego, B., Sikanen, L., Prinz, R., Heikkinen, A., ... & Väätäinen, K. (2010). Natural drying methods to promote fuel quality enhancement of small energywood stems.*Vantaa: Metla*.

Storage and logistics

Figure 23. Fixteri whole-tree baler for harvesting pulpwood and energy wood. © Ari Erkkilä.

Figure 19. Split pieces of logwood and logwood with the bark broken up by strip-debarking or scratching kept well without significant discolouration. © Ari Erkkilä.

Figure 20. Fungal and mould growth formed on the ends of untreated pieces of logwood. © Ari Erkkilä.

Röser, D., Erkkilä, A., Mola-Yudego, B., Sikanen, L., Prinz, R., Heikkinen, A., ... & Väätäinen, K. (2010). Natural drying methods to promote fuel quality enhancement of small energywood stems.*Vantaa: Metla*.

Storage and logistics

Figure 24. A skidding grapple, which can be used in forming bundles and as an auxiliary tool for bundling of split firewood. © Ari Erkkilä and http://www.posch.com

Röser, D., Erkkilä, A., Mola-Yudego, B., Sikanen, L., Prinz, R., Heikkinen, A., ... & Väätäinen, K. (2010). Natural drying methods to promote fuel quality enhancement of small energywood stems.*Vantaa: Metla*.

Storage and logistics

Figure 2. Design of the log piles in the different trials. a) Glenlivet (Scotland), b) Skye (Scotland), c) Cappella Maggiore (Italy) d) Sotkamo (Finland).

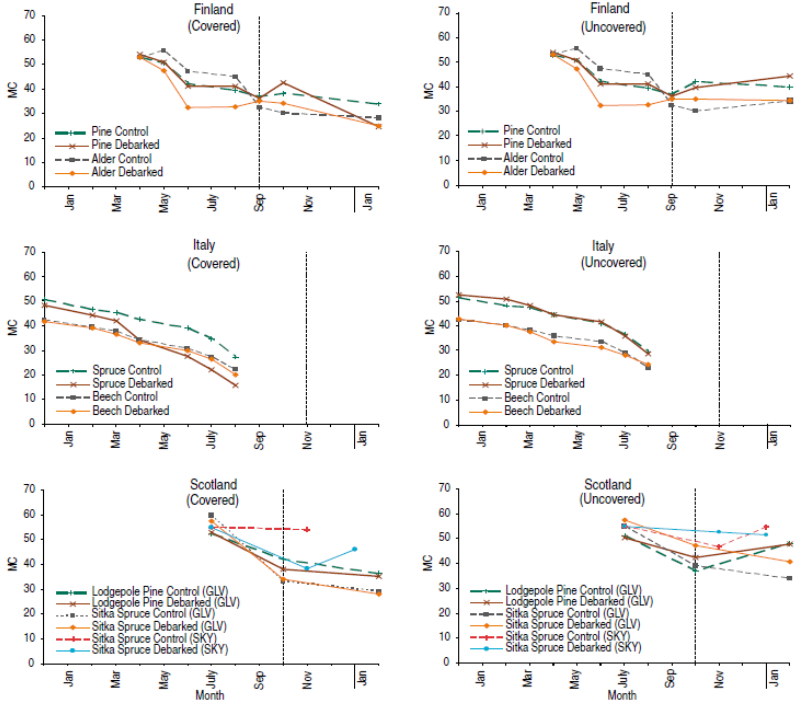
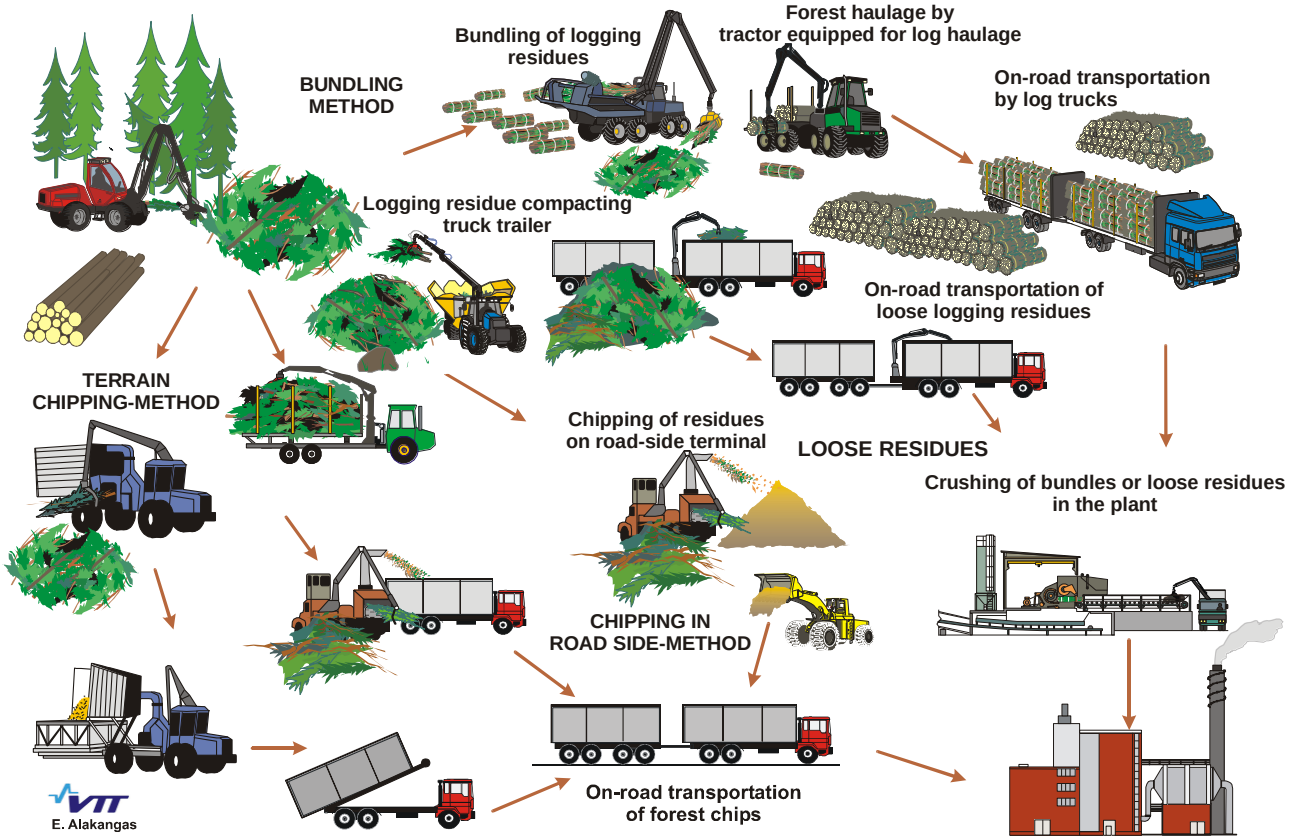


Figure 8. Changes in the moisture content of the wood piles in the different trials under different treatments. GLV: Glenlivet trial. SKY: Skye trial.

Röser, D., Erkkilä, A., Mola-Yudego, B., Sikanen, L., Prinz, R., Heikkinen, A., ... & Väätäinen, K. (2010). Natural drying methods to promote fuel quality enhancement of small energywood stems.*Vantaa: Metla*.

Supply chains: Forestry

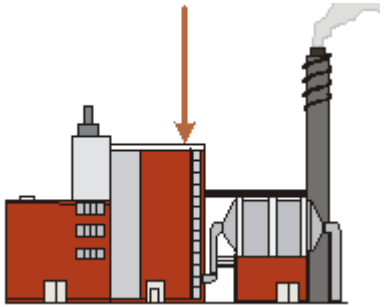


Supply chains: Plantations

As short transport distance as possible

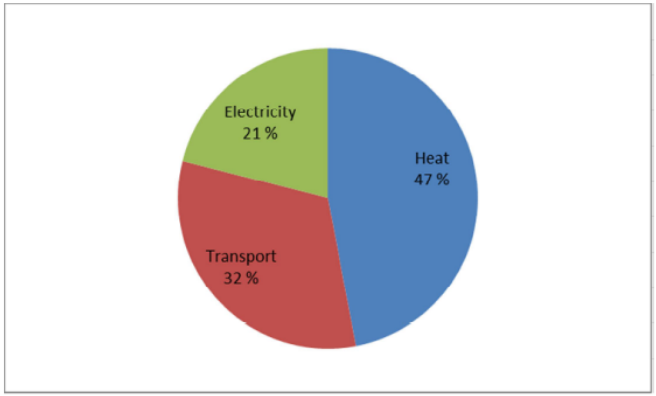
- Harvest during winter
- Shoots are cut and chipped simultaneously

Heat



Heat production and CHP

Final energy use in EU-27 in 2010



Source: European Technology Platform on Renewable Heating and Cooling

Big scale
50 - 500 MW

Commune size
1 - 50 MW

Small boilers
20 - 1000 kW

Fireplaces
5 - 20 kW

District Heating

Market penetration of district heating greatly varies, responding to different climatic, political and economic realities

Country	Penetration
Iceland	95%
Latvia	70%
Lithuania	70%
Denmark	60%
Estonia	52%
Poland	52%
Sweden	50%
Slovakia	40%
Finland	49%
Hungary	16%
Austria	12.5%
Germany	12%
Netherlands	3%
UK	1%

Source: Wikipedia

District heating plant in Joensuu, Finland 180 MW

District heating plant in the Alps, Italy
550 kw

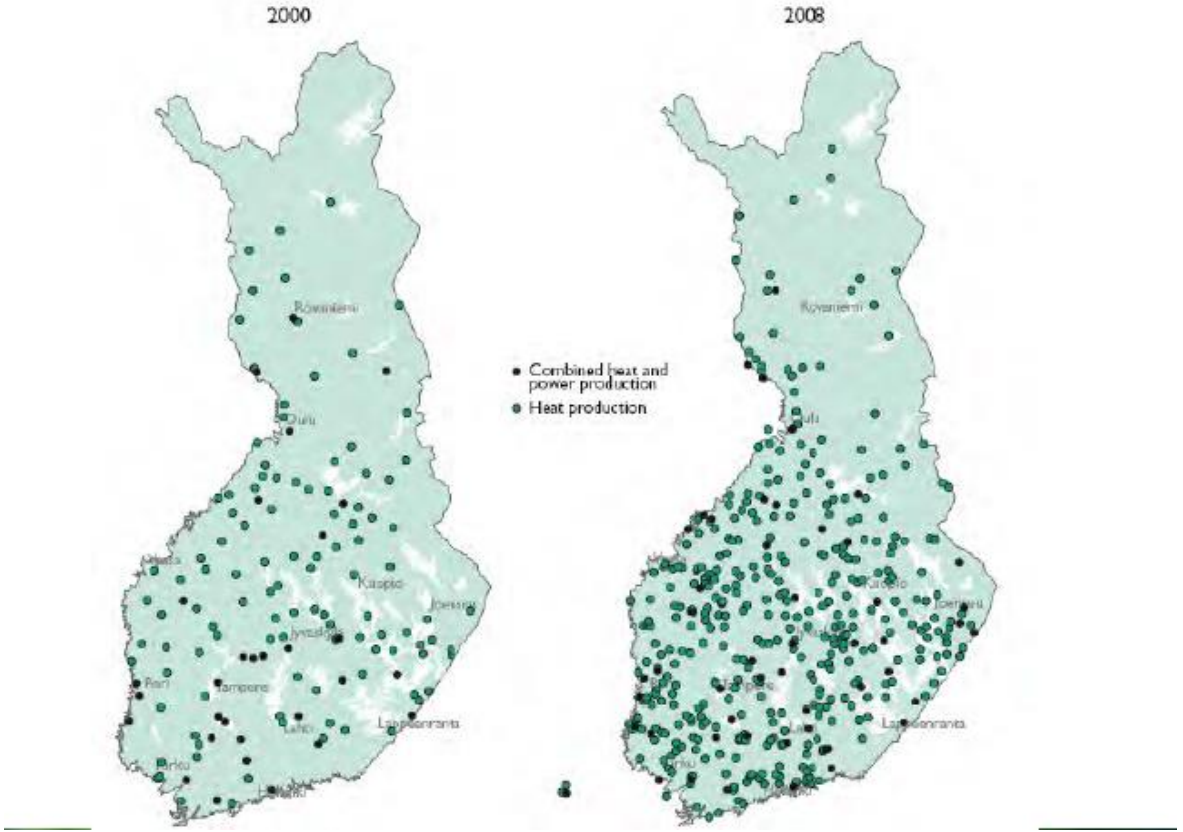
District Heating: 600 kW

A district heating plant in *Tuupovaara* municipality (capacity 600 kW, uses wood chips as fuel, ca. 3000 m^3/a). A cooperative (enterprise) of local forest owners

District Heating: 5 MW

A combined district heating system at *Eno* (3 plants, ranging 1-2 MW). Require 23 000 m^3 of wood per year. Employment effect: 7-10 jobs.

Expansion of heat and CHP plants

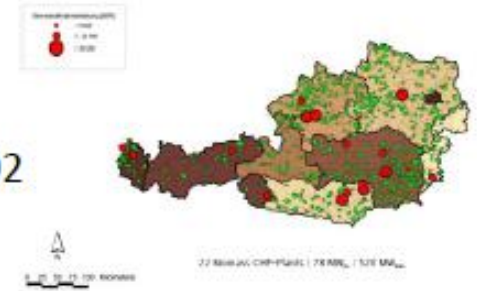


Expansion of heat and CHP plants

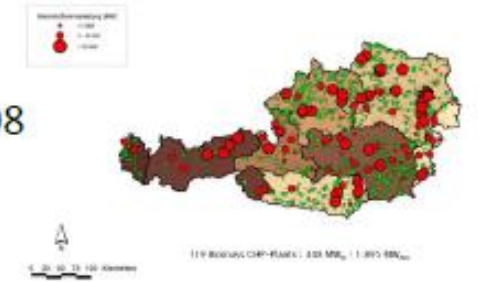
Demand is growing faster than suppply:

Austria

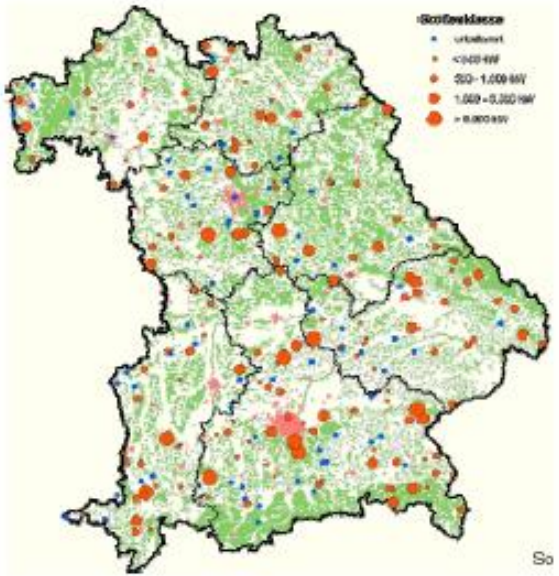
2002



2008



Bavaria



Development of district heating

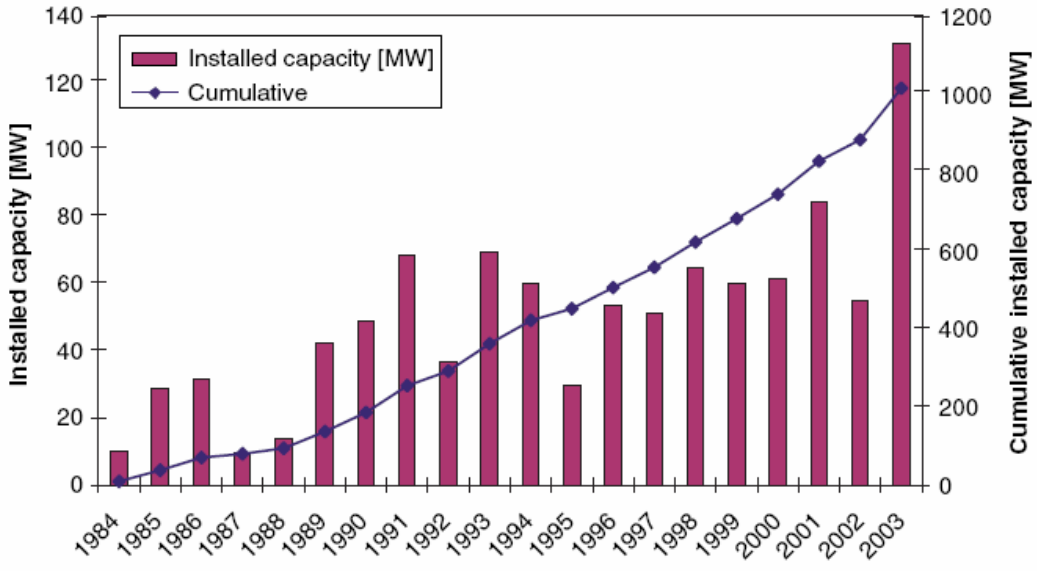


Fig. 3. Development of biomass district heating systems in Austria, 1984–2003 (total: 843 plants). *Source*: REACT (2004), Jonas and Haneder (2004), own illustration.

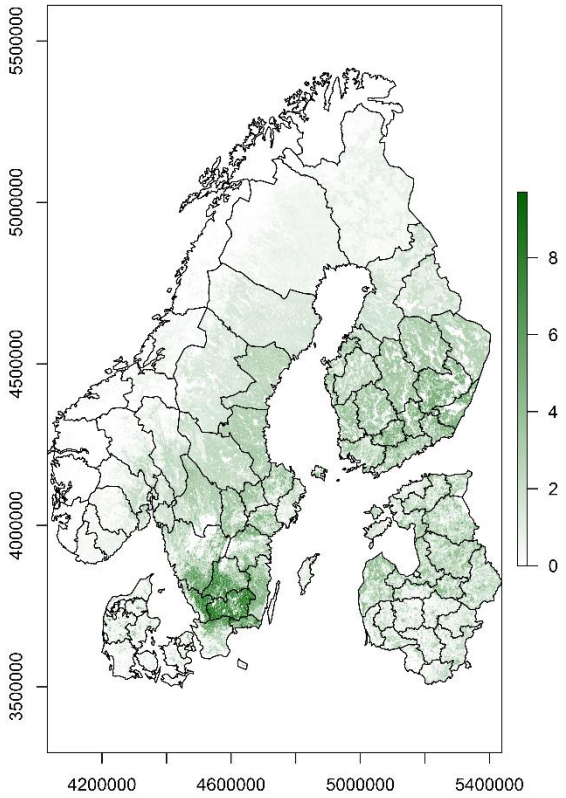
Madlener, R. (2007). Innovation diffusion, public policy, and local initiative: The case of wood-fuelled district heating systems in Austria. *Energy Policy*, *35*(3), 1992-2008.

Potentials

Forest potentials

NFI, local fellings, LiDAR, etc…

Small diameters, needles, branches, roots, stumps, tops, etc…



Mola-Yudego, B., Arevalo, J., Diaz-Yanez, O., Dimitriou, I., Haapala, A., Ferraz Filho, A. C., ... & Valbuena, R. (2017). Wood biomass potentials for energy in northern Europe: Forest or plantations?. *Biomass and Bioenergy*, *106*, 95-103.

Forest potentials

Local fellings reported, sp

Expansion factors

Small diameters, needles, branches, roots, stumps, tops, etc…

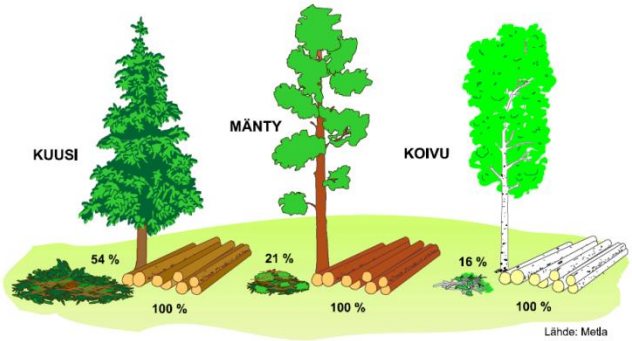


Table 2.1-5. The composition of dry whole-tree mass from trees removed in selective thinnings and final harvest of Scots pine and Norway spruce in Finland (Hakkila 1991).

Tree species	Treatment	Age, years	Foliage	Live branches	Dead branches	Stem	Whole -tree
			% of whole-tree mass				
Pine	Early thinning	30	7.7	15.0	6.0	71.3	100.0
	Late thinning	55	4.6	9.2	4.1	82.1	100.0
	Final harvest	80	3.5	10.1	1.4	85.0	100.0
Spruce	Early thinning	30	12.3	17.2	2.3	68.2	100.0
	Late thinning	55	10.1	15.5	2.6	71.8	100.0
	Final harvest	80	10.3	17.1	1.1	71.5	100.0

Forest potentials

NFI, local fellings, LiDAR, etc…

Small diameters, needles, branches, roots, stumps, tops, etc…

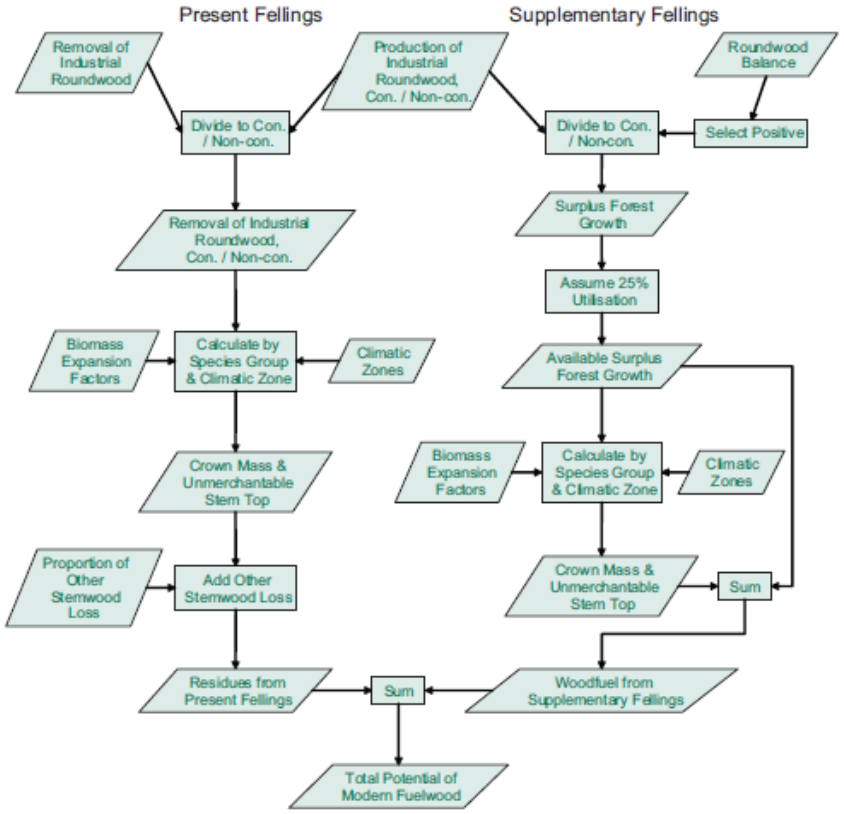


Figure 6. Procedure for calculating the total modern fuelwood potential currently available from a region.

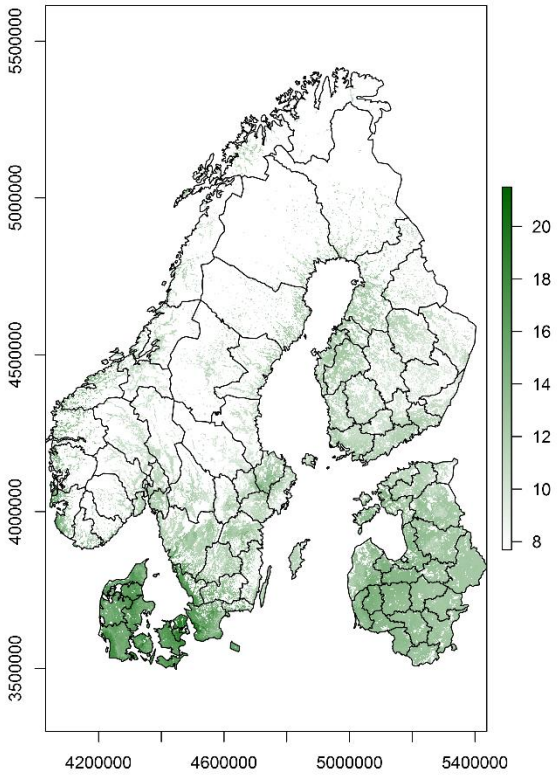
Asikainen, A., Liiri, H., Peltola, S., Karjalainen, T., & Laitila, J. (2008). Forest energy potential in Europe (EU27). Finnish Forest Research Institute, Vantaa.

Plantation potentials

Available plots or trials

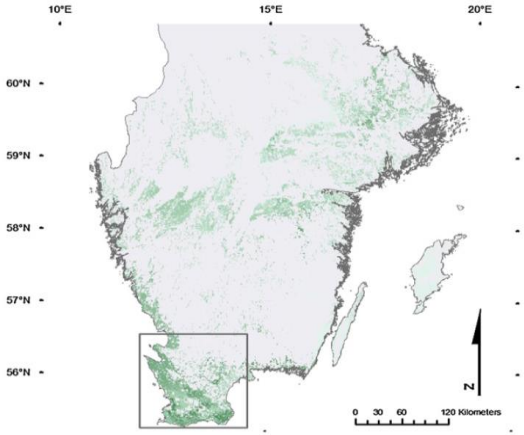
assumptions

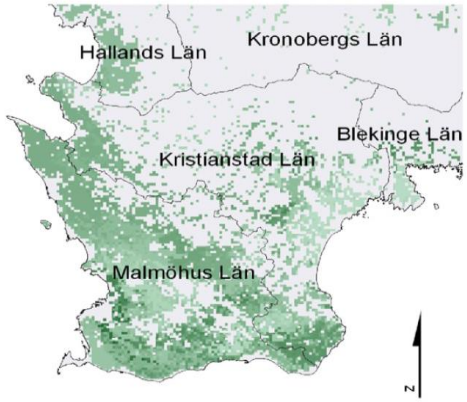
Spatial interpolation, spatial estimates



Plantation potentials: Local area level

Available plots or trials





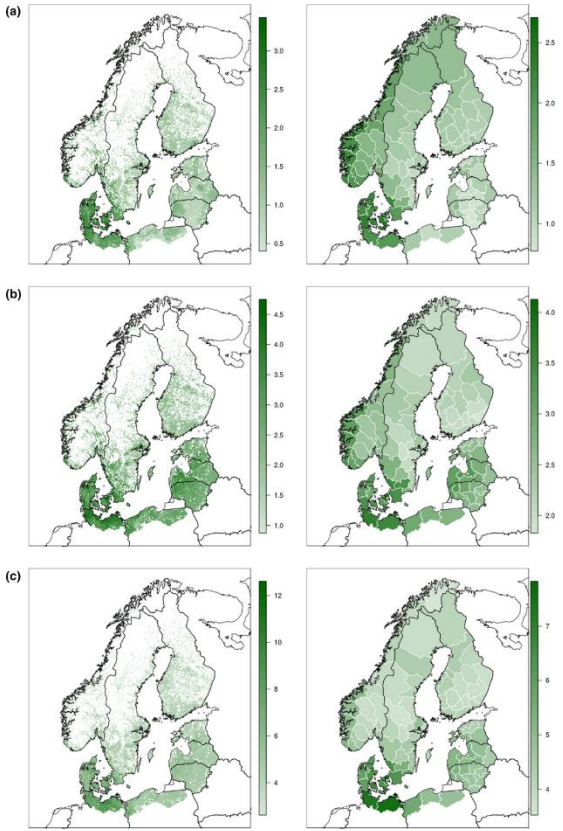
Spatial interpolation, spatial models

Mola-Yudego, B. (2011). Predicting and mapping productivity of short rotation willow plantations in Sweden based on climatic data using a non-parametric method. Agricultural and forest meteorology, 151(7), 875-881.

Plantation potentials: Region level

Estimation of yield and area available

Production subject to limitations

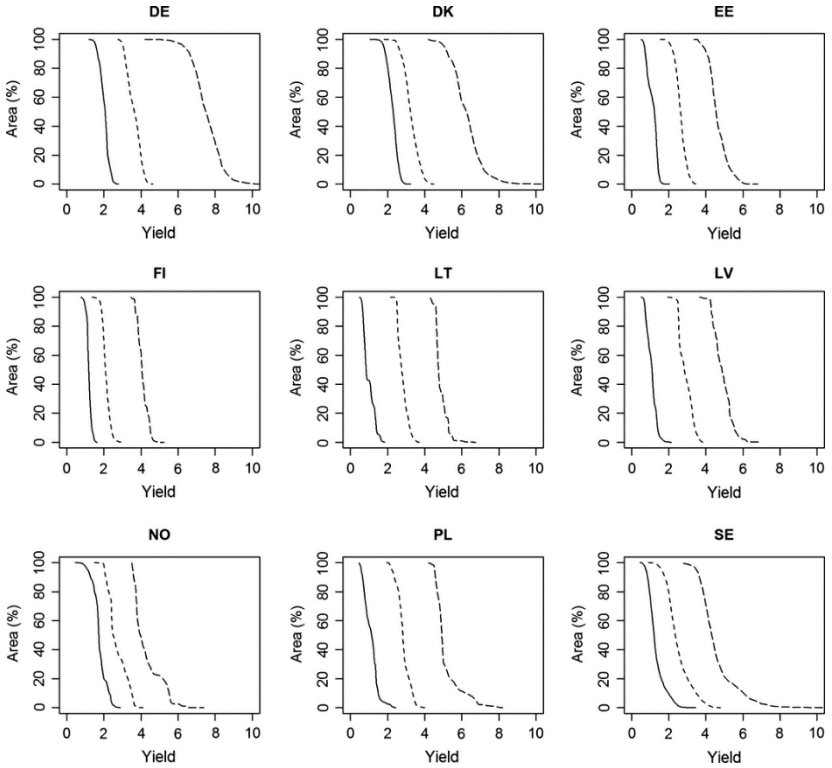


Mola-Yudego, B., Rahlf, J., Astrup, R., & Dimitriou, I. (2015). Spatial yield estimates of fast-growing willow plantations for energy based on climatic variables in Northern Europe. GCB Bioenergy.

Plantation potentials: Region level

Estimation of yield and area available

Production subject to limitations

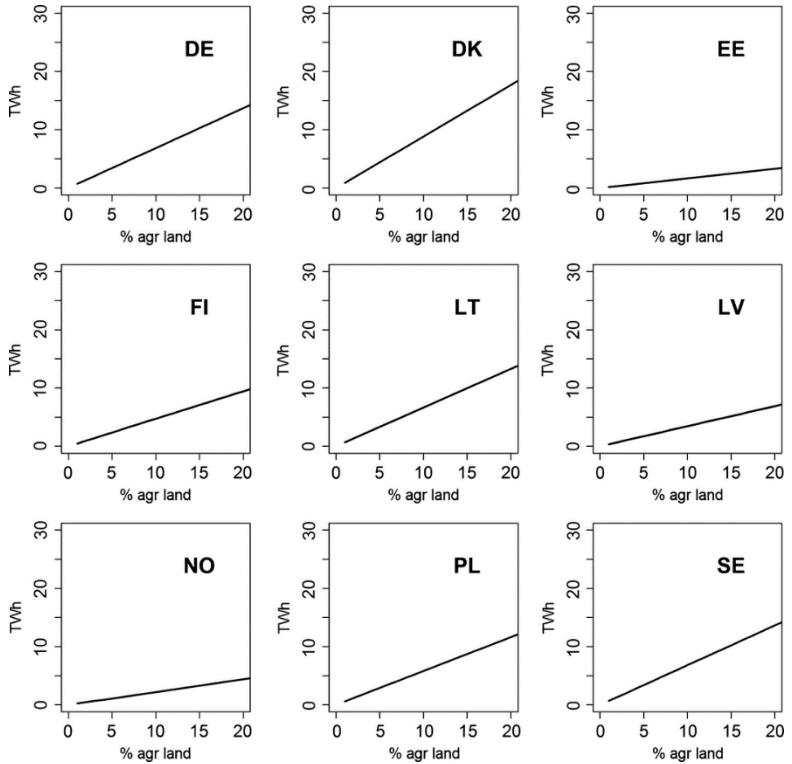


Mola-Yudego, B., Rahlf, J., Astrup, R., & Dimitriou, I. (2015). Spatial yield estimates of fast-growing willow plantations for energy based on climatic variables in Northern Europe. GCB Bioenergy.

Plantation potentials: Region level

Estimation of yield and area available

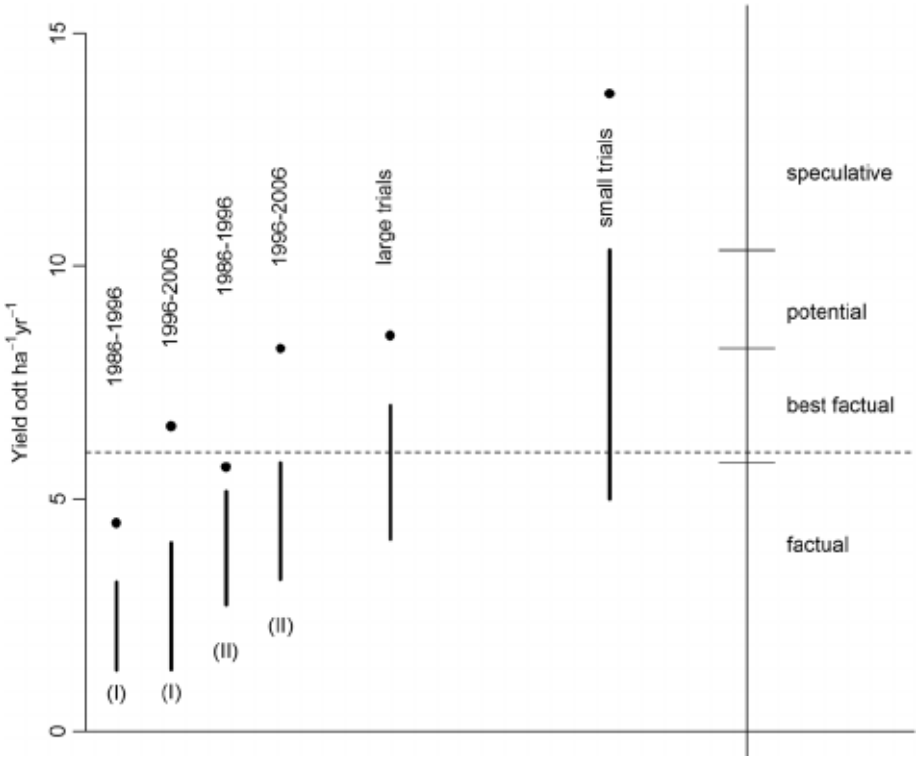
Production subject to limitations



Mola-Yudego, B., Rahlf, J., Astrup, R., & Dimitriou, I. (2015). Spatial yield estimates of fast-growing willow plantations for energy based on climatic variables in Northern Europe. GCB Bioenergy.

Yields

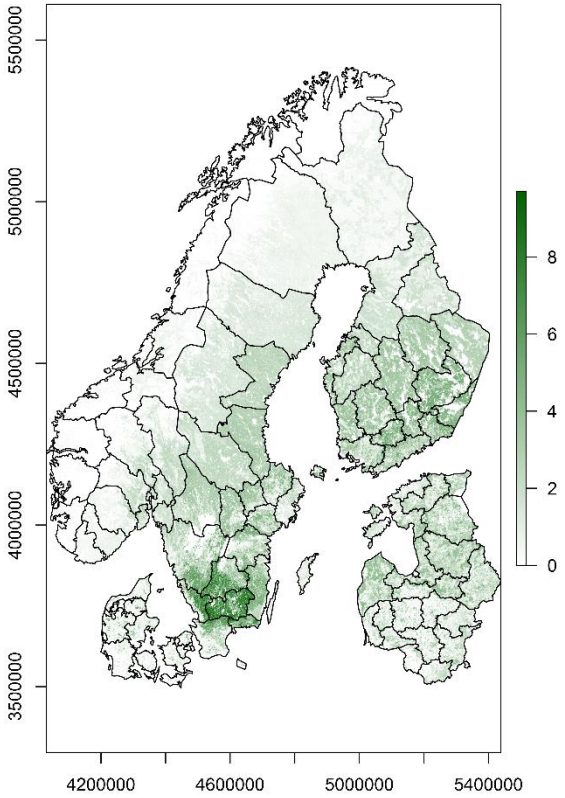
Our estimates, in Sweden, comparing comercial experience and reported yields



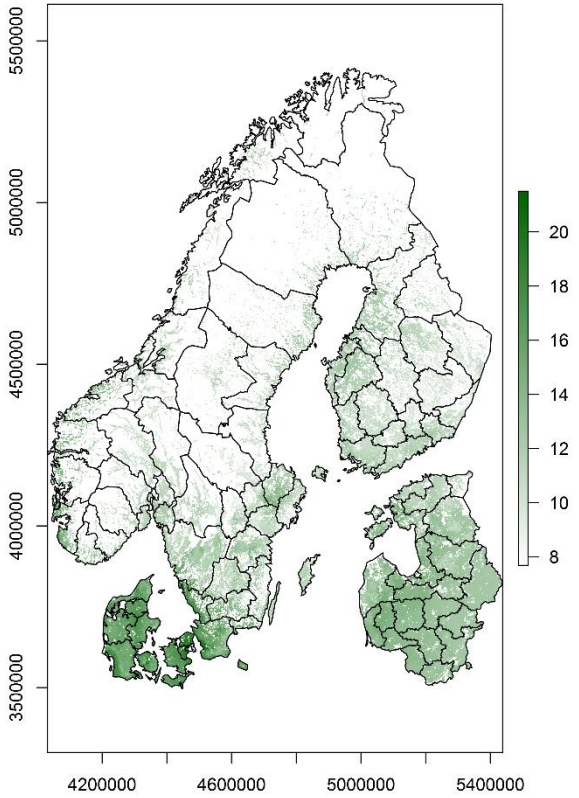
Productivity

Wood biomass production for energy ($m^3\ ha^{-1}\ year^{-1}$)

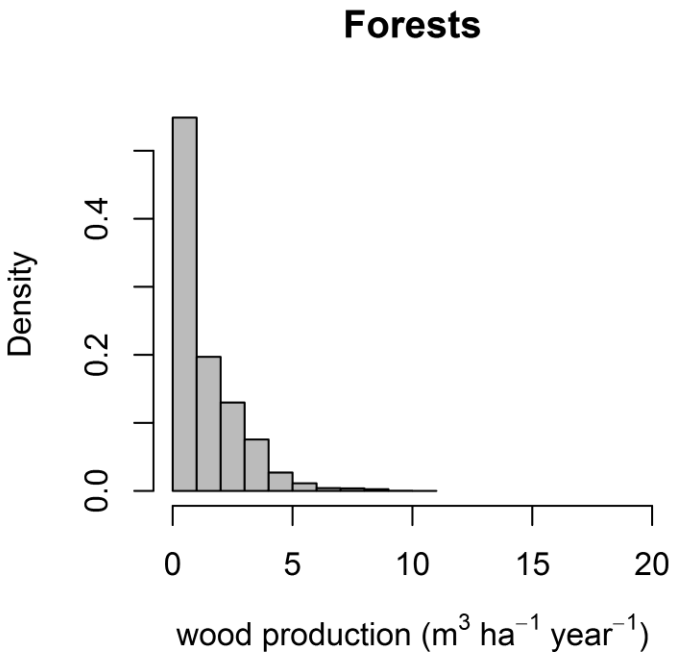
Forest sources

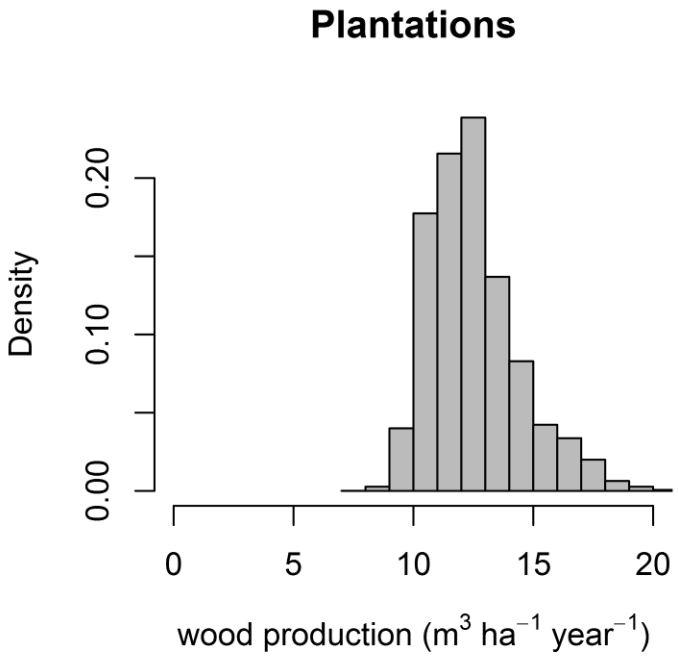


Plantation sources



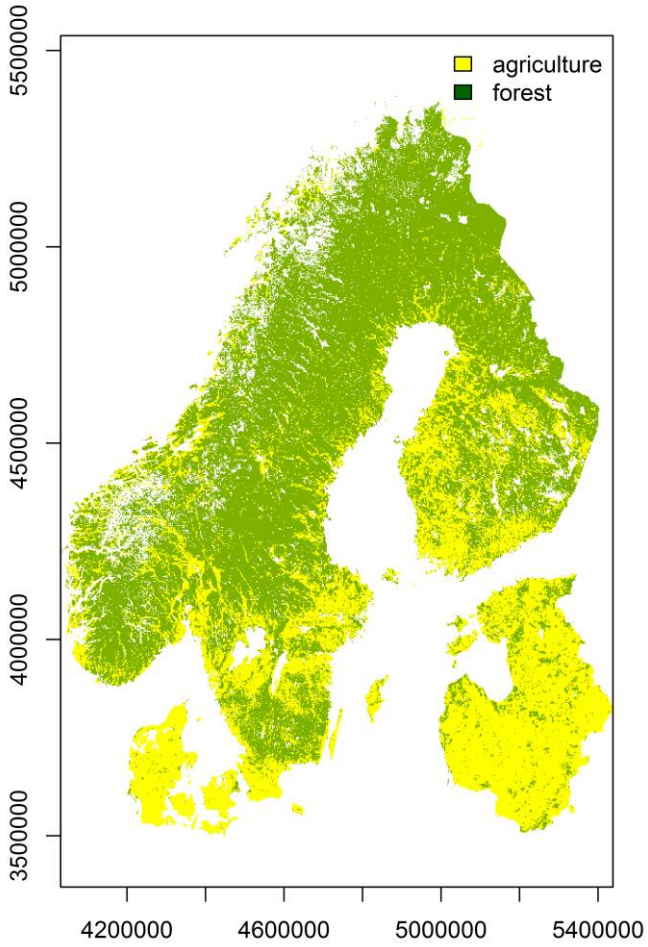
Productivity





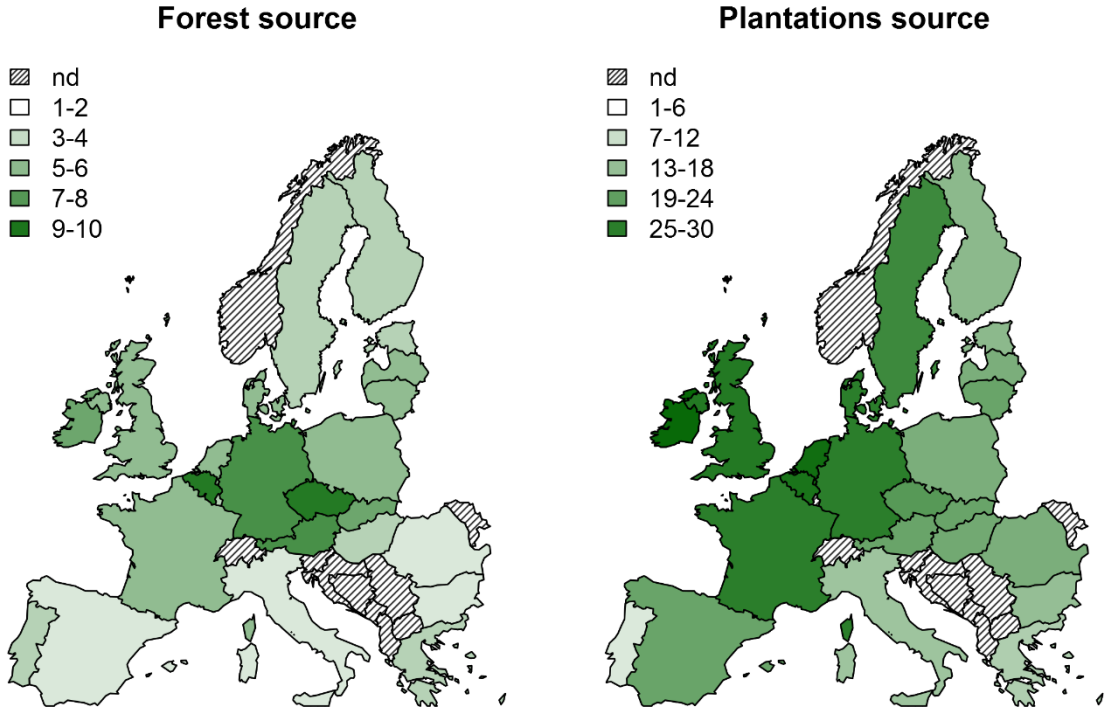
Productivity

Land uses determine the location of resources for biomass.



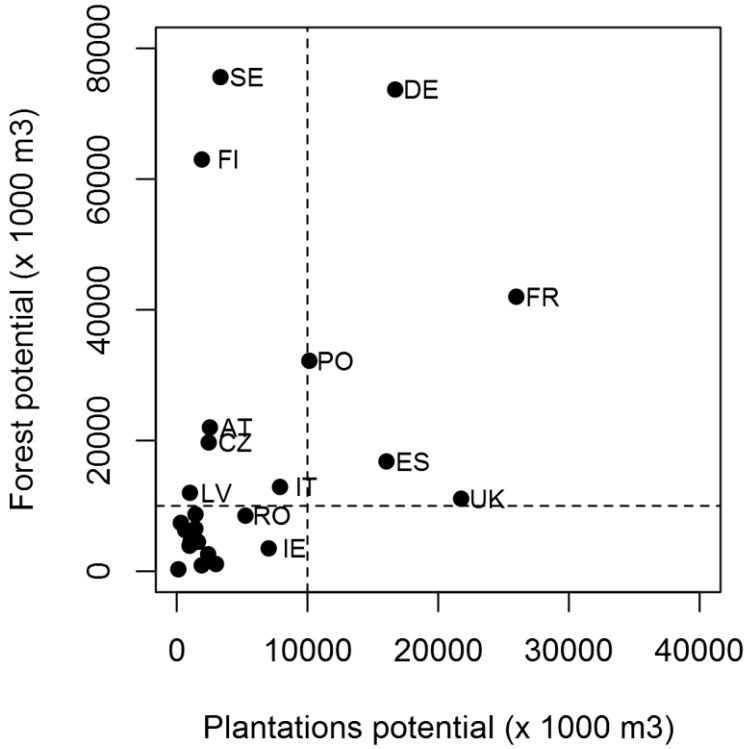
Productivity

Wood biomass production for energy ($m^3\ ha^{-1}\ year^{-1}$)



Plantation and forest potentials

Different biomass production strategies



Modelling biomass production for energy

Blas Mola-Yudego

Técnicas Modernas para la Planificación de Paisajes Forestales ante Escenarios de Fuego

Temuco, Chile

blas.mola@uef.fi