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The realisable potential supply of woody biomass from forests in the European Union

Pieter Johannes Verkerk[a,*], Perttu Anttila[b], Jeannette Eggers[a], Marcus Lindner[a], Antti Asikainen[b]

[a] European Forest Institute, Torikatu 34, 80100 Joensuu, Finland
[b] Finnish Forest Research Institute, P.O. Box 68, 80101 Joensuu, Finland

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ABSTRACT

Forests are important for providing wood for products and energy and the demand for wood is expected to increase. Our aim was to estimate the potential supply of woody biomass for all uses from the forests in the European Union (EU), while considering multiple environmental, technical and social constraints.

The potential woody biomass supply was estimated for the period 2010–2030 for stemwood, residues (branches and harvest losses), stumps and other biomass (woody biomass from early thinnings in young forests). We estimated the theoretical biomass potential from recent, detailed forest inventory data using the EFISCEN model. Constraints reducing the availability of woody biomass were defined and quantified for three mobilisation scenarios (high, medium, low). Finally, the theoretical potentials from EFISCEN were combined with the constraints to assess the realisable potential from EU forests.

The realisable potential from stemwood, residues, stumps and other biomass was estimated at 744 million $m^3\,yr^{-1}$ overbark in 2010 and could range from 623 to 895 million $m^3\,yr^{-1}$ overbark in 2030, depending on the mobilisation scenario. These potentials represented 50–71% of the theoretical potential. Constraints thus significantly reduced the biomass potentials that could be mobilised. Soil productivity appeared to be an important environmental factor when considering the increased use of biomass from forests. Also the attitude of private forest owners towards increased use of forest biomass can have an important effect, although quantifying this is still rather difficult.

The analysis showed that it is possible to increase the availability of forest biomass significantly beyond the current level of resource utilisation. Implementing these ambitious scenarios would imply quite drastic changes in forest resource management across Europe.

1. Introduction

Forests are important for providing wood for products and energy. In 2005 about 382 million m^3 overbark was removed from forests in the 27 European Union (EU) member states as industrial roundwood and 98 million m^3 overbark as woodfuel (FAO, 2010), although this is probably still an underestimation of the actual wood removals (Mantau et al., 2008). The demand for wood by forest industries has been projected to increase by 15–35% in 2030 compared to 2010 (Mantau et al., 2010).

At the same time, forests are becoming increasingly important for supplying wood for renewable energy production, given the targets by the European Commission (EC) to raise the share from renewable energy in energy consumption to 20% by 2020 in the EU (Directive 2009/28/EC). Forests are considered an important resource to meet these renewable energy targets, because (i) wood and wood waste represent currently about half of all the renewable energy production (EUROSTAT, 2010), and (ii) forests are arguably not managed to their full extent as fellings are generally well below the annual increment (MCPFE, 2007), thus suggesting that wood harvests could be increased sustainably. However, it is unclear how much wood or biomass EU forests can supply to satisfy the demand for material and energy use.

The EU Forest Action Plan (EC, 2006a) calls for assessing the availability of wood from forests for energy production at national and regional levels. Several studies have carried out such assessments and have shown a substantial range in the estimated energy potentials (Rettenmaier et al., 2010). This is because these studies have included different kinds of constraints and hence estimated different types of potentials. They also applied different methods and datasets and covered different forest biomass types. None of the studies included social factors, whereas they are considered an important constraint to wood mobilisation (e.g., Straka et al., 1984). Furthermore, these studies focused mainly on the energy potential and not on the total potentials. Concentrating only on energy potential without accounting for material use could lead

* Corresponding author. Tel.: +358 10 773 4345; fax: +358 10 773 4377.
E-mail address: hans.verkerk@efi.int (P.J. Verkerk).

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to double-counting of the same forest resources. Nabuurs et al. (2007) estimated that European forests (incl. countries outside EU) could supply 729 million m^3 overbark of stemwood for material and energy use by 2060, but did not include constraints and did not assess the potential of other tree compartments.

Our aim was to estimate the potential supply of woody biomass for all uses from the forests in the 27 EU member states when using the most recent National Forest Inventory (NFI) data and while considering multiple environmental, technical and social constraints. The results of this study were used by Mantau et al. (2010) to contrast the demand for wood for material and energy use with the potential wood supply from forests and sources outside forests.

2. Materials and methods

2.1. General approach

The potential supply of woody biomass was estimated for the period from 2010 to 2030 for stemwood; branches and harvest losses (further: 'residues'); stumps and coarse roots (further: 'stumps'); and woody biomass from early or energy thinnings in young forests (further: 'other biomass'). First, we estimated the theoretical potential of forest biomass supply in Europe based on detailed forest inventory data (Section 2.2). This theoretical potential was defined as the overall, maximum amount of forest biomass that could be harvested annually within fundamental bio-physical limits (adapted from Vis et al., 2010), taking into account increment, the age-structure and stocking level of the forests. Second, multiple environmental, technical, and social constraints were defined and quantified that reduce the amount of biomass that can be extracted from forests for three mobilisation scenarios for the future (Section 2.3). Third, the theoretical potentials from the first step were combined with the constraints from the mobilisation scenarios (Section 2.4). Following the terminology by Vis et al. (2010), the resulting potential could be classified as a technical potential, with environmental and social sustainability aspects. However, we considered this term too narrow and will further refer to the environmentally, technically and socially constrained potential as 'realisable potential'. In addition to these steps, a sensitivity analysis was performed to assess the effect of various assumptions that had to be made. Finally, the potential for energy use was estimated and a comparison was made with other studies (Section 2.5).

2.2. Theoretical potential

2.2.1. EFISCEN model

We applied the large-scale European Forest Information SCENario model (EFISCEN) (Sallnäs, 1990; Schelhaas et al., 2007) to assess the theoretical potential of forest biomass at regional to national level. EFISCEN describes the state of the forest as an area distribution over age- and volume-classes in matrices, based on data on the forest area available for wood supply (FAWS), average growing stock and net annual increment collected from NFIs. Forest development is determined by different natural processes (e.g., increment) and is influenced by human actions (e.g., management). A detailed model description is given by Schelhaas et al. (2007).

Recent inventory data was collected for Austria, Belgium, Czech Republic, Denmark, Finland, Germany, Hungary, Ireland, Italy, Latvia, Netherlands and Sweden. For other countries we used data collected by Schelhaas et al. (2006). An overview of the collected forest inventory data is given in Table 1. In the model, the forest area was scaled to match the FAWS reported by MCPFE (2007), assuming average forest characteristics.

The amount of wood that can be felled in a time-step is controlled by a basic management regime that defines the period during which thinnings can take place and a minimum age for final harvest. Age-limits for thinnings and final fellings were based on conventional forest management according to handbooks at regional to national level (Nabuurs et al., 2007). The amount of stemwood potential removed as logs was estimated by subtracting harvest losses from the stemwood felling potential. The amount of harvest losses produced during fellings was derived from UNECE/FAO (2000) for coniferous and broadleaved species separately.

Table 1
Forest inventory data used for EFISCEN model.

Country	Inventory year	FAWS (1000 ha)
Austria	2001–2002	3349
Belgium	1995–1999	587
Bulgaria	2000	3646
Czech Republic	2005	2667
Denmark	2000	473
Estonia	1999–2001	2048
Finland	2004–2008	18,550
France	1988–2000	13,872
Germany	2001–2002	10,382
Hungary	2005	1859
Ireland	2004–2005	626
Italy	2005–2008	5408
Latvia	2004–2008	3141
Lithuania	2000	1939
Luxembourg	1989	71
Netherlands	2001–2005	360
Poland	1993	6309
Portugal	1997–1998	20,267
Romania	1980s	6211
Slovakia	1994	1909
Slovenia	2000	1159
Spain	1986–1995	10,476
Sweden	2004–2008	22,647
United Kingdom	1995–2000	2202
Total	–	140,158

Branches together with harvest losses represent logging residues that can be potentially extracted as well. In addition, stumps could potentially be extracted, separately from logging residues. The volume of branches, stumps and coarse roots was estimated from stemwood volume (incl. harvest losses) using age-dependent, species-specific biomass allocation factors (Vilén et al., 2005; Romano et al., 2009; Mokany et al., 2006; Anderl et al., 2009). We assumed no difference in basic wood density between stems and other tree compartments, due to lack of information.

2.2.2. Model simulations

For countries where inventory data were available from before 2005 (Table 1), the structure of the forest resources in 2005 was estimated by running EFISCEN until 2005, using historical roundwood production (EC, 2009a; FAOSTAT, 2009) converted to overbark volumes. The EFISCEN model was then used to iteratively assess the theoretical harvest potential of stemwood for the period 2010–2030 for every five-year time-step. This potential was estimated by first assessing the maximum volume of stemwood that could be harvested annually during 50-year periods (i.e., 2010–2060, 2015–2065, etc.). From this maximum harvest level an average (maximum) harvest level was calculated. EFISCEN was then rerun to check whether this harvest level was feasible in the time step for which the theoretical potential was estimated. If it was not feasible, the harvest level was stepwise reduced until harvest was feasible. The whole procedure was repeated for every time-step and provided direct estimations of the stemwood potentials, as well as the associated potential from logging residues and stumps, from thinning and final fellings separately.