Annals of Silvicultural Research
38 (1), 2014: 13-21

http://ojs-cra.cilea.it/index.php/asr

Research paper

Increasing wood mobilization through Sustainable Forest Management in protected areas of Italy

Mauro Maesano[1*], Bruno Lasserre[1] , Marco Marchetti[1]

Received 18/12/2013 - Accepted 9/06/2014

Abstract - The European Community has long recognized the need to further promote renewable energy. Under the overall objective to support and enhance sustainable management, the promotion of the use of forest biomass could help to mitigate climate change by substituting fossil fuel, increasing carbon stock in wood products and improve energy self-sufficiency enhancing security of supply and providing job opportunities in rural areas. To what extent Italian forests can satisfy an increased wood demand, without compromising the others Ecosystem Services (ESs) remains an open question. Our aim was to assess the potential supply of woody biomass from the network of protected areas in Italy considering the felling constraints. We estimated the theoretical annual potential increment from forest inventory data performing a correlation with the Corine Land Cover 2006 at the IV level with a 1:100,000 resolution elaborated in a GIS (Geographic Information System) environment. The average annual potential increment at national level available for felling was 4.4 m^3ha^{-1}. Within the network of protected areas (EUAP and Natura 2000), the average annual increment, available to felling, was 0.98 m^3ha^{-1}, respectively 0.81 m^3ha^{-1} from coppice and 1.14 m^3ha^{-1} from non-coppice forests. Based on data obtained from this study, the availability of wood materials could be increased of almost 20 % at national level by pursuing an active management within the network of protected areas. In Italy, the actual level of resource utilization is rather low; increasing felling together with the implementation of an active management within protected areas could allow satisfying, theoretically, the Italian wood consumption.

Keywords - wood mobilisation, protected area, Sustainable Forest Management, woody biomass, supply

Introduction

In recent years, the use of forest biomass for energy purposes has gained outstanding importance due to its role in the reduction of fossil fuel dependence, the diversification of the products deriving from forests (Lamers et al. 2013), the climate change mitigation and in providing job opportunities in rural areas. Within the 2020 strategy (http://ec.europa/europe2020/) for a smart, sustainable and responsible growth, forest biomasses play a crucial role in the achievement of objectives.

The woody biomass accounts about half of Europe's renewable-energy consumption, in its various forms, from sticks to pellets to sawdust, as well as it is the more widespread renewable fuel used (Economist, April 6th 2013).

In 2010, the total supply of all woody resources in the EU 27 was about one billion cubic meters where of almost 70% came from forest and 30% from outside the forest (Mantau et al. 2010). Currently, more than half of the wood harvested from European forests is used for industrial processing purposes and future increases in the demand for timber would require forest managers to increase future management intensity (Sohngen et al. 1999).

The type of management within protected areas can influence the amount of increment that may be harvested. The choice between different forest management practices is a crucial step. A Forest Management Approach (FMA) provides a structure for decision-making, including a range of silvicultural operations throughout the stand development phases (PEER 2011). Dunker et al. (2012) proposed five FMAs by placing the management goal and decisions along a gradient of intensity of intervention with the natural process. The strategic management choices of where to conserve nature, and where to produce wood are often done at the management unit level (PEER 2011).

Most of European forests are managed (MCPFE 2007) and thus offer the possibility to improve their adaptation ability by human intervention (Köhl et al. 2010). Nevertheless about 25% of the European forest area is subject to management constraints to secure the Ecosystem Services (ESs) such as nature conservation, soil protection, water supply or recreation (MCPFE 2003), but also timber production. In Italy forests account for about 10.9 million hectares corresponding to 37% of the land area and are mainly located in hill and mountain ranges. The forest area available for wood supply

[1] Department of Biosciences and Territory, University of Molise, Italy
[*] corresponding author: mauro.maesano@unimol.it

http://dx.doi.org/10.12899/ASR-754

is about 8.08 million hectares (FOREST EUROPE, UNECE and FAO, 2011). According to the National Statistics Agency (Istituto Nazionale di Statistica - http://agri.istat.it - visited 07/2013), the national average harvested volume from forests amounted to almost 7.6 million cubic metres (21% of total annual volume increment) in 2001, of which about 67% was fuelwood.

Not all forest and Other Wooded Land (OWL) are available for wood supply, and this reflects the forests multifunctionality: as well as providing economic resources, the forests are important for both the environment and the community.

To what extent Italian forests can satisfy an increased wood demand, without compromising the others ESs remains an open question. Main concerns are biodiversity protection and carbon neutrality (Muys et al. 2013). Maintaining biodiversity in forested areas can be achieved through an adequate network of Protected Areas (PAs) and by the implementation of a silvicultural management, which integrates conservation and production functions (Parviainen and Frank 2003). Establishing PAs is a common conservation strategy pursued for the aim of biodiversity conservation, but it is also an important opportunity to safeguard the others ESs provided by forests (Cash et al. 2006, Turner et al. 2007, Nelson et al. 2008, Egoh et al. 2009, Pettorelli et al. 2012, Willemen et al. 2013). Biological and landscape diversity protection measures can result in a range of possible impacts on the economic use of forest resources. These PAs are subject to national and/or regional legislation that may dictate some restrictions on forest management (Verkerk et al. 2008), for example, on the future land use options (Norton-Griffiths and Southey 1995).

In Italy, the Law (MATTM 2010) protects 27.5% of the forest area, with a higher incidence in some regions of central and southern Italy. The NATURA 2000 network sites (SCI and SPA) include 22.2% of the national forest area (INFC 2005).

In this study, extensions and annual volume increment of the Italian forest area have been estimated with the aim of determining how PAs and others areas subject to different forms of protection weigh upon the annually available wood amount. The target was to identify concrete measures for wood mobilization in PAs. Extension and biomass volumes available for felling were estimated in three steps:

a. assessment of forest extensions with different types of protection and silvicultural treatments through CLC 2006 (Corine Land Cover - 2006) (ISPRA 2010) and INFC (Italian National Forest Inventory - 2005) data;
b. calculation of the annual increment of forest types through the correspondence between INFC and CLC 2006 data;
c. assessment of the potential felling amounts in the network of PAs in Italy and determination of the annually available wood within the PAs supposing the implementation of an active management.

The volume of wood that cannot be harvested from these PAs was assessed estimating the unconstrained potentials for wood fellings (i.e. disregarding all forms of protection or limitations to mobilize these resources) and by reducing this potential by applying felling restrictions to the protected areas (Verkerk et al. 2008).

Materials and Methods

General approach

The paper is based on capturing a large set of data and information on Italian forests and elaborating it in a GIS (Geographic Information System) environment in the CLC 2006 resolution (1:100,000) at the IV level (ISPRA 2010). For this study OWL classes (322, 323, 324 CLC classes) were not considered. The analysis mainly focused on the CLC classes typically considered as "Forest" (311, 312, and 313).

In the first step, the forest extensions were determined by overlapping the PAs network areas with CLC 2006 (ISPRA 2010). Each CLC 2006 forest polygon was classified according to the silvicultural system (coppice/non-coppice), as reported by the Italian National Forest Inventory 1985 (ISAFA 1988). A Protection Index (I_{PW}: Index of Protection Wood - ratio between protected forest area and total forest extension) was calculated at regional and national level for each type of protection, silvicultural system and CLC class.

In the next step, a correlation between the forestry categories listed within INFC (2003) and the IV level CLC forest classes was carried out to calculate the increments of each identified forest categories (Table 1) on the basis of INFC annual increment data. The correlation between INFC and CLC categories was performed considering the vegetation description of each category according to the inventory classification of forest vegetation (INFC 2003) and the description of the vegetation categories within CLC 2006 (http://sia.eionet.europa.eu/CLC2000/classes/index_html).

In the last step, the felling potential and restriction within the network of PAs were determined. Figure 1 reports the methodology applied to develop the objectives of the research.

Table 1 - Correlation table between the forests categories INFI and IVth level CLC.

Inventory Category (INFC 2005)	CODE INFC	CLC 2006 CLASSES	CODE CLC 2006	Correspondence with INFC code
Larch and Stone pine (L. decidua, P. cembra)	1	Holm-oak and cork-oak forests	3111	15;16;17
Norway spruce (P. abies)	2	Deciduous oak forests	3112	9;10
Fir (A. alba)	3	Mesophilous broad-leaved forests	3113	12
Scots pine and mountain pine (P. sylvestris, P. mugo)	4	Chestnut forests	3114	11
Black pines (P. nigra, P. laricio, P. leucodermis)	5	Beech forests	3115	8
Mediterranean pines (P. domestica, P. marittima, P. halepensis)	6	Igrophilous forests	3116	13
Others coniferous forest	7	Non Native broad-leaved forests	3117	14;19;18
Beech (F. sylvatica)	8	Mediterranean pine forests	3121	6;7
Temperate oaks (Q. petrea, Q. pubescens, Q. robur)	9	Mountain and oromediterranean pine forests	3122	4;5
Mediterranean oaks (Q. cerrid, Q. frainetto, Q. trojana)	10	Silver fir and spruce forests	3123	2;3
Chesnut (C. sativa)	11	Larch and Arolla pine forests	3124	1
Hornbeam and Hophornbeam (Carpinu spp., Ostrya Carpinifolia)	12	Non Native coniferous forests	3125	20
Hygrophilous forests	13	Mixed forests dominated by Holm oak	31311	25%(15;16;17)+ 75%(6; 7; 9; 10; 14)
Others deciduos broadleaved forests	14	Mixed forests dominated by deciduous oak	31312	25%(9;10)+75% (6; 7; 14; 15; 16; 17)
Holm oak (Q. Ilex)	15	Mixed forests dominated by mesophilous broad-levead	31313	25%(12)+75%(5; 7; 14)
Coark oak (Q. suber)	16	Mixed forests dominated by chestnut	31314	25%(11)+75%(5; 7; 14)
Other evergreen broadleaved forests	17	Mixed forests dominated by beech	31315	25%(8)+ 75%(3; 4; 5; 7; 14)
Poplar plantations	18	Mixed forests dominated by igrophilous species	31316	25%(13)+75%(6; 7; 14)
Other broadleaved plantations	19	Mixed forests dominated by non native broad-leaved	31317	25%(14; 18; 19) +75%(6; 7; 14)
Coniferous plantations	20	Mixed forests dominated by mediterranean pine	31321	25%(6; 7)+ 75% (7; 9; 10; 14; 15; 16; 17)
		Mixed forests dominated by mountain and oromediterranean pines	31322	25%(4; 5)+ 75%(2; 3; 7; 8; 14)
		Mixed forests dominated by silver fir and spruce	31323	25%(2; 3)+ 75%(4; 5; 7; 8; 14)
		Mixed forests dominated by larch and Arolla pine	31324	25%(1)+ 75%(2; 3; 4; 5; 8; 14)
		Mixed forests dominated by non native coniferous	31325	25%(20)+ 75%(7; 14; 19)

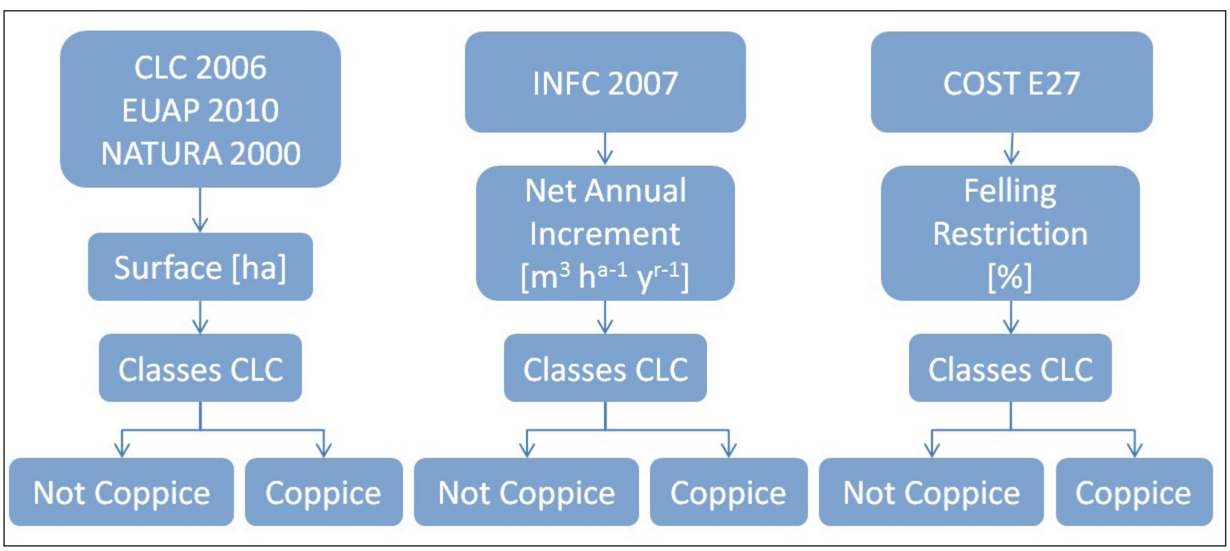

Figure 1- Schematic approach for determining the potential annual increment available and not.

Network of Protected Areas

The EUAP (Official List of the Protected Areas - MATTM 2010) areas and Natura 2000 sites made up the network of PAs used in this research. EUAP areas include 24 National Parks, 144 State Natural Reserves, 134 Regional Natural Parks, 365 Regional Natural Reserves and 171 Other Natural Protected Areas. Natura 2000 (Habitat directive 92/43/CEE) land sites (2011 Update - www.eea.europa.eu) consist in 2,549 Special Areas of Conservation (SAC) and include 2,269 Sites of Community Importance (SCI) and 600 Special Protection Areas (SPAs).

Table 2 - Comparison between the MCPFE classes, EUAP, Natura 2000, EEA and the applicable felling restrictions.

	MCPFE Classes	EUAP	Natura 2000	EEA	Restriction
Management Objective 1 "Biodiversity Conservation"	1.1 No Active Intervention	Zone A PNZ	-	A	1
	1.2 Minimum Intervention	-	-		A 2
	1.3 Conservation Through Active Management	Zone B-C-D PNZ, PNR, RNS, RNR, AANP	Natura 2000	A	3

The identified PAs network belong to the main classification of Protected Forest Areas (PFAs) at European level as they fulfilled the three general principles outlined in the MCPFE (Ministerial Conference on the Protection of Forests in Europe) guidelines (MCPFE 2002).

The MCPFE guidelines distinguish two classes of forest management in the PFAs. The first one focuses on biodiversity and is split up in three subclasses; 1.1: no active intervention; 1.2: minimum intervention; and 1.3: conservation through active management (Table 2). The second one focuses on landscapes protection and specific natural elements. The PAs network areas are included in the first class with a differentiation of the sub-classes based on the parks zonation and/or management plans.

The EUAP areas include also the CDDA (Common Database on Designated Areas) list, coordinated by EEA (EEA 2007). Regarding National Parks within EUAP, the national law established as a planning tool, the zoning of territory (Law 394/91). Based on this law, Ciancio et al. (2002), define four classes different for management degree. Zone A: the goal is the preservation regardless of the naturalness degree; zone B: preservation is realized through systemic silviculture; zone C: in addition to systemic silviculture classical silviculture can be used; zone D: the choice of silvicultural system is broader. The extension of zone A in the national parks refers to INFC (2005) data, and being evident the conservation objective, we supposed a non-coppice system in these areas.

The partial overlapping between EUAP areas and NATURA 2000 sites was considered in data processing.

This network of PAs falls within the network of High Conservation Value Forest (HCVF) defined by the Forest Stewardship Council (FSC) that represent about 40 % of the total Italian forest extension (Maesano et al. 2014).

Felling Potential

The felling potential reflects the theoretical maximum volume that is available for harvesting. There are several approaches to estimate the maximum felling potential, but the most straightforward is the Net Annual Increment (NAI) method (Verkerk et al. 2008). NAI has to be considered an upper limit, because annual felling should not exceed the annual increment to ensure long-term sustainability (MCPFE 2003). The potential increment for the whole network of PAs was calculated for each forest type, administrative region and silvicultural system according to the INFC (2005) data of the NAI.

Felling Restrictions

Data on felling restrictions in forests protected for biodiversity aims were collected from the COST Action E27 study on PFAs in Europe (Frank et al. 2007). In COST Action E27 restriction are given on a scale of 1-4, where: 1- activity is strictly prohibited; 2 - activity is usually prohibited, but with some exceptions or conditions; 3 - activity is usually allowed, but with some exceptions or conditions; 4 - activity is allowed with no restrictions. Based on the restriction scale, the limitation levels were: 1 - 0% of the potential can be harvested; 2 - 33% of the potential can be harvested; 3 - 67% of the potential can be harvested; 4 - 100% of the potential can be harvested (Verkerk et al. 2008). Table 2 shows the felling restriction applied in the network of PAs.

Results

Network of Protected Areas

The forest area inside the network of PAs was about 2.6 million hectares compared with 7.8 million hectares of Italian forest area (CLC data). This is equivalent to an I_{PW} of 33.6% made up of 15.96% (about 1.23 million hectares) of coppice and 17.64% (about 1.37 million hectares) of non-coppice forests.

Considering separately the two forms of protection that partially overlap, the EUAP areas represent an I_{PW} of 17.64% (about 1.37 million hectares) composed of 8.06% (about 0.63 million hectares) of coppice and 9.58% (about 0.74 million hectares) of non-coppice forests; while the NATURA 2000 sites represent an I_{PW} of 29.72% (about 2.3 million hectares) with 14.33% (about 1.1 million hectares) of coppice and 15.39% (about 1.2 million hectares) of non-coppice forests. At regional level, the highest value of I_{PW} was in Campania region with 3.32%, while the smallest one was in Valle d'Aosta with 0.14%. Regarding silvicultural system, in coppice forests the I_{PC} (Index of Protection Coppice) varied from 2.25% in Campania to 0% in Valle d'Aosta, while in non-coppice forests the I_{PNC} (Index of Protection Non-Coppice) ranged from 1.74% in Calabria to 0.14% in Valle d'Aosta (Tab. 3).

Considering the CLC classes, the more repre-

Table 3 - Protection indices at regional scale for the areas EUAP, Natura 2000 and EUAP+Natura 2000 . Legend: I_{PC}: Index of protection coppice; I_{PNC}: Index of protection non-coppice; I_{PW}: Index of protection wood.

Territorial District	EUAP + NATURA 2000			EAUP			NATURA 2000		
	I_{PC}	I_{PNC}	I_{PW}	I_{PC}	I_{PNC}	I_{PW}	I_{PC}	I_{PNC}	I_{PW}
Abruzzo	0.96%	1.26%	2.22%	0.73%	0.99%	1.71%	0.95%	1.24%	2.18%
Basilicata	0.61%	0.97%	1.57%	0.46%	0.90%	1.36%	0.52%	0.66%	1.18%
Calabria	1.09%	1.74%	2.83%	0.92%	1.36%	2.28%	0.77%	1.00%	1.77%
Campania	2.25%	1.06%	3.32%	1.76%	0.88%	2.64%	1.93%	0.80%	2.73%
Emilia Romagna	1.11%	0.38%	1.48%	0.46%	0.19%	0.65%	1.05%	0.36%	1.42%
Friuli V.G.	0.11%	0.79%	0.90%	0.03%	0.34%	0.37%	0.11%	0.76%	0.86%
Lazio	1.52%	1.03%	2.54%	0.58%	0.49%	1.08%	1.43%	0.86%	2.29%
Liguria	0.91%	0.34%	1.25%	0.15%	0.07%	0.22%	0.87%	0.32%	1.19%
Lombardia	0.61%	1.06%	1.67%	0.18%	0.35%	0.53%	0.59%	1.00%	1.60%
Marche	0.77%	0.24%	1.01%	0.44%	0.13%	0.56%	0.64%	0.20%	0.83%
Molise	0.44%	0.36%	0.80%	0.07%	0.13%	0.20%	0.44%	0.36%	0.80%
Piemonte	0.55%	0.99%	1.54%	0.28%	0.39%	0.67%	0.48%	0.95%	1.43%
Puglia	0.66%	0.52%	1.18%	0.43%	0.29%	0.72%	0.59%	0.50%	1.09%
Sardegna	0.63%	1.02%	1.65%	0.28%	0.22%	0.49%	0.56%	0.93%	1.49%
Sicilia	0.35%	1.25%	1.61%	0.33%	0.76%	1.09%	0.31%	1.14%	1.45%
Toscana	1.83%	1.02%	2.85%	0.62%	0.59%	1.21%	1.64%	0.94%	2.59%
Trentino Alto Adige	0.12%	1.52%	1.64%	0.04%	1.04%	1.08%	0.12%	1.34%	1.46%
Umbria	0.84%	0.25%	1.09%	0.17%	0.07%	0.24%	0.76%	0.23%	0.99%
Valle d'Aosta	0.00%	0.14%	0.14%	0.00%	0.08%	0.08%	0.00%	0.14%	0.14%
Veneto	0.60%	1.69%	2.29%	0.12%	0.32%	0.44%	0.58%	1.67%	2.25%
Italy	15.96%	17.64%	33.6%	8.06%	9.58%	17.64%	14.33%	15.39%	29.72%

sentative was the deciduous oak forest (3112), which covers 0.55 million hectares, equal to I_{PW} of 7.14%. According to silvicultural system, the classes with the highest diffusion in coppice forests were the beech forests (3115) with an I_{PC} 4.49% (0.35 million hectares) while in non-coppice forests the deciduous oak forests (3112) with an I_{PC} 2.90 % (0.23 million hectares).

Felling potential

At national level, the potential annual increment was about 35 million cubic meters, of which 42.42% derived from coppice and 57.58% from non-coppice forests. The highest annual increment of coppice forests was found in the Toscana region with 19.8%, equal to about 2.8 million cubic meters, while the Trentino Alto Adige represented the largest annual increment in non-coppice forests with 18.58% amounting to about 3.7 million cubic meters. The CLC classes with the highest annual increment were respectively the 3114 (chestnut forests) for coppice forests with 12.03% (about 4.1 million cubic meters) and the 3123 (silver fir and spruce forests) for non-coppice forests with 14.12% (about 4.9 million cubic meters) (Tab. 4).

The potential annual increment within the network of PAs amounted to about 11.7 million cubic meters, equivalent to 33.79% of the total annual increment divided in 13.53% for coppice forests (about 4.7 million cubic meters) and 20.26% for non-coppice forests (about 7 million cubic meters). The CLC classes with the highest annual increment were beech forests (3115) with 5.16% of the total annual increment (about 1.1 million cubic meters) in coppice forests, while silver fir and spruce forests (3123) with 4.17% (about 0.9 million cubic meters) in non-coppice forest (Tab. 4).

The potential annual increment distinguished by the form of protection and CLC classes was reported in Table 4.

Felling restrictions and available wood

The availability of wood in the network of PAs depends on the type of protected area and on the silvicultural system. The felling restriction affected the Zone A of the national parks, involving 1.19% (0.09 million hectares) of the forest extension and 1.09% of the national annual increment.

The annual increment unavailable within the network of PAs represents 11.88% (about 4.1 million cubic meters) of the total annual increment. However, the annual increment available through active management represents 21.9% of the total annual increment, amounting to about 7.6 million cubic meters (Tab. 5).

At national level, beech forests (3115) class was the one with the higher available annual increment (5.6% - 1,940,000 cubic meters) (Fig. 2). This is easily explainable, because the beech forest in Italy is one of the most widespread forest type representing 12% of the national forests (INFC 2005 data).

General overview of the results split up by silvicultural system showed that the annual increment was respectively 3.8 m^3ha^{-1} in coppice forests and 5.1 m^3ha^{-1} in non-coppice forests. Within the network of PAs the available annual average increment was 0.98 m^3ha^{-1} (0.81 m^3ha^{-1} in coppice and 1.14 m^3ha^{-1} in non-coppice forests). Considering the two forms of protection, the available annual average increment was 0.51 m^3ha^{-1} in EUAP areas (0.42 m^3ha^{-1} in coppice, 0.60 m^3ha^{-1} in non-coppice) while 0.9 m^3ha^{-1}in Natura 2000 sites (0.74 m^3ha^{-1} for coppice and 1.06 m^3ha^{-1} for non-coppice).

Table 4 - Share of the potential annual increment within the EUAP areas, Natura 2000 and CLC 2006. Legend: I_{CC}: Increment Current Coppice; I_{CNC}: Increment Current Non-Coppice; I_{CW}: Increment Current Wood.

	EUAP + NATURA 2000			EAUP			NATURA 2000			CLC 2006		
CLC 2006 Classess	Ic_C	Ic_{NC}	Ic_W	Ic_C	Ic_{NC}	Ic_W	Ic_C	Ic_{NC}	Ic_W	Ic_C	Ic_{NC}	Ic_W
3111	1.02%	0.90%	1.92%	0.54%	0.39%	0.93%	0.87%	0.70%	1.57%	2.22%	2.52%	4.74%
3112	2.46%	2.20%	4.66%	1.15%	1.37%	2.52%	2.23%	1.77%	4.00%	9.15%	7.49%	16.63%
3113	1.61%	1.02%	2.63%	0.70%	0.60%	1.30%	1.46%	0.94%	2.40%	6.00%	2.56%	8.56%
3114	2.60%	0.73%	3.33%	1.18%	0.49%	1.67%	2.29%	0.51%	2.80%	12.03%	2.42%	14.45%
3115	5.16%	3.36%	8.52%	3.09%	2.29%	5.38%	4.86%	3.12%	7.98%	9.86%	5.29%	15.15%
3116	0.03%	0.27%	0.31%	0.01%	0.12%	0.12%	0.03%	0.24%	0.27%	0.14%	1.16%	1.30%
3117	0.07%	0.16%	0.23%	0.05%	0.07%	0.11%	0.05%	0.15%	0.20%	0.37%	1.13%	1.50%
3121	0.00%	1.35%	1.35%	0.00%	0.68%	0.68%	0.00%	1.26%	1.26%	0.00%	2.99%	2.99%
3122	0.00%	1.06%	1.06%	0.00%	0.75%	0.75%	0.00%	0.78%	0.78%	0.00%	2.61%	2.61%
3123	0.00%	4.17%	4.17%	0.00%	1.65%	1.65%	0.00%	3.91%	3.91%	0.00%	14.12%	14.12%
3124	0.00%	1.08%	1.08%	0.00%	0.53%	0.53%	0.00%	1.05%	1.05%	0.00%	2.81%	2.81%
3125	0.00%	0.03%	0.03%	0.00%	0.01%	0.01%	0.00%	0.03%	0.03%	0.00%	0.19%	0.19%
31311	0.07%	0.20%	0.27%	0.05%	0.14%	0.18%	0.05%	0.14%	0.20%	0.14%	0.34%	0.48%
31312	0.10%	0.32%	0.42%	0.05%	0.19%	0.23%	0.08%	0.26%	0.34%	0.42%	1.08%	1.50%
31313	0.09%	0.17%	0.26%	0.03%	0.07%	0.11%	0.08%	0.15%	0.23%	0.73%	0.85%	1.57%
31314	0.08%	0.08%	0.16%	0.03%	0.04%	0.07%	0.06%	0.06%	0.12%	0.54%	0.49%	1.03%
31315	0.22%	0.64%	0.87%	0.13%	0.38%	0.50%	0.17%	0.59%	0.76%	0.71%	1.62%	2.32%
31316	0.00%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0.01%	0.01%	0.00%	0.02%	0.03%
31317	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.04%	0.05%	0.09%
31321	0.00%	0.48%	0.48%	0.00%	0.25%	0.25%	0.00%	0.43%	0.43%	0.00%	1.65%	1.66%
31322	0.01%	0.96%	0.97%	0.01%	0.68%	0.69%	0.00%	0.69%	0.69%	0.02%	2.97%	2.99%
31323	0.01%	0.83%	0.84%	0.00%	0.30%	0.30%	0.01%	0.81%	0.81%	0.06%	2.55%	2.61%
31324	0.00%	0.21%	0.21%	0.00%	0.06%	0.06%	0.00%	0.21%	0.21%	0.00%	0.60%	0.60%
31325	0.00%	0.02%	0.02%	0.00%	0.01%	0.01%	0.00%	0.02%	0.02%	0.00%	0.07%	0.07%
Italy	13.53%	20.26%	33.78%	7.01%	11.04%	18.05%	12.26%	17.80%	30.06%	42.42%	57.58%	100.00%

Table 5 - Annual increments available and not within the EUAP areas and Natura 2000.

	Wood Unavailable [m3]			Wood Unavailable [%]		
	Coppice	Not Coppice	Total	Coppice	Not Coppice	Total
EAUP (PNZ - Zone A)	0	380870	380870	0.0%	1.1%	1.1%
EUAP (Zone B-C-D PNZ, PNR, RNS, RNR, AANP)	806106	1144084	1950190	2.3%	3.3%	5.6%
EUAP (Total)	806106	1524954	2331060	2.3%	4.4%	6.7%
Natura 2000	1409644	2046279	3455923	4.0%	5.9%	9.9%
EUAP + Natura 2000	1555447	2584103	4139550	4.5%	7.4%	11.9%
	Wood Available [m3]			**Wood Available [%]**		
	Coppice	**Not Coppice**	**Total**	**Coppice**	**Not Coppice**	**Total**
EAUP (PNZ - Zone A)	0	0	0	0.0%	0.0%	0.0%
EUAP (Zone B-C-D PNZ, PNR, RNS, RNR, AANP)	1636640	2322836	3959476	4.7%	6.7%	11.4%
EUAP (Total)	1636640	2322836	3959476	4.7%	6.7%	11.4%
Natura 2000	2862004	4154566	7016570	8.2%	11.9%	20.1%
EUAP + Natura 2000	3158029	4473231	7631260	9.1%	12.8%	21.9%

Discussion

At national level, 88.4% of the forest area was available for forest logging (Gasparini and Tabacchi 2011) and the share of net available annual increment was 39.5% in 1990, 33.1% in 2000 and 26.3% in 2005 (EUROSTAT 2012). The average increment potential available for felling at national level was 4.4 m^3ha^{-1}.

According to EUROSTAT data (http://epp.eurostat.ec.europa.eu/), European countries have a large margin to increase logged wood volumes. Italy has a level of wood mobilization among the lowest ones in Europe. Considering the very low level of harvesting, a large majority of harvested volumes comes from production forests outside protected areas. Therefore, there is a potential to enhance wood supply in a sustainable way, for energy and raw materials for industry, encouraging wood mobilization (Muys et al. 2013). In contrast, due to the global economic crisis there was a rising interest in fuelwood, resulting in an increase of fuelwood imports of about 26% in Italy annually. Italy is the first importer country of firewood in Europe.

Increasing the consumption of the wood sustainably produced and boost the bio-energy in countries all over Europe could lead economic, environmental and geopolitical gains (FOREST EUROPE 2010). There are many credible reasons to move away from fossil fuels, including the reduction of the dependence on foreign petroleum, maintaining forest management infrastructures, and encouraging conservation of forest work (Gunn et al. 2012). Moreover, the biomass has several other well-recognized benefits

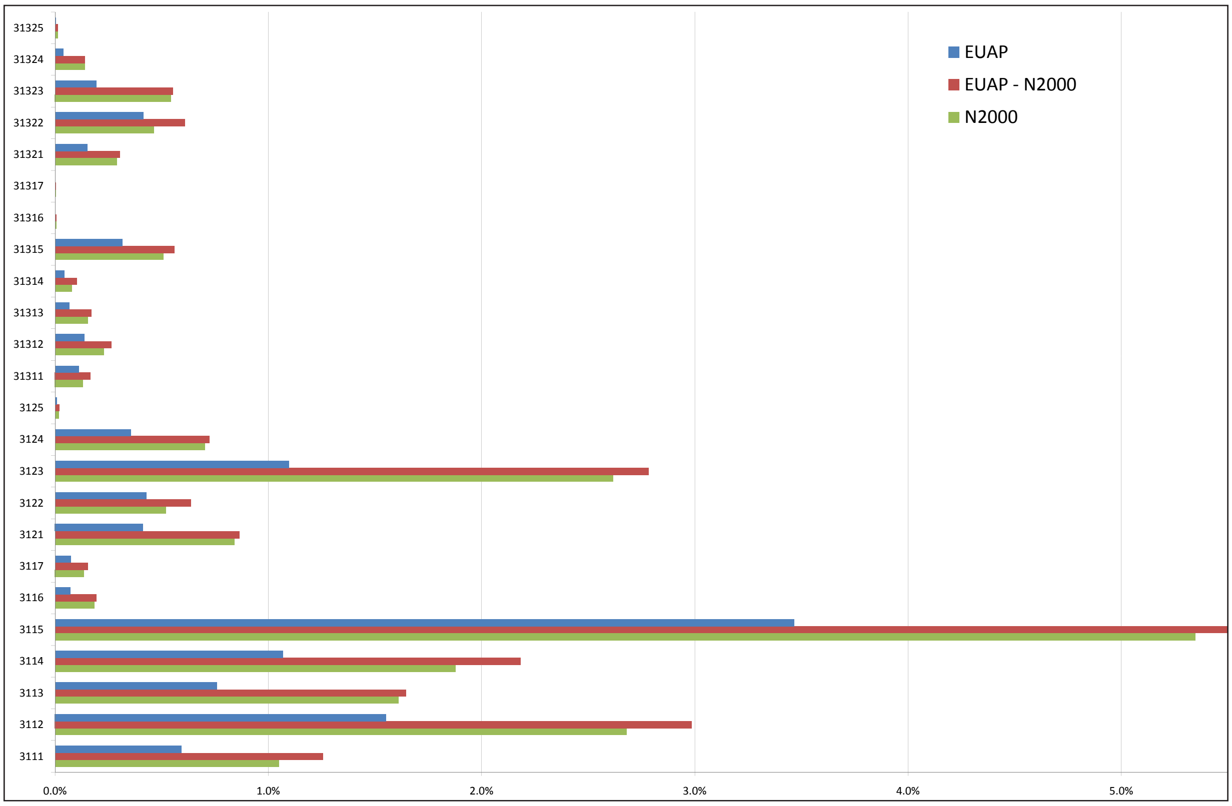

Figure 2 - Annual increments available for each CLC class within the protected areas through an active management of the territory.

such as improved security of supply, contributing to improve air quality and creation of new jobs and businesses - many of them in rural areas (Ragwitz et al. 2006).

Forests represent a combination of important ecosystems that provide habitat for numerous species, regulate water cycles, clean air and provide timber for economic use (Maes et al. 2011).

The forest growing stock, the increment and fellings could be considered directly ecosystem services indicators for sustainability of ecosystem services over time, to ensure that the long-term benefit flow of services is represented (Maes et al. 2011). Mobilizing more wood is an effort of the whole forest sector. There is a potential to enhance wood supply in a sustainable way, for energy and raw materials for industry. In line with the policy commitments all over Europe and in particular in light of the EU renewable energy targets, wood mobilization should be further encouraged in countries all over Europe (FOREST EUROPE 2010).

Conclusions

This paper assessed the amount of wood that is technically available in the protected areas by active management of the forest resources. To assess the felling potential in the network of PAs, the unbounded available wood was evaluated and divided into the two silvicultural systems (coppice, non-coppice). This upper limit does not take into account management restrictions due to biological and landscape diversity protection that may apply in PFAs and does not take into account other environmental, social and economic factors that may limit the felling potential. The research provides the dataset and suggests the rationale for wood mobilization in areas usually considered of close to strict environmental protection. Wood harvesting can be undertaken without compromising other forest functions if it is made in a sustainable way, in other words, without compacting soil, causing soil erosion, or disturbing the reproductive cycle of plants or animals.

References

Cash D.W., Adger W., Berkes F., Garden P., Lebel L., Olsson P., Pritchard L., Young O. 2006 - *Scale and cross-scale dynamics: governance and information in a multilevel world.* Ecology and Society 11: 8.

Ciancio O., Corona P., Marchetti M., Nocentini S. 2002 - *Linee guida per la gestione ecosostenibile delle risorse forestali e pastorali nei Pachi Nazionali.* Ministero dell'Ambiente, Servizio conservazione della Natura, Accademia Italiana di Scienze Forestali, Firenze, 302 p. http://www.aisf.it/monografie/linee%20guida%20parchi/Linee%20Guida%20Parchi.pdf.

Duncker P., Barreiro S., Hengeveld G.M., Lind T., Spiecker H., Mason B., Ambrozy S., Spiecker H. 2012 - *Classification of forest management approaches: a new methodological framework and its applicability to European forestry.* Ecology and Society 17 (4): 51.

EEA 2007 - *Nationally designated areas (national-CDDA)*. Version 9. EEA, Copenhagen [Online] http://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-5.1 [11 Oct 2011]

Egoh B., Reyers B., Rouget M., Bode M., Richardson D.M. 2009 - *Spatial congruence between biodiversity and ecosystem services in South Africa*. Biological Conservation 142: 553-562.

EUROSTAT 2012 - *Forestry. Forest increment and fellings (ts-dnr520)*. [Online] http://epp.eurostat.ec.europa.eu/portal/page/portal/forestry/data/main_tables [2012]

FOREST EUROPE/UNECE/FAO 2010 - *Information Document on Data Collection and Compiling the Statistics on Protected and Protective Forest and Other Wooded Land for Pan-European Reporting*. [Online] http://www.unece.org/fileadmin/DAM/timber/publications/soef2011-protected-forest.pdf [2012]

FOREST EUROPE 2010 - *Good practice guidance on the sustainable mobilisation of wood in Europe*. Publications Office of the European Union, ISBN: 978-92-79-13933-8, DOI: 10.2762/17910.

FOREST EUROPE, UNECE and FAO 2011 - *State of Europe's Forests 2011. Status and Trends in Sustainable Forest Management in Europe*.

Frank G., Parviainen J., Vandekerkhove K., Latham J., Schuck A., Little D. (eds.). 2007 - *COST Action E27 Protected forest areas in Europe-analysis and harmonization (PROFOR): results, conclusions and recommendations. Federal research and training centre for forests, natural hazards and landscape (BFW)*. Vienna. 211 p.

Gasparini P., Tabacchi G. 2011 - *L'inventario Nazionale delle foreste e dei serbatoi forestali di carbonio INFC 2005. Secondo inventario forestale nazionale italiano. Metodi e risultati*. Ministero delle Politiche Agricole, Alimentari e Forestali, Corpo Forestale dello Stato; Consiglio per la Ricerca e la sperimentazione in Agricoltura, Unità di ricerca per il monitoraggio e la pianificazione forestale. Edagricole, Milano, 653 p.

Gunn S.J., Ganz D.J., Keeton W. 2012 - *Biogenic vs. geologic carbon emissions and forest biomass energy production*. Global Change Biology 4: 239-242.

INFC 2003 - *Guida alla classificazione delle vegetazione forestale*. Istituto Sperimentale per l'Assestamento Forestale e per l'Alpicoltura - ISAFA, Trento.

INFC 2005 - *Inventario Nazionale delle Foreste e dei Serbatoi Forestali di Carbonio*. Ministero delle Politiche Agricole Alimentari e Forestali, Ispettorato Generale - Corpo Forestale dello Stato. CRA - Istituto Sperimentale per l'Assestamento Forestale e per l'Alpicoltura, Trento. http://www.sian.it/inventarioforestale/jsp/home.jsp.

ISAFA 1988 - *Inventario Forestale Nazionale Italiano 1985 (IFNI 85)*. Istituto sperimentale per l'Assestamento forestale e per l'Alpicoltura, Trento.

ISPRA 2010 - *La realizzazione in Italia del progetto europeo Corine Land Cover 2006*. Rapporto 131/2010 ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale. Roma, 50 p. ISBN 978-88-448-0477-0. http://www.isprambiente.gov.it/site/_contentfiles/00008300/8329_rapporto_131_2010.pdf.

Köhl M., Hildebrandt R., Olschofksy K., Köhler R., Rötzer T., Mette T., Pretzsch H., Köthke M., Dieter M., Abiy M., Makeschin F., Kenter B. 2010 - *Combating the effects of climatic change on forests by mitigation strategies*. Carbon Balance and Management 5: 8.

Lamers P., Thiffault E., Paré D., Junginger M. 2013 - *Feedstock specific environmental risk levels related to biomass extraction for energy from boreal and temperate forests*. Biomass and Bioenergy 55: 212-226.

Maes J., Braat L., Jax K., Hutchins M., Furman E., Termansen M., Luque S., Paracchini M.L., Chauvin C., Williams R., Volk M., Lautenbach S., Kopperoinen L., Schelhaas M.J., Weinert J., Goossen M., Dumont E., Strauch M., Görg C., Dormann C., Katwinkel M., Zulian G., Varjopuro R., Ratamäki O., Hauck J., Forsius M., Hengeveld G., Perez-Soba M., Bouraoui F., Scholz M., Schulz-Zunkel C., Lepistö A., Polishchuk Y., Bidoglio G. 2011 - *A spatial assessment of ecosystem services in Europe: methods, case studies and policy analysis - phase 1*. PEER Report No 3. Ispra: Partnership for European Environmental Research. Italy, 148 p.

Maesano M., Lasserre B., Tonti D., Marchetti M. 2014 - *First Mapping of the main High Conservation Value Forests (HCVFs) at national scale: the case of Italy*. Plant Biosystem (in press).

Mantau U., Saal U., Prins K., Steierer F., Lindner M., Verkerk H., Eggers J., Leek N., Oldenburger J., Asikainen A., Anttila P. 2010 - *EUwood - real potential for changes in growth and use of EU forests*. Final Report. University of Hamburg. Centre of Wood Science, Hamburg. http://ec.europa.eu/energy/renewables/studies/doc/bioenergy/euwood final report.pdf.

MATTM 2010 - *Elenco Ufficiale delle Aree naturali Protette (EUAP) 6° Aggiornamento 2010*. Dipartimento per l'assetto dei valori ambientali del territorio, Direzione per la Conservazione della Natura, Ministero dell'Ambiente e della tutela del Territorio, Roma.

MCPFE 2002 - *Assessment Guidelines for Protected and Protective Forest and Other Wooded Land in Europe*. Annex 2 to Vienna Resolution 4. Fourth Ministerial Conference on the Protection of Forest in Europe, 28-30 April 2003, Vienna, Austria.

MCPFE 2003 - *State of Europe's forests 2003*. The MCPFE report on sustainable forest management in Europe. Jointly prepared by the MCPFE Liaison Unit Vienna and UNECE/FAO, Vienna.

MCPFE 2007 - *State of Europe's Forests 2007*. http://www.foresteurope.org/filestore/foresteurope/Publications/pdf/state_of_europes_forests_2007.pdf

Muys B., Hetemäki L., Palahi M. 2013 - *Sustainable wood mobilization for EU renewable energy targets*. Biofuels Bioproducts and Biorefining 7: 359–360.

Nelson E., Polasky S., Lewis D.J., Plantinga A.J., Lonsdorf E., White D., Bael D., Lawler J.J. 2008 - *Efficiency of incentives to jointly increase carbon sequestration and species conservation on a landscape*. In: Proceedings of the National Academy of Sciences 105: 9471-9476.

Norton-Griffiths M., Southey C. 1995 - T*he opportunity costs of biodiversity conservation in Kenya*. Ecological Economics 12: 125-139.

Parviainen J., Frank G. 2003 - *Protected forests in Europe approaches-harmonising the definitions for international comparison and forest policy making*. Journal of Environmental Management 67: 27-36.

PEER 2011 - *A spatial assessment of ecosystem services in Europe: Methods, case studies and policy analysis - phase I*. European Commission Joint Research Centre Institute for Environment and Sustainability (JRC-IES).

Pettorelli N., Chauvenet A.L.M., Duffy J.P., Cornforth W.A., Meillere A., Baillie J.E.M 2012 - *Tracking the effect of climate change on ecosystem functioning using protected areas: Africa as a case study.* Ecological Indicators 20: 269-276.

Ragwitz M., Toro F., Resch G., Faber T., Haas R., Hoogwijk M., Voogt M., Rathmann M. 2006 - *Economic analysis of reaching a 20 % share of renewable energy sources in 2020.* European Commission, DG Environment. ENV.C.2/SER/2005/0080r. http://ec.europa.eu/environment/enveco/others/pdf/res2020_final_report.pdf

Sohngen B., Mendelsohn R., Sedjo R. 1999 - *Forest Management, Conservation, and Global Timber Markets.* American Journal of Agricultural Economics 81 (1): 1-13.

Turner W.R., Brandon K., Brooks T.M., Costanza R., da Fonseca G.A.B., Portela R. 2007 - *Global Conservation of Biodiversity and Ecosystem Services.* BioScience, 57: 868-873.

Verkerk P.J., Zanchi G., Lindner M. 2008 - *Impacts of Biological and Landscape Diversity Protection on the Wood Supply in Europe.* EFI Technical Report 27, European Forest Institute, 29 p.

Willemen L., Drakou E.G., Dunbar M.B., Mayaux P., Egoh B.N. 2013 - *Safeguarding ecosystem services and livelihoods: Understanding the impact of conservation strategies on benefit flows to society.* Ecosystem Services 4: 95-103.