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PRELIMINARY ASSESSMENTS FOR THE REGIONAL IMPLEMENTATION OF THE INVENTORY OF FOREST CARBON STOCKS IN LOMBARDY

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Lombardy Region has established a regional inventory of forest carbon sinks in order to account for a balance between absorption and emission of carbon from forest growth and changes in forest surface, as well as to have an institutional and technical tool to characterize and exploit the forest sinks in control strategies and mitigation of anthropogenic emissions.

In the first implementation has been computed the Forest Model into the regional Air Emission Inventory in order to assess and update the forest carbon stock and carbon sink of the region during the period 1990-2008.

Carbon stock and carbon sink at municipal level were assigned in view of the share of municipal area of each forest type in the Region and the provincial estimated value was obtained from its municipal contributions while harvest and fire data set reported in the National Inventory Report 2011 were brought down to the NUTS2 level in order to be processed.

Forest carbon stock in Lombardy has increased from 327 MtCO₂ in 1990 to 408 MtCO₂ in 2008, while carbon sink has been estimated 4.7 MtCO₂ in 2008 resulting in approximately 5.5% of regional GHGs emission level.

Further analysis are in progress in order to refine the accounting at local level and to have a technical tool that allows to support decision making in the allocation of obligations for reducing emissions, as well as to enhance the forestry sector in the generation of carbon credits and in procedures of environmental impact assessment related to human settlements and infrastructure works.

Key words: carbon stock; carbon sink; regional inventory; Lombardy.

Parole chiave: stock di carbonio; serbatoio di carbonio; inventario regionale; Lombardia.

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1. INTRODUCTION

The spread and intensification of the photosynthetic processes are functional steps for the mitigation of anthropogenic interference with the natural cycle of atmospheric gases and the improvement of local net balances of carbon dioxide, to be pursued through the expansion of the permanent forest surface and the efficient management of existing forests to raise the woody increases (CICCARRESE *et al.*, 2005).

According to articles 3.3 and 3.4 of the Kyoto Protocol and subsequent UNFCCC COPs, Italy shall report the net change in GHG (greenhouse gas) emissions resulting from afforestation, reforestation, deforestation and forest management activities, countable for a total of 16,2 MtCO₂ per year during the First Commitment Period (CIPE 2002; CIPE 2007).

The net change in GHG emissions by sources and removals arising from such activities should be counted in a National GHG Inventory by

annual carbon reporting since 1990, against which the central government and regional authorities play a key role in resolving specific topics concerning data collection and management issues.

In 2006, the LOMBARDY REGION has established a regional inventory of forest carbon sinks (*Regional Law 24/2006*) in order to account for a balance between absorption and emission of carbon from forest growth and changes in forest surface, as well as to have an institutional and technical tool to characterize and exploit the forest sinks in control strategies and mitigation of anthropogenic emissions.

In the first implementation has been adopted the For-est Model, developed at national level for the estimation of anthropogenic emissions by sources and removals by sinks of GHGs not included in the Montreal Protocol (FEDERICI *et al.*, 2008).

In view of the IPCC Guidelines, preliminary assessments at the level of individual provinces are in fact carried out by gain-loss methodology to calculate the current annual increment per hectare for each type of forest inventory from growing stock by derivative of the Richards function (RICHARDS, 1959).

2. METHODOLOGIES

In air emission inventory of Lombardy Region (CASERINI *et al.*, 2005) has been realized a calculation module using the Forest Model, in order to assess and update the forest carbon stock and provide the carbon sink in all 1541 municipalities of the region during the period 1990-2008.

The annual growing stock (gs) was calculated by taking the growing stock in 1985 (75.870.790 m³), reported in the first National Forest Inventory (NFI) (MAF-ISAFA, 1988), according to the following equation model:

$$gs_i = gs_{i-1} + I_i - H_i - F_i - M_i - D_i$$

where:

- I = current increase calculated by derivative of the Richards function, referred to the regional forest area (598.500 HA in 1985);
- H, F = losses from harvesting and fire;

- M = natural mortality;
- D = drain and grazing losses;
- i = year.

From estimated values of growing stock, the regional carbon stock was calculated for each carbon pool (aboveground and belowground biomass, dead mass, litter and soil) by using parameters (biomass expansion factor, wood basic density, root/shoot ratio) and linear relations (stands biomass, soil and litter) proposed in the National Inventory Report 2011 (ISPRA, 2011).

From assessed values of carbon stock, the regional carbon sink was evaluated as the difference between two consecutives carbon stocks.

Carbon stock and carbon sink at municipal level have been assigned in view of the share of municipal area of each forest type than in the Region (ERSAF, 2006). The provincial estimated value was obtained aggregating each municipal contributions, while harvest and fire data set reported in the National Inventory Report 2011 (ISPRA, 2011) were broken down to the NUTS2 level.

The forest areas classified by the regional regulation on the basis of dimensional parameters (surface ≥ 2000 m² and forest cover $\geq 20\%$ of surface) and characterized in regional forest typologies have been assigned to NFI classification (Table 1).

Forest area in 1990 has been estimated by linear interpolation between the NFI 1985 data and the National Forest and Carbon pools Inventory in 2005 (TABACCHI *et al.*, 2007). On the basis of resulting trend, forest area during the period 1990-2008 has been extrapolated (Table 2).

3. RESULTS AND DISCUSSION

The forest carbon stock in Lombardy is currently growing and has increased from 327 MtCO₂ in 1990 to 408 MtCO₂ in 2008, resulting mainly distributed (66%) in the provinces of Sondrio, Bergamo and Brescia, where are located the largest region-owned forest areas characterized as Natura 2000 sites and where many regional protected areas were established

Table 1 – Distribution of the Regional Forest Typology into the National Forest Inventory classification.

REGIONAL FOREST TYPOLOGY	NFI TYPOLOGY	FOREST MANAGEMENT	COEFFICIENT
Alders	Other broadleaves	Coppices Stands	0.9 0.1
Anthropogenic formation	Others	Plantations	1.0
Beeches	European beech	Coppices Stands	0.8 0.2
Birches and hazels	Other broadleaves	Coppices Stands	0.9 0.1
Maples and ashes	Other broadleaves	Coppices Stands	0.9 0.1
Mugo Pines	Rupicolous forest	Protective	1.0
Not classified	Others	Plantations	1.0
Oaks	Turkey Oak	Coppices Stands	0.7 0.3
Hornbeams	Hornbeams	Coppices	1.0
Oak and hornbeams	Other Oaks	Coppices Stands	0.8 0.2
Others confers	Conifers	Plantations	1.0
Particular formation	Others	Plantations	1.0
Pines and larches	Larches	Stands	1.0
Poplars	Poplars stands	Plantations	1.0
Scots pines	Mountain pines	Stands	1.0
Scrublands	Shrublands	Protective	1.0
Silver firs	Silver fir	Stands	1.0
Spruces	Norway spruce	Stands	1.0
Spruces and beeches	Other broadleaves plantations	Plantations	1.0
Sweet chesnut	Sweet chestnut	Coppices	1.0

Source: our elaboration.

Table 2 – Forest area, harvest and fires in Lombardy Region (years 1990, 2000, 2005 and 2008).

Year	Forest area (HA)	Harvest (m ³)	Fire (m ³)
1990	616,440	1,166,005	1,014,888
2000	663,040	1,750,238	155,052
2005	686,339	1,160,948	71,698
2008	700,319	1,151,798	87,008

Source: our elaboration.

with management plans for the protection of natural resources (Table 3).

The soil carbon pool is the most important, accounting for approximately 54% of the total forest carbon stock in 2008.

Forest carbon sink has been estimated in 4.7 MtCO₂ in 2008 (Figure 1), resulting in approximately 5% of that estimated at national level (ISPRA, 2011). Thus the net change in GHG emissions attributable to Lombardy region and resulting from afforestation, reforestation, deforestation and forest management would be about 0.81 MtCO₂ per year during the First Commitment Period.

The carbon pool that mainly characterizes the absorption is the living forest biomass, which represents approximately 57% of the absorption, although this contribution varies over time and depends on uses and fire incidence over the years.

These preliminary results, mainly based on

Table 3 – Carbon stock (MtCO₂) in Lombardy Region (years 1990, 2000, 2005 and 2008).

Province	1990	2000	2005	2008					
	Total	Total	Total	Living biomass		Dead organic matter		Soil organic matter	Total
				Aboveground	Belowground	Dead mass	Litter	Soil	
Bergamo	60.3	66.4	70.6	25.0	4.6	1.9	1.7	40.0	73.2
Brescia	65.3	70.9	75.1	26.2	5.4	2.1	1.8	42.5	78.0
Como	32.0	37.0	40.1	15.7	2.9	1.1	0.9	21.3	41.9
Cremona	3.3	5.0	5.5	2.5	0.4	0.0	0.1	2.7	5.8
Lecco	19.6	22.1	23.7	9.0	1.7	0.7	0.5	12.8	24.7
Lodi	2.2	3.1	3.4	1.4	0.2	0.0	0.1	1.8	3.5
Monza & Brianza	1.0	1.1	1.1	0.4	0.1	0.0	0.0	0.7	1.2
Milano	6.4	7.3	7.7	2.5	0.5	0.1	0.2	4.6	7.9
Mantova	6.6	9.5	10.4	4.5	0.8	0.0	0.2	5.4	10.8
Pavia	20.2	26.1	28.3	11.3	2.0	0.2	0.6	15.2	29.4
Sondrio	87.5	94.1	99.0	30.9	7.0	2.6	2.4	59.2	102.1
Varese	23.0	26.3	28.4	10.9	2.1	0.7	0.7	15.3	29.7
Total	327.4	369.8	393.3	140.4	27.7	9.4	9.2	221.5	408.3

Source: our elaboration.

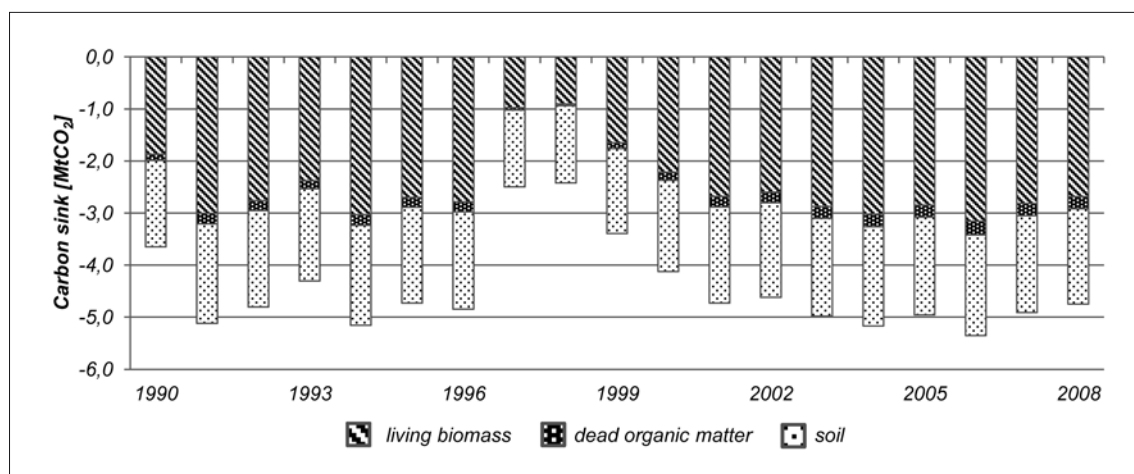


Figure 1 – Estimated forest carbon sink in Lombardy.

national statistics, indicate that the combined use of efficient forestry measures for reducing emissions from mobility and productive activities can be an effective solution in strategies for mitigation and adaptation to climate change in Lombardy Region.

The forests carbon absorption, in fact, represents about 5.5% of regional GHG emissions (86.9 MtCO₂ equivalent in 2008), which corresponds to the contribution of GHG emissions for all production processes

according to the SNAP classification (Selected Nomenclature for Air Pollutant) adopted by IN.EM.AR (ARPA, 2011).

Further basic studies are in progress to evaluate input data and implement regional statistics, in order to refine the accounting at local level and to have a technical tool that allows to support decision making in the allocation of obligations for reducing emissions, as well as to enhance a rural development that is concerned with the forestry sector in

the generation of carbon credits and in procedures of environmental impact assessment related to human settlements and infrastructure works.

RIASSUNTO

Valutazioni preliminari per l'attuazione dell'inventario regionale dei depositi di carbonio forestale in Lombardia

La Regione Lombardia ha realizzato un inventario dei serbatoi forestali di carbonio con scopi di contabilizzazione finalizzati a definire un bilancio fra l'assorbimento e l'emissione del carbonio connessi all'accrescimento forestale e ai cambiamenti nella superficie forestale, ma anche con l'obiettivo di avere uno strumento istituzionale e tecnico per caratterizzare e sfruttare i serbatoi di carbonio nelle strategie di controllo e mitigazione delle emissioni antropiche.

Nella prima implementazione il For-est Model è stato computato all'interno dell'Inventario regionale delle emissioni atmosferiche in modo da definire e aggiornare lo stock di carbonio forestale e i serbatoi di carbonio regionali nel periodo 1990-2008.

Lo stock di carbonio e i serbatoi di carbonio a livello comunale sono stati assegnati in funzione della proporzione di area municipale di ogni tipo forestale a livello regionale e il valore stimato a livello provinciale è stato ottenuto dai diversi contributi comunali mentre i dati di taglio e incendio riportati nel report dell'Inventario Nazionale del 2011 sono stati ridotti a livello NUTS2 in modo da poter essere processati.

Lo stock di carbonio forestale è passato in Lombardia da 327 MtCO₂ nel 1990 a 408 MtCO₂ nel 2008, mentre i serbatoi di carbonio sono stati stimati intorno a 4,7 MtCO₂ nel 2008, corrispondendo a circa il 5,5% del livello regionale di emissioni di gas serra.

Ulteriori analisi sono in corso allo scopo di affinare la contabilizzazione a livello locale e al fine di avere uno strumento tecnico che permetta sia di supportare i processi decisionali di allocazione degli obblighi di riduzione delle emissioni, che di rafforzare il settore forestale nella generazione di crediti di carbonio e nelle procedure di valutazione dell'impatto ambientale connesso agli insediamenti umani e alle opere infrastrutturali.

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