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**Fifth Joint Conference on**  
**Agriculture, Food, and the Environment**  
**Proceedings of a Conference Sponsored by**  
**University of Minnesota**  
**Center for International Food and Agricultural Policy**  
**Università degli Studi di Padova**  
**Dipartimento Territorio e Sistemi Agro-forestali**  
**Agricultural Development Agency - Veneto Region**  
**University of Perugia**  
**University of Bologna - CNR**

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**SESSION VIII: LAND USE AND RURAL DEVELOPMENT**

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**PAPER 3: ENVIRONMENTAL ACCOUNTING OF FOREST  
RESOURCES: TWO ITALIAN CASE STUDIES**

*Giorgio Franceschetti and Davide Pettenella*

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## FOREWORD

This volume contains the papers presented at the Fifth Joint Minnesota/Padova Conference on Food, Agriculture, and the Environment held at Abano Terme, near Padova in Italy, June 17-18, 1996. This conference was organized by the Center for International Food and Agricultural Policy at the University of Minnesota and the Dipartimento Territorio e Sistemi Agro-forestali at the Università degli Studi di Padova (University of Padova) under their international collaborative agreement, along with the Agricultural Development Agency - Veneto Region, the University of Perugia, and the University of Bologna - CNR. The first Joint Conference was held in Motta di Livenza, Italy in June 1989, the second in Lake Itasca, Minnesota in September 1990, and the third in Motta di Livenza in June 1992. The Fourth Joint Conference was held in September 1994 at the Spring Hill Center in Minnesota.

This conference focused on topics of mutual interest in the areas of (1) agricultural and resource policy, (2) land markets, (3) the food and agricultural industry, (4) agriculture and the environment, and (5) agricultural production and environmental quality and sustainability. Although the conference was not intended to provide a comprehensive coverage of all the issues, this volume hopefully represents a useful contribution to current understanding and debate in the areas of food, agriculture, and the environment.

Judy Berdahl, secretary for the Center for International Food and Agricultural Policy at the University of Minnesota, assisted with these Proceedings.

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## **ENVIRONMENTAL ACCOUNTING OF FOREST RESOURCES: two Italian case-studies**

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### **1. Introduction**

In recent years there has been renewed interest in the need to support mountain populations, economies and environments, through processes ensuring sustainable development. In his chapter in the volume "State of the World, 1995", Derek Denniston gives many convincing arguments to rouse world public opinion towards the need for further study of the problems of mountain areas. In his view, there is a lack of knowledge and information on these issues, as well as uncertainty on how to intervene on these environments which are among the most complex of the entire planet. Among the various arguments he puts forward, he states that "two billion people live downstream of these vertical islands of biological diversity (mountain areas) and depend on the abundance of their waters, electricity, prairies and timber".

It should be recalled that when we speak of mountain areas in Europe, we refer to two stereotypes: marginalisation of population and centrality of forestry. While recognising the economic importance of forestry in the past, today we should bear in mind above all the wider benefits brought by mountain areas to the economy as a whole, in terms of water supply, landscape, climatic effects, recreation, biological diversity, etc.

These important services are not itemised in national budgets, nor is account taken of the variations in natural assets generating these flows of goods and services. In the Italian System of National Accounting (SNA) the contribution of the forestry sector to GNP is only 0.05%.

While on the one hand there is a need for policies sustaining mountain areas, such policies cannot be evaluated due to the lack of economic approaches taking account of the real contribution of these areas to the country's economy. In this sense environmental accounting may play a part by evaluating the stock of natural assets and their annual variations, as well as estimating their economic and environmental benefits.

In the current Italian SNA for the forestry sector there are notable inadequacies in both the methodological approach and in organisation of field surveys. The following aspects in particular may be pointed out:

- inclusion, among the items making up national income, of some defence expenditures born by the public sector and by families regarding damages from fire, pollution or other failings in the forest system following economic activities external to forestry itself (Adger and Whitby, 1993; Cullino, 1993);
- on the other hand, non-estimation of externalities, whether negative, such as environmental damages caused to forest resources by economic activities (pollution effects, for example), or positive (soil protection, provision of recreational areas, etc.);

- no allowance for gains and losses with respect to variations in the stock of natural resources (forest flora and fauna for example).

In recent years research and applications have been developed in Italy regarding these issues. Two case studies are presented here with reference to mountain areas and forest resources in particular: the first one is an economic estimate of the role of the forestry sector in the Liguria Region (north-west Italy); the proposed satellite system of forest resources accounting is based on a Geographical Information System (GIS) comprising an extremely diversified set of physical data, associated with economic information. The second case study consists of a tentative estimate of damage costs from forest fires occurring in Italy over the past eleven years, the results of which could be a good starting point for an evaluation of the costs and benefits deriving from a program of forest fire prevention.

## 2. The Liguria Region case study

A pilot experience on organising an environmental accounting system for forest resources in Italy has been realised through the Forest Inventory of the Liguria Region financed by the Ministry of Agricultural, Food and Forestry Resources. Data collection and processing was undertaken in order to set up a GIS linked to a forestry resources accounting system; this system is based on the analysis of 4 functions of major economic relevance. Table 1 summarises the accounting system's organisation which includes some new elements with respect to forest resource accounting systems realised in other countries (Adger and Whitby, 1991 and 1993; CEA, 1991; Hultkrants, 1992; Matero and Saastamoinen, 1993; Pearce, 1994; Peskin and Lutz, 1993; Repetto, 1989; Repetto *et al.*, 1991; Solberg and Svendsrut, 1992):

- estimates of some variables on the basis of more than one methodological approach, with the objective of obtaining, rather than a single value for a product or service, a range of values which may be elaborated further;
- estimates, regarding data on the productive functions, not only of the present level of resource use, but also potential use, estimated under the constraint that the stock of resources be maintained constant; a maximum sustainable production value is thus provided;
- estimate of the value of the forest resource stock (and hence relative variations) using a different approach with respect to those presented in the literature.

In particular, the discounted value of standing trees is calculated in two phases: first of all the potential growing stock at the maturity age is estimated, under the hypothesis that the stock in the forest area under examination will increase up to point  $t$  set by forest regulations at local level. The estimated stock at year  $t$  is multiplied by the average market price over the previous 3 years for assortments from mature stands, subtracting the cost of felling, estimated according to the information deriving from the GIS (road network and land slope). The value obtained in this way is discounted (using two threshold-rates of 3 and 7%) by a number of years equal to the difference between  $t$  and the current average age of the stand. The estimated value of the timber stock is added to estimated values of bare land, according to the market price of pastureland in similar conditions. Using this procedure we do not give values equal to zero, or in any case very low values, to young stands of no commercial value but with high productive potential.

Table 1 - Organisation of forest resources accounting in the Liguria case study.

Functions	products or services	real values		potential values	
		evaluation methods	source	evaluation methods	source
1. wood and non-wood forest products	timber and fuelwood	market values	ISTAT-SF	harvesting and logging costs	IFM
	mushrooms	market values	ISTAT-SF	use of results from a survey in a nearby Region	specific survey
		no.daily permits* <i>per capita</i> harvest*market value	local associations of forest owners		
	chestnut	market values	ISTAT-SF	single tree production*area	IFM
	berries	market values	ISTAT-SF	single tree production*area	IFM
	litter	market values	auction results	non sustainable = no evaluation	
	hunting	planned killings* market values	Provincial Administration	potential no. of animals * market value	specific survey
	forage	grassland area (still in use) * Standard Gross Revenue	ISTAT-SA, field research, INEA	grassland area * Standard Gross Revenue	IFM, INEA
2. soil erosion control		reconstruction cost	costs of engineering work		
		opportunity cost	EU subsidies to grassland management		
		CV	IFM (specific survey)		
3. landscape, global warming	landscape and fire control	two CV surveys	IFM (specific survey)		
	carbon fixation	shadow price of 1 ton C	IFM		
4. outdoor recreation		TCM	IFM (specific survey)		
		CV	IFM (specific survey)		

Sources: IFM= Inventario Forestale Multirisorse of the Regione Liguria; ISTAT-SF = Statistiche forestali ISTAT; ISTAT-SA = Statistiche dell'agricoltura, zootecnia e mezzi di produzione ISTAT; INEA = Istituto Nazionale di Economia Agraria.

CV: contingent valuation; TCM: travel cost method.

Tables 2 and 3 present the results of the evaluation of the productive functions of the Liguria forests (timber, fuelwood, chestnut, mushrooms, berries, forage, game, litter)<sup>1</sup>. For comparison, the last 3 years' gross forestry production value presented by SNA official estimates is equal to 6.5 billion lire.

Table 2 - Gross production values of productive functions of Liguria forests (billion lire)

Provinces	wood	chestnut	mushrooms	berries	forage	hunting	litter	total
Imperia	376	40	202	102	1.273	1.741	-	<b>3.734</b>
Savona	3.057	177	1.024	64	246	3.442	66	<b>8.077</b>
Genova	1.427	141	1.443	1.978	568	3.738	-	<b>9.295</b>
La Spezia	1.490	93	803	29	1.018	2.792	-	<b>6.226</b>
<b>Liguria</b>	<b>6.350</b>	<b>451</b>	<b>3.472</b>	<b>2.174</b>	<b>3.104</b>	<b>11.714</b>	<b>66</b>	<b>27.333</b>

Table 3 - Ratio between economic value of the real and potential production function.

Provinces	wood <sup>(1)</sup>	chestnut	mushrooms	berries	forage	hunting	total
Imperia	6.27%	0.42%	7.71%	31.57%	45.27%	56.93%	<b>15.28%</b>
Savona	19.87%	4.40%	16.29%	8.37%	20.72%	61.91%	<b>24.12%</b>
Genova	7.22%	3.02%	25.12%	<sup>(2)</sup> 176.81%	10.11%	58.16%	<b>21.45%</b>
La Spezia	30.30%	1.87%	29.87%	12.63%	251.36%	95.21%	<b>38.55%</b>
<b>Liguria</b>	<b>12.92%</b>	<b>1.94%</b>	<b>20.03%</b>	<b>88.91%</b>	<b>30.97%</b>	<b>65.15%</b>	<b>23.28%</b>

<sup>(1)</sup> The estimate is based on average potential production

<sup>(2)</sup> The figure is altered by the presence of specialised strawberry and raspberry farming activities, surveyed by the CFS but not included in the inventory.

From examination of the data presented it clearly emerges that the Ligurian forests are underemployed, though marked differences exist between single sectors and at geographical level. More specifically, as far as timber production is concerned, real gross production is very limited with respect to the forests' real potential (less than 13% at regional level). Timber could evolve from being a subordinate component as it is now, with less than a quarter of overall production, to reach more than 40% of the entire value of gross production.

The sector which is certainly least developed, with respect to its potential, is that of sweet chestnuts, with a ratio between real and potential production of less than 2% at regional level and a 1.65% share in the productive function make-up. Chestnut harvesting could become the second productive activity in Liguria. Mushroom picking, despite the problems of controlling this activity, appears to be lower than the region's potential. However, it does not seem likely that the share of mushrooms in the overall make-up of forestry production can be significantly developed at regional or provincial level. Hunting is evenly spread through the four provinces, both in the real and potential situations, though in the latter case its relative importance is cut by half. The final factor in the overall productive function is forage production, at present concentrated in the two provinces of the region (Imperia and La Spezia); this activity could be developed somewhat, as there is a ratio of approx. 31% between real and potential production.

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<sup>1</sup>Litter has not been included in the potential production scenario because not considered a sustainable use of forest resources.

Quantitative and qualitative analysis of the various components of the productive function and its territorial distribution may be supplemented with examination of the economic value of the public services provided by Ligurian forests. The final results of these estimates are shown in Table 4. From the data presented there appears a clear discrepancy (of 1 and in some cases 2 magnitudes, see table 5) between the value of the protective function calculated on the basis of substitution costs and all the other functions, including the protective function itself estimated by contingent valuation (CV). This situation may be due to the lack of information and sensitivity of those interviewed regarding the subjects of the survey. In this regard it is singular that higher values were attributed to the outdoor recreation function (estimated by the travel cost method - TCM) than to the protective function (estimated by contingent valuation). This could be explained by the fact that, with respect to recreation, the demand for erosion control is perceived more as a demand for a public good which many interviewees consider should be provided free of charge, or at least at low cost for the beneficiaries.

Table 4 - Comparison between average annual values for various types of forest functions (billion lire)

Provinces	Production		Soil erosion control		
	Real	Potential	CV	Opportunity costs	Reconstruction costs
Imperia	3.734	24.438	8.655	125.156	292.133
Savona	8.077	33.211	18.157	182.140	425.070
Genova	9.295	43.332	13.680	220.547	514.657
La Spezia	6.226	16.150	5.358	98.251	229.337
<b>Liguria</b>	<b>27.333</b>	<b>117.133</b>	<b>45.850</b>	<b>626.292</b>	<b>1,461.087</b>
	Outdoor recreation TCM and CV	Environmental functions			
		Carbon fixation		Fire control (CV)	Landscape (CV)
		min.estimate	maz.estimate		
Imperia	2.434	1.800	4.200	650	2.256
Savona	24.169	2.250	5.250	865	3.002
Genova	32.536	3.660	8.540	2.892	10.034
La Spezia	3.086	1.500	3.500	690	2.394
<b>Liguria</b>	<b>62.226</b>	<b>9.210</b>	<b>21.490</b>	<b>5.098</b>	<b>17.688</b>

Table 5 - Quantitative relations among the various functions

⇒ column ⇓ line	Real prod.	Potential prod.	Protect. (CV)	Opport. costs	Reconstruction	Outdoor recreat.	C fixation (min.)	C fixation (max)	Fires (CV)	Landscape (CV)
<b>Real production</b>	<b>1.00</b>	4.29	1.68	22.91	53.45	2.28	0.34	0.79	0.19	0.65
<b>Potential production</b>	0.23	<b>1.00</b>	0.39	5.35	12.47	0.53	0.08	0.18	0.04	0.15
<b>Soil protection (CV)</b>	0.60	2.55	<b>1.00</b>	13.66	31.87	1.36	0.20	0.47	0.11	0.39
<b>Opportunity costs</b>	0.04	0.19	0.07	<b>1.00</b>	2.33	0.10	0.01	0.03	0.01	0.03
<b>Reconstruction costs</b>	0.02	0.08	0.03	0.43	<b>1.00</b>	0.04	0.01	0.01	0.00	0.01
<b>Outdoor recreation</b>	0.44	1.88	0.74	10.06	23.48	<b>1.00</b>	0.15	0.35	0.08	0.28
<b>C fixation (min)</b>	2.97	12.72	4.98	68.00	158.64	6.76	<b>1.00</b>	2.33	0.55	1.92
<b>C fixation (max)</b>	1.27	5.45	2.13	29.14	67.99	2.90	0.43	<b>1.00</b>	0.24	0.82
<b>Fire control (CV)</b>	5.36	22.97	8.99	122.83	286.56	12.20	1.81	4.21	<b>1.00</b>	3.47
<b>Landscape (CV)</b>	1.55	6.62	2.59	35.41	82.60	3.52	0.52	1.21	0.29	<b>1.00</b>

Note: the values should be read by column/line

The following conclusions may be drawn from the results of the economic valuations shown above:

- forest management in Liguria (perhaps more due to the effect of forest regulations and a consolidated silvicultural tradition, rather than to an explicit choice of forestry policy) is aimed at multiple use of resources, with a basic equilibrium between commercial productions with respect to those serving social purposes;
- there are wide margins for increasing potential timber production; the failure to valorise the forests in an economic sense is in line with the lack of provision of public services; economic valorisation of forest resources can and must represent an instrument for stimulating active management of the forests and hence an increase in public services; in Liguria, where the problem of forest fires is particularly serious, increased interest in active forest management would have an immediate positive effect on conservation of the forests themselves;
- the overall value of the goods and services currently supplied by forest resources in Liguria is much higher than the figure recorded in SNA; a more complete evaluation of the role of forest resources within national accounting would probably lead public decision makers to dedicate greater attention to the need to promote this sector;
- public opinion does not always have a complete view of the services provided and the savings on costs arising from the presence and management of forest resources, as is clearly shown by estimates of willingness to pay for erosion control and soil protection; there is clearly a great need to promote political sensitivity on these issues; information programmes would reinforce recognition of the role played by forest resources in the national economy.

### **3. The cost of forest fires**

As in all the other countries of the Mediterranean basin, forest fires in Italy are a problem of great relevance from an environmental and economic point of view. Two series of official data related to the cost of forest fires are periodically published by the Italian Statistical Office: the ‘value of destroyed or damaged stock’ and ‘restoration costs’ for forests damaged by fire (table 6).

Table 6 - Technical-economic data relating to damage from forest fires (ha and billions of lire, apart from the values per ha reported in millions of lire)

	forest land burnt (ha)	stock damages (current values)	restoration costs (current values)	stock damages (real values)	restoration costs (real values)	for 1 ha	
						stock damages (real values)	restoration costs (real values)
1985	76,548	52	103	89	175	1.2	2.3
1986	26,795	20	40	32	63	1.2	2.4
1987	46,040	54	64	82	98	1.8	2.1
1988	60,109	44	94	64	137	1.1	2.3
1989	45,933	27	45	37	62	0.8	1.3
1990	98,410	89	122	114	157	1.2	1.6
1991	30,172	26	33	31	40	1.0	1.3
1992	44,522	32	46	37	53	0.8	1.2
1993	116,132	111	68	122	75	1.1	0.6
1994	46,773	63	86	66	91	1.4	1.9
1995	20,994	36	35	36	35	1.7	1.7
total	612,428	-	-	711	985	-	-
average	55,675	-	-	65	90	1.2	1.7
std.dev.	28,628	-	-	31.8	45.4	0.3	0.5

Sources: ISTAT (Forest statistics and monthly statistical bulletins) on data from the forest administration (economic data); MRAAF (1995) (data on areas of forest fire).

A correct economic analysis of forest fires should be based on a hypothetical comparison between cost and benefit flows with and without fires (see Gregersen and Contreras, 1992). In this hypothetical comparison account should be taken not only of market effects connected with fires (loss of timber and non-wood products), but also unpriced products and services. Unpriced costs (or lack of benefits) probably represent a considerable part of the social costs of fires and by definition are difficult to evaluate; reference is made in such cases to recreation, soil protection, landscape enhancement, conservation of biodiversity, etc. Market costs and benefits generally have a lower weight, given the nature of the forests involved by the fires (abandoned or semi-abandoned land).

In this second case-study an attempt was made to estimate the value of four services conditioned by diffusion of forest fires: timber production, provision of recreational areas, soil protection and climate stabilisation. The modes of estimation of the four functions considered are recalled as follows (for a more detailed analysis of some methodological assumptions see Marchetti e Pettenella, 1994).

- **Timber production:** damage due to loss of income from timber sales was calculated directly from the estimates made by the forest administration regarding destroyed or damaged timber (see table 6).
- **Provision of recreational areas:** estimation of the value of the loss of recreation involved two problems: valuation of the area concerned and value of the damage per hectare of burnt forest. Using ministerial sources (MRAAF, 1994), the first figure was estimated by taking the percentage of protected recreational areas hit by forest fires from the total of burnt forest land. In estimating the average value of the recreational service, reference was made to some evaluations of this function carried out in various environmental contexts in Italy by various authors (Boatto *et al.*, 1982; Frigo, 1988; Gatto, 1988; MAF, 1991; Marchetti, 1994; Marinelli e Romano, 1987; Merlo, 1982; Tosi, 1989) and to the average number of annual visits per land area unit, thus defining two threshold values.

- **Soil protection:** the value of the lack of soil protection was estimated on the basis of the substitution criterion. Reference was made in particular to the cost of realisation and annual mowing of a meadow in conditions of average slope, as this is the situation which, as far as the provision of soil protection is concerned, represents the most logical alternative land use. Contributions for maintenance of meadows foreseen among the agro-environmental measures promoted by the European Union (Regulations 2328/91 and 1078/92) and the initiatives by single local authorities in areas where meadows and pastures tend to be abandoned, represented concrete points of reference for general estimation of substitution interventions. The area of reference was calculated on the basis of the percentage reported by the National Forest Inventory (MAF, 1988) regarding forest areas involved by soil protection constraints, with respect to the total forest area.
- **Climate stabilisation function:** this function was calculated by assuming a range of values as the shadow price for a ton of carbon, as reported in the international literature on this subject; this value was later referred, using appropriate conversion coefficients (see Cesaro and Pettenella, 1994), to average net annual increment, weighted on the basis of INFI data (MAF, 1968).

Clearly damage to a forest by fire has the effect of reducing the supply of goods and services in a period that is not limited to that of the year in which the fire takes place; it is similarly clear that the period of time to reinstate the forest's functions after a fire varies according to the case. Thus, if one wishes to estimate the economic damage from a fire in a given year, account should also be taken of the effects connected with the fall in the supply of goods and services from the forests burnt in the previous years. Referring to the 4 functions taken into account in the study, this situation may be represented analytically as follows:

$$C_t = \sum_{j=1}^4 s_{jt} + \sum_{j=1}^4 \alpha_{jt-1} s_{jt-1} + \dots \dots \sum_{j=1}^4 \alpha_{jt-m} s_{jt-m}$$

where:  $C_t$  = overall damage from fire in year  $t$   
 $s_j$  = lack of product or service  $j$  provided by the forest  
 $m$  = duration (in years) of the period in which the consequences of the fires are felt in terms of lack of products and services  
 $\alpha_j$  = weighted coefficient relating to the fall in the product or service  $j$  supplied by forests burnt in previous years (from  $t-1$  to  $m$ )

In making the estimate, it was assumed that  $\alpha$  is common to all the functions taken into consideration and that it varies following a linear trend during the period included between the year of estimation and  $m$ . The other assumptions are reported in Table 7. At the end of the study, it was thought worthwhile to undertake a sensitivity analysis for the variables that are more conditioned by subjectivity of choice.

Table 7 - Values assumed in the estimates of damages from forest fire

variables	assumptions
discount rate ( <i>i</i> )	5%
value of bare land ( <i>F</i> ; see value of grassland - mil.lire/ha)	2
age of the forest stand ( <i>n</i> - years)	10-30
planting costs ( <i>R</i> - mil.lire/ha)	5-0.1
restoration costs ( <i>Rip</i> - mil.lire/ha)	1.7
period in which the consequences of the fires are felt ( <i>m</i> - years)	5
% area for recreation that have been burnt	19.2%
value of recreational services (mil.lire/ha)	2-3.5
% area for soil erosion control (see area under 'Soil Constraint')	88.7%
cost of alternative engineering works for soil protection (mil.lire/ha)	0.4-0.6
net annual increment (cm/ha/year - coppices and highforests)	5.18-7.90
shadow value of 1 ton of C fixing (lire/ton)	35000-60000
average value of standing timber (lire/cm)	50000

Table 8 shows the results of the elaboration conducted according to the methodology described above. Estimation of the economic damages to four main services provided by forests hit by fires gave higher values than those reported in the official estimates of financial costs, confirming that the phenomenon of forest fires has social implications going well beyond the explicit costs shown in the market in the short term.

Table 8 - Estimate of damages from fires on the basis of relative loss of four services (values in billions of constant 1995 lire)

	timber and fuelwood	outdoor recreation		soil erosion control		carbon fixation		total value of the damages		cumulated values of damages	
		min	max	min	max	min	max	min	max	min	max
1985	89	29	51	27	41	4	12	149	193	n.a.	n.a.
1986	32	10	18	10	14	1	4	54	69	n.a.	n.a.
1987	82	18	31	16	25	3	7	118	144	n.a.	n.a.
1988	64	23	40	21	32	3	9	111	145	n.a.	n.a.
1989	37	18	31	16	24	3	7	74	100	324	427
1990	114	38	66	35	52	5	15	192	248	427	563
1991	31	12	20	11	16	2	5	55	72	365	484
1992	37	17	30	16	24	2	7	72	97	324	435
1993	122	44	78	41	62	6	18	214	280	453	606
1994	66	18	31	17	25	3	7	103	130	314	420
1995	36	8	14	7	11	1	3	53	65	193	258
total	711	235	410	217	326	34	95	1196	1542	2401	3195
average	64.6	21.3	37.3	19.8	29.6	3.1	8.6	108.8	140.2	343.0	456.4
std.dev.	31.8	11.0	19.2	10.2	15.2	1.6	4.4	53.5	69.4	79.2	104.6

Note: the values in the last two columns for the years 1985-88 are incomplete, as data regarding fires occurring before 1985 were not processed; the statistical indicators presented in the last three lines thus refer simply to the period 1989-95 (the total values may not be compared with those of tables 2 and 4).

For an overall valuation of the economic impact of fires on national accounting data, a first-order variable is that of defence expenditures, i.e. the set of costs borne by public and private subjects for fire prevention and control. For an estimate of defence expenditures borne by private owners, reference was made to the results of some studies on the costs of services provided by farmers for environmental conservation (Franceschetti and Rela, 1991; Tempesta and Sartore, 1993; Tempesta,

1994). No source of information was found regarding expenditures borne directly by volunteers and other private subjects and not reimbursed by public contributions. Table 9 reports an estimate of average annual defence expenditures for the period 1989-1995.

The economic dimension of the phenomenon of forest fires is equivalent to an annual average of approx. 523-736 billion lire over the period 1989-1995. The average annual values of timber mass destroyed or damaged by fire as recorded by ISTAT are, respectively, equal to 8.18% and 12.4% of the value estimated in this way. The average cost per hectare of fires is equivalent to 8.2-11.6 million lire, as compared to an average value, calculated on the basis of official statistics, of 1.1-1.6 million lire.

Table 9 - Average annual values of damage from fires and defensive expenditures over the period 1989-95 (in billions of lire; values per ha in millions of lire)

	average of the min	value damages max	defensive expenditures						total costs	
			State		Regions and	local auth.	private owners			
			min	max	min	max	min	max	min	max
total	343	456	40	60	110	170	31	51	523	736
1 ha	5.4	7.2	0.6	0.9	1.6	2.5	0.5	0.8	8.2	11.6
%	65.6%	62.0%	7.4%	7.9%	20.4%	22.4%	5.7%	6.7%	100.0%	100.0%

Sensitivity analysis was performed on the results of the estimates (table 10), from which it can be deduced that three critical variables in determining the final values of the estimates are, in order, the interest rate, defence expenditures and the value of bare land. Choice of an appropriate interest rate is a critical factor in every valuation involving problems of inter-temporal comparison of flows of environmental goods and services, while correct valuation of defence expenditure, once an appropriate system of classification of the latter has been defined, is exclusively a problem of data availability and accessibility.

Table 10 - Sensitivity analysis of cumulated damages costs of forest fire (1989-95)

variable	base-line value	test value	variation in damages estimate	test value	variation in damages estimate
value of recreational service	2-3,5 mil.lire/ha	1,5 mil.lire/ha	-6.2%	4,5 mil.lire/ha	8.6%
value of soil protection service	0,4-0,6 mil.lire/ha	0,3 mil.lire/ha	-4.7%	0,8 mil.lire/ha	7.1%
value 1 ton of C	35-60000 lire/ton	20000 lire/ton	-1.5%	75000 lire/ton	1.3%
net annual increment	5,2-7,9 cm/ha/year	3 cm/ha/year	-6.1%	10 cm/ha/year	5.6%
standing tree prices	50000 lire/cm	30000 lire/cm	-3.4%	80000 lire/cm	5.1%
defensive expenditures	181-281 bil/lire	150 bil.lire	-12.7%	300 bil.lire	11.1%

#### 4. Conclusions

The non-market roles played by mountain areas in the national economy should be recognised by introducing criteria of environmental accounting in SNA. The gap between the role of forestry in national accounting systems and the real value of the flow of social benefits deriving from the sector is particularly relevant in countries like Italy, which is highly populated, with more than 70% of its territory in mountainous and hilly areas and huge problems of soil erosion prevention.

The two case-studies presented in the paper demonstrate the feasibility of a system of forest resources accounting which allows for more correct quantification of the benefits and hence the defence expenditures needed to maintain the stock of forest resources.

However, it should be borne in mind that numerous problems, connected with organisation of surveys and more general methodological aspects, make it difficult to apply techniques of forest resource accounting. Among the methodological problems, it seems worthwhile to point out those connected with modes of valuation of variations in the stock of resources (Baardsen and Eid, 1992), classification of defence expenditure (Cullino, 1993) and application on a large scale of techniques of valuation of unpriced services. These problems should certainly not discourage attempts to construct new systems of accounting, but simply encourage greater caution in analysing the results that may be obtained from them.

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