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ENVIRONMENTAL ACCOUNTING OF FOREST RESOURCES IN ITALY: SOME RECENT DEVELOPMENTS

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Technical abstract. The paper reviews the main inadequacies of the Italian current System of National Accounting for the forestry sector. In recent years research and applications have been developed in Italy to overcome some of these inadequacies. The paper presents two case studies of environmental accounting of forestry resources at regional/national level: 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 account is based on a Geographical Information System (GIS) comprising an extremely diversified set of physical data, associated with economic information collected through the use of various evaluation methods (Travel Cost Method, Contingent Valuation, reconstruction costs, opportunity costs, etc.). Production of wood and non-wood forest products, soil erosion control, landscape protection, carbon fixing, provision of outdoor recreational areas are taken into account in the proposed System of Regional Accounting for the forestry sector. The second case study consists of a tentative estimate of damage costs from forest fires occurring in Italy over the past eleven year. Official statistical data related to financial costs deriving from forest fires are compared with the results of a tentative estimate of some social costs. Results from the two case studies could be used to evaluate the real contribution of forest activities to national economy and to better orientate public funding and defensive expenditures in the forestry sector.

Non-Technical. The paper presents two case studies of environmental accounting of forestry resources at regional/national level: the first one is an economic estimate of the role of the forestry sector in the Liguria Region (north-west Italy) through an analysis of some functions of main economic relevance: production of wood and non-wood forest products, soil erosion control, landscape protection, carbon fixing, provision of outdoor recreational areas. The main conclusions drawn from the case study results is that the overall value of the goods and services currently supplied by forest resources in Liguria is much higher than the figure recorded in SNA. 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.

The second case study consists of a tentative estimate of damage costs from forest fires occurring in Italy over the past years. 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 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 official statistics 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.

1. Introduction

In the Italian System of National Account (SNA) the contribution of the forestry sector to the GNP is only 0.05%. While on the one hand many policy-makers believe that there is a need for increasing public funding efficiency and monitoring forest policies, such policies cannot be evaluated for the lack of economic approaches in evaluating the real contribution of the sector to national economy.

In the Italian current SNA for the forestry sector inadequacies in both the methodological approach and in organisation of field surveys are relevant (Battellini *et al.*, 1996). 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 linked to damages from fire, pollution or other failings in the forest system following economic activities that are external to forestry itself (Adger and Whitby, 1993; Cullino, 1993);
- on the other hand, non-estimation of non-priced externalities, whether negative, such as environmental damages caused to forest resources by economic activities (pollution effects, for example), or positive (soil protection, water supply, landscape and biodiversity protection, carbon fixing, 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 account 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 fires prevention.

2. The Liguria Region case study

A pilot experience on organising an environmental accounting system for forest resources in Italy has been realised by means of 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 some functions of main economic relevance: production of wood and non-wood forest products, soil erosion control, landscape protection, carbon fixing, provision of outdoor recreational areas. 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 on the basis of which further elaboration may be carried out;

- 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 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, with 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 values but with high productive potential.

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)¹. For possible 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 | - | 3.734 |
| Savona | 3.057 | 177 | 1.024 | 64 | 246 | 3.442 | 66 | 8.077 |
| Genova | 1.427 | 141 | 1.443 | 1.978 | 568 | 3.738 | - | 9.295 |
| La Spezia | 1.490 | 93 | 803 | 29 | 1.018 | 2.792 | - | 6.226 |
| Liguria | 6.350 | 451 | 3.472 | 2.174 | 3.104 | 11.714 | 66 | 27.333 |

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

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

⁽¹⁾ The estimate is based on average potential production

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

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

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.

From examination of the data presented it clearly emerges that the Ligurian forests are under-employed, though marked differences exist between single sectors and at geographical level. More specifically, as far as timber production is concerned, the 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.

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 it 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). The possible reasons for this situation are 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 |
| Liguria | 27.333 | 117.133 | 45.850 | 626.292 | 1,461.087 |
| | Outdoor recreation TCM and CV | Environment functions | | | |
| | | Carbon fixation | | Fires control (CV) | Landscape (CV) |
| | | min.estimate | max.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 |
| Liguria | 62.226 | 9.210 | 21.490 | 5.098 | 17.688 |

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 of the Ligurian 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.

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

Note: the values should be read by column/line

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).

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).

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).

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. The first figure was estimated by taking from ministerial sources (MRAAF, 1994) 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 constraint, 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 the damage of 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 functions undertaken by the forest before the fire are reinstated over a period of time varying 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:

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

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

α_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 α 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) | 5% |
| value of bare land (F ; see value of grassland - mil.lire/ha) | 2 |
| age of the forest stand (n - years) | 10-30 |
| planting costs (R - mil.lire/ha) | 5-0.1 |
| restoration costs (Rip - mil.lire/ha) | 1.7 |
| period in which the consequences of the fires are felt (m - 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 'Vincolo Idrogeologico') | 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. The attempt to estimate the economic damages due to four main services provided by forests hit by fires led to 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 elaborated; 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 variable of first order 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 Relà, 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 value of the damages | | defensive expenditures | | | | | | total costs | |
|-------|------------------------------|-------|------------------------|------|-------------------------|-------|----------------|------|-------------|--------|
| | min | max | 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, with huge problems of soil erosion prevention.

The two case-studies presented in the paper demonstrate the feasibility of a system of accounting forest resources, providing the base for a 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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