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Subject:

PROPOSAL FOR A HARMONIZED METHODOLOGY TO ASSESS SOCIO-ECONOMIC DAMAGES FROM FOREST FIRES IN EUROPE

FINAL REPORT

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Executive summary:

In this work, results obtained by the comparative analysis of the national and international literature on the evaluation of forest resources are specifically referred to the aspects and procedures adopted in the economic and environmental estimate of forest fires.

In the last few years the importance of an economic evaluation of the environmental damages has increased, due to both the gradual emergence in the modern society of the environmental matter, and the many levels in which the evaluation inserts.

The economic evaluation of the environmental damage, particularly of the monetary one, represents one of the essential elements for environmental accounting.

This has become a procedure of interest not only for researchers but mainly for public officers.

In the sustainable (or better eco-compatible) development vision, it is possible to build up correct environmental policies that aim both to the reduction of restoration cost, and to the maximization of the benefits deriving from the flow of natural services, through actions of prevention.

The identification of the various types of damage and their quantification is an essential element for a correct accounting at regional and local level, functional to the public decision.

Such information is important for the execution of adapted action of prevention and fight against forest fires and then for the allocation of adapted financial resource for the execution of efficient policies.

In chapter 1, a literature review has been performed either consulting journals and specific sector studies both contacting Universities, research centers and companies in various countries that in some cases have provided useful information and documentation.

In chapter 2, we focused on the methodology for evaluating the first component of fire damages, i.e. the cost related to the decreased value of the damaged forest.

In chapter 3, we proposed a methodological approach based on the experience recently gained in Italy on forest fire damage assessment, which could be considered in developing a modular approach for fire costs evaluation at EU level. We suggest the use of 3 evaluation procedures depending on the size of the fire and the accuracy of the evaluation required.

CONTENTS

Acronyms and abbreviations

BEF	Biomass expansion factor
C	Carbon
CCX	Chicago Climate Exchange
CO_2	Carbon dioxide
DB	Data Base
EC	European Commission
ECE	Economic Commission for Europe
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GIS	Geographical Information System
GPS	Global Positioning System
ha	Hectare
l	Litre
m^2	Square meter
m^3	Cubic meter
MILVA	Mean Indicative Land Values-
NWFP	Non-Wood Forest Products
r	Discount rate
Reg.	European Commission Regulation
SAFE	Semi-Automatic Fire costs Evaluation
t	Tonne
UNFCCC	United Nations Framework Convention on Climate Change

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INTRODUCTION

The European scenario of forest fire is characterised by high frequency of the events in the Mediterranean countries. The average area annually covered by fire throughout Europe is more than half a million hectares, of which 95% occur in Mediterranean countries, with about 35.000 fires annually.

Socio-economic assessment of damages from forest fires has a particular importance in terms of support to country environmental accounting.

Nevertheless, information on the economic damage caused by various types of forest fires are still few.

As costs of fire extinction operation than costs linked to the diminution of damaged good value (products lack and supplied services) are important for a correct economic valuation of forest fire damages (Flowers 1985).

Difficulty in the economic valuation of the damage consists in the presence of multiple and joined forest productions.

Damages can be divided in (Grittani 1987):

- Permanent or temporary, when good looses the functionality it had before the event in a definitive or only a momentary way.
- Total or partial, depending if good has been concerned entirely or only in some part.

Main problems associated to damage are:

- determination of damage entity, as value of the impact of the event on economical-financial components in the event period, comprehensive of eventual loss due to good rescue operations meanwhile started;
- determination of compensation, that are due to who endured the damage, for economic-financial losses

Hence economic valuation of damages from forest fires is resulting essential even in terms of damage compensation. Then for a correct valuation, damages are classified as:

- damages to things;
- damages to environment.

For this purpose the main aim of the project was the build of a methodology for economical valuation of damages from forest fires; this method will be able to assess damages to products and services (with or without cost) characterising forest area crossed by fire and also direct extinction costs. The origin of such requirement is to search out in the political addresses of EU which require always more detailed information on protection of forests from forest fires. Therefore, knowledge of environmental, social and economic damages is important for addresses to follow for forest antifire plans and for actuation of an efficient prevention politic.

Therefore specific aims of this study were:

1. Analysis of standards, studies, reports and methods for economic valuation of damages on forest area crossed by fire in EU territory.
2. Methodological proposal for economic valuation of damages by forest fires.

Proposed methodology has to take into account various aspects.

Were analysed the costs linked to fire extinction operations performed by public and private personal to extinguishing fire and the environmental damage.

For the extinction operations was analysed:

- cost of occupied staff,

- cost of operating team,
- cost of used engines,
- effective costs for intervention (combustible consumption, delaying and other consumption material);

For environmental damage instead were analysed:

- average value for forest and uncultivated land,
- costs for restoration of burned area separating area with touristic-recreational function from other forest functions,
- single functions offered by forests (wood production, non wood goods production, tourism-recreation, hunting activities, hydrogeologic protection, fight against climate change in terms of CO_2 emission, naturalistic)

1. LITERATURE REVIEW

1.1 The context

In the last few years the importance of an economic evaluation of the environmental damages has increased, due to both the gradual emergence in the modern society of the environmental matter, and the many levels in which the evaluation inserts.
In the last decades, with the increase of the knowledge of the interaction between the human system and the environmental one, the need to evaluate the capacity of the second to support the growing weight of the first has increased.
In particular the necessity of an assessment, throughout always more analytical methodologies able to take into account the different levels of the environmental resource, has grown; on one side the value of the environment –the natural capital and the services provided for the well-being of the society – and on the other the damage associable to the loss of the environmental resource and its qualitative degradation.
Insertion of costs and environmental benefits has become a fondamental task to permit An exaustive evaluation of the sustainable development; moreover, it has pushed traditional national accounting systems towards the search for correctives.
The Earth Map[1], at point 6, indicates that it is mandatory to "Prevent the environmental damages as better way for environmental protection and, in case of unsufficient knowledge, to apply a preventive approach".

The economic evaluation of the environmental damage, particularly of the monetary one, represents one of the essential elements for environmental accounting.
This has become a procedure of interest not only for researchers but mainly for public officers.
In the sustainable (or better eco-compatible) development vision, it is possible to build up correct environmental policies that aim both to the reduction of restoration cost, and to the maximization of the benefits deriving from the flow of natural services, through actions of prevention.
In the monetary accounting, dealing with environmental costs (United Nation, 1993) means the evalutation of the necessary expenses for the maintenance of natural, almost natural or artificial ecosystem functions. In particular it is possible to distinguish expenses for the environment protection, the restoration and the compensation against environmental damages.
The costs attributed in the setting of the SEEA[2], that is the ones concerning the monetary evalutation of the damages to the natural capital, are the expenses necessary to maintain the natural resources at the same level than in the initial period. It is necessary to take into account the expenses in relation to the actions, which if performed would have allowed to avoid the damage (*avoidance* costs), or the necessary costs to restore the initial condition of the environment (*restoration* costs) and the direct evaluation method of the marketplace (as the method of the *willingness to pay*).
In a *Paretian* vision of the well-being, the costs of prevention – as in the meaning of defensive expenses as well as the loss of economic well-being for a minor economic activity level – should not be greater than those of the damage. However , in the

[1] Published in the march 2000 from the Committee for the earth map, UNEP
[2] System of Environmental and Economic Accounts

accounting of environmental costs the time element is very important: an underestimate of the "current" environmental damage compared to the "future" one would mean a decrease of well-being for the next generations and for the benefit of the current generations.
The identification of the various types of damage and their quantification is an essential element for a correct accounting at regional and local level, functional to the public decision.
For example, the costs for territory maintenance – included into the "defensive expenses" – can be compared with those coming from the loss of the environmental and social functions from a correct management of agricultural practices and forest activities. The possibility to reach an accounting at a reduced scale would allow to address the resources of the public policies (for example the agri-environmental politics actions) in a much more specific and effective way. The possibility of evaluating in advance the costs relative to the environmental damage, would allow to start explicit management policies or to define specific protection threshold (Polelli, 2003).
The juridical character is a second level to deal with the problems of the environmental damage. The modality for monetary evaluation of the environmental damage, further than supporting the environmental policies, are used in the context of compensation for environmental[3] damages. In particular with the 2004/35/CE Directive on the environmental responsibility regarding prevention and restoration of environmental damage a common discipline has been introduced for the prevention and restoration of the environmental damage, inspired from the principle "*who pollutes pays*".
The normative definition of damage involves important evaluational and economic implications, since it contributes to the definition of the environmental damage, handling with quantification methodologies.
According to the national and EU standards[4], and according to the principle "who pollutes pays", the compensation of the damage is in fact directed towards the economic recovery of the environmental damage or towards the restoration of the original level of the damaged environmental resource, and it can be made in specific way (restoration) or through indemnity (through a precise economic/monetary damage quantification) [5].
Damage effects have to be evaluated in relation to the scope, that are the various environmental components (atmosphere and water environment, soil and subsoil, vegetation, flora, fauna, ecosystems, landscape and healthyness) certainly or potentially exposed to the impacts. The damage quantification takes place starting from analytical measure of the damage caused to the environment in terms of alteration level (varation of quality level), deterioration level (usability and/or functionality loss) and destruction level, partial or total, of the ecological functions.
In the White Book, the terms "damage to the environment" include two different types of damage: damage to the biodiversity and damage in the form of site contamination. Moreover the "traditional damages" must be added, such as damage to the people –

[3] According to APAT (2006) the civil responsibility for environmental damage is between the usable tools to support the sustainable development. Standards are present at national level in Italy (art. 18 L. 349/86) and communitary (Directive 2004/35/CE of the European parliament and Council, on April 21st, 2004, on the environmental responsibility on prevention and restoration of the environmental damage).
[4] The directive is the result of reflections followed to the White Book on environmental responsibility, published in February 2000, carried out with the aim of studying the modes of execution of the environmental common policy.
[5] It is useful to specify that the law handles more on the prevention (the State force upon the potential polluter to adopt appropiate preventive actions) than on the restoration (the competent authority force upon the interessed operator to adopt the suitable restoration action).

especially to the human[6] health – and to the things. To the juridical context is tightly correlated the economic one, considering that the compensation for environmental damage, which from its nature does not have a market price, has to be however quantified in monetary terms.
According to Pallotta (2003), the preventive identification of precise criteria of the damage quantification "constitutes an indispensable condition so that the connected responsibility exercises a real preventive function: only knowing in advance the indemnity cost, one is stimulated to avoid a determinate action or anyhow to realize it with the observance of the opportune cautions".
If the economic evaluation is the approach which allow to determine the economic value of environmental good and therefore to be able to measure the improvements or worsening of the environmental state, analysis methods have been developed only recently. This reflects on the continuous evolution of tools and on the debate, between the researchers, regarding their application.
According to Pearce and Turner (1991), when the economic values are referred to the natural environment, there is an emergence of components of value which traditional economy has ignored, as the option value and existence value, that add to the traditional value components, associated whit the use of the natural resources.
In general, problems of economic evaluation of environmental goods exist in the fact that the economic evaluation tools commonly used are unable to fully gather some aspects of life quality, the inter-generation dimension of evaluation and the intrinsic value of the natural resources.
The evaluation of the environmental damage, understood as a worsening of the flow of well-being coming from a good with collective fruition, must permit the identification of the sum with which it is possible to acquire goods able to provide a utility flow equivalent to the one lost. Such sum corresponds to the well-being contraction experienced by the user (broadly speaking, present and future) of the damaged good. The evaluation is essentially divided in four phases.

- The first, identifies the affected subjects, in order to distinguish the damages to goods or private activities, from those to public fruition goods.
- The second, identifies the most appropriate methods to estimate each damage component, based on traditional estimate methods or indirect type methods, when some adaptations are observable in the market of the affected subjects and/or responsibles, and with direct type method or methods based on the principle "*resource for resource*" or "*service for service*", in case these behaviour are not observable.
- The third, is dedicated to the identification of the damage temporal profile and it aims to calibrate the estimate on the basis of the reversibility of the damage and the resource restorability.
- The fourth, finally quantifies the damages on the basis of the costs of restoration (not limited exclusively to the "remediation" actions), the lack of transient or permanent benefits, the subrogation costs or, alternatively, the profit improperly received by the transgressor.

[6] The article 174, paragraph 1 of the CE treaty affirm that the environmental communitary policy contributes to pursue, among others, the objective of human healt protection.

In addition to the above mentioned tool an analytical approach, which is called "Costs-Benefits Analysis", gives informations on the economic value of the changes in terms of quality and quantity of the environment state and informs the policy maker about the efficiency of the actions to undertake.
The environmental goods - air, water, fauna, landscape, are, according to economic perspective, assessable goods as they offer a flow of services to individuals. The activities of the state and of other institutions, those of single citizens and of the companies, involve some changes in the flows of such services which cause costs and benefits. The measurement process of the changes in the economic value of the services provided by the natural resource is, therefore, similar to a costs/benefits approach as intended from an economic point of view

1.2 Estimating forest fires

The methodologies for evaluating the environmental goods were developed initially from well-being economies with the "purpose of comparing *ex ante* all those costs and social benefits that come from the restricted areas of the financial analysis (exclusively based on the costs and private benefits)" [Bognetti, Moretti and Rimini, 1994, p. 179] and that must be considered when taking decisions on public projects [7] (Nuti, 1987).

For the goods that have a reference market, the estimate of environmental damage can be performed as in place, with the example of the quantitative reduction resulting from the pollutant agent, as in reference to the reduction of the price of the good as a result of its contamination to estimate the extent of deterioration.
For environmental goods that do not "pass" by the market, estimate techniques are classified into direct and indirect methods.

The direct methods are based on the treatment of answer, since it's possible to obtain relations between price and quantity of an environmental resource by linking it to the purchase and to the use of goods of different nature, easily quantifiable and having a connection with it or simulating the existence of markets, asking directly respondents, through sophisticated polls, their assessments for the ecological wealth in question [Bresso, 1993].
The indirect procedures "try to appraise the environment with reference to market valuations in some way dependent on the quality of the environment" [Musu, 2000, p. 62].

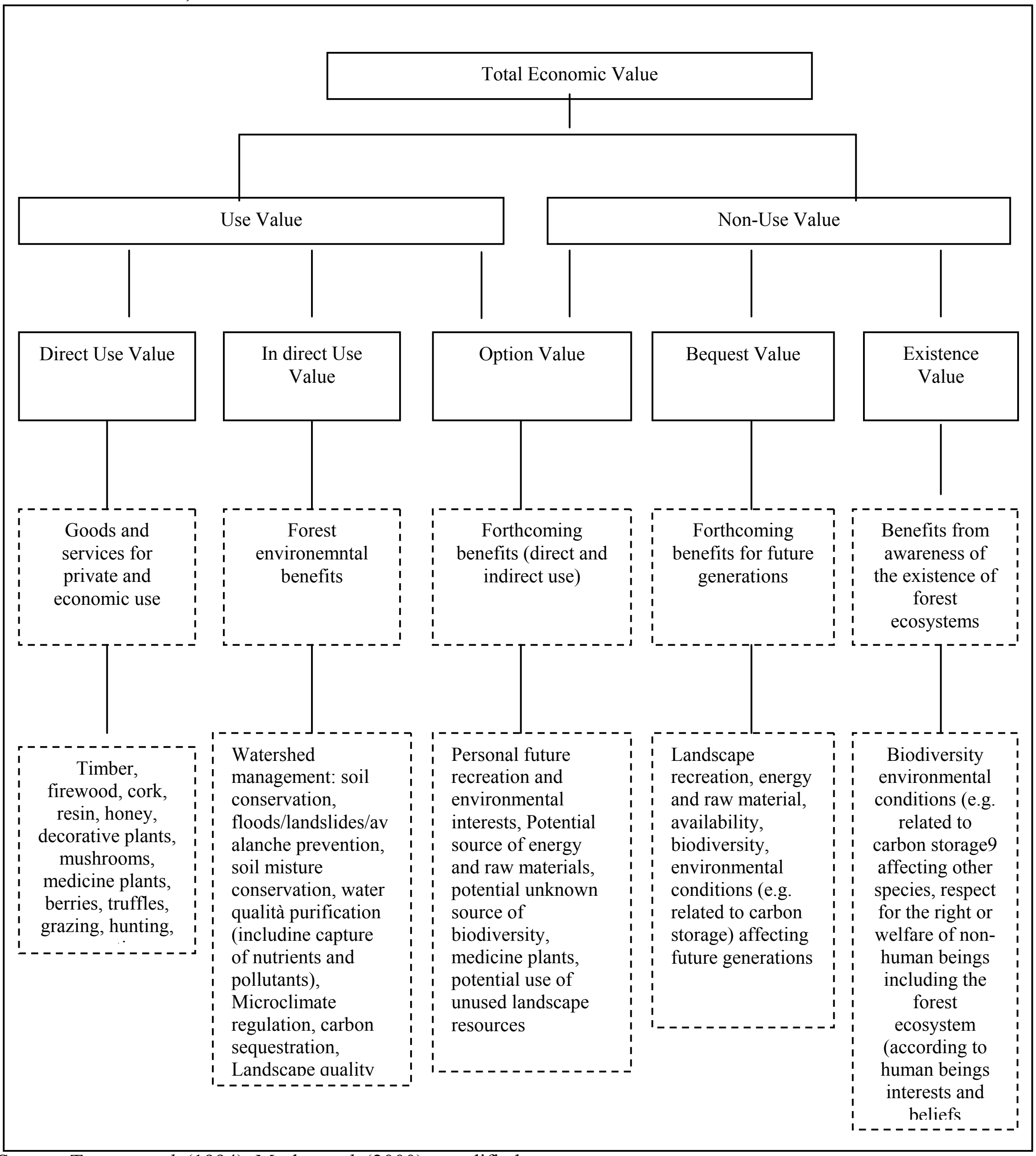
The assessment of environmental damage, relating to the monetization phase, can be carried out with various methodologies.
Polelli et al., (2003) report among other cost-benefit analysis, cost-effectiveness analysis, the analysis of "the ecological economy" (which includes sustainable development, the load ability, life cycle and stationary economy), the analysis "of

[7] The investigation takes the name costs-beneficts analysis and intends to drive the public choices between various intervention hypotheses with the aim of maximising the collective well being; it founds on the principle of the verification of the best one between the alternative or the ascertainment that costs are lower than the obtainable benefits from a project with public repercussions so as to realize a situation for the company preferable to the previous one, according to the Paretian criteria [Pozzo; 1998].

environmental economy " (which includes evaluation of monetary value in use through quota evaluation, travel costs, edonic prices).
The methodological approach proposed in the present project for the assessment of environmental- economic of damage of forest fires, is built largely on one of the basic concepts of the environment economic - the Total Economic Value, TEV - which defines the value of an environmental good as the sum of the different types of values - of use and non use - linked to the flow of benefits that human being receives from the good; here the damage is defined according to the loss of individual functions performed by forests.
Forest resources provide a range of goods and services to the society in the form of private and public goods.
In particular, TEV, as depicted in Figure 1, consists of a variety of components (Marangon and Storm 2000; Cavatassi, 2004; Merlo and Croitoru, 2005). The value of use results from the real use of the resource and can be divided value of direct and indirect use.

The first essentially concerns the goods such as timber, non wood goods – NWG, firewood, grazing, hunting and services that provide private benefits such as recreational tourism.
The value of indirect use concerns environmental functions carried out by a forest such as hydrogeological protection, water cycle regulation, biodiversity conservation and fixation of atmospheric carbon.
Regarding the option value, it refers to the preservation of a possible future direct or indirect use of forest resources. The value of non-use is related to the possibility to preserve forests resources for future generations (bequest value) and to the fact that forest exists. (existence value).
The functions and individual services return by the environment are included in the equation, but it only return the secondary economic value, as the total one comes from interaction and integration of all components of an ecosystem and is due to its ability to support life [Turner, Pearce and Bateman, 1996]. Table 1 shows an example of the forests outputs (according to TEV) applied to forests in the Mediterranean region.

FIGURE 1 – TEV, TOTAL ECONOMIC VALUE COMPONENTS IN FORESTRY



Source: Turner *et al.* (1994), Merlo *et al*. (2000), modified

TABLE 1 – OUTPUT FROM FORESTS IN THE MEDITERRANEAN AREA

POSITIVE OUTPUTS*
1. USE VALUES
1.1 Direct use values
1.1.1 Products: timber, firewood, cork, resin, hunting* grazing, sparto grass, honei*, decorative plants*, mushrooms*, recreation*, medicine plants*, berries*, truffles*, etc.
* outputs than can be internalised, depending upon property rights of hunters, pickers, etc., paying a price, or by the Public Autorities selling permits. Often, forest owners do not have rights over the so called "secondary products".
1.2 Indirect use values*
1.2.1 Protection: watershed management, soil conservation, avalanche prevention, flood prevention, etc.
1.2.2 Landscape quality
1.2.3 Micro-climate regulation
1.2.4 Water quality and purification
1.2.5 Conservation of the local ecosystem
* Outputs can be internalised, to a certain extent, within the local economy. Internalisation can occur spontaneously, or through co-operative efforts amongst activities, as can be in the case of water resources.
2. OPTION VALUES*
2.1 Personal future recreation and environmental interests
2.2 Potential source of energy and raw materials
2.3 Potential unknown source of biodiversity, medicine plants, etc
2.4 Potential use of un-used landscape resources
* Outputs can be internalised, to a certain extent, within the households and the local economy, e.g. the value of properties increases with proximity to forests.
3. NON-USE BEQUEST VALUES*
3.1 Landscape, recreation, energy and raw material availability, biodiversity, environmental conditions e.g. related to carbon storage affecting future generations
* Outputs can potentially be internalised through conservation incentives
4. NON USE –EXISTENCE VALUES*
4.1 Biodiversity, environmental conditions e.g. related to carbon storage affecting, other species, respect for the right or welfare of non human beings including the forest ecosystem
* Outputs can potentially be internalised throught conservation incentives
NEGATIVE OUTPUTS*
Erosion, floods and avalanches due to poor or no forest management
Loss of landscape values to excessive expansion of forest land use
Pollen and other allergic factors
Risk of damage by forest fire
Loss of biodiversity, landscape values, etc due to plantation forestry

Loss of recreation opportunities due to intensive plantation forestry and poor management

Source: Merlo *et al* (2000)

The economic assessment of forest fires is part of the above described plan and requires an estimate of marketed value, costs, use of the different elements that are potentially involved (Giacomelli et al., 2003).
The damage from forest fires owes its main peculiarity to the nature of mixed good of forest (Muraro & Merlo, 1987) from which derives the existence of a public and a private profile.
The damage estimation to private goods shows many references in the literature (Pomelli 1997, Michieli & Michieli 2002, Galleranti et al., 2004), although only Michieli & Michieli (2002) have dealt in a specific way with damage from fires in wooded areas with a brief case unable to explain fully the complex issue of fires. In relation to studies on damage to public goods the few studies has been summarized in Marangon & Gottardo (2001).
A calamitous event, with human or natural origin, that affects the territory, can cause direct (or primary) damages, and/or indirect (or secondary) to collectivity.
In particular, for direct damages we mean the effects to those (company, consumers, peoples) that suffer an immediate loss of well-being due to the loss or the damaging of goods which are normally used for the productive function and settlements. Thus goods of law, market and private.
In the case of forest fires the direct damages are the one which strike private goods and can lead to the loss of agricultural production and of lands productivity with time, to damages to the estate structures and to the decrease of the land value imputable to the different productive potentiality of the ground, the loss of wood and non wood products (mushrooms, truffles and others ground cover products).
The indirect damages are still charged to the individuals who, in this case, suffer a loss of benefit as consequence of a reduction or compromising of the functions which, normally, are produced by the damaged resources and that carries, even if in an indirect way, to a decrease of the collective well-being.
The loss of usefulness due to the environmental damage, which happens with the loss or the damaging of the environmental goods falls down in this category, and then the reduction of the relative flows of public services normally produced. In this category service loss of hydrogeological protection, landscape loss, biodiversity damages, carbon dioxide emission are included.
The sociale damage has to be then added to these two fundamental types. In fact, events as acute than diffuse, relative to the land fragility sharpen the one that sociologists call the perception of the environmental risk (Beck, 1986).
Definitively, the evaluation of the imputable damage to forest fires involves the analysis of market goods, prevalently private, and public goods, close to goods and service with environmental nature. While the first are easily referable to the traditional estimate, the second, of more recent interest, has to be examined with the methods of the environmental estimate. In addition to social and economic goods connected to the risk and its perception, have to be then considered.
The concept of TEV appears as a basis from which it is necessary to start, but that will turn out useful to get over. Such methodological difficulties, both in the typologies of considered goods, than in the estimation methodologies, arise from the literature analysis.

1.3 Approaches to the study of economic damages from fire, cases study

In this paragraph results obtained by the comparative analysis of the national and international literature (see Appendix I) on the evaluation of forest resources are specifically referred to the aspects and procedures adopted in the economic and environmental estimate of forest fires.

The research has been performed either consulting journals and specific sector studies both contacting Universities, research centers and companies in various countries that in some cases have provided useful information and documentation (see Appendix 2).

A first result that emerges from the work has been the poorness at international level of studies performed in this sector. Furthermore, the theme is treated in a quite heterogeneous way, with various degrees of examination. Under the methodological profile these studies face the theme of the forest fires highlighting and estimating differentiated damage components, while estimation processes can be of synthetic or analytical type. The single methods will fully be described in paragraph 1.5.

Vega Araya[8] proposes a simplified methodology for the economic estimate of the environmental damage caused by the fires in Costa Rica[9], on two study cases: national refuge de Vida Sylvan Black Caño and Palo Verde national park. The methodology foresees the damage calculation according to a synthetic and an analytical procedure, where all the environmental functions are evaluated. The author reports only data regarding the synthetic estimate. The National Refuge de Vida Sylvan Black Caño has been interested in the period between March and May 2003 by ten fires which have covered a 906,50 ha area affecting various vegetation types. Damage (table 2) has been estimated taking into account the renovation cost, linked to the loss of the environmental functions (water, biodiversity, carbon fixation, aesthetics) and to the costs for active struggle for fire extinction; the social cost, linked to goods and services provided by the natural resources as for example hydrogeological damage, biodiversity, carbon fixation and aesthetics beauty has not been calculated.

TABLE 2 – FOREST FIRES EVALUATION DAMAGES IN COSTA RICA

Cost typologies (US$)	RNVS Cano Negro (906 ha)	PN Palo Verde (448 ha)
Reconstruction costs	842.329	823.626
Social cost	0	503.240
Others costs	78.759	0
Total costs	**921.088**	**1.326.866**

Same process has been used for the estimate of the environmental damage in the national park. On april 14th 2004 the park has been affected by violent fires that has destroyed 448,46 ha including natural vegetation and crops. In this case the extinction

8 IPS Foundation (http://ips.or.cr). The methodological proposal is based on the evaluation of environmental damage of SINAC (Barrantes, G., Di Mare M.I., 2001. Metodologia para evaluacion economica in Costa Rica).

9 www.fire.unifreiburg.de/.../Oct%2004%20Network%20Meeting/PAWFC-Net-04-Vega-Barrantes-Paper-22-Oct-2004.pdf

costs have not been considered. Considered damages refer to those actions which can change natural resources functioning:

- Contamination
- Introduction of exotic organism
- Deforestation
- Mining
- Landscape modification
- Water regime modification
- Abusive soil uses
- Buildings

In the specific, the impact of fires on the natural resource can concern:

- Soil and substrate
- Water
- Air
- Energy: calories from combustion
- Biology: fauna, flora, funga, unicellular organism, estuaries, lake, wetland, forest
- Landscape: panoramic view, mosaic habitat, aesthetic elements.

Barrantes G.M., considering again the case study of RNVS Cano Negro dealing with environmental and social damages through analytical process: the cost has been estimated $ 1.176.700. Therefore, the total amount is $ 2.097.788.

A different process is the one elaborated by the Economic and Environmental Program for Southeast Asia (EEPSEA) and the World Wide Fund for Nature (WWF) to assess damage caused from fires and smoke in 1997 in Indonesia. Such fire affected 5 million ha (20% forest, 50% plantations/agriculture and 30% unproductive) and 70 million peoples had been menaced in various regions. The work has been performed with researcher coming from Indonesia, Malaysia and Singapore and international experts advice and brought to results in the table 3. The document[10] provides only economic value of the damaged components, without entering the estimate procedures. Losses in agriculture concerned plantations and young agricultural companies. Damages caused by smoke on the photosynthesis and pollination have not been included.
The direct benefits included non wood forest products (food, local medicine, raw materials) while the damages connected to the indirect benefits have been estimated depending on the missing protection from hurricanes, supply and regulation of water, control of erosion, soil formation, nutrient cycle. For biodiversity the damages connected to the potential loss of species have been estimated.
In table 3 amonts are shown, included those connected to the smoke regarding health, tourism and other; instead, damages at long term scale such as productivity reduction, aesthetic value, incident, life loss, evacuation and losses of confidences of foreign investors have not been included.

10 www.idrc.ca/eepsea/ev-8439-201-1-DO_TOPIC.html

The value of timber taken into account for the estimate is 50 \$/m3 value which takes into account the timber stock estimates by the Indonesian government, the estimates of forest growth and net property of the international prices. The value related to direct benefits is equal to 530 \$/ha/year. For the non wood products a period of five years has been considered for the regeneration. The values concerning the culture, the wood, the climate regulation and the genetic resources have not been considered to avoid double accounting.
A similar procedure has been used for the estimate of the indirect benefits. The data considerated is of 1.481 \$ /ha/year considering a period of 2 years to restore the initial conditions. The calculation was based on the consideration that the 50% of the total forest has been "really burned".

TABLE 3 - DAMAGES LINKED TO FOREST FIRES AND SMOKE IN INDONESIA, 1997

Forest fires damage evaluation	
Loss type	**(\$US millions)**
Timber	493,7
Agricultural	470,4
Direct forest benefits	705
Indirect forest benefits	1.077,1
Biodiversity loss	30
Costs connected to fire management	11.07
Carbon release	n.d.
Total	**2.787,9**
Damages from smoke	
Health	924
Tourism	70,4
Other	17,6
Total	**1.012**

For the estimation of damages to biodiversity the value of 300 \$/km2/year has been calculated on the basis of several studies concerning the willingness to pay to preserve the rain forests. The costs connected to the fire management activity refer to the costs linked both to the participating staff from Indonesia and to the staff from other countries.
For the estimate of carbon emission the figure considered in the study is 10 \$/ton taking into account the surface of 4,56 millions with respect to 5 millions of the total surface. The *Intergovernmental Panel on Climate Change* consider a 30 \$/ton as maximum price.

Various studies have been conducted also by Türker[11]. A first one has allowed to assess damages suffered by Turkish forests depending on timber loss and reforestation and extinction costs (tab. 4)

[11] Karadeniz Technical University, Faculty of Forestry, Departement of Forest Engineering, Forest Economics Division, Turkey

TABLE 4 – ESTIMATED DAMAGES IN TURKEY

Damages type	**Damage value($US)**
Timber damage	2.222.987
Riforestation costs	4.548.601
Extinction costs	1.835958
Total	**8.607.537**

Such costs together with those connected to the soil erosion and the illegal actions represent the components that negatively affect the TEV.

In table 5 are reported the positive components of TEV together with the damage values. In some cases components of TEV are classified in main components and sub components as positive, use value, non use value, existence and legacy option (Permane t al., 1995, Adamowicz, 1995; Merlo and Briales, 2000; Türker et al., 2003a).

TABLE 5 – TOTAL ECONOMIC VALUE OF FOREST IN TURKEY

Components of TEV	**Type of Outputs**	**Value ($US)**	**%**
Direct used value	Wood Forest Products	44.9815.000	41,9
	Non – Wood Forest Products	86.044.495	8
	Grazing	225.000.000	21
	Hunting	17.800.000	1,7
	Angling	20.148.000	1,9
	Recreation	2.000.000	0,2
in direct used value	Carbon storage	158.400.000	14,8
option value	Pharmaceuticals	112.500.000	10,5
existence value	Biodiversity Conservation	1.380.000	0,1
Positive TEV Components		1.071.087.995	100
Negative Externalities	Erosion	-125.000.000	72
	Forest fires	-8.607.537	5
	Illegal fuelwood	-40.000.000	23
Negative TEV Components		-173.607.537	100
TEV		897.480.458	-

Sources. Türker et al. (2002a) and Bann and Clemens (2001)

Türker used a critical approach for the calculation of economic value of damage by forest fires in Turkey[12]. In addition to loss of timber, reforestation and extinction cost, additional damages were estimated, such as: loss of revenues of the land (Deprived Land Revenues), General Administration Costs and alternative employment costs (Alternative Labour Costs). The data reported in Table 6 refer to the estimate of damage calculated in Kumluca. This is an area of 417 ha which in 2000 suffered a forest fire. In particular, the loss of timber damage was calculated by multiplying the volume of timber by the price fixed by SFE[13] according to the Forest Law n. 6821 - article 112, whereas the reforestation cost multiplying the area by the relative price fixed according

[12] Turker M.F. (2005). A critical Approach to the Calculation Method of Economic Value of Forest Fire Damages in Turkish forestry: A Case of forest Enterprise From Mediterranean Region, International Forest Fire News n. 33
[13] State Forest Enterprise

to article 114. The extinction costs (machinary and food) were calculated in function of data reported in the Fire Damage Report.

TABLE 6 – TOTAL ESTIMATE OF ECONOMIC DAMAGE IN KUMLUCA (TURKEY)

Damage type	**Damage value ($US)**
Timber	129.991
Reforestation Cost	192.405
Extinguishing Cost	45.268
Loss income from land use	15.490
General Administration Cost	5.922
Alternative employment costs	21.568
Total Damage Value	**410.644**

Forest fires damages have also been studied in Spain by Armando Gonzáles-Cabán[14], which indentified the environmental components involved in the forest fire. In the paper an overview to evaluate the economic damage is presented, considering:

- Loss of marketed timber and others goods;
- Loss of soil productivity
- Destruction of property
- Effects on catchment areas
- Loss of agricultural production
- Effects on landscape, recreation activities and wildlife.

In Italy recently, a methodology for estimating economic damage from forest fires has been proposed by the Italian Academy of Forestry Sciences[15] providing an exausthive methodology for estimating the cost of extinction, environmental damage and special external costs. The study has been commissioned by the National Forest Service.

The costs of extinguishment are those relative to machinery, equipment and personnal used in fighting against fires; environmental damage is calculated on the basis of goods and services with and without market and finally the special external costs are related to personal injuries, infrastructure damage, general organizational costs associated with interventions to fight against fires and post – fire restoration.

The adopted procedures can be divided into (Figure 2):
- synthetic: based on costs and standard coefficient;
- intermediate: based on price list
- analytical: based on data collection and processing.

[14] Gonzáles-Cabán A. (1998) Aspetos Ecónomicos de la Evaluación del Daño de Incendios. Serie Geográfica vol.7 pp.87-95

[15] Ciancio O., Corona P., Marinelli M., Pettenella D., Valutazione dei danni da incendi boschivi, AISF, Firenze (Italy), 2007

The methodology is being testing for some fires that affected Italy, starting with the the south, so far one case in the Province of Cosenza, Longobucco municipality. The fire covered an area of 13.5 ha of pine forest with an age of about 60 years (tables 7 and 8).

TABLE 7 - EXTINCTION COST OF THE LONGOBUCCO FIRE (ITALY)

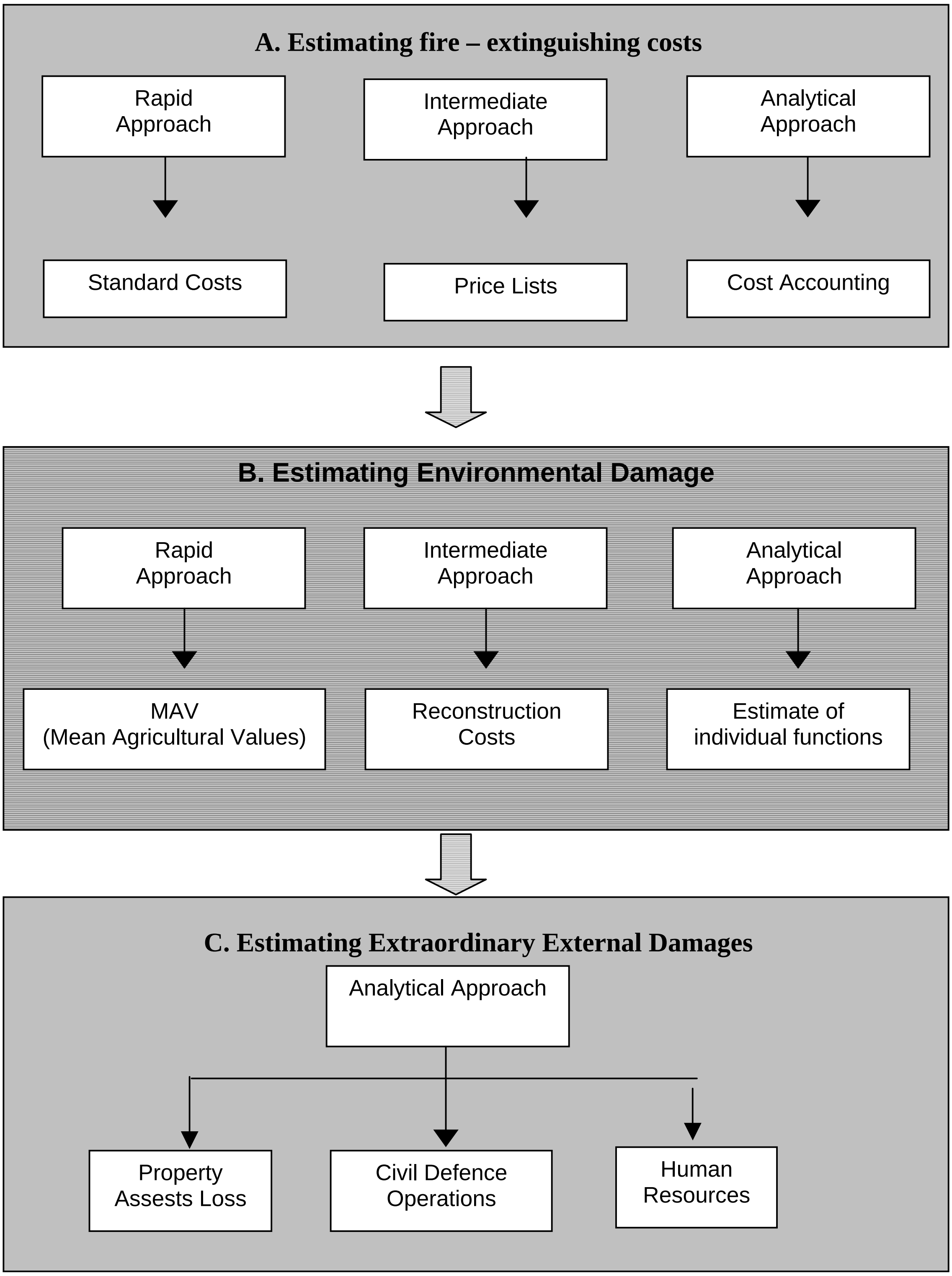
Extinction Cost	
NFS patrols and aircraft costs	47.572 €
Extinction cost of private workers	780 €
Total extinction cost	**48.352 €**

TABLE 8 - ECONOMIC ESTIMATES OF ENVIRONMENTAL DAMAGE ACCORODING TO THE APPROACHES IN FIG.2

Environmental Damage	
Rapid Approach	66.555 €
Intermediate Approach	72.078 €
Analytical Approach	76.335 €€

The table 8 shows the results obtained adopting the three different procedures for the estimate of environmental damage.

FIGURE 2 – PROCESSES OF ESTIMATE OF THE DAMAGES, THREE DIFFERENT WAYS (ITALY), 2007



1.4 Comparison and Discussion

Table 9 compares parameters involved in the studies above examined.

TABLE 9 – FIRE FEATURES AND METHODOLOGIES

Authors	Burnt area (ha)	Aim	Goods type	Year of reference	Vegetation types	Institution	Typology of estimated costs/damages
IAFS, Italy	13,5	Methodological	public/private goods	2007	Pine forest	AISF/NFS	Timber product, nwgs, recreation, hunting, soil and water protection, carbon emission, biodiversity, fire extinction costs
EEPSEA-WWF Indonesia	5.000.000	Methodological	public/private goods	1997	plantation, rice fields	EEPSEA-WWF Indonesia	Farming, timber product, biodiversity, damages connect to the direct and indirect benefit loss of forest, carbon emission
Araya, Costarica	906,5	Methodological	public/private goods	2003	various vetetable typologies	IPS	restoration of the damaged ecosystem, environmental service loss (water, biodiversity, carbon emission, aesthetics beauty), fire extinction costs
Araya, Costarica	448,46	Methodological	public/private goods	2004	mixed forest, grass, aquatic plant, agricultural	IPS	restoration of the damaged ecosystem, fire switching off costs
Turker, Turkey	417	Methodological	public/private goods	2000	n.d.	Karadeniz technical University,	Timber product, extintion costs, deprived Land Revenues, General Administration Costs, Alternative Labour Costs

The studies are quite heterogeneous both under the evaluation profile - type of vegetation and size – either for the values that the researchers have considered. Beside recurring voices such as the costs of the exticntion and the loss of primary products (wooden and agricoltural), others exist much more differentiated, also inside the same category. Furthermore, although the considered cases are limited to a concentration in recent years, factor to be correlated both to the recent development of the economic-environmental evaluation methodologies and a bigger environmental and emotional phenomenon impact, this would prevalently explain also the methodological nature of some studies, mainly performed in the research domain than for supporting decisors or as environmental accounting tool. The analysis has also shown the adoption of processes as of synthetic type than of analytical type. In the one of IAFS and of IPS, unlike the other ones, it has to be noted that both processes have been used (table 10). This can also be taken as a sign of the will to explore different approaches.

TABLE 10 - METHODOLOGIES COMPARISION ACCORDING TO ESTIMATE CRITERIA

APPROACH	AISF	IPS	TURKER	WWF- EEPSEA
SYNTHETIC	X	X	X	
ANALYTICAL	X	X		X

Table 11 shows a comparison between the methodologies regarding the level of detail of the estimates referred to the involved environmentantal components. As the table underline the AISF methodology is the most exhaustive for some aspects since it suggests an analytical estimate of the single functions performed by the forests. The multipurpose approach is generally present in the various studies, but for environmental damage estimates, both IPS and EEPSEA methodology, remain at an associated level, considering togheter the loss of goods and services, the human healt damages and the benefits loss linked to the existance value – legacy value. In particular, the environmental damage calculated according to IPS has been estimated adding the rebuilding expenses to those relative to the loss of goods and services offered by the natural resource and the human healt damages. Regarding the environmental damages estimate according to EEPSEA-WWF it includes the expenses for the loss of direct and indirect forest benefits, biodiversity and timber. The raw material and the final consumer product is naturally always considered, and the procedure proposed by IPS explain also social aspect as those connected to the health.

TABLE 11 – ENVIRONMENTAL COMPONENTS

<table>
<tr><th>VALUE</th><th>AISF</th><th>IPS*</th><th>TURKER</th><th>EEPSEA-WWF</th></tr>
<tr><td>Agriculture</td><td>X</td><td></td><td></td><td>X</td></tr>
<tr><td>Timber production</td><td>X</td><td rowspan="8">X</td><td>X</td><td rowspan="8">X</td></tr>
<tr><td>NWG</td><td>X</td><td></td></tr>
<tr><td>Hunting</td><td>X</td><td></td></tr>
<tr><td>Soil and Water protection</td><td>X</td><td></td></tr>
<tr><td>Recreation</td><td>X</td><td></td></tr>
<tr><td>Carbon fixation</td><td>X</td><td></td></tr>
<tr><td>Biodiversity</td><td>X</td><td></td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>Human health</td><td></td><td>x</td><td></td><td></td></tr>
</table>

Note: for IPS methodology the environmental damage connected to the loss of services performed by forests (water protection, conservation biodiversity, carbon fixation, aesthetic beauty) is reported.

Table 12 shows a comparation between methodologies in terms of quantification of damage related to the extinction costs, environmental damage, agricultural damages and those connected to the property destruction. Data relative to the environmental damage estimate according to Turker, refer to the costs connected to timber loss and reforestation.

As showed by the standard deviation, differences are remarkable. In the case of extiction costs, voice regarding all the evalutations, it seems to be a direct relation whith the event scale. Besides explanations regarding the economic structure (labour cost, raw material markets, etc.) and the scale, changes are imputable to methodologies. These "weight" overall with regard to the analyticity of the environmental evaluation. In any case this first review shows the demand of an in-depth scientific comparison at international level, but also the necessity of leading other studies to improve methodology and have a complete case history.

TABLE 12 - QUANTIFICATION DAMAGE FOR GOOD TYPE ON HECTARE

Type of Istitution	fire-extinguishing costs		Environmental Damage		Agricolture		Total Costs	
	$	$/ha	$	$/ha	$	$/ha	$	$/ha
AISF	61.891	4.585	97.709	7.237	0	0	159.600	11.822
IPS (*caso studio PN Palo Verde)*	0	0	1.326.866	2.959	0	0	1.326.866	2.959
IPS (*caso studio RNVS Cano Negro)*	78.759	86,89	1.176.700	1298,11	0	0	1.255.459	1.385
Karadeniz technical University, faculty of Forestry, Departemente of Forest Engineering, Forest Economic Division Trabzon, Turkey	45.268	108,59	322.396	773,4	0	0	367.664	882
EEPSEA - WWF Indonesia	11.700.000	2,34	2.305.800.000	461,16	470.400.000	94,08	2.787.900.000	557,58
Aritmetic mean		957		2.546				3.521
Standard deviation		2259,99		2793,83				4731,04

1.5 Estimate functions and Values

1.5.1 Private goods

1.5.1.1 Timber products

González Cabán: Economic aspects of assessing damage from forest fires

For the estimate connected to timber loss, Gonzáles Cabán proposes the following formulas which are used in most economic literature by the analysts.

$VP_{damage} = VP_{cut} – VP_{unburned}$ *(Montgomery et al., 1986; de Ronde et al., 1986)*

The damage can be also evaluated depending on the difference between the current value with and without fire

$VP_{damage} = VP_{no\ fire} – VP_{fire}$ *(Brown y Boster, 1978***)**

Montgomery et al. (1986) suggest the following formulas to estimate the damage depending on the waited production

$VP_{damage} = SE_{no\ fire} – SE_{fire}$ *(Montgomery et al., 1986) ,* where

SE= Soil Expectation
VP = Economic value

Italian Academy of Forestry Sciences

The evaluation of the loss of timber products according to the methodology of IAFS is considered as depending on the market value of the destroyed mass following:

$$ED_w = area * Vol * \frac{P_{ro} - C_{fl}}{(1+r)^m}$$

where:
ED_w = environmental damage due to wood-producing loss (€);
area = area burned by the fire (hectares);
Vol = volume of wood lost after the fire (m^3/ha);
P_{ro} = mean roundwood price at roadside (€/m^3);
C_{fl} = felling and logging costs (€/m^3);
r = discount rate;
m = years needed to reach the mean rotation age.

1.5.1.2 Non wood goods

Italian Academy of Forestry Sciences

The evaluation of the damage connected to the non timber products loss is estimated following the missed incomes of the product sale according to:

$$ED_{NWFP} = area_{NWFP} * R_{NWFP} * \frac{(1+r)^p - 1}{r*(1+r)^p}$$

where:
ED_{NWFP} = environmental damage from the loss of non-wood forest products (€);
$area_{NWFP}$ = area that produces non-wood products burned by the fire (ha);
R_{NWFP} = mean annual income from non-wood forest products (€/ha);
r = discount rate;
p = years of lost harvests of non-wood products following the fire

Methodological approach for the economic assessment of forests TEV and of damages from fires in the Forests (Turkey)

Only a figure of the economic value has been provided concerning the non timber forest products in Turkey. It is equal to 86.044.495 US$, the 8% of the TEV of the total forest.

EEPSEA – WWF Indonesia for the fires forest estimate in Indonesia

The figure taken into consideration for the estimate is equal to 530 \$/ha/year. The values have not been considered concerning culture, wood, climate regulation and genetic resources to avoid double accounting.

1.5.1.3 Missing income relative to the land use

Methodological approach for economic estimate of forests TEV and damages from fires in the Forests (Turkey)

Turker proposes the following formula to calculate the economic loss for the missed land use.

$K_0 = B\ (1.0\ P^n - 1)/1.0\ P^n$ *(Firat and Miraboğlu 1977; Miraboğlu 1979)*

where:
K_0 = is the return from the soil for year of non use
B = Soil value
n = years of missed productivity
p = rate of interest

and
missed income = K_0 * fired surface

1.5.1.4 Destruction and lost property

González Cabán: Economic aspects of assessing damage from forest fires

No specific procedure is reported to assess the damage. Informations are given about possible losses of properties that are classified as direct and indirect loss.

1.5.1.5 Loss of raw materials and final consumer products

IPS, Methodology for economic assessment of environmental damage in Costa Rica

When fire affects the natural resource, losses occur both for raw material and final consuming. These losses are estimated by the following equation:

$$BP_1 = \sum_{t=1}^{T} \sum_{J=1}^{n} \sum_{i=1}^{m} (p_{ji}^{mp} q_{tji}^{mp} + p_{ji}^{cf} q_{tji}^{cf})(1+r)^{-1}$$

where:

BP_1 = benefit lost from primary goods and consumer goods (¢ Colón Costaricano)

p_{ji}^{mp} = primary goods price *i*, which is derived from the J^th primary good *j* (¢Colón Costaricano /unita)

p_{ji}^{cf} = price of the final product *i* (¢ Colón Costaricano /unita)

q_{tji}^{mp} = quantity of primary goods *i* from *j* at the time *t* (unit)

q_{tji}^{cf} = quantity of final product *i* derived from *j* at the time *t* (unit)

1.5.1.6 Benefits lost connected to level of protection of natural resources

IPS: Methodology for economic assessment of environmental damage in Costa Rica

Natural resources provide protection against natural disasters and goods and services. An estimate of economic damage can be obtained accounting: 1) the costs incurred to minimize the risks of natural disasters, 2) the costs of alternative measures to ensure the flow of goods and services. The estimate can be made through the equation:

$$BP_2 = \sum_{i01}^{n} (c_i^{pr} q_i^{pr} + c_i^{afp} q_i^{afp}) + \sum_{t=1}^{T} (G_t + M_t)(1+r)^{-t}$$

where:

BP = Lost of Benefits linked to the level of protection provided by natural resources

c_i^{pr} = Cost of the entrance which is used to determine the measures of protection (¢ Colón Costaricano per unit)

c_i^{pr} = Cost of entry for the creation of alternative future deliveries of products (¢Colón Costaricano per unit)

q_i^{pr} = Quantity of the necessary inputs for the implementation of protective measures (units)

q_i^{pr} = Quantity of the input needed for carrying out alternative measures for future supply of products (units)

G_t = Expenditure for management and administration in t (¢Colón Costaricano / year)

M_t = Maintenance costs for the year t (¢Colón Costaricano / year)

1.5.1.7 Damages to agriculture

González Cabán: Economic aspects to assess damage from forest fires

When fire damage causes serious losses for farmers and local community. Baumgartner (1984) proposed the following equation, to estimate the losses in agriculture:

Loss of harvest = cost of replanting * burned area + estimated loss of performance * price * burnt surface

The equation must be adjusted, if all or part of the harvest can be saved. In this case, the damage is the difference between the expected return and saved value.

EEPSEA - WWF Indonesia for the estimate of forest fires

The EEPSEA-WWF took into account the market value of agricultural land and the lack of production in terms of years. The two main variables that enter in this calculation are the value of agricultural land and the loss of production over the years. In the study, the analysis foresaw 1-2 years to restore a partial productivity and 3 years for full productivity.

1.5.2 The Public Goods: Natural Resources and Biodiversity

1.5.2.1 Loss of indirect benefits

EEPSEA - WWF Indonesia for the estimate of forest fires

The estimate of damage relative to the loss of indirect benefits provided by forests uses a similar procedure to the one described for the direct benefits. Even in this case no equation is provided but only the loss of economic value. It has to be noted that indirect benefits means protection against storms (especially in Costa Rica), regulating of water cycle, control erosion and formation of soil.

1.5.2.2 Loss of benefit tied the existence of natural resource

IPS: Methodology for economic assessment of environmental damage in Costa Rica

When a natural resource is modified by human actions an impact is expected on the landscape. People can accept this change or choose to get closer to a site with features similar to the previous one. Considering the latter case costs must be accounted for transportation, food, time, travel expenses, lodging and more. For the estimate of such costs, IPS provided the following equation:.

$$BP_4 = \sum_{t=1}^{T} c_t^d H_t^d (1+r)^{-1}$$

Where:

BP_4 = lost of benefits associated with the non-recreation and spiritual development of natural resource (¢Colón Costaricano)

c_t^d = cost-shift to reach a place more closely with the same characteristics as the one damaged

H_t^d = population affected by the damage (people)

1.5.2.3 Variation of the state of conservation of natural resource

IPS: Methodology for economic assessment of environmental damage in Costa Rica

In the estimate of the total cost it is necessary to include value associated with the product in case of extraction. This estimate use the following equation.

$$CE = \sum_{s=1}^{R} c_s e_s$$

where:

CE = value of extracted total production (¢Colón Costaricano)

c = unit value of the resource s (¢Colón Costaricano units)
e = quantity extracted from the resource s (units)

1.5.2.4 Loss of biodiversity

<u>*EEPSEA - WWF Indonesia for the estimate of forest fires*</u>

The estimate relative to the loss of biodiversity has been calculated using the willingness to pay for preserving Tropical Forests; the equation used to estimate the damage is not reported but only the figure of 300 $\$/km^2$/year.

<u>*Italian Academy of Forestry Sciences*</u>

The value is estimated with the IAFS methodology through the equation:

$$ED_{bio} = 0,5 * area * DL * PCI* (1+r)^{n}$$

where:
ED_{bio} = environmental damage (€);
area = area burned by the fire (ha);
DL = damage level of the fire;
PC = planting costs (€/ha);
r = discount rate;
n = number of years needed for reconstruction

1.5.3 The Public Goods: Environmental services

1.5.3.1 Carbon emissions

<u>*EEPSEA-WWF Indonesia for the estimate of forest fires*</u>

In the estimate of damage relative to the issue of carbon, EEPSEA WWF has used as a market price of $ 10/ton C on the basis of studies of Intergovernmental Panel on Climate Change, which sets a maximum value of $30. No equation is reported.

<u>*Italian Academy of Forestry Sciences*</u>

IAFS proposes the following equation:

$$ED_C = Area * Vol_b * BEF * 0,5 * PR_c$$

where:
ED_C = environmental damage from carbon emitted into the atmosphere (€);
Sup = forest area burned by the fire (ha);
Vol_b = volume of the wood mass burned by the fire (m^3/ha);
BEF = biomass expansion factor (coefficient of transformation of the wood volume, expressed in m^3, into above-ground tree biomass, expressed in t of dry matter);
PR_C = price of one ton of carbon (€/t).

The price per ton of C varies as a function of the C – international market. At the time the current price is € 29,38 (1 July 2008).

1.5.3.2 Landscape, recreation and fauna

<u>*González Cabán: Economic Aspects of assessing damage from forest fires*</u>

The methodology proposed by Gonzalez-Cabán considers the Edonic Price Method, the Travel Cost Method (TCM) and the Contingents Valuation Method (CVM). Loomis and Gonzalez-Cabán (1994, 1997) used this method to estimate the economic value linked to the reduction of owl habitat in California.

<u>*Italian Academy of Forestry Sciences*</u>

The tourism-recreational function is estimated by IAFS with the following equation.

$$ED_{rec} = V_{rec} * N_{rec} * \frac{(1+r)^g - 1}{r*(1+r)^g}$$

Where:

ED_{rec} = environmental damage from loss of tourism-recreational activities (€);
V_{rec} = mean value of one visit (€);
N_{rec} = mean number of visitors per year;
r = discount rate;
g = years of lost tourism-recreational business following the fire.

1.5.3.3 Cost recovery of resources damage

<u>*IPS: Methodology for economic assessment of environmental damage in Costa Rica*</u>

The cost of restoring environment and natural resources depends on their intrinsic characteristics. The equation in Costa Rica is the following:

$$CR = \sum_{t=}^{T} \sum_{j=1}^{n} \sum_{t=1}^{m} p_i q_{tji} (1+r)^{-1}$$

y T = Max {tj / j della risorsa naturale y j = 1,2,..., n}

where:

$CR =$ restoration costs
$p_i =$ price
$q_{ij} =$ quantity of productive factors adopted for restoration (units of input)
$r =$ discount rate (%)
$t =$ time (years)
$T =$ time to recover
y= quantity of the necessari inputs by natural resources
$m =$ productive factors adopted for restoration of i
$n =$ natural resources

1.5.3.4 Effects on catchment areas

<u>*González Cabán: Economic aspects of assessing damage from forest fires*</u>

Among the components of the damage identified by Gonzales-Caban is also reported the water catchment area which covers the exchange of water regulation with relative increase in the sliding surface and erosion of soil, sediment deposition and contamination of rivers (Connaughton, 1972; Lowe et al, 1978; Pellant 1990; Riggan et al 1994). The size of the damage must take into account various aspects such as the intensity of the fire, the size of the basin, the distance between the basin and its fires concerned. The estimated damage is difficult to quantify. There are no equation.

Italian Academy of Forest Sciences

To assess losses in protective functions, the following equation is proposed:

$$ED_{prot} = area_{prot} * \left(C_{rev} * r + C_{ann} * \frac{(1+r)^i - 1}{r*(1+r)^i} \right)$$

where:

ED_{prot} = environmental damage from the decreased water cycle regulation and soil protection (€);
$area_{prot}$ = area with protective functions burned by the fire (ha);
C_{rev} = cost of revegetation (€/ha);
C_{ann} = annual maintenance costs of the revegetation area (€/ha);
r = discount rate;
i = years needed to maintain the area.

1.5.3.5 Hunting

Italian Academy of Forest Sciences

Forest fires also negatively reduce performance in hunting. The IAFS has proposed the following equation to estimate this loss:

$$ED_{hun} = Area_{hun} * R_{hun} * \frac{(1+r)^v - 1}{r*(1+r)^v}$$

where:

ED_{hun} = environmental damage from decreased hunting (€)
$area_{hun}$ = area used for hunting burned by the fire (ha);
R_{hun} = mean annual income from hunting (€/ha);
r = discount rate;
v = years of lost hunting activity following the fire.

1.5.4 Social damage

1.5.4.1 Lost of benefits for population health

IPS: economic evaluation of environmental damage in Costa Rica methodology

$$BP_3 = \sum_{t=0}^{TH} \left[c_t^{tre} H_t^e + c_t^{mpp} H_t^{mpp} \right] (1+r)^{-1} + \sum_{t=0}^{TH} \sum_{i=o}^{n} \left(c_{ti}^{pl} q_{ti}^{pl} + c_i^m q_{ti}^m \right) (1+r)^{-1} + \sum_{k=1}^{K} c_k^{\inf r} q_k^{\inf r}$$

Where:

BP_3 = Benefit lost for the damage to the health because of the effects on the natural resource(¢Colón Costaricano)
C_t^{tre} = Cost of the handling of the illness for the year t (¢Colón Costaricano persona)
c_t^{mpp} = cost some preventive population measures in act in the year t (¢Colón Costaricano persona)
c_{ti}^{pl} = Cost entrance i bound to the parasites' check at the time t (¢Colón Costaricano unità)
$c_{ti}^{\inf r}$ = Cost of entry i for the infrastructure replacement damage(¢Colón Costaricano unità)
c_i^m = Cost of the product i to mitigate the effects in the t time cause from the damage to the basic infrastructures(¢Colón Costaricano unità)

H_t^e = number of people who have suffered the alteration of the natural resource because of illnesses at the time t (people)

H_t^{mpp} = Number of people submitted to measures of prevention because of the alteration of the natural resource at the time t (people)

q_{ti}^m = Amount of product the used in the t time to mitigate the effects caused by the damage to the basic infrastructure (unity)

q_{ti}^{pl} = Amount of input the required for the check some parasites at the time t(¢Colón Costaricano unità)

$q_k^{\inf r}$ = Amount of k inputs necessary for the infrastructure realization(¢Colón Costaricano unità)

1.5.4.2 Intervention and fire fighting costs

EEPSEA-WWF Indonesia for the estimate of the fires forest

EEPSEA-WWF method enters the costs connected to the employed staff.

IPS: Methodology for the economic evaluation of the environmental damages in Costa Rica

It considers the intervention and extinction costs referring to fuel costs, equipment, time and expenses linked to the event.

Italian Academy of Forest Sciences

IAFS foresees the monetization of such expenses according to synthetic, intermediate and an analytical approaches.

The synthetic process is based on a standard approach based on the costs of the staff estimated with the following formula

$$C_{spc} = ((N_{tot} * 2) - N_{un}) * D * C_{mh}$$

Where:
C_{spc} = cost of extinguishing the fire (€);
N_{tot} = the total number of persons who participated in fire suppression;
N_{un} = total number of unpaid persons;
D = duration of the operation, including the time needed to get to the operations zone (hours);
C_{mh} = mean hourly cost of paid personnel (€/hour).

and a standard approach based on the costs of the teams:

$$C_{scc} = C_m + \sum_1^{ns} D_{cr} * C_{cr}$$

where:
C_{scc} = cost of extinguishing the fire (€);
D_{cr} = duration of the operations (hours), including the time needed to get to the operations zone;
C_{cr} = mean hourly cost of the crew (€/hour);
C_m = cost of earth_moving equipment and aircraft (€);
ns = number of crews involved.

The intermediate approach uses prices of the unitary costs of equipment use and staff in the fire fight. Such prices are based on the calculation of the operational cost of the used machinary (chainsaws, hedge trimmer, air-spray, pump at shoulder, fires maagement module, oiler, soil moviment machine).

The analytical procedure at last, takes into account the costs really entered for the specific intervention. So for example instead of consider a cost of aircraft, number of hours of flight and average cost, it refers to fuel consumptions, retardant and others materials.

Methodological approach for economic estimate of forests TEV and damages from fires in the Forests (Turkey)

About such costs Turker proposes the following formulas

ALC = P * W * T * D

where:
ALC = Alternative labour cost
P = number of people intervened
W = average wage per hour
T = average working time in a day
D = number of working day

1.5.4.3 Administrative Costs

Methodological approach for economic estimate of forests TEV and damages from fires in the Forests (Turkey)

Adoption of a formula *(Firat and Miraboğlu 1977; Miraboğlu 1979*) that predict the calculation of variable K_0 . Turker has considered the general administration expenses linked to the forest part not used in the years.

$K_0 = B\ (1.0\ P^n - 1)/1.0\ P^n$

General expenses = K_0 * surface not used

2. METHODOLOGICAL APPROACHES IN FOREST FIRE DAMAGES EVALUATION[16]

A correct economic evaluation of fire damages involves two main components of costs:

- the costs related to the decreased value of the damaged asset (that is the loss of products and services it provides – see section 2.1 and 2.2);
- the fire suppression costs and the forest restoration costs incurred by public and private operators as well the temporary external costs to the infrastructure and community due to emergency actions (see section 2.3).

The first cost component of fire damages involves greater problems in evaluation and it is of fundamental importance in policy making, i.e. in planning fire prevention activities, in defining compensations, in establishing legal procedures to persecute the responsible of fire ignition, etc.

The problems of a correct fire damages evaluation have increased in recent years: in the past loss in timber production was by far the most relevant item (and often the only one) on the damage scale. Under current economic conditions, the commercial value of damaged wood products, especially in Mediterranean areas, is rather limited if compared with the costs related to loss of public non-market services (i.e. biodiversity protection, water cycle regulation, supply of recreational areas, soil protection, carbon sequestration, etc.). Furthermore, the costs related to these services are difficult to standardize or generalize (e.g.: IIED, 2003; Aylward, 2004; Merlo and Croitoru, 2005). On the contrary, the costs of extinguishing fires, for which better accounting documentation is normally available, are much easier to determine and calculate.

In the following pages we concentrate on the methodology for evaluating the first component of fire damages, i.e. the cost related to the decreased value of the damaged forest. In presenting the methodological approaches some examples of true field data referred to the Italian context will be introduced to exemplify the implementation of the suggested assessment procedures.

The environmental damage caused by forest fires is often the most significant factor from the economic standpoint. For this reason procedures for estimating this component are of central importance in assessing the total costs of forest fires. Furthermore, as we have already mentioned, an accurate estimate of environmental damage usually requires the availability of quite a lot of data and a complex series of estimating procedures that are not needed for the other cost components.

We suggest two procedures for estimating environmental damage (Figure 3):

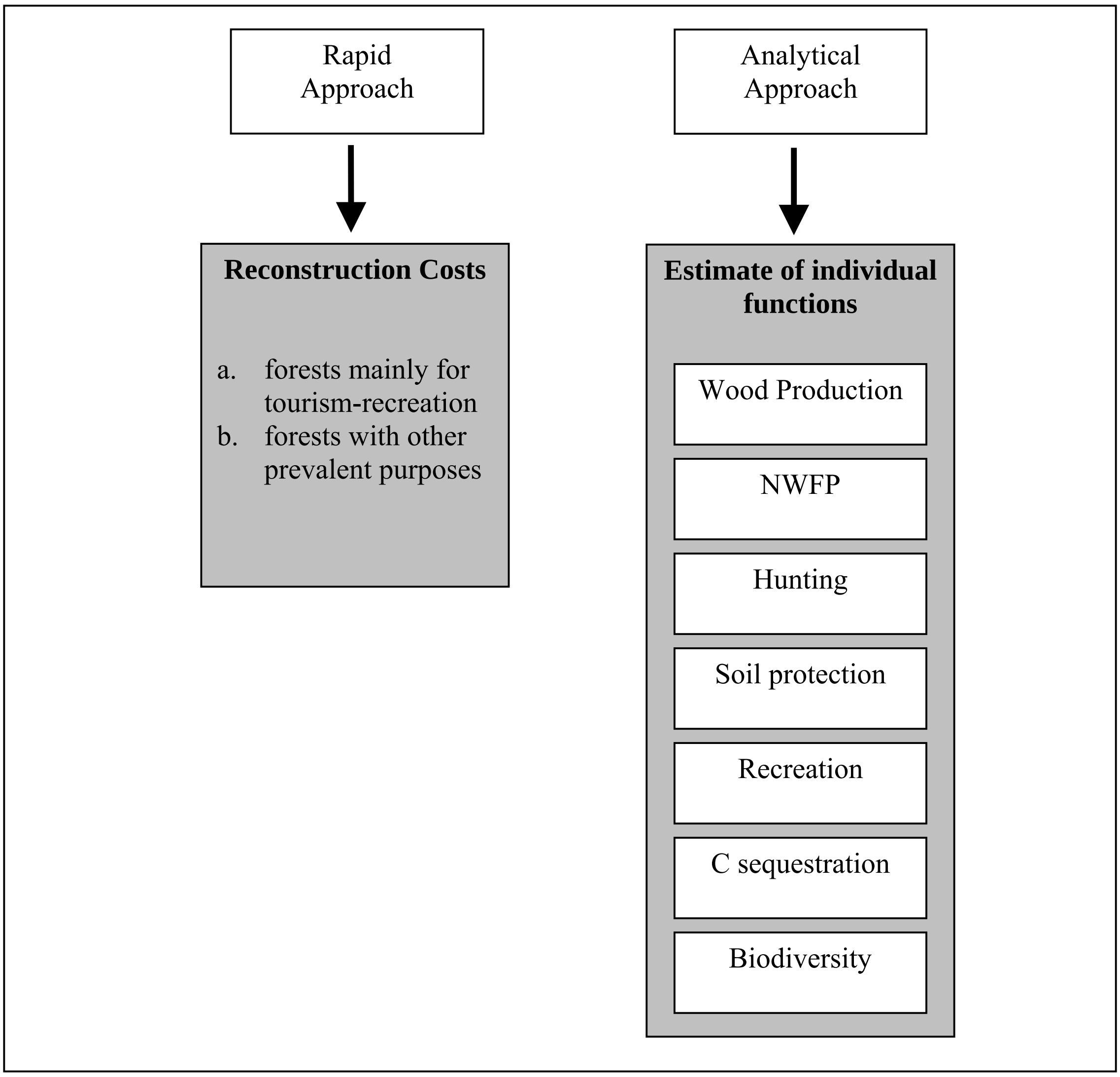
- an analytical procedure (see section 2.1) based on reconstruction cost criteria differentiated on the bases of two types of forests (forests used mainly for tourism-recreation and other forests);

[16] This chapter has been derived from a previous analytical work prepared by the *Accademia Italiana di Scienze Forestali* (Ciancio *et al.,* 2007) aiming at the definition of a methodology for fire environmental damage costs evaluation by the Italian *Corpo Forestale dello Stato* (State Forest Corp).

- an analytical procedure (see section 2.2) based on separate estimates of the forest's different functions.

In Annex 2 an operational implementation of the analytical procedure is reported.

FIGURE 3 – Procedures for estimating environmental damage



2.1 Estimating the environmental damage: a rapid approach based on reconstruction costs

A conventional approach for an analytical estimate of environmental damage could be based on reconstruction or restoration costs.
The evaluation criterion is based on the assumption that an asset is worth at least what it cost originally. Thus, the reconstruction cost criterion could lead to underestimations of the value of the damaged asset. Indeed, it is quite logical to hypothesize that if the value

of the asset were only linked to its cost and not to the total of benefits (that should exceed the costs), no rational operator would even accept the responsibility for managing the asset. The approach is relatively simple. The procedure is based on the following formula:

$$ED = RC * Sup * DL$$

Where:
EA = environmental damage (€); RC = reconstruction cost (€/ha); FBA = area burned by the fire (ha); DL = level of damage caused by the fire.

The level of damage (*DL*), expressed by a coefficient between 0 and 1, is a variable that has a high impact on the final outcome of the estimate. We wish to emphasize that the damage level does not correspond to individual tree mortality, a parameter that varies highly in relation to different, specific conditions (tree species, season, vegetative state). The problem in applying the formula is related to the use of a correct reconstruction cost (*CR*). There are two considerations in this regard: the first refers to the main function of the damaged forest, the second to the forest's age.
Regarding the main function of the damaged forest, it is useful to distinguish between two macro-types, characterized by two different sets of reconstruction costs:

- for forests used primarily for *recreation* the most logical reconstruction cost refers to ornamental trees; the reference costs thus refer to operations in urban park type areas;
- for other *forests* the reference is to conventional forest plantation techniques, based on the use of planting stock, with bare roots or in containers from forestry nurseries.

For *areas of considerable nature conservation value* restoration methods and hence costs can be derived from a combination of these two approaches. In these areas, in fact, it may be necessary to replant both big trees in some areas and seedlings in others. Other complementary actions such as planting shrubs and small-scale engineering interventions (seeding, drainage works, fencing, etc.) could be also considered.
As to the age of the forest, we must point out that the estimate cannot ignore the difference, for example, between a 10 year-old stand burned by fire as opposed to a 90 year-old forest. Although the reconstruction costs many be similar, it is obvious that the environmental damage is much greater in the latter case. In other words, we must assess not only the reconstruction cost per se, but also the "cost" related to the period until the forest reaches an age that allows it to fulfil functions similar to those of the forest before the fire. For this reason the per hectare cost of reconstruction must be estimated as follows:

$$RC = PC * (1 + r)^n$$

Where:
RC = reconstruction cost (€/ha); PC = planting cost (€/ha); r = discount rate; n = number of years needed for reconstruction.
In light of these considerations the proposed procedure, with the two methods of estimating planting costs, can be summarized as follows:

$$ED = PC * (1 + r)^n * Sup * LD$$

We must emphasize that this procedure often gives rise to underestimates. In fact, the reconstruction cost criterion does not explicitly take into consideration the benefits (with special reference to the non-commercial products and services) that can motivate any given forest owner to manage a forest.
In the EU Mediterranean area standard planting costs (*PC*) for recreational forests cover a very broad range, roughly from 2,000 to 50,000 €/ha. In the other cases we can refer to the standard costs for reforestation programs financed under Rural Development Plans (3-5,000 €/ha).
The number of years (*n*) can be estimated by referring to the age of the burned forest and the type of planting material used.
In most cases the discount rate (*r*) can be assumed to be between 2% and 5%, with higher values for *r* in cases of more productive forests on fertile soil which can yield greater financial profits.

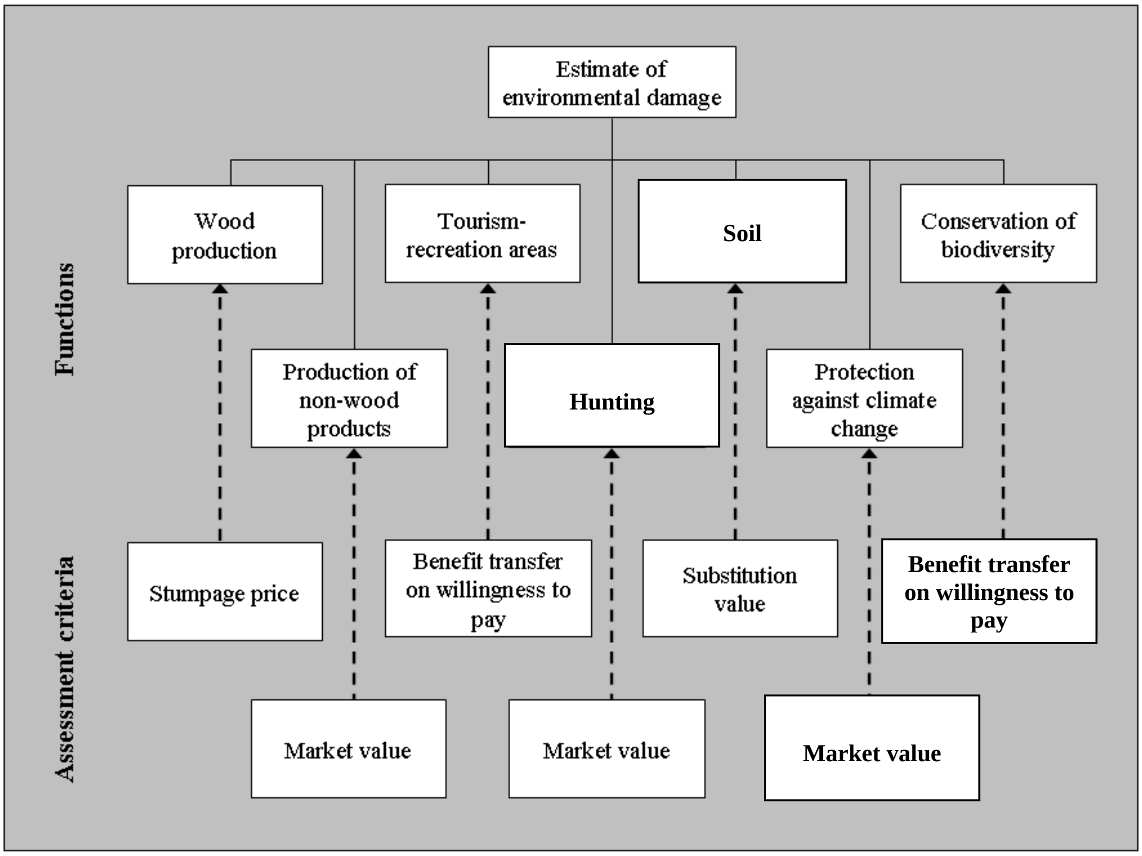
2.2. Estimating the environmental damage: an analytical approach based on single functions assessment

The analytical approach based on the single economic evaluation of differently forest's functions is the most articulated and complex. The proposed method is based on seven functions (Figure 4) estimated with different criteria:
- wood production;
- production of non-wood products;
- tourism-recreation;
- hunting;
- soil protection;
- protection against climate change (CO_2 sequestration);
- biodiversity conservation.

The total value of the environmental damage is the sum of the seven functions.

Identification of the seven components of the damage does not mean that they are all and always involved in the assessments of the various operating conditions. On the contrary, it is highly unlikely that it is necessary to assess all seven components when estimating the economic damage in a specific site. It is, indeed, unlikely that a fire will cause both significant damage to recreational areas and impact biodiversity protection at the same time.

FIGURE 4 – Functions and criteria for the analytical estimate of forest fire damage



2.2.1. Productive function: wood products

The loss of forest biomass and wood-producing capacity is assessed in terms of the market value of the destroyed wood volume. This value is obtained from an estimate of the stumpage value obtained by subtracting the costs of felling and logging from the roundwood market price (i.e. on the forest road price). In the case of forests that have not reached the maturity age, the commercial value of the destroyed wood does not correctly represent the true roundwood value. For this reason the stumpage value must be evaluated assuming the roundwood market price at maturity discounted by the number of years equal to the difference between the (usual) rotation age and the mean age of the destroyed trees.

Thus the estimate is made on the basis of the following formula:

$$ED_{le} = FBA * Vol * \frac{P_{imp} - C_{te}}{(1+r)^m}$$

Where:

ED_{te} = environmental damage due to wood-producing loss (€); FBA = forest area burned by the fire (hectares); Vol = volume of wood lost following the fire (m^3/ha); P_{imp} = mean roundwood price at roadside (€/m^3); C_{te} = felling and logging costs (€/m^3); r = discount rate; m = years needed to reach mean rotation age.

Below is a more detailed analysis of the variables needed for the estimate.
The forest area burned by the fire (*FBA*) is a variable that must be carefully surveyed, possibly using GPS instruments.
The volume of the wood loss (*Vol*) has to be deduced from a visual estimate which is very difficult and risky, or better by analytical surveys. When estimating *Vol* it is important to remember that two conditions may arise:

- the forest damaged by fire is of an age equal or close to commercial maturity, estimated on the basis of the mean rotation of other forests in the area: in this case (which is the more simple) the volume of wood loss is estimated on the basis of the damaged area;
- the forest damaged by fire is younger than commercial maturity: in this case, starting from an evaluation of the damaged plants, we must estimate the volume they would have attained once they reached commercial maturity.

The roadside price (P_{imp}), that may be differentiated by species, timber/firewood, are in Italy systematically gathered by forest administrations as mean provincial values. In the case of coppice forests (other than chestnut forests) reference can be made exclusively to the mean roadside price of fuelwood. For other forests the prevalent assortment can be used as the reference.
The felling and logging costs (C_{te}) can be estimated in parameterized form, for example they can be broken down into categories, which depend on the value of two variables: the slope and the mean distance of the damaged wood from the roadside.
Standard felling and logging costs developed for the Italian context are shown in Table 13, based on five site conditions:

- easy access (slope gradient ≤20% and distance from the roadside ≤300 m), 15 €/m^3 are to be subtracted from the mean roadside price;
- moderate access (slope gradient between 20 and 35% and distance from the road ≤300 m or between 300 and 2500 m, but with a gradient of ≤20%), 20 €/m^3 are to be subtracted from the mean roadside price;
- difficult access (slope gradient between 20 and 35% and distance from the roadside between 300 and 2500 m), 30 €/m^3 are to be subtracted from the mean roadside price;
- very limited access (slope gradient greater than 35% and thus requiring cable logging equipment), 35 €/m^3 are to be subtracted from the mean roadside price;
- if the area is very far from the forest road (>2500 m), the felling and logging costs become prohibitive and the productive function is omitted.

TABLE 13 – Standard felling and logging costs (€/m^3)

Distance from the roadside (m)	Slope		
	≤20%	20-35%	>35%
≤300	15	20	35
300-2500	20	30	
>2500	no productive function		

And finally, the years needed to attain the technically suitable age for wood utilization (*m*) are a variable that can be estimated at sight by the surveyor. In Italy this variable does not have strong impact on the estimate since under current market conditions price of firewood (which is generally obtainable with relatively short rotations) is very similar to that of sawlogs, so a young forest can be characterized by unit wood prices similar to those of adult forests in similar environmental conditions.

2.2.2. Productive function: non-wood forest products

With regard to the assessment of the economic damage deriving from the reduced availability of non-wood forest products (mushrooms, truffles, aromatic and medicinal herbs, etc.) we proceed with the estimate by referring to the loss of income from the sale of the goods, based on the area damaged by the fire. Since the effects of forest fires are extended over time, the damage must be estimated as the initial accumulation of the yearly damages on the basis of the following formula:

$$ED_{NWFP} = FBA_{NWFP} * R_{NWFP} * \frac{(1+r)^p - 1}{r * (1+r)^p}$$

Where:

ED_{NWFP} = environmental damage from the loss of non-wood forest products (€); FBA_{NWFP} = area that produces non-wood products burned by the fire (ha); R_{NWFP} = mean annual income from non-wood forest products (€/ha); r = discount rate; p = years of lost harvests of non-wood products following the fire.

The area burned by the fire (FBA_{NWFP}) refers to the areas that will temporarily lose their capacity to produce non-wood products. According to stand composition and the site's condition FBA_{NWFP} could be the total area burned by the fire (*FBA*), part of it, or in extreme cases, equal to zero.

The mean annual income from non-wood products (R_{NWFP}) can be estimated by either of two different methods.

The first, which will presumably be more widely used in Italy, is based on the income from harvesting rights based on the sale of annual, monthly, weekly or daily collection permits. Obviously, by referring to the sale of harvesting rights we probably underestimate the damage since this method does not take into account the total real harvest (more than a few, mainly local, users do not pay harvesting fees). Furthermore, the payment of the permit is independent of the quantity actually harvested and, in theoretical terms, is always less than the maximum set by law. Thus, this variable refers more to the willingness to pay for a product/service that often has a high tourism-recreational value than the market value of the harvested products.

The second method refers to the market value of cultivated products such as chestnuts, hazelnuts, cork, etc. For example in the rare case of fires in chestnut forests, the estimate is made by referring to the market prices of the chestnuts lost output taking into account the age of the forest and a suitable reconstruction period needed to return to ordinary production levels. This category can also include damages related to the loss of the possibility of grazing in the forest due to fire.

For the mean annual income from non-wood products (R_{NWFP}) we must also refer to the differing local situations. For example: for the mushroom harvest in the Veneto region, a mean annual value of 9.8 €/ha was estimated for the provinces with the highest productivity (Belluno, Treviso) and of 0.3 and 0.5 €/ha for those that produce less (Rovigo and Venice, respectively).

On the national level, Croitoru and Gatto (2001) estimated a mean annual harvest rate in mushroom producing forests of 3 kg/ha. This was confirmed by Bartolozzi (1988) who, in a detailed study of Tuscany, estimated a mean annual rate of 3.1-4.2 kg/ha. In an area that can be taken as a reference for outstanding production and harvests, Borgotaro in the province of Parma, Giovannetti *et al*. (1998) estimated an annual output of up to 15-20 kg/ha.

2.2.3. Tourism-recreational function

The tourism-recreational function is estimated with a procedure that refers to the number of visits which, following a fire, are no longer made. In particular, two variables are estimated for assessment purposes: the total number of visits per area unit and the mean value of each visit.

The recommended procedure does not include an assumption on the area since it is easier to estimate the number of visitors in general terms for the entire area burned by the fire than for area units. The reference to area for tourism-recreational purposes is done, however, in implicit form by taking into consideration that the subject of the assessment is the forest area subject to significant use by visitors during all or part of the year. The reference area must be the one used for informal recreation (camping, walks, picnics, etc.), sports (hiking, mountain biking, orienteering, cross-country skiing, etc.) or nature-oriented activities (bird watching, environmental education, etc.) while in order to avoid double assessments the areas used mainly for harvesting non-wood forest products, and hunting are not considered since they are the subject of separate assessments.

In this case, too, since the fire's effects extend over time, the damage will be estimated as an initial accumulation of a few years loss of the function. The following formula is proposed for this purpose:

$$EA_{rec} = V_{rec} * N_{rec} * \frac{(1+r)^g - 1}{r * (1+r)^g}$$

Where:

EA_{rec} = environmental damage from loss of tourism-recreational activities (€); V_{rec} = mean value of one visit (€); N_{rec} = mean number of visitors per year; r = discount rate; g = years of lost tourism-recreational activities following the fire.

According to accessibility, slope and the quality of the forests, the reference area could be total area burned by the fire (*FBA*) or part of it, either because of difficult access, steep slope. Where vegetation is particularly thick and impenetrable, the reference area could equal to zero. Furthermore, in some cases the reference area could be bigger than the burnt area when the existence of a section damaged by the fire leads to the lack of utilization of adjacent areas for tourism-recreational purposes.

The value of the single visit (V_{rec}) can be estimated by using the benefit transfer approach, that is by using the results of estimates of willingness to pay for tourism-recreational activities done with methodological approaches like the Contingent Valuation methods or the Travel Costs methods. These results can be used as reference values to be applied in the fire damage evaluation once weighted to make reference to the specific socio-economic and environmental aspects of the burned area.

For example, in Italy, on the basis of more than 50 surveys on forest recreational benefits, it is possible to assume that, excluding extreme and anomalous data, the value of a single, one-day visit falls between 3 and 10 Euro. In order to direct the appraiser to choosing a reliable value using a short-cut procedure, reference can be made to Table 14.

For the European Union, the following data-base on publications related to environmental damages could be used:

- EVRI (http://www.evri.ca/english/default.htm)
- ENVALUE (http://www.environment.nsw.gov.au/envalue/)
- RED Database – Review of Externality Data (http://www.red-externalities.net/start_search.asp)
- BeTa - Benefits Table Database (http://ec.europa.eu/environment/enveco/studies2.htm).

The number of annual visits (N_{rec}) can be estimated with a reasonable approximation by using the values of some proxy indicators related to tourism-recreational activities and business in the study area (number of parking permits sold, data on local vehicular traffic, data on food and lodging services, etc.), which can be compared with the values before and after the fire.

The duration of the period of lost recreational function following the fire (*g*) is a variable with a very wide range. The number of years will refer to the time needed to restore a recreational-tourism function similar to that of the forest before the fire. Considerable care must be taken if a very high number of years is selected since the decision can have a significant impact on the total estimated damage.

TABLE 14 – Criteria for choosing reference values for estimating recreational services

Value of a day visit	Purpose of the visit	Social class of visitors	Frequency by individual visitor	Visitor provenance	Site conditions	Accessibility
3 € ↑	Informal recreation; crossing area	Low income level, very young or very old, unemployed or retired	High number of visitors per year	Mainly local	Sloping areas, very dense with much undergrowth, closed landscape	Difficult, unmarked trails with natural obstacles
↓ 10 €	Organized sports activities; camping, areas for overnight and longer stays	High income level, intermediate age group, working	Occasional visits	Mainly from long distances	FBAt areas, low density forests with clearings and ecotones, open landscape	Easy, with nearby parking facilities

2.2.4. Hunting

In order to estimate the damage related to the decreased potential for hunting we use criteria similar to those given for non-wood products. We evaluate willingness to pay for hunting with reference to the area originally used for this activity. In this case too, as for non-wood products, the environmental damage extends over time and this must be taken into account through an initial accumulation of yearly income loss following the fire. Thus, the proposed formula is:

$$ED_{hun} = FBA_{hun} * R_{hun} * \frac{(1+r)^{v} - 1}{r * (1+r)^{v}}$$

Where:
ED_{hun} = environmental damage from decreased hunting (€); FBA_{ven} = forest burned area used for hunting (ha); R_{hun} = mean annual income from hunting (€/ha); r = discount rate; v = years of lost hunting activity following the fire.

FBA_{hun} is the extent of the area where the possibility of hunting is temporarily lost. As for non-wood products, according to the composition and conditions of the site FBA_{hun} can be identified with the total area burned by the fire (*FBA*), with part of it, or in extreme cases, it can equal to zero.
For the estimate of the mean yield from hunting (R_{hun}) we suggest referring to the hunters' real payments on the basis of the data on licensed hunters in the area, to the annual cost of hunting licenses, thus estimating the mean unit value of the area where hunting is permitted.
The above estimating procedures can also be used to assess damage related to loss of grazing, obviously when conducted in full compliance with forestry regulations and local rules. In this case, the mean income will be estimated on the basis of the annual rental fee for the land or other types of contractual arrangements between the land owners and grazers.
As for the local hunting contexts, for the mean income from hunting (R_{hun}) reference must be made to the various local situations. As a guideline, in a study conducted in the Veneto region, a mean annual value of 89 €/ha was estimated for hunting areas; the extreme values on a provincial scale ranged from 38 to 120 €/ha (for the provinces of Rovigo and Vicenza, respectively).

2.2.5. Soil protection function

In order to estimate the value of the forest's protective function, we suggest an approach based on the criterion of replacement costs, using the lump sum costs for revegetation (i.e. grassland regeneration) of the area burned by the fire. In particular, revegetation costs comprise two components: the *una tantum* costs of the operation and the costs of area maintenance which we suppose must be done annually for a number of years in order to recover the previous protective capacities of the area that has been burned.
Hence, the following formula can be used:

$$ED_{prot} = FBA_{prot} * \left(C_{rev} * r + C_{ann} * \frac{(1+r)^{i} - 1}{r * (1+r)^{i}} \right)$$

Where:
ED_{idr} = environmental damage from the decreased water cycle regulation and soil protection (€); FBA_{prot} = forest area with protective functions burned by the fire (ha); C_{rev} = cost of revegetation (€/ha); C_{ann} = annual maintenance costs of the revegetation area (€/ha); r = discount rate; i = years needed to maintain the area.

The area with soil protection function burned by the fire (FBA_{prot}) must be considered with caution: the use of the replacement cost criterion involves reference to intensive engineering works that are highly effective but also particularly expensive and are only justified when there is significant deterioration of the soil stabilizing and water cycle regulation functions. To avoid overestimates, this approach must be restricted to areas with very steep slopes and which have become highly unstable specifically after the fire and not to those which play a minor protective role.
In order to arrive at an easier definition of FBA_{prot} a threshold values for mean slopes for different types of ground should be defined, below which the economic damage related to the soil erosion can be assumed to be not significant (in Italy we defined a minimum threshold of a 40% mean slope). We can also consider variable mean slope thresholds to correspond with different types of operations with costs that rise in proportion to the increase in slope. For example, for the Italian context, the following slope values have been defined:

- <40%: no significant damage;
- 40-70%: damage valued in relation to the need for extensive interventions (consolidation of rocks, grass seeding, etc.);
- >70%: damage valued in relation to intensive interventions (stepping, planting cuttings, drainage, stone supporting walls, protecting the ground with nets, etc.).

Another hypothesis is to proceed with the determination of stabilization costs only for steep areas located immediately above main roads.
The mean cost of revegetation (C_{rev}) can be estimated in relation to grass seeding techniques. The prices of seeding vary in relation to the equipment used, which in turn is related to the size and location of the area. For localized operations we assumed a cost of 12,000 €/ha, and for extensive operations using helicopters we defined a mean cost of 3,000 €/ha.
The annual maintenance costs for the replanted area (C_{ann}) and the number of years that maintenance is required (i) refer to the grassland care and management operations (cutting, reseeding and thickening, etc.) which are needed to stabilize the new green cover replacing the one destroyed by the fire.

2.2.6. Carbon dioxide sequestration function

Carbon dioxide emissions following the combustion of wood biomass and organic matter, with a consequent increase in the concentrations of greenhouse gases in the atmosphere involve a cost that can be estimated by referring to market prices of carbon credit (see carbon credit prices in a voluntary market like as the Chicago Climate Exchange – CCX – where C offset forest investments are explicitly traded).
The proposed calculation procedure is based on the use of the data relative to the area burned by the fire, the destroyed stock, the price of a ton of carbon and a series of data adjustment coefficients according what is summarized in the formula:

$$ED_C = FBA * Vol_b * BEF * 0.5 * P_C$$

Where:
EA_C = environmental damage from carbon emitted into the atmosphere (€); FBA = forest area burned by the fire (ha); Vol_b = volume of the above-ground woody biomass burned by the fire (m^3/ha); BEF = Biomass Expansion Factor (coefficient of

transformation by volume of the above-ground woody biomass, expressed in m^3, into total biomass, expressed in t of dry matter); P_C = price of one ton of carbon (€/t).

For the quantification of the area burned by the fire (*FBA*) see section 2.2.1. The volume of the burned above-ground woody biomass (Vol_b) can be obtained from a visual estimate, which however, is very difficult and risky, or better by analytical surveys. As a rule Vol_b will be equal to the volume estimated for the quantification of the damage deriving from the loss of commercial timber.
The data concerning the destroyed stock generally refer to the cormometric/ dendrometric wood mass and therefore must be multiplied by an expansion factor (*BEF*) in order to estimate the total loss of carbon stock. DB with BEFs that can be used in estimates for forest types in Europe are available (e.g. that one build during the EC founded project CARNOINVENT). Table 15 presents average BEFs developed for Italy. BEFs in the table combine the values of two coefficients used for obtaining: (a) the total volume of the above-ground wood biomass from the cormometric/dendrometric volume of the wood biomass, and (b) the value to total biomass (dry matter) from the total volume of the above-ground wood biomass. The BEFs shown refer only to above-ground biomass since it is very rare for a fire to lead to the carbonization of the underground C content, and even in those cases the estimate of the destroyed underground mass is usually very hazardous.
The price per ton of carbon on the international market (P_C) can be updated by analyzing the quotations on some organisation that monitor C quota transactions (http://www.pointcarbon.com/, http://carbonfinance.org/).

TABLE 15 – Approximate BEF values for forest types in Italy

Class Code	BEF (t/m^3)
A	0.80
B	0.95
C	0.60
D	0.70
E	0.80
F	0.90
G	1.00
H	0.90
I	0.60

2.2.7. Biodiversity protection function

Of all the functions under consideration the biodiversity conservation role of forests (ED_{bio}), that is the value attributed to the biodiversity of its components, is the most difficult to assess.
As for the valuation of recreational function, this value could be estimated by using the benefit transfer approach, that is by making reference to the results of estimates of willingness to pay for biodiversity conservation activities done with methodological approaches like the Contingent Valuation methods or the Travel Costs methods. These results can be used as reference values to be applied in the fire damage evaluation once weighted to make reference to the specific socio-economic and environmental aspects of the burned area.

In this case we cannot made present some reference data of the value of biodiversity loss for Italy, not having a minimum set of survey made at national level to implement properly a benefit transfer approach.
Anyway, the suggested formula would be the following one:

$$ED_{bio} = V_{bio} * FBA * DL * \frac{(1+r)^n - 1}{r * (1+r)^n}$$

Where:
ED_{bio} = environmental damage (€); V_{bio} = value of biodiversity loss (€/ha/year); FBA = forest area burned by the fire (ha); DL = damage level of the fire; r = discount rate; n = number of years lost in biodiversity conservation (with the case of $n \rightarrow \infty$ that, in extreme cases, could also be assumed).

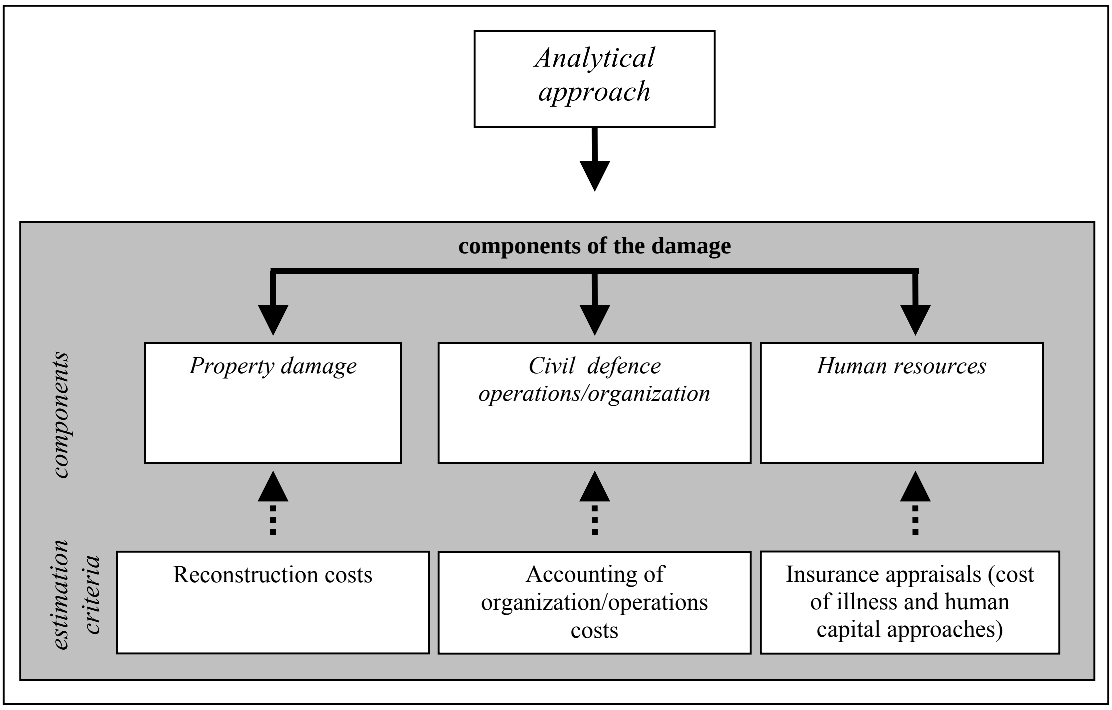
For the estimation of the formula's other variables (*FBA*, *DL*, *r*, *CI*, *n*) we refer to the foregoing.

2.3. Estimating fire suppression, forest restoration and other damages costs

According to the principle "Who polluters, pay", other components of fire damages cost should be, when relevant, assessed when calculating the total environmental damage:
- the fire fighting costs;
- the restoration costs;
- the temporary external costs to the infrastructure and community due to emergency actions.

Some forest fires, like those large events recorded in the summer 2007 in Greece and Italy, are often associated with external damages of remarkable economic impact (temporary loss of communication means, resettlement of residents and tourists, interdiction of access to some areas, etc.).
All these costs fall into three categories (Figure 5):
2.3.1 property damage;
2.3.2 damages related to civil defence operations that were made necessary as a result of the fire;
2.3.3 damage to human resources, that is temporary or permanent disability and, in extreme cases, loss of life.
We will briefly consider the estimation methods for the three types of damages. In all cases we use an analytical approach without providing specific appraisal procedures but only general methodological guidelines.

FIGURE 5 – Procedures for estimating extraordinary damages



2.3.1. Property damage

Even moderate fires causing limited environmental damage can involve significant costs related to the partial or total destruction of property (not considering the burned forest area). "Property" includes both public and private assets of different types:

- civil infrastructures, such as power lines, roads, parking and rest areas, signage, etc.;
- homes and rural structures and buildings (shelters, storage facilities, sheds, fencing, etc.);
- farm crops (orchards, vineyards, etc.) and animals (other than wildlife);
- monuments and the historical cultural heritage (shrines, tabernacles, capitals, etc.);
- environmental heritage and assets (monumental and historical trees, biotypes, scenic areas, etc.).

When dealing with property damage, the appraisal method is generally based on the cost of reconstructing the damaged parts, which is reduced as necessary by the use of an appropriate ageing coefficient.

If the damage affects a portion of a larger asset, but comprises its overall value it is appropriate to make two separate appraisals of the asset (with and without damage) and obtaining the value of the damage from the difference between the results of the two appraisals.

In the case of monuments and the historical, cultural and environmental heritage the criteria of cost of reconstruction may not always be appropriate and more complex methods will have to be used such as the edonometric price, travel costs and contingent evaluations. In these cases the complexity of the appraisal methods requires a specific contribution from professionals.

2.3.2. Damages related to civil defence operations

This category includes the organizational expenses related to civil defence operations in cases of severe events, even of local nature, but in densely populated areas: evacuation of residents and tourists, closing roads, suspending services, interrupting businesses (hotels, food services, sports, farming, etc.), operations providing support and information to the residents, etc.

The costs of such operations are difficult to standardize and the appraisal must, therefore, be based on costs and loss of income verifiable through the accounting records of the parties involved in the operations.

Only in some cases, for services similar to those provided under ordinary conditions, can the appraisal methods be based on short-cut methods such as standard costs or prices lists (e.g. transportation of persons and things).

2.3.3. Personal injuries

Accidents leading to temporary or permanent disability or loss of life related to extinguishing a fire or caused by the fire itself are not uncommon occurrences.

In the first case the accident victim generally has insurance coverage and the appraisal can be taken from the one made by the insurance company in determining the compensation (obviously not including any deductibles).

In the second case, even when the victim has no insurance coverage, the procedures followed in estimating the compensation for insured persons (cost of illness and human capital approaches) provide a consolidated reference in estimation practice.

3. A PROPOSAL FOR FOREST FIRE DAMAGES ASSESSMENT AT EU LEVEL

The methodological approaches presented in the previous chapter mainly based on the experience recently gained in Italy on forest fire damage assessment, could be considered in developing a modular approach for fire costs evaluation at EU level.

Here we suggest the use of 3 evaluation procedures depending on the size of the fire and the accuracy of the evaluation required:

- **a rapid evaluation procedure** where the assessment is the result of the overlapping of two information strata: the burned forest area (with, if possible, some weighting factor related to the damage level of the above-ground forest vegetation) and the data deriving from a pre-defined map of mean standard values of forest areas (***M**ean **I**ndicative **L**and **VA**lues* - **MILVA** - see section 3.1);
- **an intermediate evaluation procedure** (***S**emi-**A**utomatic **F**ire costs **E**valuation* - **SAFE** – see section 3.2) based on a field control f the MILVA data and eventually with the correction and integration of its average value;
- **a detailed evaluation procedure** based on the implementation, along with some pre-defined common guidelines, of Contingent Valuation approach.

In the following sections we discuss the implementation of the 3 suggested approaches, while in the final one some general criteria for selecting and integrating the 3 procedures are presented.

3.1. The rapid evaluation procedure based on the Mean Indicative Land VAlues (MILVA)

For developing a system for mapping the average forest land values we suggest an approach similar to that presented in section 2.2, namely the separate estimate of 5 benefit values per each plot of forest land.

- wood production function based on elaboration of the following standard values:
  - standing wood prices (sources of data: national data, UNECE-FAO DB of wood products prices, European Forest Institute DB),
  - accessibility (road network and GTM),
  - *average standing stock* (sources of data: national inventory, FAO DB).

- recreational service based on elaboration of the following standard values:
  - average forest cover (possibly related to forest with recreational functions, i.e. those open to public access, with moderate slope, not managed as intensive plantations and close to roads),
  - values of the willingness for pay for a single visit (sources of data: see DB mentioned in section 2.2.3);

  these values, using a benefit transfer approach, will be weighted in relation to the national *pro-capite* GDP and the population density of the region.

- soil protection service based on elaboration of the following standard values:
  - forest land with a slope > 15%,
  - surrogation costs referred to the most appropriate regional alternative, i.e. grassland management, drainage systems, engineering works, etc. (sources of data: national standard values).

- Carbon sequestration service based on elaboration of the following standard values:
  - price of 1 t CO_2 in voluntary market of C offset investment (sources of data mentioned in section 2.2.6),
  - above-ground biomass annual increment and Biomass Expansion Factors (sources of data: national inventory, National Communications to the UNFCCC).

- values related to site (or region) specific services like those one related to NWFP (cork, chestnut, mushrooms, truffles, resin, etc.), water provision, hunting, etc.
  This fifth category could be considered as a sort of dummy variable to include those values that cannot be assumed as standard functions valid for all around Europe.

Once defined for any *i* forest type the values of these 5 services, the mean annual forest land values ($MILVA_i$) could be derived by discounting to the actual value the sum of the average annual value of benefits (*Bi*), considering an average value of the annual maintenance costs (C_i):

$$MILVA_i = \left(\sum_{n=1 \to 5} B_{i_n} - C_i \right) * r^{-1}$$

where: $MILVA_i$ = mean annual forest land values of the forest type i; n = number of services; Bi_n = benefits deriving from the 5 services; C_i = average maintenance costs of the forest type; r = social discount rate.

Average annual costs (C_i), as some other values of services, can be derived from the estimates recently made by EU regional and national authorities in the definition of the forest measures of the Rural Development Programmes: all the compensation measures had to be defined looking at the average real costs and revenues deriving from ordinary forest activities. These estimates represent a huge, non structured but easily accessible DB, publicly available and officially approved by the EC.

To assess the fire damage costs (see Figure 6 and Table 16 as an example for setting out the calculations), we will make reference to the forest types. For each forest type *i*, the value of its services (i.e. the benefits and costs used in defining MILVA values), weighted in relation to a certain level of damage, and referred to a standard number of years of lost services, will be considered to assess the environmental damage cost:

$$ED_i = \left(\sum_{n=1 \to 5} B_{i_n} - C_i \right) * DL_i * \frac{(1+r)^m - 1}{r * (1+r)^m}$$

Where:

ED_i = environmental damage for the i forest type; Bi_n = annual benefits deriving from the 5 services; C_i = average annual maintenance costs of the forest area; n = number of services; DL_i = damage level of the fire in the forest type i; r = social discount rate; m = number of years lost in biodiversity conservation (with the case of $m \rightarrow \infty$ that, in extreme cases, could also be assumed).

FIGURE 6 – A theoretical example of MILVA mapping and area damaged by fire

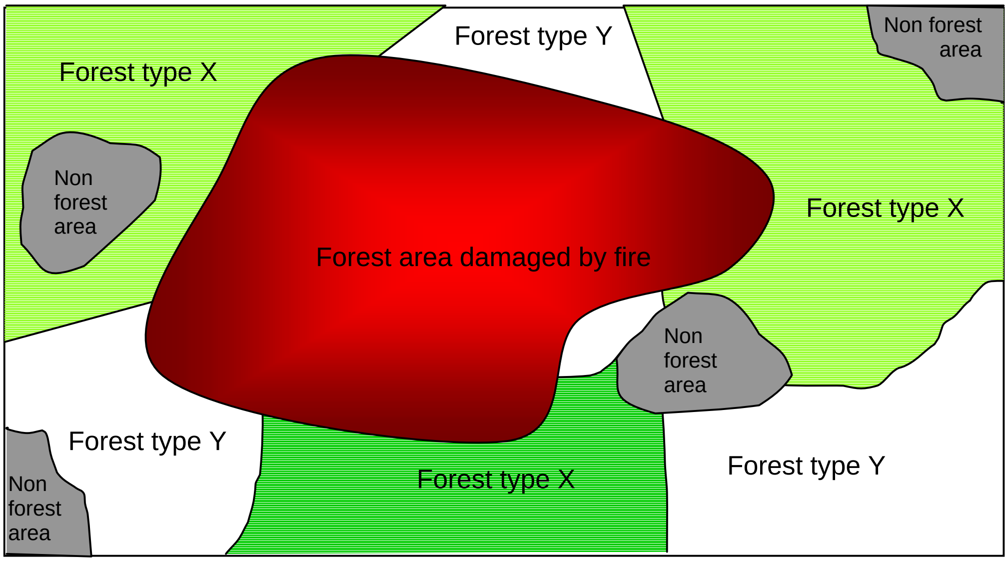


TABLE 16 – Summary presentation of basic data for assessing the fire environmental damage costs (MILVA procedure)

	Values of the services					MILVA total values (€)	Fire damage level (%)	Damage period (years)	Environ. damage (€)
	Wood production (€)	Recreation (€)	Soil protection (€)	C sequest. (€)	Other services (€)				
Forest type X									
Forest type Y									
Forest type Z									
…									
Total									

The level of damage (DL_i) could be defined employing 3-5 classes of forest cover damages (<30%; 30-60%; > 60% or <20%; 20-40%; 40-60%; 60-80%; > 80%) that could be detected directly from aerial and satellite observations

For the number of years of lost services following the fire event (*m*), a standard value of 5-10 years could be defined in relation to various factors, namely:

- the forest cover damage (with higher levels of cover damage the period tends to be longer),
- the resilience of the forest type (see evergreen broadleaves, deciduous broadleaves and conifers),

- o the management regime (coppice vs. highforests; semi-natural forests vs. plantations),
- o the frequencies of fire events in the same site (repeated fire events in few years tend to have longer effects) .

3.2 The intermediate evaluation procedure based on the Semi-Automatic Fire costs Evaluation (SAFE)

In a step-wise approach, the improvement of the data deriving from the MILVA methodology can obtained through the SAFE procedure: MILVA data are very rough estimates that could be checked and improved through a more accurate evaluation and inspections in the field.

With the SAFE procedure a revision of same assumptions made in MILVA could be carried out (see Table 17), namely:

- the value of each function could be re-assessed making reference to the information available at local level, like forest management plans, forest inventories, surveys; MILVA data could be in this way improved using a correction coefficient *k* (e.g.: with *k* = 1 the MILVA value is considered correct; with *k* = 1.5 the correct value is assumed to be 50% higher than the MILVA assumption);
- the level of damage (*DL*) could be defined with reference to each function and not as a standard level for all the benefits from the same forest type;
- the number of years of lost services following the fire event (*m*) could also be better defined with reference to each function;
- the inclusion of other services, out of the 5 already taken into consideration in MILVA, could be possible.

TABLE 17 – Summary presentation of basic data for assessing the fire environmental damage costs (SAFE procedure)

	Values of the services						**Environ. damage (€)**
	Wood production (€)	**Recreation (€)**	**Soil protection (€)**	**C sequestration (€)**	**Other services (€)**	***Other site-specific services (€)***	
	k DL m	***k DL m***	***k DL m***	***k DL m***	***k DL m***	***k DL m***	
Forest type X							
Forest type Y							
Forest type Z							
…							
Total							

3.3 The detailed evaluation procedure

The third and final step is represented by a more detailed evaluation procedure based on the implementation, along with some pre-defined common guidelines, of a Contingent Valuation approach. The implementation of Contingent Valuation techniques can be justified for the evaluation of large fire events, when the non-market effects of the forest damages are important and predominant. Contingent Valuation can provide a correct estimate of the Total Economic Value of the environmental damage, including the non-market and non-use values, like the option and bequest values.

Implementation of Contingent Valuation is quite an expensive exercise and its results may have a judicial use during a trial for request of cost compensations. These are two remarkable motivations for basing the Contingent Valuation exercises on sound, advanced and largely accepted guidelines.

However the definition of common frame protocol for carrying out the Contingent Valuation of forest fire damage costs is considered of particular utility also for assuring consistency and comparability of results. These are extremely important issues in organising a DB of evaluation results for Benefit Transfer applications and thus for improving the MILVA approach itself.

Finally, it is possible to mention the criteria to be used in selecting the most appropriate among the 3 above-mentioned procedures in the evaluation of a single event. Assuming to have MILVA mapping available, a decision making matrix based on two criteria could be elaborated (see table 18):

- the absolute size of the environmental damage (in €) of the single event deriving from:

  FDA = forest damaged area (ha) * damage level (%) * MILVA (€)

- the relative size of the environmental damage (in %), based on the rate of d_i and the MILVA value of a region (MILVA tot).

Table 18 – Criteria to be used in selecting the most appropriate assessment procedure

		Absolute damage		
		FDA < x	***x < FDA < y***	***y < FDA***
Relative damage	***FDA /MILVA tot < z***	Rapid procedure	Rapid procedure	Intermediate procedure
	z < FDA/MILVA tot < s	Rapid procedure	Intermediate procedure	Analytic procedure
	s < FDA/MILVA tot	Intermediate procedure	Analytic procedure	Analytic procedure

x and *y* are absolute threshold values to be defined by the responsible of the procedure selection
z and *s* are relative threshold (percentage) values to be defined by the responsible of the procedure selection

In the implementation of these criteria attention should be given to the events based on mostly simultaneous, spotted and close related small fire events. When these “fire clusters” events occur, they should be treated as a unique, large scale event to avoid that small fires will be evaluated always and only using the rapid procedure.

4. CONCLUSIONS

Gli incendi boschivi rappresentano da sempre una calamità a cui molti paesi devono far fronte soprattutto durante la stagione estiva. Ad oggi purtroppo le informazioni in possesso sui danni da incendi boschivi risultano essere carenti a causa da un lato la complessità del fenomeno indagato dall'altro i pochi studi condotti a riguardo. La mancanza di questi dati risulta essere una difficoltà per le decisioni relative agli investimenti ai fini dell'adozione di corrette politiche di prevenzione e lotta e di conseguenza allo stanziamento di adeguate risorse finanziarie.

Tali carenze riguardano principalmente la valutazione economica del danno apportato dagli incendi boschivi, aspetto ad oggi non affrontato nel dettaglio da parte della letteratura scientifica internazionale come mostrano i risultati legati all'analisi delle più note riviste di carattere economico, economico forestale ed economico ambientale (cfr §1).

In riferimento a quanto sopra il presente documento vuole offrire un contributo innovativo legato da una parte ad individuare le componenti ambientali che possono essere coinvolte negli incendi e dall'altra individuare per ognuna un procedimento in grado di stimarne il danno economico.

In particolar modo è stata riportata una metodologia di analisi per la valutazione economica degli incendi boschivi messa a punto dall'Accademia Italiana di Scienze Forestali (cfr § 2). Lo studio è avvenuto attraverso un percorso di analisi multidisciplinare che ha riguardato sia aspetti generali sia specifici di tipo estimativo, con integrazioni di concetti legati alla selvicoltura, alle utilizzazioni forestali, alla pianificazione forestale, all'ecologia, all'economia e all'estimo ambientale.

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APPENDIX I

A case study (in Italian): An operational implantation of the analytical procedure

Di seguito sono riportati i dati relativi alla sperimentazione della metodologia (cfr §2) per la stima del danno causato dagli incendi boschivi nella località di Longobucco in Italia. Le caratteristiche dell'area e dell'incendio sono riportate nella tabella A.2.1

TABELLA A.2.1 – AREA ED EVENTO OGGETTO DI INDAGINE

Nazione	Italy
Regione	Calabria
Provincia	Cosenza
Comune	Longobucco
Località	Monte Altare-Gustiniello
Superficie percorsa dall'incendio	13,50 ha
Vincoli naturalistici	Zona 2 del Parco Nazionale della Sila
Tipo forestale	Pineta di pino Larico composta da gruppi, più o meno estesi, tendenzialmente coetanei, con età media di circa 60 anni, ma con molti soggetti arborei anche di minore o maggiore età.
Usi principali	Produzione di legname; raccolta di funghi; scarso uso turistico-ricreativo
Classe di vegetazione forestale	D (Pinete di Pino Silvestre in ambiente collinare e di Pianura - Pinete di Pino Nero in ambiente collinare e pinete di Pino Larico e di Pino Coricato).
Tipo di incendio	Fuoco in parte radente e in parte di chioma, che ha causato danneggiamento diretto e mortalità soprattutto a carico dei soggetti arborei di minore dimensione/età e a gruppi di rinnovazione affermata (stato di perticaia)
Inizio fuoco	Ore 19:30 del 24.05.2006
Fine intervento	Ore 17:30 del 25.05.2006
Personale CFS intervenuto	Quattro agenti
Personale non CFS intervenuto	Tre operai
Mezzi aerei	Due Canadair

STIMA DEL COSTO DI ESTINZIONE

I costi di estinzione sono stati stimati attraverso un approccio sintetico basato sull'impiego di costi standard. Nel caso in esame il costo è stato stimato in funzione dei costi standard delle squadre intervenute secondo la seguente formula:

$$C_{e\_ss} = C_m + \sum_{1}^{ns} D_{sq} * C_{sq}$$

Dove:
C_{e_ss} = Costo di estinzione (€);
C_m= costo mezzi aerei;
D_{sq} = durata intervento della squadra (ore) comprensivo del tempo per il trasferimento in zona operative;
C_{sq}= costo medio orario della squadra (€/ora)
ns= numero di quadre intervenute

I dati utilizzati per la stima del costo di estinzione sono riportati in tabella A 2.2

TABELLA A 2.2 DATI UTILIZZATI PER LA STIMA DEL COSTO DI ESTINZIONE

Variabili	**Valore**	**Note**
D_{sq1}	10,30 ore	Squadra CFS
D_{sq2}	6,00 ore	Squadra operai del proprietario del bosco
C_{sq}	130 €/ora	Costo medio orario di una squadra leggera con mezzo non allestito
C_m	46.233 €	Valore ricavato sulla base dei costi standard di utilizzo di Canadair

Nella fase di spegnimento dell'incendio è intervenuta una squadra del CFS costituita da due persone che hanno operato per 10,30 ore (due gruppi di persone, il primo operativo per 6,15 ore sostituito dal secondo per 4,15 ore). In questa fase sono intervenuti due Canadair che hanno operato per 5,16 ore (il primo ha operato per circa 2,66 ore, l'altro per 2,50 ore). Il costo medio orario è stato stimato intorno a 8.000€/ora, mentre il costo del carburante è stato calcolato considerando un consumo medio di 1.200 l/ora con un costo medio del carburante pari a 0,80 €/l.

Di conseguenza il costo relativo all'intervento della squadra CFS e dei mezzi aerei è pari a:

C_{e_ss1} = 46.233+10,30*1*130= 47.572 €

Nella fase di spegnimento dei restanti focolai e nella fase di bonifica dell'incendio è intervenuta anche una squadra di operai costituita da tre persone. Il costo degli operai è stato stimato in:
C_{e_ss2} = 6* 1 * 130 = 780 €

Di conseguenza il costo totale di estinzione è pari a:

C_{e_ss}= C_{e_ss1} + C_{e_ss2} =48.352 €

STIMA DEL DANNO AMBIENTALE

L'esempio applicativo ha previsto l'utilizzo di un approccio sintetico, di un approccio intermedio ed uno analitico per la stima del danno ambientale.

La stima del danno ambientale è stata comparativamente condotta secondo lo schema riportato in figura 2 (cfr § 1.3)

APPROCCIO SINTETICO

Secondo questo approccio la stima del danno viene effettuata in base alla formula:

$$ED_{MAV} = (MAV_{for} - MAV_{bs}) * area * DL$$

dove:
ED_{MAV} = environmental damage (€); MAV_{for} = Mean Agricultural Value for the forest type most similar to the one that was damaged (€/ha); MAV_{bs} = Mean Agricultural Value for uncultivated barren lands (€/ha); area = area burned by the fire (ha); DL = level of damage caused by the fire.

Per la stima del danno sono state utilizzate le informazioni riportate in tabella A.2.3

TABELLA A.2.3 – DATI UTILIZZATI PER LA STIMA DEL DANNO SECONDO L'APPROCCIO SINTETICO

Variabili	Valore	Note
MAV_{for}	7.700 /ha	Valore riferito al tipo di coltura "Bosco di alto fusto"*
MAV_{bs}	1.900 €/ha	Valore riferito al tipo di coltura "Incolto produttivo"*
Sup	13,50 ha	Superficie percorsa dal fuoco
LD	0,85	Valore stimato secondo il metodo degli effetti riscontrabili

* Dati pubblicati sul Bollettino Ufficiale della regione Calabria n. 5 del 16 marzo 2005 relativi alla Regione Agraria 3 – Sila Greca (Comuni di Acri, Bocchigliero, Campana, Longobucco)

Secondo questo approccio il danno ambientale può essere quindi quantificato pari a:

ED_{MAV} = (7.700 – 1.900) * 13,50 *0,85 = 66.555 €

APPROCCIO INTERMEDIO

Il procedimento prevede la stima del danno ambientale secondo la seguente formula.

$$ED = RC * Sup * DL$$

Dove:

EA = environmental damage (€); RC = reconstruction cost (€/ha); FBA = area burned by the fire (ha); DL = level of damage caused by the fire.

Il coso di ricostruzione è stato stimato con la seguente formula:

$$RC = PC * (1 + r)^n$$

Dove:
RC = reconstruction cost (€/ha); PC = planting cost (€/ha); r = discount rate; n = number of years needed for reconstruction.

$$ED = PC * (1 + r)^n * Sup * LD$$

ED = 3.000 * $(1+0,03)^{25}$ *13,50 * 0,85 = 72.078€

I dati utilizzati per la stima del danno sono riportati in tabella A2.4

TABELLA A2.4 - DATI UTILIZZATI PER LA STIMA DEL DANNO SECONDO L'APPROCCIO INTERMEDIO

Variabili	Valore	Note
PC	3.000 €/ha	Costo medio di impianto a livello nazionale
r	0,03	Saggio di sconto cosiddetto legale
n	25 anni	Valore stimato sul bosco incendiato
Sup.	13,50 ha	Superficie percorsa dall'incendio
LD	0,85	Valore stimato secondo il metodo degli effetti riscontrabili.

APPROCCIO ANALITICO

Productive function: wood products

Come indicato nel § 2.2.1 la stima analitica del danno legato alla perdita di prodotti legnosi è calcolata con la seguente formula:

$$ED_{le} = FBA * Vol * \frac{P_{imp} - C_{te}}{(1 + r)^m}$$

Dove:
ED_{le} = environmental damage due to wood-producing loss (€); FBA = forest area burned by the fire (hectares); Vol = volume of wood lost following the fire (m^3/ha); P_{imp} = mean roundwood price at roadside (€/m^3); C_{te} = felling and logging costs (€/m^3); r = discount rate; m = years needed to reach mean rotation age.

Per la stima sono state utilizzate le informazioni riportate in tabella A2.5

TABELLA A2.5- DATI UTILIZZATI PER LA STIMA DEL DANNO CONNESSO ALLA FUNZIONE DI PRODUZIONE LEGNOSA

Variabili	Valore	Note
FBA	13,50	Superficie percorsa dal fuoco
Vol	35 m^3/ha	Valore stimato sul bosco incendiato
Pimp	35 €/ m^3	Prezzo medio di macchiatici a maturità commerciale del bosco incendiato
r	0,03	Saggio di sconto cosiddetto legale
m	20 anni	Valore stimato sul bosco incendiato

Il danno legato alla perdita di legname può essere quantificato pari a:

$$ED_{le} = 13{,}50 * 35 * \frac{35}{(1+0{,}03)^{20}} = 9.156 \text{ €}$$

Productive function: non-wood forest products

Come indicato nel § 2.2.2 la stima analitica del danno inerente questa funzione è calcolata con la formula seguente:

$$ED_{NWFP} = FBA_{NWFP} * R_{NWFP} * \frac{(1+r)^p - 1}{r * (1+r)^p}$$

Dove:

ED_{NWFP} = environmental damage from the loss of non-wood forest products (€); FBA_{NWFP} = area that produces non-wood products burned by the fire (ha); R_{NWFP} = mean annual income from non-wood forest products (€/ha); r = discount rate; p = years of lost harvests of non-wood products following the fire.

Per la stima sono state utilizzate le informazioni riportate in tabella A2.6

TABELLA A2.6 - DATI UTILIZZATI PER LA STIMA DEL DANNO CONNESSO ALLA FUNZIONE DI PRODUZIONE NON LEGNOSA

Variabili	Valore	Note
FBA_{NWFP} = FBA	13,50	Superficie percorsa dall'incendio con funzione di produzione di prodotti non legnosi
R_{NWFP}	11€/ha	Valore riferito a stime medie a livello nazionale per la tipologia di bosco in esame
r	0,03	Saggio di sconto cosiddetto legale
p	10 anni	Valore convenzionale

Il danno legato a tale funzione è stato identificato in:

$$ED_{NWFP} = 13{,}50 * 11 * \frac{(1+0{,}03)^{10} - 1}{0{,}03 * (1+0{,}03)^{10}} = 1.267 \text{ €}$$

Tourism-recreational function

Come indicato nel § 2.2.3 la stima analitica del danno inerente tale funzione, riferita al numero medio di visite per anno nel soprassuolo in oggetto prima dell'incendio, viene effettuata in base alla seguente formula:

$$EA_{rec} = V_{rec} * N_{rec} * \frac{(1+r)^g - 1}{r*(1+r)^g}$$

Dove:

EA_{rec} = environmental damage from loss of tourism-recreational activities (€); V_{rec} = mean value of one visit (€); N_{rec} = mean number of visitors per year; r = discount rate; g = years of lost tourism-recreational activities following the fire.

Per la stima sono state utilizzate le informazioni riportate in tabella A2.7

TABELLA A.2.7 - DATI UTILIZZATI PER LA STIMA DEL DANNO CONNESSO ALLA FUNZIONE TURISTICO-RICREATIVA

Variabili	Valore	Note
V_{rec}	5 €	Valore riferito a stime medie a livello nazionale per la tipologia di bosco in esame
N_{rec}	4	Valore stimato sul bosco incendiato
r	0,03	Saggio di sconto cosiddetto legale
g	5 anni	Valore stimato sul bosco incendiato

Il danno legato a tale funzione può essere quantificato pari a:

$$EA_{rec} = 5*4*\frac{(1+0{,}03)^5 - 1}{0{,}03*(1+0{,}03)^5} = 91 \text{ €}$$

Soil protection function

Come indicato nel § 2.2.5 la stima analitica del danno inerente tale funzione, riferita alla superficie in condizioni di rilevante degrado legata alla funzione di stabilizzazione idrogeologica a seguito dell'incendio, viene effettuata in base alla formula:

$$ED_{prot} = FBA_{prot} * \left(C_{rev} * r + C_{ann} * \frac{(1+r)^i - 1}{r*(1+r)^i} \right)$$

Dove:

ED_{idr} = environmental damage from the decreased water cycle regulation and soil protection (€); FBA_{prot} = forest area with protective functions burned by the fire (ha); C_{rev} = cost of revegetation (€/ha); C_{ann} = annual maintenance costs of the revegetation area (€/ha); r = discount rate; i = years needed to maintain the area.

Per la stima sono state utilizzate le informazioni riportate in tabella A2.8

TABELLA A2.8- DATI UTILIZZATI PER LA STIMA DEL DANNO CONNESSO ALLA FUNZIONE DI PROTEZIONE IDROGEOLOGICA

Variabili	Valore	Note
FBA_{prot}	0,6	Superficie con funzione di protezione direttamente danneggiata a seguito dell'incendio (vedi considerazioni di

		cui al § 2.2.5
C_{rev}	11.900 €/ha	Valore riferito a costi medi per la tipologia in esame
C_{ann}	4.000 €/ha	Valore riferito a costi medi per tipologia in esame
r	0,03	Saggio di sconto cosiddetto legale
I	3 anni	Valore stimato sul bosco incendiato

Il danno connesso alla funzione di protezione idrogeologica può quindi essere quantificato in:

$$ED_{idr} = 0{,}6 * \left(11.900 + 4.000 * \frac{(1+0{,}03)^3 - 1}{0{,}03 * (1+0{,}03)^3}\right) = 13.884\ €$$

Carbon dioxide sequestration function

Come indicato nel § 2.2.6 la stima analitica del danno inerente tale funzione viene effettuata in base alla formula:

$$ED_C = FBA * Vol_b * BEF * 0.5 * P_C$$

Dove:
EA_C = environmental damage from carbon emitted into the atmosphere (€); FBA = forest area burned by the fire (ha); Vol_b = volume of the above-ground woody biomass burned by the fire (m^3/ha); BEF = Biomass Expansion Factor (coefficient of transformation by volume of the above-ground woody biomass, expressed in m^3, into total biomass, expressed in t of dry matter); P_C = price of one ton of carbon (€/t).

Per la stima sono state utilizzate le informazioni riportate in tabella A2.9

TABELLA A2.9- DATI UTILIZZATI PER LA STIMA DEL DANNO CONNESSO ALLA EMISSIONE DI ANIDRIDE CARBONICA

Variabili	Valore	Note
FBA	13,5 ha	Superficie percorsa dall'incendio
Vol_b	19 m^3/ha	Valore stimato sul bosco incendiato
BEF	0,7 t/ m^3	Valore medio per la classe di vegetazione forestale D (vedi tabella 6)
Pc	16 €/t	Prezzo medio 2006 (dati EU-TS)

Il danno connesso alla emissione di carbonio in atmosfera può essere quantificato pari a:

EA_C = 13,5*19*0,7*0,5*16= 1.436 €

Biodiversity protection function

La formula utilizzata nel § 2.2.7 per la stima analitica del danno inerente questa funzione può essere applicata per la valutazione degli incendi boschivi in Europa. Nel caso specifico dell'incendio di Longobucco in Italia la formula utilizzata è la seguente:

$ED_{bio} = V_{bio} * FBA * DL * PC * (1+r)^n$

Dove:
ED_{bio} = environmental damage (€); V_{bio} = value of biodiversity loss (€/ha/year); FBA = forest area burned by the fire (ha); DL = damage level of the fire; PC = planting cost (€/ha) r = discount rate; n = number of years lost in biodiversity conservation (with the case of n $\rightarrow \infty$ that, in extreme cases, could also be assumed).

Si tratta di una formula che tiene conto di indagini effettuate negli anni precedenti l'incendio e si basano su un approccio di *benefit transfer* che prende come riferimento i risultati di stime con metodologie della valutazione contingente.

Per la stima sono state utilizzate le informazioni riportate in tabella A2.10

TABELLA A.2.10- DATI UTILIZZATI PER LA STIMA DEL DANNO CONNESSO ALLA FUNZIONE NATURALISTICA

Variabili	Valore	Note
V_{bio}	0,7	Valore riferito alla tipologia di bosco incendiato (Fustaie monospecifiche)
FBA	13,5 ha	Superficie percorsa dall'incendio
DL	0,85	Valore stimato secondo il metodo degli effetti riscontrabili
r	0,03	Saggio di sconto cosiddetto legale
n	25	Valore stimato sul bosco incendiato
PC	3.000 €/ha	Costo medio di impianto a livello nazionale

$ED_{bio} = 0,7 * 13,5 * 0,85 * 3.000 * (1+0,03)^{25} = 50.455$ €

La stima analitica complessiva del danno ambientale è pari a:

$ED_{env} = ED_{le} + ED_{NWFP} + EA_{rec} + ED_{idr} + EA_C + ED_{bio}$

$ED_{env} = 9.156+1.267+91+13.884+1.436+50.455 = 76.289$ €

Conclusioni

In tabella A 2.11 sono riportati i risultati ottenuti dalla sperimentazione della metodologia concernente la valutazione economica dei danni legati all'incendio boschivo verificatosi nel comune di Longobucco in Italia.
In particolar modo la stima del danno ambientale secondo l'approccio sintetico è legata direttamente alla diminuzione del valore fondiario dell'area interessata dall'evento.
Il procedimento intermedio, legato al costo di ricostruzione generalmente utilizzato nella prassi estimativa, fornisce risultati leggermente inferiori ma sostanzialmente comparabili rispetto a quelli dell'approccio analitico.

Per quanto riguarda quest'ultimo approccio, la singola funzione ambientale che risulta aver subito il maggior danno in termini economici è quella naturalistica (con una perdita di biodiversità stimata di circa il 66% del danno economico totale), seguita da quella di protezione idrogeologica (18%) e da quella di produzione legnosa (12%).
Per quanto riguarda invece le restanti funzioni danneggiate dall'evento nell'area esaminata la funzione ricreativa ha subito un danno molto ridotto, come quello legato alle produzioni non legnose e all'emissione di carbonio in atmosfera.

Inoltre è da precisare in riferimento a quest'ultima tipologia di danno, che le previsioni di mercato legate al prezzo del carbonio sono in crescita. Infatti, il prezzo del carbonio riferito al mese di maggio del 2006 era pari a 16 €/t mentre la quotazione media del mese di agosto 2008 è di circa 23 €/t e che le tendenze di mercato sembrerebbero indicare prezzi in aumento.

TABELLA A 2.11- RISULTATI DELLA VALUTAZIONE ECONOMICA DEI DANNI DELL'INCENDIO BOSCHIVO

Costo di estinzione (€)	48.352
Danno Ambientale€	
- Approccio sintetico	66.555
- Approccio intermedio	72.078
- Approccio analitico	76.335

ANNEX 1

LITERATURE

1.1 ECONOMIC ANALYSES OF THE COSTS OF FOREST FIRES

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ANNEX 2

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