FOREST AND AGRICULTURE SYSTEMS

FOREST SYSTEMS

[Orazio Ciancio, Piermaria Corona, Marco Marchetti, Susanna Nocentini]

THE ECOSYSTEM APPROACH IN SILVICULTURE

Over the last decade in many developed countries the objectives of forest management, the management practices and even the managers themselves have radically changed: the growing attention to environmental values has led to a significant expansion of protected areas' systems (frequently dominated by forest covers) in many countries; a greater stress on multiple use natural forest management and a greater attention to environmental factors have been conducive to reducing exploitation intensity and to modifying silvicultural practices; initiatives that insist in the scientific debate on '*continuous cover forestry*' are proliferating; in relation to high forest management it is, in our country, a long-time acquired concept, that came into existence along with the debate on European forests' deterioration, only to gain momentum even in countries with a strong forestry tradition, together with certification processes and with the increase in general public's awareness.

'Sustainable' management of North American and European temperate, boreal and Mediterranean forests is thus all the more oriented toward environmental protection, biodiversity conservation and recreational use, and the efforts toward a better management of wood production forests include silvicultural improvements and commitment to responsible ecological practices of log extraction. In the face of this situation, problems are building up in tropical and subtropical biomes, where sustainability is but a series of wishful declarations of intent, and deterioration phenomena, indiscriminate resource exploitation and harvesting – wood mining – are still on the rise; only to be hopefully checked by investing first and foremost in promoting lawfulness.

Fig. 6.1 - Beech high forest in Pollino National Park (Photo by S. Bonacquisti).

At the beginning of the '90s European governments began encouraging common initiatives for the conservation of forest heritage. By approving[1] in 1998 a 'Forestry

Strategy for the European Union' proposed by the Commission[2], the EU and its member States have emphasized the importance of sustainable forest management and of forest protection. The constructive establishment of the Nature 2000 Network, as well as the other initiatives, such as for example the National Forest Programs and the application of the resolutions of the *Ministerial Conference on the Protection of Forests in Europe* (MCPFE), all represent important results for the EU at an international level (European Commission, DG Environment, Nature and biodiversity Policy, 1998).

MCPFE has created an essential network for the progress of *Sustainable Forestry Management* (SFM) in Europe. In 1993 European countries agreed to the Helsinki declaration by bringing forth a resolution – H1 – based on the '*Forest principles*', in which the General Guidelines for Sustainable Management of Forests in Europe were defined. Thereafter a series of actions was undertaken, related to the formulation of the General Principles, of SFM Criteria, and of a coherent set of performance Indicators for the management of forest activities.

[1] Council Resolution of 15.12.1998, GU C 56 of 26.9.1999, pg. 1.
[2] COM (1998) 649 def. of 3.11.1998, GU of 18.11.1998.

In parallel to the SFM concept, a new approach connected to sustainable growth was developed within CBD: the *Ecosystem Approach* (EA) (see box *Ecosystem Approach*). Ecology thus takes on a fundamental role, by working on the interactions and retroactions between the organisms and the environment in terms of integrated systems: the ecosystemic approach is of great value in the management of terrestrial resources as it takes into account the links between the biotic system –which man is an integral part of – and the physical system the latter is based on. This holds true at all scales, from the planet to the wood to the cultivated land, and is all the more important at a time in which global changes are increasingly rapid and the demand for resources is on a continuous rise.

The ecosystem approach is conceptually very similar to the *systemic approach* applied to the management of natural resources in the MAB (*Man and Biosphere*) Programmes of UNESCO, and similar to the '*Ecosystem management approach*' adopted by the *Forest Service* and by the *Bureau of Land Management* of the United States in 1992, to serve as a guideline in the handling of federal territory natural resources. EA does not rule out other categories of conservation and management approach, such as the ones that are under current application in the reserves of the biosphere, in protected areas, in single

Fig. 6.2 - Panoramic view of the Pollino massif (Pollino National Park. Photo by S. Bonacquisti).

species conservation programmes, etc., instead it can integrate all of them in order to face up to and solve more complex management issues. In fact there is no single unique Ecosystem Approach implementation strategy: it rather depends upon what conditions are present at local, provincial, regional, national or international scale (Wilkie *et al.*, 2003; MCPFE, 2004).

The debate is on over 'how to do' natural resources integrated management, so that it may be effectual in the different environmental settings, and in taking all different issues into account. Among them, 'the forestry issue' (Ciancio, 1999) has gained relevance, and interest is growing in this domain for the new silvicultural systems that are becoming established in many parts of the world; they aim at joining conservation and multifunctionality, though through different avenues and in general through specifically referred environments in North America, Australia, North and Central Europe, and now in the Mediterranean (Dhubhain and Pommerening, 2004).

An occasion for discussion may be offered by taking into consideration the Italian situation, which is peculiar as it represents the different environmental conditions that are typical of the Mediterranean area, and the relative inconveniences: depletion of water resources, desertification, pollution, hydrogeological imbalance, etc.

Moreover, it has been many years since Italian schools of thought regarding forestry underlined the aspects emerging from EA Principles, such as the necessity to preserve forest ecosystems' structure and functionality in order to ensure the provision of assets and services over time; the importance for management approach to be comprised within the limits of ecosystem functionality; the adoption of a spatial and temporal scale tuned in on local characteristics, both environmental and social; the consideration of long term objectives, laying stress on temporal scale variability and on 'feedback' effects of the ecosystem processes; consciousness of the inevitability of the impacts on the forest ecosystem that are caused by silvicultural activities, and the revisitation of past technocratic convictions; the tendencies to integrate to a greater extent resource use and biological diversity conservation; finally, the opening up of the forestry sector to other relevant sectors of society and scientific disciplines, as evidence of triumph over limiting academic sectarianism. At any rate, it is evident how EA stresses the importance of greater holistic perception of environmental management issues, so that systemic silviculture should take into further account the effects – both actual and potential – of silvicultural practices on adjacent and non adjacent ecosystems. EA, being the more recently outspread concept, has benefited from a few experiences having been conducted in diverse ecosystems, but still suffers from the lack of tested and true guidelines for its practical implementation, which have been the aim of the discussion at the *Expert Meeting on the Ecosystem Approach*.

Fig. 6.3 - Mixed deciduous forest in the Natural Reserve Montagne della Duchessa (Photo by S. Bonacquisti).

However, examples of comparative analysis of the results issuing from the application of the two approaches to a given forest do not exist. For the time being, Systemic Silviculture can be considered to be the best technical instrument available for EA application to forest ecosystems, while all tools contrived in view of sustainable forest management are apt to be used for enhancing EA implementation.

ITALIAN FOREST HERITAGE

Physiognomic diversity and consistency of Italian forest heritage

Just about 32 percent of Italian forest stands are included in the Alpine biogeographic region (following the Habitat Directive), 16 percent in the continental and 52 percent in the Mediterranean.

With respect to this marked biogeographic variability, Italian forest systems are characterized by high specific and physiognomic diversity. According to data from worldwide reports on the status of forests, based on the last global level exhaustive research run by FAO, which includes Italy in the *Temperate and Boreal Forest Resources Assessment* (dubbed TBFRA2000, see UN, 2000), there are 86 Italian forest-occurring species; one of them, *Abies nebrodensis*, is a high-priority species according to the Habitat Directive, and is officially in great danger of extinction. *Salix pentandra* is also in danger of extinction as far as Italy is concerned (CONTI *et al*., 1992). Moreover, according to FENAROLI and GAMBI (1976), a moderate number of tree forest species is endemic, to Italy alone (*Acer lobelii* and *Genista aetnensis*, to which recently identified *Zelkova sicula* must be added) or to a small range comprising Italy itself (*Alnus cordata*, *Quercus macrolepis*, *Q. trojana*, *Pinus leucodermis*).

Following BOLOGNA *et al.* (2004), the most common formations are represented by deciduous species dominated woods, in particular of the *Quercus* genus (27 percent of total forest cover); *Fagus sylvatica* follows (12 percent) and then other broadleaf trees, both mesophyte and mesothermophyte (12 percent) especially of the genus *Acer*, *Carpinus*, *Ostrya*, *Fraxinus*. The most widespread conifer coenoses are those dominated by *Abies alba* and/or *Picea abies* (10 percent), followed by *Pinus*-dominated woods (5 percent), in particular the mountain and oromediterranean species (Table 6.1).

Mixed woods are scattered all over Italian forest formations with variable percentage amounts. It is not straightforward to bestow a clearcut vegetational connotation on these formations, even though some are well characterized typologically, the beech-fir woods by way of an example, and the spruce-beech-fir woods. Pine and broadleaf trees mixed woods partly stem from the renaturalization operated by native deciduous plants in culturally abandoned reforestation stands.

According to FERRARI *et al.* (1996) the most endangered forest formations to date are:

Physiognomic category	Area [ha]	Area [%]
Holm oak and Cork oak dominated woods	781,462	9.9
Deciduous oak dominated woods	2,134,733	27.1
Chestnut dominated woods	158,843	2.0
Beech dominated woods	960,151	12.2
Other native broadleaved mesophyte and mesoxerophyte dominated woods	973,656	12.4
Hygrophilous broadleaves dominated woods	73,653	0.9
Non native broadleaves dominated woods	157,371	2.0
Mediterranean pines dominated woods	135,490	1.7
Mountain pine and oromediterranean pine dominated woods	404,448	5.1
Silver Fir or Norway Spruce dominated woods	779,177	9.9
Larch and/or Swiss Pine dominated woods	298,475	3.8
Non native conifers dominated woods	11,703	0.1
Tall shrublands	278,310	3.5
Low shrublands and garrigues	715,465	9.1

Table 6.1 - Forest cover distribution in Italy (BOLOGNA *et al.*, 2004)

- Mediterranean dune phyto-coenoses;
- *Abies* sp.p. and *Fagus sylvatica* on mixed stands;
- stands of natural origin with a prevalence of *Abies* sp.pl.;
- coenoses with a prevalence of *Pinus leucodermis*;
- riparian and plain forests;
- many Mediterranean sclerophyllous forests (including *Chamaerops humilis* formations).

Overall forest cover has been estimated at 106,735.89 sq km, that is 35 percent of the Italian territory, which also comprises 'other forest areas' (*sensu* UN, 2000): essentially evolving shrubland and Mediterranean macchia, and timber tree culture nurseries (CFS, 2004). The expansion rate of forest cover can be estimated at approximately 0.3 percent per year over the 1990-2000 decade, against the European average of 0.1 percent (CORONA *et al.*, 2004).

Data from trees outside the forest, such as thickets (1,862.12 sq km) and linear forest formations (shelter belt plantations, etc.: 2,921.19 sq km), can be taken into account in addition to the forest cover data.

According to TBFRA2000, the carbon content of woody epigeal mass out of woods and other Italian forest areas comes close to 365.8 Tg (1 Tg = 1E+12 g), corresponding to an average value of 0.37 t (sq km)$^{-1}$. Carbon annual absorption rate of woody epigeal mass has been evaluated as 10 Tg year^{-1}, whereas the estimate for carbon uptake out of forest use is 3.3 Tg year^{-1}; therefore, the rate of carbon fixation in woody mass of woods and other forest areas in Italy can be gauged as approx-

Fig. 6.4 - *Acer campestre* L. in its autumn livery (Natural Reserve Montagne della Duchessa. Photo by S. Bonacquisti).

ITALIAN FOREST PROTECTION STATUS

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A quantification of forest surface area comprised in protected areas is supplied by TBFRA2000, which provides the estimate of around 19 percent of total forest surface. 'Strictly protected' forest surface (categories I and II of the IUCN World Conservation Union) can be considered to almost reach 14 percent, on the basis of data output from ISTAT, 1991 land use map elaboration (as reported by CIANCIO *et al.*, 2002), that is more than 13,260 sq km, distributed over National Parks, integral and oriented natural reserves, biogenetic reserves and oases. The latter figure, however, is likely to be overestimated, considering that inside a National Park the area actually set aside for biodiversity conservation depends on zonation (see art. 12, L. 394/91); only A zones - integral reserves - and B zones – general oriented reserves – represent regions where the conservation of biological diversity is the high priority objective.

Specific data on the biodiversity protection of Italian forests can be obtained from the action COST E4 *Forest Reserves Research Network*, which is currently under revision within the scope of another European concerted action, PROFOR E27 – *Protection of Forest in Europe*: at the end of the '90s protected forest surface area solely devoted to conservation purposes (*strict forest reserves*) was judged to be 620 sq km – 0.6 percent of total national forest surface – distributed over a network of 119 forest reserves. Among them, 70 Natural Reserves managed by the National Forest Police and included in the network of Biogenetic Reserves of the Council of Europe.

On the basis of data produced by CHIRICI *et al.* (2002), it can be pointed out that, at national level, woody formations cover more than 46 percent of terrestrial land cover in the territories included in the Official List of Protected Areas (2000). In particular, it is to be observed that the National Parks, when grouped together, include significant areas from all of the principal Italian forest formations (table 1), to the exception of mixed woods dominated by hygrophilous species, and of woods – pure and mixed – dominated by non-native deciduous plants.

As for the ample framework of Natura 2000 Network in Italy – approximately 47,790 sq km, distributed over 2,256 SIC and 503 ZPS – forest habitats are involved with the majority of the sites, covering, by and large, more than 42 percent of their surface area. High priority habitats according to the Directive, represent around 27 percent of the 77 different types of forest habitats that are present in the Italian Natura 2000 Network, and interest almost 40 percent of the total forest habitat sites. Some synthetic data on the characteristics of forest habitat sites are reported by BARBATI *et al.* (2002): significant is the high percentage of sites – more than 48 percent - whose forest area is more than 50 percent occupied by forest formations that are not included in the Habitat Directive (for example, reforestations, formations of allochtonous naturalized species, etc.); more than half of the surface area contained in Natura 2000 sites belongs to zones currently deprived of any type of specific protection; more than half of them incorporate forest habitats; more than two thirds of the SIC/ZPS with forest habitats are not endowed with any form of forest planning process: what is more, almost half of the latter fall outside of protected areas, so as to be also removed from any formal procedure of protection or management; around 40 percent of the sites include non-ordinarily managed formations - that is, ones in which all forest use interventions are conducted on a totally casual basis.

BARBATI A., CORONA P., GARFÌ G., MARCHETTI M., RONCHIERI I., 2002 – *La gestione forestale nei SIC/ZPS della rete natura 2000: chiavi di interpretazione e orientamenti per l'applicazione della direttiva Habitat*. Monti e Boschi, 2: 4-13.

CHIRICI G., CORONA P., MARCHETTI M., BLASI C., 2002 – *Elaborazione della carta dell'uso del suolo e delle coperture vegetazionali a copertura nazionale in scala 1:250.000*. Atti, 6ª Conferenza ASITA, Perugia, 2002, vol. I, pp. 787-792.

CIANCIO O., CORONA P., MARCHETTI M., NOCENTINI S., 2002 – *Linee guida per la gestione sostenibile delle risorse forestali e pastorali nei Parchi Nazionali*. Accademia Italiana di Scienze Forestali, Firenze, 300 pp.

Physiognomic category	Included surface	
	[km²]	[%]
Holm oak and Cork oak dominated woods	675	9%
Deciduous oak dominated woods	1,442	7%
Chestnut dominated woods	203	2%
Beech dominated woods	2,149	18%
Other native broadleaved mesophyte and mesoxerophyte dominated woods	600	6%
Hygrophilous broadleaves dominated woods	33	3%
Non native broadleaves dominated woods	0	0%
Mediterranean pines dominated woods	131	4%
Mountain pine and oromediterranean pine dominated woods	412	10%
Silver Fir or Norway Spruce dominated woods	261	3%
Larch and/or Swiss Pine dominated woods	278	8%
Non native conifers dominated woods	2	2%

Table 1 - Forest cover inside the national Parks (included in the 2000 Official List). Data produced by CHIRICI *et al.* (2002) and further processed.

imately 7 Tg year^{-1}, according to official estimates. However, this figure is believed to be underestimated, for various reasons (CORONA *et al.*, 2004). At any rate, the significant share contributed by the forest sector to atmospheric carbon containment policies is to be argued for, as has been acknowledged at international level by the United Nations Framework Convention on Climate Changes - UNCCC, and at national level by the CIPE 123/2002 Deliberation (Guidelines revision for national measures and policies of greenhouse gas emission reduction).

Structural factors of forest biodiversity

In LARSSON *et al.* (2001) the principal structural, compositional and functional factors (*biodiversity key factors*) have been identified, reflecting and influencing forest biological diversity variations at different spatial scales: national, district, and forest management unit. Together with what was expounded in the previous paragraphs, this paradigm will be used below to evaluate the status of forest biodiversity on a national level, with particular reference to the following factors: degree of naturality of forest systems; species composition, differentiating between native and non native species; chronological structure. At European level recommendations will soon be put forth on the development and measurement of specific indicators for the monitoring of biodiversity changes. This in compliance with the Resolution L2 'Pan-European Criteria, Indicators and Operational Level Guidelines for Sustainable Forest Management', adopted by the III MCPFE - *Third Ministerial Conference on the Protection of Forests in Europe* – in June 1998, and subsequently confirmed and worked out in detail at the IV MCPFE (Vienna 2003), particularly as regards the definition of the indicators, expounded in the document 'Improved Pan-European Indicators for Sustainable Forest Management'. These official documents form the actual basis of the text 'National Guidelines for Forest Planning, according to art. 3, § 1 of legislative decree 5/18/01 no. 227, "Emplacement and Modernization of the Forest Sector, according to art. 7 of law 3/5/01, no. 57"', developed by the Ministry of the Environment and of the Protection of the Territory and already agreed to by the State and Regions Conference.

The primary source of information for the derivation of the factual items should be represented by inventory systems based on probabilistic sampling techniques, especially in view of report editing requirements (*reporting*), along scientifically sound criteria, on the state of forest biodiversity (BACHMANN *et al.*, 1998; CORONA *et al.*, 2002a). In fact, the National Forest Inventory, whose second cycle was set out at the beginning of 2003, fosters the acquisition of most such parameters, but in the meantime said factors have to be gathered and compounded from other, not always homogeneous, sources.

Old growth forests

Italian woods can be defined for the most part as 'semi-natural forests', that is, according to international nomenclature (see TBFRA2000), neither as 'forests non disturbed by man' nor as artificial 'forest plantations'.

The impact of plurimillenary anthropogenic action on the forests of southern Europe has brought about a profound alteration both of the structure of forest landscape and of the structural and compositional complexity of the original forests. Actually they represent the most 'ancient' in Europe, as they have been less affected by glaciations than North European ones, at the same time having experienced longer exposure to anthropogenic impact. In fact the first settlements in Greece date from 8,000 years ago, while the ones in Scandinavia from 2,500 years.

The intensity of anthropogenic exploitation has always been strongly influenced by local conditions, of both environmental and socio-economic nature, which single forest districts have come in touch with. In the hill, and especially, in the mountain areas, forest use and cultivation, and the ensuing structural and compositional alteration of the stands, have been more frequent and intense where the woods were more favourably placed – closer to inhabited sites, more accessible, on more fertile soils, etc.

As a consequence, forest sections that can correctly be defined as '*old growth forests*' are rare in Italy. They represent, in fact, just a small share of national forest area, mainly confined to impervious mountain zones: according to TBFRA2000 they constitute not more than 0.0006 percent of national forest area. A larger extension has been estimated by PETRETTI and LOMBARDI (1994, mentioned in FERRARI *et al.*, 1996), with reference to 'forest coenoses in next-to-natural conditions': a full 1,600 sq km (approximately 1.6 percent of national forest area). In terms of biodiversity conservation and of forest dynamics in the absence of anthropogenic disturbance, these areas and those exhibiting high genetic value should both deserve particular attention.

Aspects of structural and compositional simplification of forest coenoses

Italian forests are the result of agelong coevolution of ecological and social-economic issues. Cultivation and management as means to economic ends have deeply modified their structure and composition, reducing complexity and diversity, to the benefit of renovation rate predictability and of granted maximum and constant wood production (CIANCIO *et al.*, 1999; NOCENTINI, 2001). The simplification of forest systems is not only concerned with the genetic aspects, but also with structure and process variety, both considered at different scales.

Most of the processes that bring forth and support biological diversity of a forest stand refer back to events that took place in remote past times – for example, forest fires – or in landscape areas removed from the area that is under exam (for example, pollution). A few Authors have defined these phenomena as 'invisible present' and 'invisible site', so as to stress that erroneous spatial and temporal perspectives may lead to erroneous conclusions in the evaluation of ecosystem diversity (MAGNUSON, 1990; SWANSON and SPARKS, 1990).

In many areas of our country the differentiation of the mosaic landscape, to the effect of the wood becoming interposed to other land use activities (pasture, agriculture), and the diversification of the cultural processes within the different forest tiles, have produced diversity enriched landscapes, not only of biological but also of historical, cultural and aesthetic value.

Beside old growth forests, all other forest areas show more or less distinct signs of anthropic induced adjustments to the 'primitive' state, in the species composition of their crown canopy, in the dimensions and age of the trees, and in their spatial distribution (CIANCIO, 1996). In particular, anthropogenic activity has led to:

the modification of the species composition of original forests: decrease in species variability to the advantage of forest systems with prevailing conifers or deciduous plants of greater productive interest, such as, for example, the diffusion of *Picea abies* over the Alpine Arc. This partly explains the reduced share of mixed conifer and deciduous stands, representing 13 percent of total Italian forests as against 70 percent of woods with broadleaf prevalence and 17 percent of woods with conifer prevalence (BOLOGNA *et al.*, 2004). Native mixed forests of major conservation interest - for example, the mixed *Fagus sylvatica* and *Abies* sp.pl. woods – are cut down to small-size relics, dispersed along the Apennine Arc;

the introduction and the diffusion of allochtonous species, through forest plantations or cultivation, somewhere near forest areas (table 6.2). A few of these species, endowed with highly competitive potential in areas exhibiting phytoclimatic characters that were close to their sites of origin, have spread ('naturalized') over the territory, growing to be invasive species to a few natural forest ecosystems; for example, *Robinia pseudoacacia* spreading over stations proper to hornbeam and oak-hornbeam lowland forests, or over riparian hygrophilous formations. The high specific contamination potential of invasive species represents a critical element for natural formations, as it can lead to their regression with subsequent decline of the biological diversity of the coenoses. Species diversity connected to forest systems made up of non indigenous species is generally less than that associated with native species, as the other populations of the community – e.g. the wood invertebrates – have not had enough time to adapt to the new species;

structural modification of original forests, going from uneven-aged to even-aged. In particular, about 53 percent of Italian forests is portrayed by forest systems that do not exist in nature, such as simple, with-standards and composed coppices, chestnut and pine seed orchards, cork farms and other specialized stands (Manna ash orchards, etc.); moreover, almost 60 percent of all Italian high forests are even-aged formations and share a homogeneous and uniform structure over relatively wide areas (TBFRA2000);

the elimination of mature and senescent phases of biological development, and altogether the decline of forest species related to such phases; even-aged high forests and so-said articulate ones for the most part are not older than 60 years and less than a fifth of them grows to be older than 100, thus only rarely attaining the coenoses' potential staying power (DEL FAVERO, 2000a);

Abies cephalonica	*Juglans nigra*
Acacia pycnantha	*Larix leptolepis*
Acacia saligna	*Paulownia tomentosa*
Cedrus atlantica	*Pinus canariensis*
Chamaecyparis lawsoniana	*Pinus eldarica*
Cupressus arizonica	*Pinus excelsa*
Cupressus glabra	*Pinus radiata*
Eucalyptus camaldulensis	*Pinus strobus*
Eucalyptus globulus	*Quercus rubra*
Eucalyptus x trabutii	*Pseudotsuga menziesii*
Eucalyptus occidentalis	*Robinia pseudoacacia*

Table 6.2 - Main allochtonous arboreal species used throughout reforestation practices and in wood plantations in Italy.

the creation, over pastures and in degraded or abandoned farmland, of monospecific stands that frequently cannot meet the requirements of naturality, not only in terms of composition and structure, but also in terms of functionality and of the capability of facing anthropogenic impacts;

the extreme reduction of forest surface over plain areas, with ensuing effects on the survival chances of forest formations and of their related species. It is the case of the oak-hornbeam forests of the Padana plain: the widest stands, such as Bosco Fontana in the province of Mantova, Bosco delle Sorti della Partecipanza of Trino Vercellese, La Mandria in the province of Turin, measure a bare minimum of 2 sq km, whereas all others only form thickets a few acres wide. On the other hand, the widespread presence of trees outside the forest (*sensu* TBFRA2000), though valued as an incentive to species biodiversity at the scale of the territory, still needs to be completely apprehended and properly exploited, and but rarely leads to the involvement of forest-type functional processes, under present-day management conditions.

Fig. 6.5 - Beech forest in Pollino National Park (Photo by S. Bonacquisti).

SILVICULTURAL MANAGEMENT AND FOREST TYPES

Silvicultural management

Biological diversity and its role in the performance of forest ecosystems with respect to management have been dealt with almost always through researches conducted at short spatial and temporal scales, if compared to the whole range of involved ecological processes. Natural disturbance factors occur in forest systems through an ample variety of micro- and meso-scales, which determine the spatial and temporal contexts of every process.

Forest management operates on a spatial scale varying from one or few trees (thickets and tree-rows) to entire woods or forests, and over basins and districts of different dimensions; the temporal scale is issued by the planning cycles – 10 to 20 years – by the adopted shifts – 15 to 120 years – and by the duration of the planning tools, rather than by the intervals interposing natural perturbations – 1 to 1,000 years – or by the longevity of the forest species – resident times varying from many decades to few centuries, to over 1,000 years - (SPIES and TURNER, 1999).

Wood management at the landscape level entails the labelling of single tiles through the fluctuation of the age class distribution of the stands, and has a bearing over the presence and the characteristics of border zones, over the dynamics of the water bodies, over the succession processes of contiguous open areas, etc.

The adoption of time shifts that are considerably shorter than the longevity of the natural species is the factor through which the main difference emerges between anthropogenic and natural forest landscapes. In the latter, which are subjected only to natural disturbances, the different tiles display great variability in terms of age and succession stages, but the distribution always shows a 'tail' extending toward the older ages (SPIES and TURNER, 1999).

Fig. 6.6 - Holm-oak forest in Pollino National Park (Photo by S. Bonacquisti).

In the managed forest, instead, one or more species are favoured in relation to peculiar characteristics, such as coppice capacity, growing rate, quality of wood production, hardiness, etc. Silvicultural practices favouring distinct species and disregarding contemporary damage inflicted upon others are not too rare; it is only through different silvicultural methods that diverse forest models can be obtained with the typical species – the best known, or the more sought after – of the system in hand (CLAUSER, 1999, 2001). As far as the arboreal species are concerned, for example, Norway spruce has often been promoted over Silver fir by cultivation practices in the Alpine fir/beech woods; treatment normally prescribed for beech woods, based upon uniform successive cuts, has given advantage to total beech renewal over other, often associated, species, such as maple and ash, that need more complex structures to be able to assert themselves. The vast spread of some species, such as the chestnut, has consistently diminished the area at the disposal of species, as the Sessile oak, that once were surely more common. Again, in deciduous oak coppices, especially so in stations with poor, chalky soils, repeated coppice cuts favour the Hop Hornbeam, which displays quicker growth and sucker production than oaks (BERNETTI, 1995). Less well known are the follow ups of these alterations on the diversity of the species that take part in the soil fauna and in the soil flora.

Management affects the forest structure, the renewal processes, the distribution over age classes, and, in particular, the maximum age – in relation to the rotation or to the diameter limit cut. For example, in the forest of Vallombrosa (Florence), where management for over a century has been centered on low-cut treatment and deferred artificial renewal of Silver fir, the surface area occupied by this species has gone from 2.17 sq km in 1876 (GIACOMELLI, 1878) to 6.8 sq km by 1960 (PATRONE, 1960). Moreover, constant application of 100 years rotation has made for only 6 percent of total fir wood surface currently presenting stands over 120 years old, in spite of an ongoing harvesting suspension that was started in the '70s. This situation is shared by all other public owned fir woods in Central and North Apennine, where the 100 years rotation has been systematically prescribed, and has taken on the characteristics of a truly 'accustomed rotation'.

Furthermore, forest management may induce habitat fragmentation, cause disturbance to the wildlife, promote humus removal, as well as the mixing between different soil layers, the onset of erosive phenomena, etc. The latter aspects are particularly evident in coppice woods. This form of governance can cause soil richness reduction, and, in some cases, even depletion, through extraction of great quantities of nutritional substances, owing to cuts being repeated at short intervals. Moreover, it offers but scarce protection to the soil, because of cuts' continual iteration, after each application the cover being drastically reduced for some time.

CIANCIO *et al.* (2002b), in a research on 30 year-old Holm oak coppices in Calabria, have ascertained that at the end of rotation, through the extraction of the trunks and of loppings up to 3 cm wide in diameter, as is the case in Holm oak coppice production, about two thirds of the immobile mineral elements trapped inside the plants are removed. This percentage drops to 41 percent only for nitrogen and manganese. Without doubt, all of this determines the pauperisation of nutritional elements in the system, only partly dampened by leaving minute loppings, including the foliage, over the surface of the felling site.

In the Mediterranean environment, where rain intensity often builds up, erosion removes the surface layer of the soil so that, at times, nothing remains but the rocks cropping out. In a beech coppice in the Tosco-Emiliano Apennine, felled to stumps with residual leave trees, FALCIAI *et al.* (2002) have noticed that surface runoff has undergone a steep increase at the time of the felling, going out to reach, in the two years following the treatment, values as high as 3.5 times those registered in an unused stand. Leveling off to the initial values recorded before the felling only occurred after a 10-year period.

Fig. 6.7 - *Acer obtusatum* L. in its autumn livery (Natural Reserve Montagne della Duchessa. Photo by S. Bonacquisti).

The governance and the treatment influence the rate and the methods of natural renewal, with an additional side-effect on gene frequencies, which are related to the phenotypic characters of single individuals belonging to one or more species amid those present on the site (GIANNINI and BORGHETTI, 2001).

Silviculture and forest management act on biological diversity through a plurality of effects, strictly interrelated and often difficult to quantify. The more evident and more easily detectable ones are connected to the cultural models pursued. Such effects determine some alteration to the following parameters, all of which exhibit a well-known close relationship with species' diversity, and with the functional processes of forest ecosystems:

1) *vertical structure* – The vertical space arrangement of flowers, fruits, leaves is in agreement with the availability of food, and of suitable nesting, resting, mating and sheltering sites for many animal species (BELL *et al.*, 1991). The vertical organization of forest cover influences the microclimate inside the stand. As a general rule, the more varied is the vertical structure of the forest, the greater is the species diversity. This is well documented, especially for the bird fauna: numerous studies conducted through a wide range of different environments have pointed out how the richness of bird species is directly related to the increasing complexity of vertical structure (MAC ARTHUR and MAC ARTHUR, 1961; MOSS, 1978; BARBATI *et al.*, 1999);
2) *chronological structure* – The species richness of a forest ecosystem increases with the increase in the age of the arboreal component, especially so as the latter goes through a series of steadily more mature succession phases. This also depends on the fact that the vertical complexity of forest stands augments with age and with the stage of development (BROKAW and LENT, 1999). Moreover, large, old trees provide a range of habitats for a multitude of plant and animal species alike;
3) *presence of arboreal necromass* – Dead trees standing, and dead wood lying, both participate to numerous processes, which are best assessed concisely as relating to the *habitat* of plant and animal species, to the nutrients cycle, and to the hydrogeological cycle, particularly to surface erosion and water bodies dynamics (ELTON, 1966; MASER *et al.*, 1979; HARMON *et al.*, 1986; SAMUELSSON *et al.*, 1994);

4) *forest clearings in the arboreal cover* – Interruption of the arboreal cover, over more or less ample areas, triggers vegetation succession patterns, and weaves a spatial *configuration* that is likely to have a strong impact on population dynamics and on the ecosystem processes. The dimension of the clearings is particularly relevant as it has a bearing on the local stations conditions – light, temperature, etc. – and on seed source availability. The opening of gaps in the cover may produce a 'mobile mosaic' of tiles, each one of a different age, composition and structure, thus contributing to the diversity at the landscape level (PICKETT and WHITE, 1985; OLIVER and LARSON, 1990; FRANKLIN, 1993; TURNER *et al.*, 1995).

Other anthropic factors, off forestry practice in strict sense, may become strongly related to the diversity of species, of structures and of processes in the forest systems. In particular, hunting activity, through the input of particular animal species, such as the big ungulates, and especially through the alteration of their population structure, may cause disturbances throughout the arboreal component renewal processes (PROVINCIA AUTONOMA DI BOLZANO, 1997; SCRINZI *et al.*, 1997; MOTTA, 1999; MOTTA and PUPPO, 2001).

Silvicultural systems and biodiversity

Italian woods can be sorted into the following classes, based on individual management practices:
- Coppices:
  - simple coppices;
  - coppices with standards;
  - uneven-aged coppices;
  - composed high-coppice systems.
- High forests:
  - articulate and even-aged high forests;
  - uneven-aged high forests;
  - 'irregular' high forests.
- Plantations:
  - reforestation;
  - afforestation;
  - timber woodland.

Each one of these silvicultural systems is the product of a characteristic combination of changes in the composition, structure and processes of the ecosystem. The individual cultural and directional itinerary of each wood varies the aforementioned parameters, all relevant to the aim of biological diversity conservation (vertical structure, chronological structure, presence of arboreal necromass, forest clearings in the arboreal cover).
- Sustained yield woods,
  - ordinarily managed,
  - non-ordinarily managed;
- freely evolving abandoned woods;
- woods undergoing planned transition to other silvicultural systems (high forest conversion, re-naturalization, etc.);
- newly formed woods.

Simple coppices

Coppice wood is characteristic of many Italian mountain and hill landscapes. This form of management touches on a vast set of situations, each one differing from the other in relation to the climate, the soil, the orography, the setting, the species composition, etc. The great expanse of coppices in our country has been the logical outcome of necessity: that is, the need to produce fire wood or coal in relatively short periods of time, for food cooking, for house heating, and for small stocks to be landed at factory and farm enterprises.

Fig. 6.8 - Coppiced Turkey-oak forest in high Molise (Photo by P. Di Marzio).

Coppices constitute 53 percent of our woods. The greater part of coppice woods is privately owned (Table 6.3). Their distribution over the territory is by and large limited to mountains and hills (Table 6.4). More than half of them is of mixed composition; oak coppices – evergreen and deciduous – cover around 24 percent of the total area; chestnut and beech coppices occupy a little less than 20 percent (Table 6.5).

By the end of the '50s the introduction and the widespread diffusion of other low cost energy resources, and the contemporary sharp reduction of the population on the

	State and Regions		Municipalities		Other institutions		Privates		Total
	ha	%	ha	%	ha	%	ha	%	ha
Simple coppices	156,542	5.5	572,998	20.2	158,195	5.6	1,946,024	68.7	2,833,759
Mixed coppices	37,007	4.7	159,630	20.4	28,249	3.6	558,760	71.3	783,646
Total	**193,549**	**5.3**	**732,628**	**20.3**	**186,444**	**5.2**	**2,504,784**	**69.2**	**3,617,405**
Shrubland	29,852	11.2	37,263	14.0	3,676	1.4	195,493	73.4	266,284
Total	**223,401**	**5.8**	**769,891**	**19.8**	**190,120**	**4.9**	**2,700,277**	**69.5**	**3,883,689**

Table 6.3 - Coppice and shrubland surface area in hectares subdivided into ownership categories. The values are referred to 1997. Source: ISTAT, Agriculture Statistics (2000).

	Mountain		Hill		Plain		Total
	ha	%	ha	%	ha	%	ha
Simple coppices	1,585,520	55.9	1,163,589	41.1	84,650	3.0	2,833,759
Mixed coppices	386,212	49.3	364,392	46.5	33,042	4.2	783,646
Total	**1,971,732**	**54.5**	**1,527,981**	**42.2**	**117,692**	**3.3**	**3,617,405**
Shrubland	26,755	10.0	205,177	77.1	34,352	12.9	266,284
Total	**1,998,487**	**51.5**	**1,733,158**	**44.6**	**152,044**	**3.9**	**3,883,689**

Table 6.4 - Coppice and shrubland surface area in hectares divided per altitude areas. The values are referred to 1997. Source: ISTAT, Agriculture Statistics (2000).

Dominant species	*ha*	%
Chestnut	375,300	10.2
Beech	331,200	9.0
Turkey oak	208,800	5.7
Holm oak, Cork oak	137,700	3.7
Sessile oak, Pedunculate oak, Downy oak	539,100	14.7
Hornbeams	160,200	4.4
Mixed woods or woods dominated by other broadleaves	1,921,500	52.3
Total	**3,673,800**	**100.0**

Table 6.5 - Composition-based coppice surface area in hectares with respect to the dominant species. Source: MAF/ISAFA, 1988.

mountains and high hills have brought about coppice crisis. In particular, the rising costs of exploitation have not been matched by an analogous increase in the value of fire wood (HIPPOLITI, 2001), and of the yielding profit of the coppice throughout. As a result, in quite a few areas the coppices have experienced a rather dramatic age increase.

A partial inversion of this tendency came about at the end of the '70s: the rise in the cost of fossil fuels promoted by the energy crisis, the presence – ever more massive though discontinuous – of many town dwellers on the hills and mountains in their second residential properties and the diffusion of forest fire ovens all determined a renewed interest in fire wood. This brought about a resumption of coppice felling in those woods that had not been managed in the previous decades, where a lot of wood mass had heaped.

The current average global age of Italian coppices is around 20-25 years. According to official statistics (ISTAT, 1990-2000), coppices yield 4-5 Mm^3 of fire wood per year, that is approximately 60 percent of all wood usage on a national level. It should be kept in mind, however, that these figures are probably underestimated (CORONA *et al.*, 2002b, 2004).

At the same time, especially in public properties and at the higher elevations, a re-orientation has occurred toward the conversion to high forests of those woods that have not been coppice-cut since a long time.

Current coppice state comes as the result of said events. Coppices may be distinguished in the following categories, which refer back to their silvicultural status:

- *actively managed coppices*: they are regularly exploited;
- *evolution-oriented coppices*: they have gone past the consuetudinary rotation, and are at the onset of a new phase or of a conversion to high forest;
- *freely oriented coppices*: they are not any more subjected to any silvicultural operation, as their owners are no longer interested in wood production, so that they are abandoned for all practical purposes.

Coppices with standards

The dimension of the cutting depends on many factors, amid which the most relevant ones are accessibility, ground fertility, coppice age, the presence of an active market for the coppice products, the pression exerted by business operators. So, in the face of small or even tiny expanded cuttings back in the 'old home forest', other cuttings can be found taking on big dimensions, especially in the larger properties, both public and private (table 6.6).

In actively managed coppices the exploitations follow a

	State and Regions		Municipalities		Other institutions		Privates		Total	
	N	ha	N	ha	N	ha	N	ha	N	ha
Simple coppices	249	796	1,463	4,506	563	1,495	62,853	44,390	*65,128*	*51,187*
Mixed coppices	118	375	266	898	70	428	13,564	8,397	*14,018*	*10,098*
Total	**367**	**1,171**	**1,729**	**5,404**	**633**	**1,923**	**76,417**	**52,787**	**79,146**	**61,285**

Table 6.6 - Clearings number and surface area in hectares divided per ownership category and per forest management type. The values are referred to 1997. Source: ISTAT, Agriculture Statistics (2000).

regimen of rotation of the areas on the basis of the adopted shift. Management maintains a mosaic of tiles formed by agamic origin populations of different age. The vertical structure of the coppiced stands is generally quite simplified, as it is composed by the sprouts layer, which, a few years after the cut, tends to fill up the cover completely. Coppice governance maintenance reduces the presence of old age and big dimensioned tree individuals: in simple coppices the maximum age is that of the consuetudinary rotation – 15 to 25 years, depending on the main species; in with-standard coppices the leave trees can reach an age that doubles the rotation. In stored coppices the leave trees may attain an age that is 4-6 times the rotation, which is in general largely shorter than the species' longevity, however.

Coppicing has diverse effects on biodiversity depending on the considered component and on the temporal scale of reference. Throughout the plant component, during the first years following coppicing a general increase in the shrub layer species is observed, as well as the incursion of herbaceous species typical of meadow-synanthropic environments with strong disturbance, which tends to compensate the regression of other nemoral species (SPINELLI, 1999; VENANZONI *et al.*, 2002). Such temporary rise in species diversity readily undergoes resorption as soon as the crown canopy is closed.

On a longer temporal scale repeated coppicing tends to advantage species with stronger sprouting faculties, more xerophytic and more hardy. Selective pressure is also applied by the choice of leave trees and generally leads to the reduction of specific arboreal diversity over long since coppiced stands. The conditions of the station, the characteristics and behaviour of the species – either single or more - with regard to light, the treatment and the rotation that were applied in the past, all have an influence on composition. PERRIN (1954) maintained that short rotations promote soft wood species – willows, alders, aspens, birches – over oaks, which, on the contrary, are better conserved with rather longer rotations. Oaks, however, as already observed, back away when confronted with the competition of hornbeams and chestnuts.

In some cases, as, for example, in the Mediterranean mixed coppices with high 'macchia' or forest 'macchia', coppicing perpetuates shrub species presence, the same as tend to wither away with the end of the yields, and the aging and the progressively higher reach of the crown canopy of the trees.

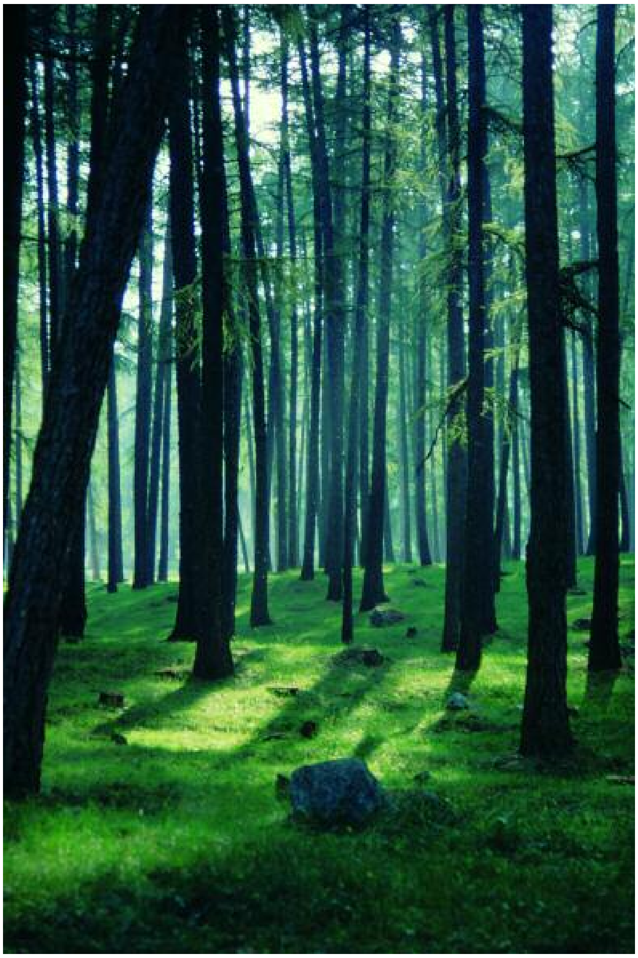

Fig. 6.9 - Spruce-forest in National Park of Foreste Casentinesi, Monte Falterona, and Campigna (Photo by S. Bonacquisti).

With regard to the animal component, coppicing leads to different effects, which can be referred back to the alterations produced in habitat distribution and characteristics, particularly for what concerns the dimensions of the cuttings and the upkeep of stands with little differentiated vertical structure. Periodic cuttings create a mosaic of stands with diverse structures, which may contribute to the differentiation of ecological niches.

For example, it may be significant to report the results of a research by CAPIZZI *et al.* (1997) on the relations between stand age and micromammal communities in a simple with-standards Turkey oak coppice on an 18-year rotation, in the Rome Province. The data gathered have stressed the great relevance that time gone by since the last coppice cut takes on in determining the composition of micromammal communities. The first species to colonize the cuttings is the Wood mouse, while a role of primary importance is played by the Insectivores, most surely among the first to be attracted by – and to take advantage from – the large quantity of invertebrates that are present in the exploited wood segments. During the following stages of regrowth the slow re-colonization by the Bank vole is observed, while it is only in older wood sectors – 12 to 18 years - that the Yellow necked mouse finds the proper conditions to settle in stably. Owing to the rarefaction or to the complete disappearance of a few species over the years subsequent to the cutting, the fundamental importance of settling-in emerges, in order to consent a rational disposition over time and space of the surfaces assigned to cutting.

Among the birds, the perching birds are likely to be favoured by the increase in underwood vegetation (GHETTI *et al.*, 2002) that occurs in the freshly cut areas. On the contrary, coppicing does not create favourable situations for bird species that are connected to more evolved and complex stand structure (for example, the Great Spotted woodpecker and the Green woodpecker). Moreover, these species, through their pecking activity, dig out the holes that are liable to be occupied by other animal species in subsequent years.

Among the big ungulates the Roe deer and the Boar find good trophic resources in the exploited areas. In particular, the Roe deer prefers a series of clear cut wood margins, such as can be found at the borders of the cutting, as they satisfy the needs of the different species all at the same time: orienteering, shelter, food, housing (REIMOSER and GOSSOW, 1996).

Regular coppice exploitation keeps the presence of necromass on a low level, it being almost exclusively constituted by the progressively dying suckers, as competition rises up inside the stumps.

Uneven-aged coppices

Evolution-oriented coppices are coppices that are in the midst of conversion to high forest. In Italy such managing directions have been mainly applied to public owned coppices. Generally speaking, steering to high forest has been conducted in coppices that have grown over consuetudinary rotation age and has consisted in one or more sprout thinnings.

According to the National Forest Inventory of 1985 (IFNI85, see MAF/ISAFA, 1988), the transient stands cover less than 2 percent of total coppice surface. The actions have been carried out especially in beech (5.4 percent) and in Turkey oak (4.7 percent) prevalent coppices.

From the point of view of the impact on biodiversity, steering to high forest leads to different effects:

- elimination of dominated suckers and of the oldest, ill-shapen and declining leave trees ‘regulates’ the structure of the stands, leading in the short and medium term to an increase in the monotonous structure of the wood;
- cessation of the periodic opening of the arboreal cover determines the disappearance of the shrubby and herbaceous components.

On a positive note steering to high forest, by deactivating coppice cuttings, consents to the increase in wood storage and in old age of the tree component, does not interrupt soil evolution processes and favours fructification of the leave suckers, all of which have a bearing on the habitat’s carrying capacity with respect to numerous animal species (CASANOVA and MEMOLI, 2002). For example, the evolution towards a more articulate structure, with the presence of bigger and older trees, may give an advantage to particularly interesting species such as the Pine marten. This species is present discontinuously throughout various zones, such as, to mention but few, the Farma Torrent Reserve, the High Merse and the Low Merse Reserves in the Siena Province, all characterized by deciduous oak coppices; here conversion to high forest of portions of the coppice may favour protection of this species (BOITANI *et al.*, 1999).

Composed high-coppice systems

Freely oriented coppices are those inside of which no cultivation practice has taken place since a long time, as the owner’s interest in wood production has faded, so that they end up being abandoned. More often than not they are degraded coppices.

The evolution processes that establish themselves, following the end of productive management in freely oriented coppices, proceed along different lines according to the composition and structure of the coppice, to the station characteristics, to the interactions with nearby systems (open areas, water bodies, farm land, etc.).

The end of coppicing leads to changes taking place in the features of the different tiles that are comprised in the landscape mosaic. Along with the rise in age there is an increase in competition among the suckers, which leads to death out of self thinning and to the subsequent increase in necromass. In this way evolutive mechanisms are triggered, which, over medium to long term periods of time, are going to show the way to more complex and compound forest structures.

By examining the relationships between biodiversity and abandonment in the coppices with prevailing deciduous oaks in the Chianti region, for example, MANCINI E. and MANCINI F. (2002) have pointed out a few positive aspects with respect to the soil: given the more complete and thus effective crown cover, erosion and surface runoff phenomena have disappeared or have come close. This is also brought about by the consistent humus-enrichment of the soil. The surface horizons, endowed with optimal lumpy structure and relevant biological activity, turn to very dark hues, bordering on blackish or heavy brownish. As for biodiversity, the authors noted that the changes had been modest in the plant component, probably more consistent in the animal one, and, especially in the soil, they observed intense activity displayed by numerous animal species (insects, springtails, mites, and few earthworms).

High forests

High forests represent slightly less than half of all Italian forests. About 75 percent of them is of natural origin. According to IFNI85 (MAF/ISAFA, 1988) more than half of high forests had a structure that could be cast in the even-aged model (56 percent), about a quarter in the uneven-aged (26 percent), while 17 percent presented an 'irregular' structure, and 1 percent an articulate[3] one (Table 6.7).

The different forms of treatment determine alterations to the vertical structure of the stands, to the presence of necromass, and to the differentiation of landscape tiles. These alterations can lead to variations in the species richness and in the population density of many animal species. For example, bird fauna is particularly sensitive to such alterations (see DE FILIPPO and KALBY, 1985; ZOVI and FAVERO, 1990; MASCI *et al.*, 1999).

The current structure of Italian high forests is the product of a silvicultural history that has been influenced by opposing phenomena: on the one side, the restraints introduced by forestry legislation; on the other, the pressures to obtain profitable yield. Often this contrast has given in to compromises not always beneficial to the forest's actual functionality.

Articulate and even-aged high forests

A typical even-aged structure characterizes:

- many formations with prevailing conifers over the Alpine Arc;
- fir-forests of the Apennine Tosco-emiliano;
- stands of artificial origin out of reforesting practices.

Even-aged structure can be traced over more than half of Mediterranean and mountainous pine-woods, and over

Fig. 6.10 - High-mountain beech forests on calcareous rocks of Central Apennine (Photo by M. Marchetti).

[3] IFNI85 adopts the following definitions: even-aged high forests: forest stands with even-aged structure, and an expanse of at least 5,000 sq m; uneven-aged high forests: contemporary presence of individuals of all development stages, not aggregated in structural types, or else so aggregated over less than 1,000 sq m expanses; articulate high forests: over the classification surface only few structural types are present, with an expanse normally ranging from 1,000 to 5,000 sq m; irregular high forests: all situations not fitting into the preceding sets.

Dominant species	even-aged and complex high forestss			unven-aged high forests			irregular high forests			Total
	volume m^3	surface ha	vol/ha m^{3}ha^{-1}	volume	surface	vol/ha m^{3}ha^{-1}	volume m^3	surface ha	vol/ha m^{3}ha^{-1}	Surface ha
Norway Spruce	64,581,350	183,578	351.8	37,544,067	138,433	271.2	15,341,326	57,474	266.9	**379,485**
Silver Fir	11,536,438	27,538	418.9	8,412,216	26,496	317.5	3,288,419	9,388	350.3	**63,422**
Larch	21,606,931	87,937	245.7	17,170,251	97,819	175.5	10,061,056	54,919	183.2	**240,675**
Mountain Pines	35,025,733	170,147	205.9	9,471,606	63,217	149.8	5,379,671	33,857	158.9	**267,221**
Mediterranean Pines	9,351,107	74,133	126.1	2,777,532	24,369	114.0	1,089,592	9,425	115.6	**107,927**
Other conifers	2,749,296	20,477	134.3	126,506	1,468	86.2	135,652	1,439	94.3	**23,384**
Beech	41,328,793	151,454	272.9	16,368,370	67,241	243.4	8,906,348	46,166	192.9	**264,861**
Turkey Oak	8,518,904	48,247	176.6	3,625,818	18,913	191.7	1,841,557	12,374	148.8	**79,534**
Other Oaks	7,428,564	64,929	114.4	7,262,503	59,032	123.0	4,866,392	41,453	117.4	**165,414**
Other broadleaves	19,582,405	140,796	139.1	8,241,703	49,271	167.3	12,367,451	74,590	165.8	**264,657**

Table 6.7 - High forests: surface area and volume divided per composition and topsoil structure. Source: MAF/ISAFA, 1988.

otherwise dominated woods too, by other conifers, beech, Turkey oak, and mixed deciduous plants.

Normally applied rotations vary from 60 to 80 years for pine-woods, 80 to 100 years for Turkey oak-woods and fir-woods, 100 to 120 years for spruce-woods and beech-woods. The adoption of rotations that are considerably shorter than the longevity expressed by these species has led to rather young forests: approximately 80 percent of Mediterranean pine-forests is younger than 60 years; beech-forests are on average 80 years old, only 10-15 percent of them being older than 120 years; Turkey oak-forests are on average 60 years old, only 5-10 percent of them being older than 120 years.

In the past low clear-cutting treatment has been generally prescribed for all forests formed by heliophyte-leaning species (spruce, Scots pine, Mediterranean pines, etc.), and for those woods experiencing difficulties for natural pure renewal (the fir-woods of the Apennines). Instead, subsequent uniform cuttings treatment has been prescribed for beech high forests and for Turkey oak high forests, even though this treatment has been applied with any regularity almost only in the case of Alpine beech-forests, of those in the Avellino Province and in few cases of short-lived beech stands converting to high forest in the North Apennine.

Beech-forests and Turkey oak-forests of Central and Southern Apennine often present differentiated structures, at times still displaying the reserves left in the 19th century following the application of the Borbonic law of 1826 (BIANUCCI, 1982). In fact, even though silvicultural indications and classic forest management education argue in favour of subsequent cuttings with rotations of around 80 years for Turkey oak-woods and of around 100 years for beech-woods, these forests have been managed following other criteria, varied, but substantially traceable back to commercial induced cuttings, that have at times taken up a more distinct silvicultural flavour only through the occasional ability and experience of the operators.

The silvicultural handlings that should take place over the development cycle of the settlements – dispersions and thinnings – tend to reduce or to completely extinguish the presence of woody necromass. In real settings these operations have not always been carried out according to silvicultural prescriptions, and as a result the stands may present many withered or declining trees, especially in the young stages. Following IFNI85, the volume of truncated, dried up or knocked down trees recorded in Italian high forests varies from 5.7 m^{3}ha^{-1} (forests with other conifers) to 19.4 m^{3}ha^{-1} (fir-forests);

Fig. 6.11 - Conifer reforestation in high Molise (Photo by P. Di Marzio).

truncated, standing dried up or knocked down trees represent from 2.9 percent (spruce-forests) to 7.8 percent (mixed forests of other deciduous plants) of the mass of standing trees.

Uneven-aged and 'irregular' high forests

According to IFNI85, uneven-aged high forests are found in 42 percent of fir-forests, in 40 percent of European larch-forests, in around one third of spruce-forests and mixed oak-forests, in about one fourth of beech-forests, Turkey oak-forests and pine-forests - with both mountain and Mediterranean pines. 'Irregular' structures are detected mainly in mixed woods of oaks and other broadleaved trees. The typical uneven-aged structure is a distinctive trait of woods since a long time managed following the occasional cutting programme. In many high forests of the North East Alpine Arc since long ago a silvicultural process has been going on, that tends to favour even-aged woods' age disruption, in the context of sustainable management based on closer to nature forestry practices (SUSMEL, 1980; DEL FAVERO *et al.*, 1998; DEL FAVERO, 2000b).

The uneven-aged high forest is characterized by the continuous cover of the arboreal layer, which becomes new again through sprouting and settlement of the saplings inside the small clearings left by the felling of the 'mature' plants. Species diversity is influenced by station and treatment characteristics. Researches have been conducted in uneven-aged woods of Oriental Alps (GIANNINI *et al.*, 2001; BAGNARESI *et al.*, 2002), managed after a long time through occasional cutting, and they have drawn attention to high indexes of vegetation and genetic diversity, which tend to diminish with the increasing altitude of the station. This treatment, applied to these forests over the last few centuries, has favoured high structural diversity, and has made it possible to preserve genetic diversity through subsequent generations of the arboreal component.

The occasional cutting practice, however, by periodically eliminating the trees of bigger dimensions, may diminish the number of ecological niches that are useful for many plant and animal species (for example, the epiphytes, see BROKAW and LENT, 1999).

High forest dynamism

High forests differ from coppices in that yield exploitation is progressively reduced. This also stems from the fact that at the legislation level the concept of sustainable management has been agreed to, ruling out intensive use of the forest and low cutting over vast areas[4].

The current silvicultural state of Italian high forests depends on a collection of general and local factors of social-economic, structural, environmental, and cultural nature; it can be briefly condensed into the following cases:

- abandonment;
- conservative management;
- management planned along silvicultural lines;
- contingent exploitation.

Abandonment

The abandonment of high forest stands is common in small private properties. It has taken place often as a result of reforestation practices carried on by the authorities through the systematic procedure of temporary land occupation.

The abandonment of the wood leads to different effects in regard to the composition, the origin and the structure of high forest stands. Through abandonment the most evident phenomena are the increase in age, in wood provision, and in woody necromass (standing dead trees and knocked down trees), with a progressive accumulation of organic substance in the soil.

The relatively young age of Italian high forests does not solicit fears of possible generalized collapses following abandonment, over a short to medium term period. The evolution of the stands will probably occur following a more or less gradual process, depending on the structure and on the composition of the stands, on ground depth, on the topography of the soil, etc.

In even-aged high forests, with a unique layer structure and monospecific composition, especially if the species are positioned out of their optimal climatic and edaphic range, cessation of silvicultural practices, over medium to long term, leads to a change in structure and composition, following evolution paths that are difficult to predict as far as time and methods are concerned. A probable outcome is the reentrance, via an autonomous path, of ecologically coherent species, and the formation of composite structured stands. In particular, during reforestation these renaturalization processes also interact with the vitality and thus with the stability of the tree cover, formed by the implanted species – single or more than one. The latter in

[4] See art. 6 of the legislative decree of May 18, 2001, no. 227. A few Regions have agreed to incorporate these indications into their own legislation, as is the case of forestry laws by Toscana (Regional Law of March 21, 2000, no. 39), and by Lazio (Regional Law of October 28, 2002, no. 39), the latter followed by its Rules of Application.

Fig. 6.12 - Meadow-grazing land in the Regional Park of Castelli Romani (Photo by S. Bonacquisti).

fact may disappear even in a short time, following attacks by parasites, physiological stresses, etc. (DE MAS, 1993).

Wood abandonment is often associated to the abandonment of neighbouring pasture land. The two phenomena, taken together, may contribute to the alteration of landscape diversity, especially through natural distribution of shrub and tree species over open areas.

Conservative management

Conservative management, confined to phytosanitary cuttings or to the recovery of collapsed trees and dead plants, is frequent in high forests owned by the State (Natural Reserves), especially when they have been included inside National Parks and are waiting for the ratification of a book of rules and of specific management tools (CIANCIO *et al.*, 2002a). The effect of this type of management on the diversity and on the evolution tendencies depends upon the circumstances of the composition and structure of the stands. The more simplified they are, the more the stands depend on silvicultural practices for their renewal, the greater the alterations. Three exemplary cases of this phenomenon are the pure even-aged fir-forests of Central and Northern Apennines, the domestic pine-forests along the Tyrrhenian coast, and the stands of *Pinus nigra* ssp. c*alabrica* on the Sila mountains.

Over the last few decades of the last century the management of fir-forests of Toscana, which, as already mentioned, was mainly centered on low cutting and delayed artificial renewal with a rotation age of 100 years, has undergone a big slowdown, owing to the change in management top referring values. The stands are progressively growing older, and, though along differing lines, the spontaneous distribution of broadleaves and other species inside the fir-forests has begun. This process, despite being quite slow, will lead in time to a change in the compositional and structural characteristics of the stands, with ensuing alterations to the landscape. As far as the animal biodiversity is concerned, the slow rise in the forest age, for it is no longer subjected to renewal cuttings, is already promoting changes in the bird populations. In particular, an increase has been observed, both relative and absolute, in the number of bird species that are connected to the forest, especially conspicuous for those associated with mature forests (DREAM, 2001).

In the pine-forests along the littoral zones, planted for the production of wood and pine nuts, the social-economic changes, in particular the increase in tourist and recreational importance, have induced a change in the management that has focused on the cessation of low cuttings. In this case too, the rise in age and the ceasing of silvicultural chores are favouring the spontaneous distribution of shrub and tree species that are typical of the Mediterranean Macchia under the pine cover.

In the pine-forests of *Pinus nigra* ssp. c*alabrica* throughout the State owned properties of the Sila mountains included in the National Park of Calabria, the elimination of dead or declining specimens alone is favouring the gradual substitution of that species perpetuated by the beech (Iovino and Menguzzato, 1999).

*Management planned along silvicultural line*s

Management based on settlement plans is carried out especially throughout State or privately owned properties along the Alpine Arc, as well as in many Region owned properties of the Central and Northern Apennines; more rarely in the Central-Southern Apennines, hardly ever in the Islands (Sicilia and Sardegna).

The tendency toward a sustainable management of the forest, by now present in stipulatory national and regional legislation, is gradually reorienting the silvicultural objectives checked out by settlement plans. Silviculture is becoming more refined, as it is based by now on low impact environmental actions, that have the primary objective of increasing the stability and the functional efficiency of the forest taken as a whole.

This change of plans is not always agreed upon and may lead to some strife, especially since it casts aside the key points of past management direction, which saw in the magnification of the productive aspects its sole *raison d'être*.

Contingent exploitation

In most of the private properties of the Apennines and in many public properties, especially in Central and Southern Italy, high forest management is still conducted out of mainstream management control, with actions based upon the contingent economic and financial needs of the owner.

The actions, referring back to timber marking as executed by Forestry Service operators – or by other specialized operators – are accomplished in various ways, that can be traced back to silvicutural and exploitation cuttings following the specific needs of the diverse forest sections.

The effects of this type of management on forest efficiency and diversity depend upon many different factors, among which the operators' professional competency is paramount. When this type of management has built upon local skills, out of continual adjustment, then the high forests have been preserved with their complex structure, rich biodiversity, and high functional efficiency. At other times, when imperative business interests have been predominant, the stands have been degraded by intensive exploitation.

Dynamics of the territory and forest biodiversity

From the point of view of collecting and planning relevant information it is important to single out the qualitative variations accompanying the fluctuations in extent of Italian forests. Three chief phenomena are at the origin of current quantitative dynamics of the entire Italian forest area:

- forest fires;
- forest recolonization of rural landscape;
- wood plantations and reforestations over farm land.

These events bring about significant changes in forest landscape conditions at the local scale, and, by consequence, significant variations in forest biodiversity.

Forest fires

Forest fires are a widespread phenomenon over the entire national territory and represent the first current cause of degradation of Italian forests. According to the *Corpo Forestale dello Stato* (National Forest Service), the average area interested yearly by forest fires has undergone a progressive increase over the 1970-1999 period, only to diminish in recent years: data pertaining to the total area overrun by fires in the 1980-1989 decade can be compared to IFNI85 data, resulting in a 6 percent ratio of forest land ravaged by fires to total forest land. A slightly inferior data – a little more than 5 percent - is obtained by comparing the data of forest land ravaged by fires over the 1990-1999 period to the land forest cover estimated by INFC.

Forests overrun by fires undergo extensive and rapid variations in the state of biodiversity, at the scale of the species, of the population, and of the landscape. In fact, forest fires modify the chronological structure and the species composition of the settlements, and they subsequently influence the capability of incorporating successive perturbations – additional fires, epidemic diseases introduced by pathogens, etc. – thus bearing down heavily on the environmental mosaic junctions. The alteration is, within limits, temporary and reversible. Numerous studies on post-fire periods agree in observing that after the fire is over many reconstituting communities are identical to those that were present before the disturbance, both in composition and structure. The post-fire floristic richness attains maximum value few – two or three – years after the fire, to decline later on and then stabilize (TRABAUD and LEPART, 1980; NE'EMAN *et al.*, 1993). The floristic richness during the first years is even greater than that of the areas not touched by the fire, even though this is due essentially to the presence of nonnative annual or biennial species, foreign to the community. However, this only works for moderately frequent fires. With a high fire frequency rate there can be a strong reduction in the number of species previously composing the phyto-coenoses, with the settling in of pioneer, more tolerant species; such a mechanism leads rapidly to the substitution of the original community, especially as a result of the modifications induced in the soil, which also becomes exposed to the risk of erosion. This is what is likely to happen, for example, in our Mediterranean environments, where the recurring cycles of the passage of fire are generally shortened by the contemporary occurrence of unfavourable seasonal climate changes and of social and economic situations that are likely to play the predisposing causes.

From the point of view of the species composition it has been confirmed that the major changes are experienced by those forest formations – especially in the Mediterranean and in mountain pine forests, and in reforestation practices – where an increase in the number of annual and shrubby species is observed, favouring the heliophytes and the mechanisms of dispersion and of sprouting advantaged by the fire. Instead, throughout the formations of 'macchia' and scrubland, even when heavily damaged, the regenerating powers of the component species build back the original structure in a rather short time – 5 to 6 years – leaving the ecological conditions – especially light – more or less unaltered, so that the floristic composition is guaranteed to remain virtually unchanged (BARBERIS *et al.*, 1994).

On the other hand, as far as the effects of fire on the structure are concerned, strong differences are observed especially as a function of the fuel model constituting the top soil, as defined mainly by the load of alive and dead substance and by its spatial distribution (therefore essentially by its density, degree of cover and vertical structure continuity): thin pine-forests with shrubby underwood, just as dense aged broadleaved coppices with heavy necromass amassed as a result of abandonment, represent cases of extreme danger (MARCHETTI, 1994), as in the case of dense thick Mediterranean scrubland and of hornbeam-oak-forests of the Apennines and of the Prealps. Instead,

Fig. 6.13 - Celano-Foggia cattle-track recolonization in high Molise (Photo by P. Di Marzio).

Fig. 6.14 - Downy-oak forest recolonization on abandoned farm land (Pollino National Park. Photo by S. Bonacquisti).

where the fire propagates through low herbaceous or thinned shrubby fuel, it does dwell near the surface in passing, so that in a short time a formation similar to the one preceding the fire is established again. Different still is the case of an evergreen sclerophyllous evolved forest, which manifests high resilience capability and often good resistance to fire, so that the forest fire may restrict itself to the elimination of the shrubby underwood.

The in-depth analysis of the impacts of fire on biodiversity should not neglect the role that the passage of fire may play, especially if managed and controlled, in the areas where an under way massive restructuring of forest tissue could, over time, lead to a lowering of species and landscape diversity, for example where the presence of clear-cut margins and clearings could be on the decrease (MARCHETTI *et al.*, 1998).

Forest recolonization of rural landscape

Spontaneous colonization of rural landscape by forest coenoses is a phenomenon which, depending on the single case, may represent a positive or a critical element for biodiversity conservation at a local scale. It generally occurs at the expense of marginal rural areas in the high hills and in the mountains, characterized by traditional forms of agriculture and livestock breeding, to which seminatural habitats of important conservation value may come to be associated.

Abandoned or underused rural areas are easily colonized by spontaneous vegetation – arboreal and shrubby – typical of the environmental conditions of the station. This is the way in which, for example, over the last decades the forest formations have consistently spread out to the former pastures of the calcareous masses of the Apennine ridge. Rural landscape, characterized by the dominance of open areas, progressively shifts toward evolving vegetational consortia, physiognomically akin to 'other forest areas', starting from existing forest margins, or from the nuclei formed by 'trees outside the forest', such as hedges, belts, thickets and tree-lines (MARCHETTI *et al.*, 2002); non-woody forest areas, in fact, play an extremely important multifuncional role especially in rural landscapes, where they often represent the only natural-like elements, true biodiversity reservoirs and ecological corridors. Such elements, and the forest surfaces that they contribute to spread, initially possess high specific variability, that makes them particularly adequate as food and shelter for many species mostly belonging to macrofauna wildlife. On a counter perspective, these areas are highly vulnerable under the profile of fire ignition and fire propagation processes, and, moreover, when the thorny shrub formations take

Plantation site suitability	The implant should not induce any harm or surface area reduction upon contiguous natural ecosystems (habitats of conservationist value, woods, riparian formations) and should not in any way entail the elimination or reduction of rural landscape elements that are characteristic of the local mosaic landscape.
Selection of implant material	The choice of the species (more than one whenever possible) should occur on the basis of ecological suitability criteria to the plantation site. The species should preferably be autochthonous (places of origin/local ecotypes). The choice of exotic species should only be justified by the case of a proven advantage in terms of reproductive/protective capacity. At any rate, planting of exotic species should be strictly bound to: (1) the knowledge of the species' distribution processes; (2) intervention protocols in the case of possible eradication due to the species' distribution in natural habitats; (3) the evaluation of exotic species assessing that they are not vectors or intermediate hosts of harmful organisms to the native species.
Structural diversity	In order to favour structural differentiation conditions inside the plantations it is preferable to: (1) create a mosaic of uneven-aged implants with cultural cycles of different lengths; (2) ensure the presence of ecological corridors for the displacement of wild fauna and the possible presence of protection belts along the water courses; (3) maintain high value landscape or natural elements possibly present inside the plantation site (for instance, monumental specimens, small wetlands, hedges, etc.).

Table 6.8 - Operative procedures towards the implementation of forest plantations that are compatible with biodiversity conservation (CORONA, 1993a,b; CORONA and MARCHETTI, 2002).

the lead (for example as was the case in the former high hill seeding lawns of Central Italy overtaken by formations of *Prunus*, *Rubus*, *Crataegus*, etc.) the vegetational succession may be interrupted for decades (CORONA and MARCHETTI, 2002).

However, there are cases in which the transformation of rural landscape following abandonment – diffusion of intensive forms of agriculture and livestock breeding, natural forest recolonization – may constitute a threat to the conservation of the natural habitats present in those areas. This condition is shared by quite a few grassland habitats, such as, for example, the high status *Thero-Brachypodietea*, to which various bird species of EU importance are associated, such as the Little bustard. These habitats can and must be conserved through the support of traditional agro-pastoral practices.

Wood plantations and reforestations over farm land

The attention to the ecological compatibility of silvicultural transformation of the rural territory is behind current renewed interest in forestation of agricultural surfaces – wood plantations, reforestations – especially regarding the *ad hoc* funding availability within the range of the Regional Rural Development Plans (in practical application of Rule book 1257/99/EC) and of the measures following the ratification of the Kyoto Protocol.

The facilities implemented over the period 1994-2000 in Italy with the funds of Rule book 2080/92/EC are concerned overall with approximately 1,040 sq km, 22 percent of which have rapidly growing species - primarily poplars – 75 percent with a prevalence of other broadleaves (especially prized wood species), 3 percent with a prevalence of other conifers (COLLETTI, 2001). INFC estimates the surfaces currently invested with wood tree culture at around 1,455 sq km.

Forest plantation may represent, at the same time, both a critical element for the conservation of biodiversity at a national, regional, or local scale, and a positive opportunity, if it is implemented following adequate environmental compatibility criteria and paying attention to the re-composition of the eco-landscape tissue (Table 6.8). It is at any rate necessary to underline the mounting tendency, especially in recent arboreal culture practices devoted to prized wood broadleaved species, to implement mixed stands, by associating two or three different species along appropriate and diversified cultural lines.

It is necessary to point out the current urgency in retrieving suitable planting material. The seed stocking, nursery and afforestation sector is still arranged on the basis of law no. 269 of May 22 1973, which has been only partially applied, especially after the jurisdiction on forest nurseries having being conveyed to the Regions: for example, new detection of seed forests, currently around 150 in number, has in fact come to a stop by the end of the '70s, leaving out broadleaved plants in particular. The national territory has never been split up into source and usage areas of propagation materials; this has allowed for the use of any material, from whatever origin – often from foreign countries, out of areas with vastly different ecological conditions from those of employment – in any part of the country, with bad damage issuing both in terms of planting outcome and of genetic pollution; moreover, systematic control procedures on the trade of propagation materials have loosened up quite a bit, to the point that the law is not being enforced over entire Regions (MEZZALIRA, 2003). The legislation frame has recently entered a dynamic phase, promoting the adjustment of national lawmaking (see D.L. 386/2003) to the pronouncements mentioned by the 105/1999 EU directive, and what is more under regional perspective, but the effects at the operative level are yet to be evaluated.

Critical management for biodiversity conservation in forest systems

Critical points for the conservation of the complexity of forest systems and thus of their biological diversity are mainly the outcome of two different and opposing phenomena:

progressive confinement, ensuing in the abandonment of many forests;

simplification of silvicultural techniques and the concentration of employments into those forests, especially coppices, that are experiencing favourable circumstances of market approach and availability.

In the first case the consequences for the conservation of biodiversity might be positive, especially over a short term, as regards the increase in age and the progressive enrichment of the soil through continual supply of organic substance. The main negative effect stems from the higher risk of wood fires.

Over a medium to long term period of time, especially in the case of stands oversimplified through management, the conservation and the increase of biodiversity should be pursued by favouring higher structural diversity through the system's natural mechanisms of self-organization.

The phenomenon of abandonment may lead to the modification of landscape diversity owing to the loss of particular silvicultural forms, such as the chestnut orchard. In some cases it may be appropriate to preserve such diversity, which has a historic and cultural value on top of the biological one, by retrieving traditional techniques of cultivation.

In other cases cessation of employment may give the chance of monitoring the evolution of rare and particular formations within specific environments.

Without fail the second case imposes higher risks to the conservation of biodiversity in forest systems. The major critical point appears to be tied to the presence of higher wood provisions in coppices than the ones that were normally extracted in the past. This situation tends to press the owner toward an excessive employment of these forests. Employments over vast coppice areas that have largely gone by the 40 years mark are not a rare sight by now, leading to negative effects on the composition of the territory and on the landscape, with serious damage from the bioecological point of view.

In such cases the resumption of coppicing takes the system back again, undoing its chances of evolving toward more complex structures. Thus it would seem appropriate to try and control this tendency, in order not to quickly dissipate a true 'natural asset' that has come of age over the last few decades, wasting away a good opportunity for improving the functional efficiency of our forests.

Coppice to high forest conversion represents the best solution in these cases, possibly through the adoption of silvicultural techniques dedicated to providing the forthcoming high forest with variety in composition and structure. At any rate it would be appropriate to promote the leave of old trees and of rare or sporadic species.

Planning is a precious tool in the distribution of actions over time and space, so as to consent to the fulfillment of biological diversity maintenance at the landscape level, through an accurate reckoning of the various stational, compositive and structural situations. Furthermore, planning allows for management diversification, so as to pinpoint and protect the more delicate areas, such as riparian zones along minor water bodies, nesting or reproduction sites of particular animal species, etc.

A particular aspect is concerned with the precise identification of ancient forests over the territory, and with their vegetational and structural characterization, in view of creating an explicitly committed national network.

Again, in some areas, a critical factor is represented by the presence and the diffusion of particularly intrusive alien forest species, such as the Black locust and the Tree-of-Heaven, which can sweep away forest formations typical to the area, or interfere with re-naturalization processes that are under way. In such cases extremely accurate actions have to be taken in order to avoid the creation of conditions favouring their further expansion.

Particular aspects connected to the conservation of forest biodiversity have already been agreed upon at legislation level (see for example the legislative references at footnote no. 2). However, for management to be truly oriented to the objective of biodiversity conservation, it cannot be condensed to a collection of technicalities that are called upon by the pressing needs of the various species each time they are selected for protection.

The systemic approach has to be reinforced, in order to overcome once and for all the reductive outlook taking to the forest as to a collection of trees of economic relevance, or to a more or less extended list of species. A forest is much more than that: it is a complex biological system that reacts to any natural event or to any human action by shaping a new reality, a synthesis of interactions and interlinks (CIANCIO and NOCENTINI, 1996). Based on analyses going through different temporal and spatial scales, forest management will have to be conducive to increasing the overall efficiency of the forest system, and leading to the increase in its complexity and diversity as a side effect.

NATIONAL CENTRES FOR THE STUDY AND CONSERVATION OF FOREST BIODIVERSITY

[Giulia Bonella]

The Centres are referred to the Legislative Decree no. 227 of May 18, 2001, 'Orientation and modernization of the forest sector, according to article no. 7 of the law no. 57 of March 5, 2001', and to the Legislative Decree no. 386 of November 10, 2003, 'Realization of Directive 1999/105/CE relative to the marketing of forest multiplication material'. As indicated in art. 10 of the Legislative Decree no. 227 of May 18, 2001, they pursue the objective of protecting the biological diversity of the national forest heritage through *ex situ* conservation actions of forest genetic variability aimed at the intraspecific level, indispensable, first and foremost, to the integration of *in situ* conservation procedures.

These actions up to the present time have been carried out in Italy by the Seed Banks of Pieve Santo Stefano and of Peri, both National Forest Bureau affiliates, already classified as National Centres for the conservation of forest biodiversity (Legislative Decree 227/01 – art. 10, § 1).

In fact, they are two seed-stocking and nursery Centres, which, since their inception, are concerned not only with conservation issues, but also with the production and distribution of genetic variability, and in particular of local ecotypes, to the support of actions over the territory, so as to stand for correct and, under all instances, adequate use of propagation material in the relative areas.

Bibliography

BACHMANN P., KOEHL M., PAIVINEN R. (a cura di), 1998 – *Assessment of biodiversity for improved forest planning.* Kluwer Academic Publishers, Dordrecht, London.

BAGNARESI U., GIANNINI R., GRASSI G., MINOTTA G., PAFFETTI D., PINI PRATO E., PROIETTI PLACIDI A.M., 2002 – *Stand structure and biodiversity in mixed, uneven-aged coniferous forests in the eastern Alps.* Forestry, 75: 357-364.

BARBATI A., CARRARO G., CORONA P., DEL FAVERO R., DISSEGNA M., LASEN C., MARCHETTI M., 1999 – *Developing biodiversity assessment on a stand forest type management level in north-eastern Italy.* Annali Accademia Italiana di Scienze Forestali, 48: 157-176.

BARBERIS G., PAOLA G., PECCENINI S., 1994 – *Influenza dell'incendio sul dinamismo della vegetazione in Liguria.* In: FERRARI C., MANES F., BIONDI E. (a cura di), *Alterazioni ambientali ed effetti sulle piante.* Edagricole, Bologna, pp. 177-193.

BELL S.S., MC COY E.D., Mushinsky H.R., 1991 – *Habitat structure: the physical arrangement of objects in space.* Chapman and Hall, Londra.

BERNETTI G., 1995 – *Selvicoltura speciale.* UTET, Torino, pp. 415.

BIANUCCI V., 1982 – *Ricerche sull'accrescimento dei novelleti e delle spessine di faggio dell'Irpinia.* L'Italia forestale e montana, 5: 217-241.

BOITANI L., MORINI P., PINCHERA F., 1999 – *Valutazione faunistica, proposta di regolamento, zonizzazione e monitoraggio ambientale. Piani di Gestione del Sistema delle Riserve Naturali Senesi - Quadro Conoscitivo.* Sistema Riserve naturali della Provincia di Siena.

BOLOGNA S., CHIRICI G., CORONA P., MARCHETTI M., PUGLIESE A., MUNAFÒ M., 2004 – *Sviluppo e implementazione del IV livello Corine Land Cover 2000 per i territori boscati e ambienti semi-naturali in Italia.* Atti, 7a Conferenza Nazionale ASITA, Roma

BROKAW N.L.V., LENT R.A., 1999 – *Vertical structure.* In: HUNTER M.L. Jr. (a cura di), *Maintaining biodiversity in forest ecosystems.* Cambridge University Press, Cambridge, pp. 373-399.

CAPIZZI D., HORAK S.M., LUISELLI L., 1997 – *Le comunità di micromammiferi nel bosco ceduo: un approccio multivariato al problema del turno.* L'Italia forestale e montana, 2: 118-127.

CASANOVA P., MEMOLI A., 2002 – *Problematiche legate alla presenza di ungulati in alcune fitocenosi della Toscana.* In: CIANCIO O., NOCENTINI S. (a cura di), *Il bosco ceduo in Italia.* Accademia Italiana di Scienze Forestali, Firenze, pp. 397-412.

CFS, 2004 – *Inventario nazionale delle foreste e dei serbatoi forestali di carbonio. Risultati della prima fase di campionamento.* Corpo Forestale dello Stato, Ministero delle Politiche Agricole e Forestali, Roma

Ciancio O., Nocentini S., 1996 – *Il bosco e l'uomo: l'evoluzione del pensiero forestale dall'umanesimo moderno alla cultura della complessità. La selvicoltura sistemica e la gestione su basi naturali.* In: Ciancio O. (a cura di), *Il bosco e l'uomo*. Accademia Italiana di Scienze Forestali, Firenze, pp: 21-115.

Ciancio O., Corona P., Iovino F., Menguzzato G., Scotti R., 1999 – *Forest management on a natural basis: the fundamentals and case studies.* Journal of Sustainable Forestry 1/2: 59-72.

Ciancio O., Corona P., Marchetti M., Nocentini S., 2002a – *Linee guida per la gestione sostenibile delle risorse forestali e pastorali nei Parchi Nazionali.* Accademia Italiana di Scienze Forestali, Firenze, 300 pp.

Ciancio O., Iovino F., Menguzzato G., Tabacchi G., 2002b – *Entità e distribuzione di elementi minerali nella biomassa arborea epigea di un ceduo di leccio.* In: Ciancio O., Nocentini S. (a cura di), *Il bosco ceduo in Italia*. Accademia Italiana di Scienze Forestali, Firenze.

Ciancio O., 1999 – *Gestione forestale e sviluppo sostenibile.* Atti del II° Congresso Nazionale di Selvicoltura per il Miglioramento e la Conservazione dei Boschi Italiani. Venezia, giugno 1998, Vol. 3: 131-187.

Ciancio O. (a cura di), 1996 – *Il bosco e l'uomo.* Accademia Italiana di Scienze Forestali, Firenze.

Clauser F., 1999 – *Chiaro-scuri della biodiversità forestale.* L'Italia Forestale e Montana 54 (4): 191-195.

Clauser F., 2001 – *Biodiversità, premesse di valore e pensiero debole.* Linea ecologica 34 (1): 26-32.

Colletti L., 2001 – *Risultati dell'applicazione del Regolamento CEE 2080/92 in Italia.* Sherwood 70: 23-31.

Commissione Europea DG Ambiente, Unità natura e biodiversità, 1998 – "*Natura 2000" e Foreste: sfide ed opportunità. Guida interpretativa.*

Conti F., Manzi A., Pedrotti F., 1992 – *Il libro rosso delle piante di Italia.* WWF, Ministero dell'Ambiente, Roma.

Corona P., 1993a – *Study outline on ecological methods of afforestation.* In: Bunce R.G.H., Ryskowski L., Paoletti M.G. (a cura di), *Landscape ecology and agroecosystems*, Lewis Publishers, Boca Raton, pp. 169-176.

Corona P., 1993b – *Applying biodiversity concepts to plantation forestry in northern Mediterranean landscapes.* Landscape and Urban Planning, 24: 23-31.

Corona P., Garfì G., Maetzke F., Marchetti M., 2001 – *Riconoscibilità dei luoghi forestali e organizzazione dei processi gestionali.* Documenti IAED 4: 53-66.

Corona P., Chirici G., Vannuccini M., 2002a – *Contributo conoscitivo sugli aspetti dendrometrici, auxometrici e gestionali dei cedui italiani.* In: Ciancio O., Nocentini S. (a cura di), *Il bosco ceduo in Italia.* Accademia Italiana di Scienze Forestali, Firenze, pp. 73-124.

Corona P., Chirici G., Marchetti M., 2002b – *Forest ecosystem inventory and monitoring as a framework for terrestrial natural renewable resource survey programmes.* Plant Biosystems, 136: 69-82.

Corona P., Marchetti M. (a cura di), 2002 – *Rimboschimenti e piantagioni nelle trasformazioni del paesaggio.* Quaderni IAED 15, Ed. Papageno, Palermo.

Corona P., Macrì A., Marchetti M., 2004 – *Boschi e foreste in Italia secondo le più recenti fonti informative.* L'Italia forestale e montana, 2: 119-136.

Crow T.R., 1988 – *Biological diversity: why is it important to foresters?* In: *Managing north central forests for non-timber values.* Society of American Foresters, Duluth.

Crow T.R., 1990 – *Old growth and biological diversity: a basis for sustainable forestry.* In: *Old growth forests; What are they? How do they work? Toronto, Canada.* Canadian Scholar Press.

De Filippo G., Kalby M, 1985 – *Modificazioni nella struttura di una comunità di uccelli in seguito allo sfruttamento selvicolturale di una fustaia di faggio.* Atti del 5° Convegno italiano di ornitologia (citato in Masci *et al.*, 1999).

De Mas G., 1993 – *Tecniche selvicolturali nel restauro ambientale.* Monti e Boschi 1: 16-22.

Del Favero R., Andrich O., Carraro G., 1998 – *Norme per la redazione dei piani di riordino forestale.* Regione Veneto, Direzione Foreste, Mestre-Venezia.

Del Favero R. (a cura di), 2000a – *Biodiversità e indicatori nei tipi forestali del Veneto.* Commissione Europea, Accademia Italiana di Scienze Forestali, Direzione Regionale delle Foreste e dell'Economia Montana, Regione Veneto, Mestre.

Del Favero R. (a cura di), 2000b – *Direttive per i piani di gestione delle proprietà forestali nella regione Friuli-Venezia Giulia.* Regione Autonoma Friuli Venezia Giulia, Direzione regionale delle foreste,Udine.

Dhubhain A.N., Pommerening A., 2004 – *Transformation to continous cover forestry.* EFI News, 2004, 2:7.

DREAM, 2001 – *Monitoraggio ornitologico delle Foreste Casentinesi. Struttura e composizione dei popolamenti di uccelli nidificanti nelle abetine.* Relazione finale. Regione Toscana, Comunità Montana del Casentino. DREAM Italia, Poppi.

Elton C.S., 1966 – *Dying and dead wood.* In: *The Patterns of Animal Communities.* John Wiley, New York, pp. 279-305.

Falciai M., Ghinassi G., Trucchi P., 2002 – *Deflussi superficiali stagionali da un ceduo di faggio sottoposto a trattamenti selvicolturali differenziati.* In: Pugliesi S. (a cura di), *Nuovi temi sistematori.* Quaderni di Idronomia Montana, 18. Editoriale Bios, Cosenza.

Fenaroli L., Gambi L., 1976 – *Alberi. Dendroflora italica.* Museo Tridentino di Scienze Naturali, Trento.

Ferrari C., Senni L., Tibiletti E., 1996 – *Boschi italiani di elevato valore naturalistico non sottoposti a tutela.* Ecosistema Italia, WWF-Settore diversità biologica, Roma.

Franklin J.F., 1993 – *Preserving biodiversity: Species ecosystems or landscapes?* Ecological Applications, 3: 202-205.

Ghetti L., Amori A., Chiappini M., Lancioni M., Montefameglio M., Muzzatti M., 2002 – *Aspetti faunistici.* In: *Gestione sostenibile e multifunzionale dei boschi cedui: il progetto. SUMMACOP.* Regione dell'Umbria, Assessorato Agricoltura Foreste Caccia e Pesca, Perugia.

Giacomelli C., 1878 – *Tassazione della foresta inalienabile di Vallombrosa in Toscana.* Annali del Ministero dell'Agricoltura, Industria e Commercio. Roma.

Giannini R., Borghetti M., 2001 – *Valutazione della biodiversità per la gestione dei sistemi forestali.* L'Italia Forestale e Montana 5: 320-332.

Giannini R., Proietti Placidi A.M., Paffetti D., 2001 – *Valutazione della biodiversità dei boschi di abete rosso dell'Alto Cadore.* Atti del Convegno, Boschi del Comelico e della Valle del Gail. Dosoledo, Tipografie Piave, pp. 61-73.

Harmon M.E., Franklin J.F., Swanson F.J., Sollins P., Gregory

S.V., LATTIN J.D., ANDERSON N.H., CLINE S.P., AUMEN N.G., SEDELL J.R., LIENKAEMPER G.W., CROMACK K. JR, CUMMINS K.W., 1986 – *Ecology of coarse woody debris in temperate ecosystems.* Advances in Ecological Research 15, 302 p.

HIPPOLITI G., 2001 – *Sul governo a ceduo in Italia (XIX-XX Sec.).* In: AGNOLETTI M (a cura di) *Storia e Risorse Forestali.* Accademia Italiana di Scienze Forestali, Firenze, pp. 353-374.

HOLLING C.S., 1988 – *Temperate forest insect outbreaks, tropical deforestation and migratory birds.* Memoirs entomological society of Canada 146: 22-32.

HOLLING C.S., CARPENTER S.R., BROCK W.A., GUNDERSON L.H., 2002 – *Discoveries for sustainable futures.* In: GUNDERSON L.H., HOLLING C.S. (eds.), *Panarchy. Understanding transformations in human and natural systems.* Island Press, Washington D.C., pp. 395-417.

IOVINO F., MENGUZZATO G., 1999 – *La gestione delle pinete di laricio nelle aree protette.* In: *Selvicoltura ed arboricoltura da legno: quale gestione?* Azienda Foreste Demaniali, Università di Palermo, pp. 25-34.

ISTAT, 2000 – *Statistiche dell'Agricoltura.* Istituto Nazionale di Statistica, Roma.

ISTAT, 1990-2000 – *Statistiche forestali.* Istituto Nazionale di Statistica, Roma.

LARSSON T.B. (a cura di), 2001 – *Biodiversity evaluation tools for European forests. A report from the FAIR project Indicators for monitoring and evaluation of forest biodiversity in Europe.* Ecological Bulletins 50.

MAC ARTHUR R.H., MAC ARTHUR J.W., 1961 – *On bird species diversity.* Ecology, 42: 594-598.

MAF/ISAFA, 1988 – *Inventario forestale nazionale 1985. Sintesi metodologica e risultati.* Ministero dell'Agricoltura e delle Foreste. Direzione Generale per l'Economia montana e per le Foreste. Roma.

MAGNUSON J.J., 1990 – *Long term ecological research and the invisible present.* BioScience, 40: 495-501.

MARCHETTI M., 1994 – *Pianificazione antincendio boschivi: un sistema informativo forestale per la modellistica, la cartografia, le cause, i danni.* Collana Verde n. 93/1994, MIRAAF-CFS, Roma, pp.1-259.

MARCHETTI M., CAMPAIOLA F., LOZUPONE G, TOSI V., 1998 – *Clearings and margins survey in forest inventory for diversity assessment in Liguria region.* In: BACHMANN P., KOHL M., PAIVINEN R. (a cura di), *Assessment of Biodiversity for improved forest planning.* EFI Proceedings N. 18, 1998. Kluwer Academic Publishers, pp. 291-300.

MARCHETTI M., LA MANTIA T., MESSANA G., BARBERA G., 2002 – Il *significato dei popolamenti arborei ed arbustivi fuori foresta nel paesaggio agrario e la loro dinamica evolutiva in due aree campione della Sicilia.* L'Italia forestale e montana, 57: 369-389.

MARCOT B.G., 1997 – *Biodiversity of Old Forests of the West: a lesson from our elders.* In: KHOM K.A., FRANKLIN J.F., *Creating a forestry for the 21st century.* Island Press, Washington D.C., pp: 87-105.

MASCI A., PAPI R., SCARASCIA MUGNOZZA G., 1999 – *Struttura selvicolturale di faggete appenniniche e rapporti con la biodiversità.* In: SCARASCIA MUGNOZZA G. (a cura di), *Ecologia strutturale e funzionale di faggete italiane.* Edagricole, Bologna, pp. 201-220.

MASER C., ANDERSON R.G., CROMACK K. JR, 1979 – *Dead and down woody material.* In: THOMAS J.W. (a cura di), *Wildlife Habitats in Managed Forests: the Blue Mountains of Oregon and Washington.* USDA Forest Service Agriculture Handbook, 553: 78-95.

MCPFE, 2003 – *Fourth Ministerial Conference on the Protection of Forests in Europe. State of Europe's Forests 2003.* UN/ ECE/ FAO e MCPFE. Vienna, pp. 126.

MCPFE, 2004 – *Development of Pan-Europan Understanding of the Linkage between the Ecosystem Approach and Sustainable Forest Management,* Kracow, Background Paper.

MEZZALIRA G., 2003 – *La situazione normativa dell'attività vivaistica forestale a livello europeo, nazionale e regionale.* In: MEZZALIRA G., PIOTTO B. (a cura di), *Biodiversità e vivaistica forestale. Aspetti normativi scientifici e tecnici.* Manuali e linee guida APAT 18: 17-29.

MOSS D., 1978 – *Diversity of woodland song-bird populations.* Journal of Animal Ecology 47: 521-527.

MOTTA R., 1999 – *Wild ungulate browsing, natural regeneration and silviculture in the Italian Alps.* Journal of Sustainable Forestry, 8: 35-54.

MOTTA R., PUPPO C., 2001 – *L'impatto degli ungulati selvatici sul sorbo degli uccellatori (*Sorbus aucuparia *L.) nelle foreste di montagna dei parchi provinciali del Trentino.* Dendronatura, 1: 43-57.

NE'EMAN G., MEIR I., NE'EMAN R., 1993 – *The effect of ash on germination and early growth of* Pinus, Cistus *and annuals.* Seed Sci. Technol., 21: 339-349.

NOCENTINI S., 2001 – *La rinaturalizzazione come strumento di recupero dei sistemi forestali semplificati nell'Italia Meridionale.* L'Italia Forestale e Montana, 5: 344-351

OLIVER C.D., LARSON B.C., 1990 – *Forest stand dynamics.* McGraw Hill, New York.

PARVIAINEN J., LITTLE D., DOYLE M., O'SULLIVAN A., KETTUNEN M., KORHONEN M. (a cura di), 2000 – *Final report summary: Mission, goals, outputs, linkages, recommendations and partners.* In: *COST Action E4, Forest reserves research network.* Office for Official Publications of European Communities. Luxembourg, pp. 9-38.

PATRONE G., 1960 – *Piano di assestamento delle foreste di Vallombrosa per il decennio 1960-1970.* Pubblicazione Azienda di Stato per le Foreste demaniali. Firenze.

PERRIN H., 1954 – *Sylviculture (Tome II). Le Traitement des Forêts, Théorie et Pratique des Techniques sylvicoles.* Ecole Nationale des Eaux et Forêts, Nancy. Traduzione Italiana a cura della Accademia Italiana di Scienze Forestali, con note di G. Bernetti, Firenze.

PETERSON G.D., ALLEN C.R., HOLLING C.S., 1998 – *Ecological resilience, biodiversity and scale.* Ecosystems, 1: 6-18.

PICKETT S.T.A., WHITE P.S. (a cura di), 1985 – *The ecology of natural disturbance and patch dynamics.* Academic Press, New York.

PROVINCIA AUTONOMA DI BOLZANO, 1997 – *L'influsso della selvaggina sul bosco in Alto Adige.* Provincia Autonoma di Bolzano, Ufficio Caccia e pesca, Bolzano.

REIMOSER F., GOSSOW H., 1996 – *Impact of ungulates on forest vegetation and its dependence on the silvicultural system.* Forest Ecology and Management, 88: 107-119.

SAMUELSSON J., GUSTAFSSON L., INGELÖG T., 1994 – *Dying and dead trees: a review of their importance for biodiversity.* Swedish threatened species unit, Uppsala.

SCRINZI G., FLORIS A., PIGNATTI G., 1997 – *Impatti della fauna superiore erbivora di grossa taglia sulla vegetazione e la rinnovazione in boschi montani del Trentino: biodiversità e bioindicatori.* ISAFA, Comunicazioni di ricerca dell'Istituto sperimentale per l'Assestamento forestale e per l'Alpicoltura, Trento.

SPIES T.A., TURNER M.G., 1999 – *Dynamic forest mosaics*. In: HUNTER M.L. Jr. (a cura di), *Maintaining biodiversity in forest ecosystems*. Cambridge University Press, Cambridge, pp. 95-160.

SPINELLI R., 1999 – *Utilizzazioni forestali e biodiversità*. L'Italia Forestale e Montana, 3: 148-149.

SUSMEL L., 1980 – *Normalizzazione delle foreste alpine*. Liviana, Padova.

SWANSON F.J., SPARKS R.E., 1990 – *Long-term ecological research and the invisible place*. BioScience, 40: 502-508.

TRABAUD L., LEPART J., 1980 – *Diversity and stability in garrigue ecosystems after fire*. Vegetatio, 43: 49-57.

TURNER M.G., GARDNER R.H., O'NEILL R.V., 1995 – *Ecological dynamics at broad scales*. BioScience, Supplement S-29 – S-35.

UN, 2000 – *Forest resources of Europe, CIS, North America, Australia, Japan and New Zealand (industrialized temperate/boreal countries)*. UN/ECE/FAO Contribution to the Global Forest Resources Assessment 2000. Main Report. Geneva Timber and Forestry Study Papers, N°. 17. United Nation Publication, New York and Geneva. 445 pp.

VENANZONI R., APRUZZESE A., NICOLETTI G., VALE F., 2002 – *Aspetti floristici e fitosociologici*. In: *Gestione sostenibile e multifunzionale dei boschi cedui: il progetto SUMMACOP*. Regione dell'Umbria, Assessorato Agricoltura Foreste Caccia e Pesca, Perugia.

WILKIE M.L., HOLMGREN P., CASTANEDA F., 2003 – *Sustainable Forest Management and the Ecosiystem Approach: two concept, one goal*. Forest Resources Development Service, Working Paper FM 25 FAO, Rome, Italy.

ZOVI D., FAVERO P., 1990 – *Struttura del bosco e "aree di canto" di Gallo cedrone*. EM-Linea Ecologica, 3: 23-30.