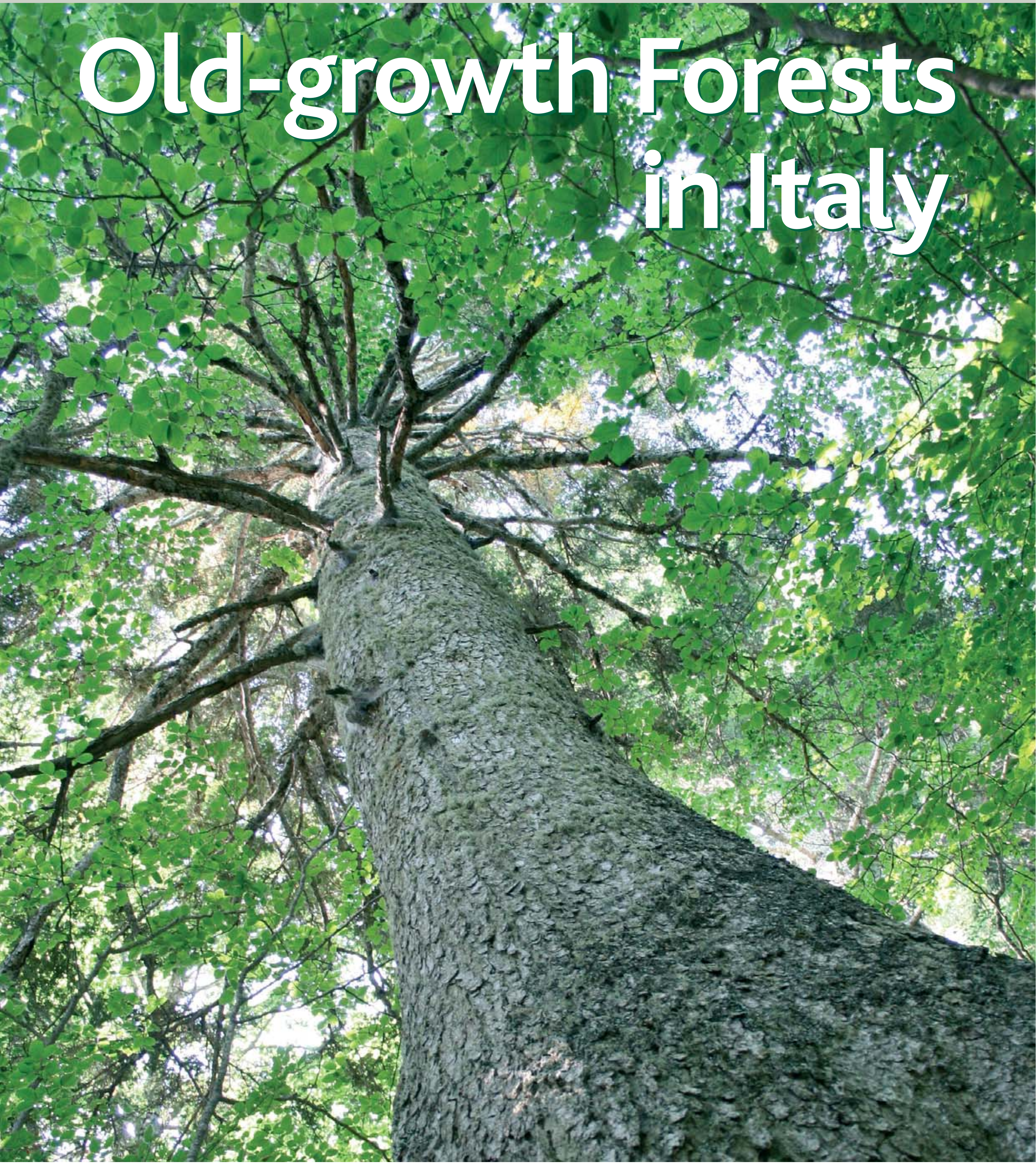
A thematic contribution to the

National Biodiversity Strategy

Old-growth Forests in Italy



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E DELLA TUTELA DEL TERRITORIO E DEL MARE

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ED ECOLOGIA DEL PAESAGGIO

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A thematic contribution to the National Biodiversity Strategy

Old-growth Forests in Italy

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Introduction – Old-growth Forests in Italy

Italy is characterized by a high degree of environmental heterogeneity and biological diversity. Forests in Italy are estimated to cover 8,759 km2, i.e. 29.1% of the national territory (INFC 2005).

Although the forest systems in Italy have been subjected to the influence of human activities ever since thousands of years, they maintained a high degree of naturalness representing an important legacy both in terms of resources and biological diversity.

In recent decades, the increasing costs of silvicultural practices has led to the concentration of timber exploitation in the most easily accessible zones and, consequently to the abandonment of many woods. As a result, the interest in woodlands driven by a predominantly natural dynamics has been growing considerably in Italy.

These general observations provided the starting point for the project "Old-growth forests in Italian National Parks", which is promoted by the Nature Protection Directorate in collaboration with the "Biodiversity, Plant Sociology and Landscape Ecology" Interuniversity Research Centre of the Sapienza University of Rome. The first phase of this project was conducted between 2006 and 2008. It was aimed at gathering information on Italian forests with old-growth features, selecting those that satisfy the old-growth forest definition drawn up for the purposes of this project. The selected forests were mapped, classified according to an old-growth scale and included in a geodatabase that stores structural and vegetation data.

Although Italy does not boast forests that have never been touched or have not been disturbed for several centuries, numerous forests with old-growth features were identified and studied.

The considerable variety of vegetation types that characterize these forests makes this sample an important starting point for a nationwide Old-growth Forests Network, which may become the object of important monitoring initiatives

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Hepatica nobilis.
Photo E. Giovi

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Majella National Park: G. Pirone, G. Ciaschetti
Abruzzo, Lazio & Molise National Park: C. Blasi, L. Rosati, S. Burrascano
Circeo National Park: C. Blasi, L. Rosati, S. Burrascano, R. Copiz, A. Tilia, E. Lattanzi
Vesuvio National Park: L. Filesi
Cilento & Vallo di Diano National Park: C. Blasi, L. Rosati, S. Burrascano
Alta Murgia National Park: V. Leone; G. Misano
Gargano National Park: V. Leone, G. Misano, R. Wagensommer
Pollino National Park: R. Di Pietro, S. Fascetti
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Old-growth Forests

What are old-growth forests?

The term old-growth forest has broadly been used to indicate stands in a developmental phase characterized by a high structural heterogeneity. Although various attempts have been made to define the term "old-growth" more accurately, these forests are inevitably characterized by some similarities and numerous differences depending on the forest types; a widely accepted definition for this term has consequently not yet been found.

A concise definition was proposed in a conference, organized by FAO in 2001, that was aimed at the harmonization of forest-related definitions. The definition of old-growth forest drawn up by the participants on that occasion is:

An old-growth forest is a primary or a secondary forest which has achieved an age at which structures and species normally associated with old primary forests of that type have sufficiently accumulated to act as a forest ecosystem distinct from any younger age class (UNEP/CBD/SBSTTA 2001).

It is, however, difficult to apply this definition when attempting to identify old-growth forests simply because primary forests (i.e. forests in which human disturbance has always been negligible) of most forest types, no longer exist, especially in Europe.

We have, therefore, decided to cite some of the definitions (which refer to temperate forests) that have been proposed since 1980 in order to provide a brief illustration of the scientific dabate surrounding this issue and highlight the most widely accepted criteria.

Silver fir (*Abies alba*) stand, Ai Pez.
Dolomiti Bellunesi National Park. Northern Italy.
Photo C. Lasen

Northern Spotted Owl
(*Strix occidentalis caurina*), which is
closely linked to old-growth forests.
Pacific NorthWest, USA.
Photo F. Eatherington

The American Perspective

The interest surrounding old-growth forests suddenly increased in the 1980s following some noteworthy studies conducted in North-America, particularly in the Pacific Northwest. An "Old-growth definition task group" was founded, in that region to draw up a definition based on precise parameters that had previously been identified as significant by Franklin *et al*. (1981), such as the number of stems over a certain size and the amount of standing and fallen dead wood.

The importance of structural characteristics for the identification of old-growth forests has been highlighted in previous studies, since structure can be surrogate of forest functions and species composition (Franklin & Spies 1991). Indeed, this observation underlies one of the most widely used definitions of old-growth:

Old-growth forests are ecosystems distinguished by old trees and related structural attributes […] that may include tree size, accumulations of large dead woody material, number of canopy layers, species composition, and ecosystem function (USDA 1989).

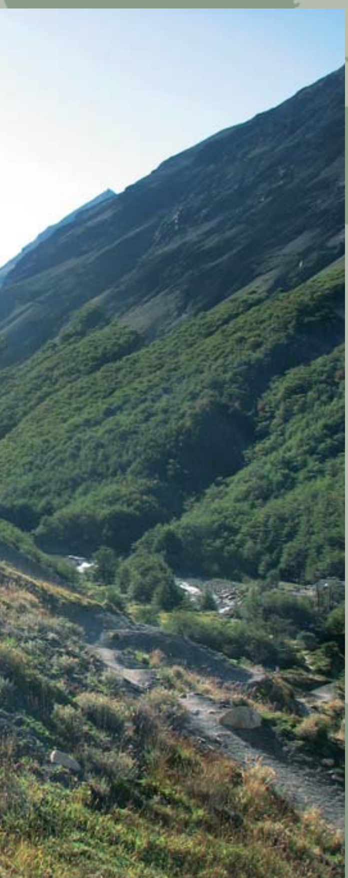
A study on deciduous temperate North-Eastern American forests (Keddy & Drummond 1996) attempted to define old-growth through both ecological (tree species diversity, understorey characteristics, overall species composition) and structural parameters (basal area, amount of deadwood, number of senescing trees).

Studies from the temperate region of South America report on forests with old-growth features in Chilean Islands. Although the studies conducted in this region do not focus on criteria in the old-growth definition, the main structural features of such forests are identified: tree basal area, density of shade-tolerant species, tree species richness, presence of large canopy emergent trees, high vertical heterogeneity and minimum stand ages older than 200 years (Gutiérrez *et al*. 2004).

Forest landscape
of Torres del Paine National Park. Chile.
Photo M. Baumflek

The Asian Perspective

In Asia, the temperate forests most widely recognized as being old-growth in the literature are the ones located in the Changbaishan Natural Reserve (China). Although the studies conducted in this area do not focus on the definition of old-growth either, they do describe the main structural and compositional features of those forests. From a structural point of view, the J-shaped diameter class distribution, which has already been observed in old-growth forests of other regions, characterizes this site, as does the occurrence of large trees. Besides these features, the Chinese studies highlight the importance of the spatial pattern of trees and canopy openings. The canopy proved to be particularly varied on account of its multi-layered composition, the most heterogeneous layer being the lowest. The canopy openings in this region, which are clumped and characterized by an irregular morphology, are more complex than those described in studies from other regions (Chen & Bradshaw 1999).
This structural complexity was found to be related to the spatial pattern of biological diversity (Wang *et al*. 2008).



The Australian Perspective

Australian scientists were the first to focus on the diverging features of old-growth forests according to the different forest types and regions, thus recognizing the difficulties involved in defining such ecosystems.
The Australian point of view focuses above all on the disturbance regime to which forests are subjected, the definition provided by Woodgate *et al*. (1996) being:
a forest which contains significant amounts of its oldest growth stage in the upper stratum – usually senescing trees – and has been subjected to any disturbance, the effect of which is now negligible.

Uprooted tree in Białowieża forest. Poland.
Photo F. Pretto

The European Perspective

Structural features (large old trees) and disturbance history (lack of human disturbance at least since the development of the trees now present) are considered to play a key role in the identification of old-growth forests in Europe as well (Nilsson *et al*. 2002).

The definitions reported in a french review on this topic (Gilg 2004) are:

- *ecosystems that are differentiated by the presence of old trees and by the structural characteristics that are included;*
- *forests including the final stages of site development, which typically differ from more recent ones by: tree size, the accumulation of large quantities of deadwood, the number of arborescent storeys, specific composition and ecological functions;*
- *forests without signs of recent logging that contain native species*

Huge individual of Norway spruce (*Picea abies)*.
Dolomiti Bellunesi National Park. Northern Italy.
Photo C. Lasen

Beech and silver fir mixed stand, Lagoduglia.
Pollino National Park. Southern Italy.
Photo R. Di Pietro

The Italian Perspective

This subject has recently aroused new interest in Italy as a result of the research project, funded by the Italian Ministry for Environment and Protection of Land and Sea, carried out by the Interuniversity Research Center for "Biodiversity, Phytosociology and Landscape Ecology" of the Sapienza University of Rome. One of the aims of the project was to develop a definition of old-growth that took into account both data previously published in the literature and the features of Italian old-growth forests:

Forests in which human disturbance is absent or negligible, and in which natural dynamics create a mosaic of all the forest regeneration phases, including the senescing one. Such phase is characterised by large old trees, deadwood (snags logs and coarse woody debris) and a vascular plant species composition that is consistent with the biogeographical context and includes highly specialized taxa related to the small-scale disturbance and the microhabitats resulting from structural heterogeneity.

Fagus sylvatica stand. Central Italy.
Photo R. Copiz

Why study old-growth forests?

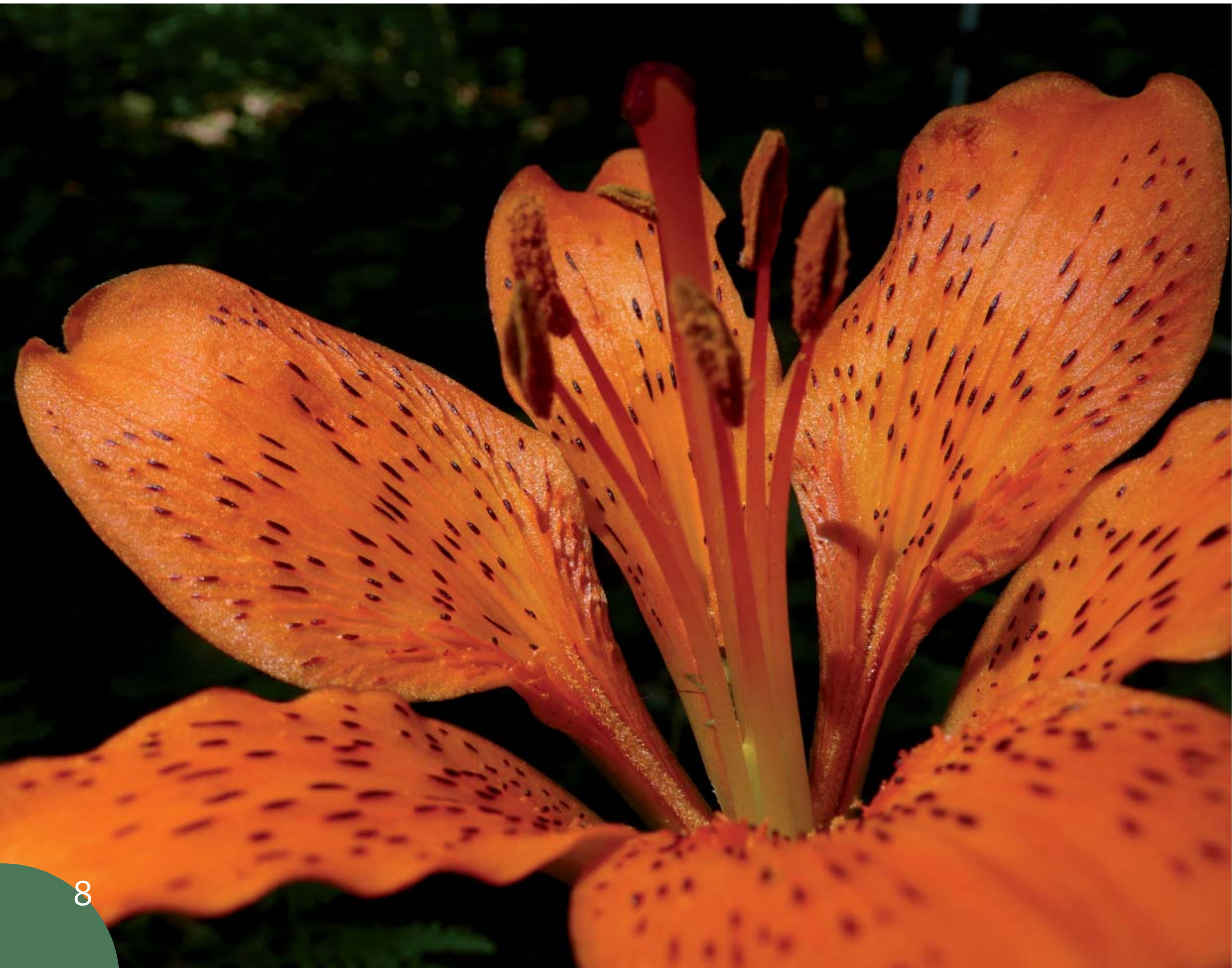
There are several reasons, related to biodiversity and forest management, that justify studying old-growth forests.

Many authors recognize old-growth forests as an important reference point when evaluating human impact on forest ecosystems (Peterken 1996; Keeton 2006), within the global view of achieving a Sustainable Forest Management which integrates ecological, social and economic objectives (UNCED 1992; FAO 2005).

Moreover, forest management has been shown to have an impact on biological diversity of different taxonomic groups, such as invertebrates (Siitonen 2001), lichens, mosses, fungi (Norden *et al*. 2007), birds (Jansson & Andren 2003) and vascular plants (Aude & Lawesson 1998).

The orchid *Cephalanthera damasonium*.
Photo F.M. Sabatini

Lilium bulbiferum.
Photo M. Azzella



Young cohort growing up in a gap in the Valle Cervara beech stand.
Abruzzo, Lazio & Molise National Park.
Photo S. Burrascano

Developmental stages in natural forest series (Franklin *et al*. 2002)

A variety of models of forest dynamics have been developed by different authors on the basis of studies performed in various regions; shown below is a model developed for one of the old-growth forest types studied most, i.e. Douglas-fir forests in the Pacific northwest.

1. **Disturbance/legacy creation stage –** Stand development begins with a disturbance that provides conditions for the establishment of a new dominant tree cohort. Natural disturbances rarely eliminate all structural elements from the preceding stand. Many living organisms often survive including tree regeneration or sexually mature trees whose density affects the spatial patterning of colonizing tree seedlings. The dead remnants are typically snags (standing dead trees) and logs on the forest floor.

2. **Cohort establishment stage –** A new generation of trees establishes. Stand establishment is typically most rapid when it forms from surviving advance regeneration; indeed, cohort establishment sometimes precedes disturbance and legacy creation.

3. **Canopy closure stage –** This stage is one of the most dramatic developmental episodes as regards the rate and degree of change in stand conditions due to forest canopy closure. The main environmental changes in the understorey include markedly reduced light levels, moderate temperature regimes, increased relative humidity and near-exclusion of wind. Significant shifts occur in both the composition and function of the forest ecosystem. Some species of shrubs, herbs, and lichens are suppressed or eliminated, while others, such as saprophytes and invertebrate detritivores, may increase.

4. **Biomass accumulation/competitive exclusion stage –** This is an extended period of young stand development in which the tree cohort totally dominates the site. A rapid biomass accumulation from growth in both tree diameter and height characterizes this phase that is so prized by production foresters. Trees are subject to density-dependent mortality mechanisms (self-thinning). Species diversity of many groups of organisms, such as vertebrates, declines because of shading that suppresses or eliminates light-dependent understorey plants and reduces food for herbivores; whereas species favoured by shaded, humid, litter-rich environments flourish.

5. **Maturation stage –** The pioneer cohort of trees attains maximum height and crown spread during this stage. The mass of coarse woody debris typically reaches its minimal levels for the sere. The understorey community is re-established as the thinning canopy of overstorey dominants allows more light to reach the forest floor. The causes of overstorey tree mortality shift from competitive to non-competitive factors (insects, disease, wind, etc.), thereby causing a stand-level change from uniform to spatially-aggregated patterns of mortality.

6. **Vertical diversification stage –** A significant development of late-successional or old-growth forest attributes occurs. The canopy continuity between ground and dominant tree crowns re-establishes owing to the growth of shade-tolerant species into intermediate and co-dominant canopy positions as well as to the development of epicormic branch systems.
   Large numbers of snags and logs are generated through mortality of larger trees so that the masses of coarse woody debris approach levels typical of old-growth stands.

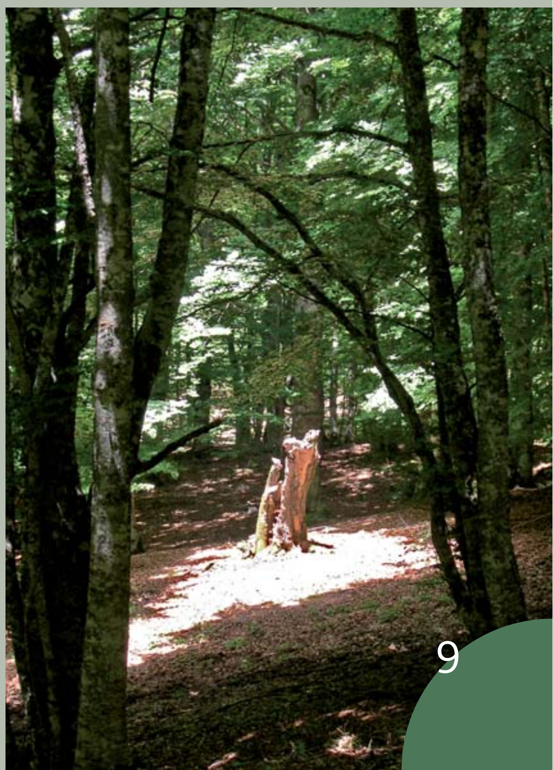
7. **Horizontal diversification stage –** The stand evolves into multiple structural units, primarily as a result of gap creation and expansion. Dominant processes during this stage contribute to development of high levels of horizontal variability: creation of gaps through spatially-aggregated mortality and creation of heavily-shaded areas where dense patches of shade-tolerant species have reached the mid- or upper-canopy.

8. **Pioneer cohort loss stage –** This developmental stage occurs when shade-intolerant species are present in the sere but the gaps present in older stands are too small for their successful regeneration.

Structural endpoint

The preceding stages are characteristic of a sere initiated by a catastrophic disturbance and composed of a mixture of pioneer shade-intolerant and associated shade-tolerant species. The sere culminates in a stand that is horizontally and vertically diverse, with many kinds of individual structures and a high level of niche diversity.

A structurally diverse endpoint characterizes natural forests in regions of chronic low- to moderate-intensity disturbances. Spatial heterogeneity is often more obvious in chronically-disturbed forest types than it is in the denser forest subject to catastrophic disturbances. The former develop a mosaic of structural units that collectively constitute the stand.



The breakage of a beech tree created a small gap.
Cilento & Vallo di Diano National Park.
Photo S. Burrascano

Disturbance regime and biodiversity

In recent decades, numerous studies have highlighted the important role played by old-growth forests in maintaining a high degree of biological diversity (Franklin & Spies 1991; Keddy & Drummond 1996). Indeed, biological diversity results from the presence of interior forest species which benefit from low disturbance levels and from the presence of suitable microhabitats created by structural heterogeneity (Nordén & Appelqvist 2001). Many authors stress the importance of disturbance regimes for biological diversity. Frequent disturbance allows the presence of unspecialized species alone, whereas when disturbance is infrequent, competitive exclusion mechanisms cause a lower species richness. Moderate levels of disturbance will therefore tend to maintain the highest levels of diversity, allowing, at a stand scale, pioneer species to co-exist with more specialized species (Bazzaz, 1999). The scale at which disturbance acts is also very important for species diversity. Old-growth forests are more often affected by a small-scale disturbance (*gap dynamic*), which causes a high structural heterogeneity that markedly influences the species/area curve (Peterken 1996).

Platanthera chlorantha.
Cilento & Vallo di Diano National Park.
Photo S. Burrascano

Ecological Continuity

Small-scale disturbance is closely related to the concept of Ecological Continuity, i.e. the persistence for a long time and in the same place, of similar environmental conditions only marginally affected by disturbance events. Such a situation allows colonization and survival of specialist taxa, which find suitable ecological conditions in the mosaic of developmental phases that make up natural forests.

The term Ecological Continuity is often applied to old-growth forests, as well as natural woodland and many forest organisms are assumed to be dependent on this condition.

Umpqua National Forest,
about two weeks after the wildland
fire in September 2008. Oregon. USA.
Photo F. Eatherington

Deadwood breathes life into forests

Another key role in maintaining biological diversity, besides those played by structural heterogeneity and ecological continuity, is that of deadwood (Christensen & Emborg 1996). Decaying wood is now widely recognized as a typical features of old-growth forests since the amount of deadwood depends on stand age and disturbance regime. Many studies suggest that decaying wood plays an important role in biological diversity for a variety of species in different taxonomic groups, such as invertebrates (Samuelsson *et al*. 1994), fungi (Heilmann-Clausen 2001), bryophytes (Ódor & Standovár 2001), lichens (Humphrey *et al*. 2002), amphibians (Raymond & Hardy 1991), small mammals (Harmon *et al*. 1986), birds (Mikusinski & Angelstam 1997) and plants (Burrascano *et al*. 2008).

Fomes fomentarius on a dead downed beech tree.
Abruzzo, Lazio & Molise National Park. Central Italy.
Photo S. Burrascano

Oxalis acetosella growing close to woody debris.
Abruzzo, Lazio & Molise National Park. Central Italy.
Photo S. Burrascano

Mosses on coarse woody debris.
Białowieża forest. Poland.
Photo F. Pretto

Old-growth forests in conservation policies

The need to study old-growth forests has been recognized both in the scientific literature and by several international agreements designed to promote biodiversity conservation.

The **Pan-European Biological and Landscape Diversity Strategy** in the Action Theme 9, which focuses on forest ecosystems, indicates the following goals:

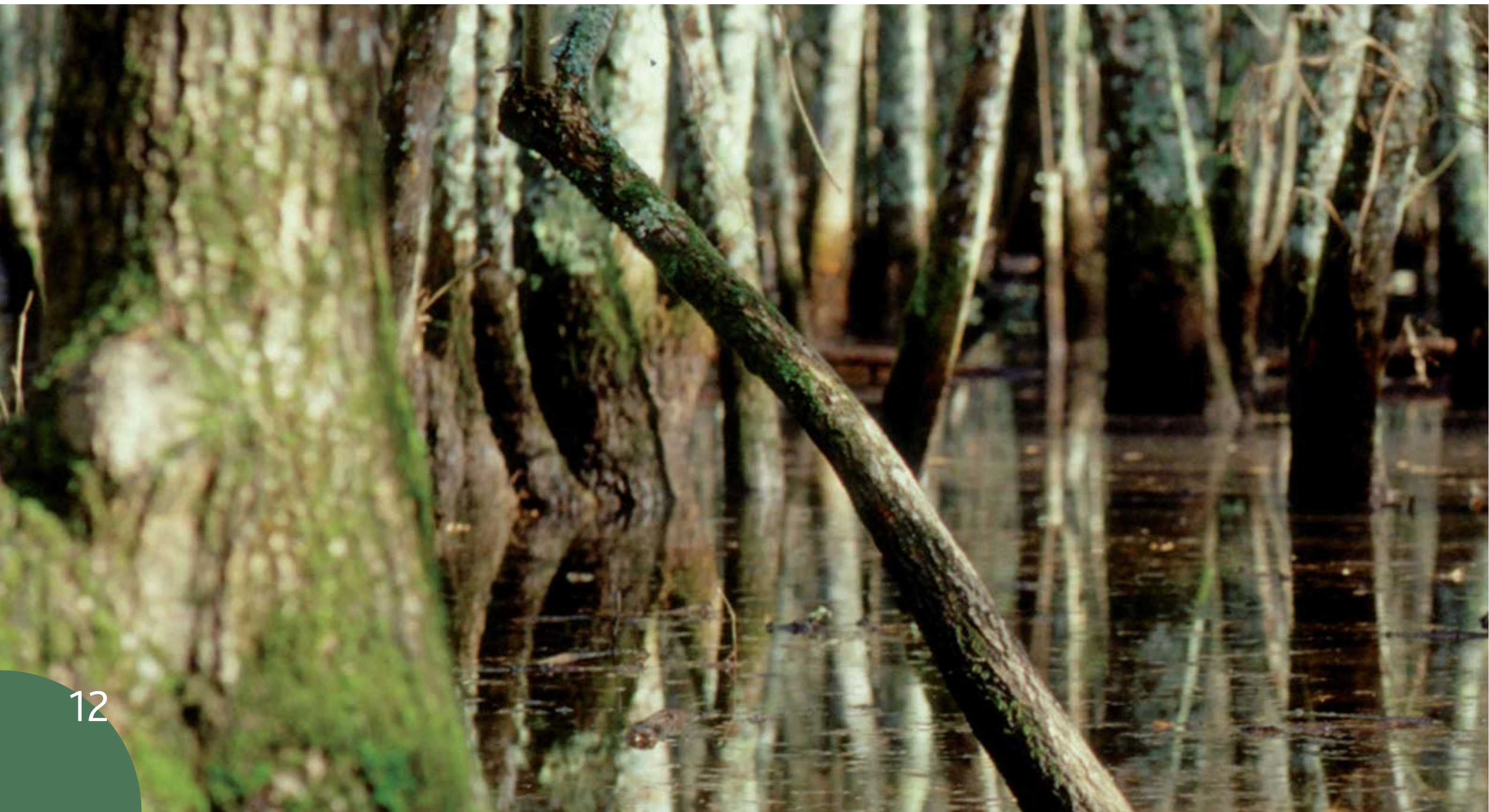
- the conservation of adequate areas to ensure the preservation of all types of forests in Europe [...] the majority of the remaining ancient secondary woodland;
- the conservation of forest habitats of species requiring large undisturbed forest ecosystems, including the high profile Bern Convention, Habitats Directive and UNECE threatened species.

At regional scale the strategy aims to:

- strengthen sustainable management and protection of viable old growth forests in south-western and south-eastern Mediterranean regions to prepare case studies and ensure the exchange of expertise in the process.

Despite the fact that the forest area in Europe is increasing, the **European Strategy for Plant Conservation** (2008-2014) has pointed out that old-growth forests with a high biodiversity, are threatened by intense logging, at times illegal, especially in south-eastern Europe. To preserve plant diversity, the strategy aims to ensure the sustainable management of at least 30% of forests exploited for commercial purposes.

Taxus baccata.
Photo E. Giovi



Old-growth Forests Network in Italian National Parks

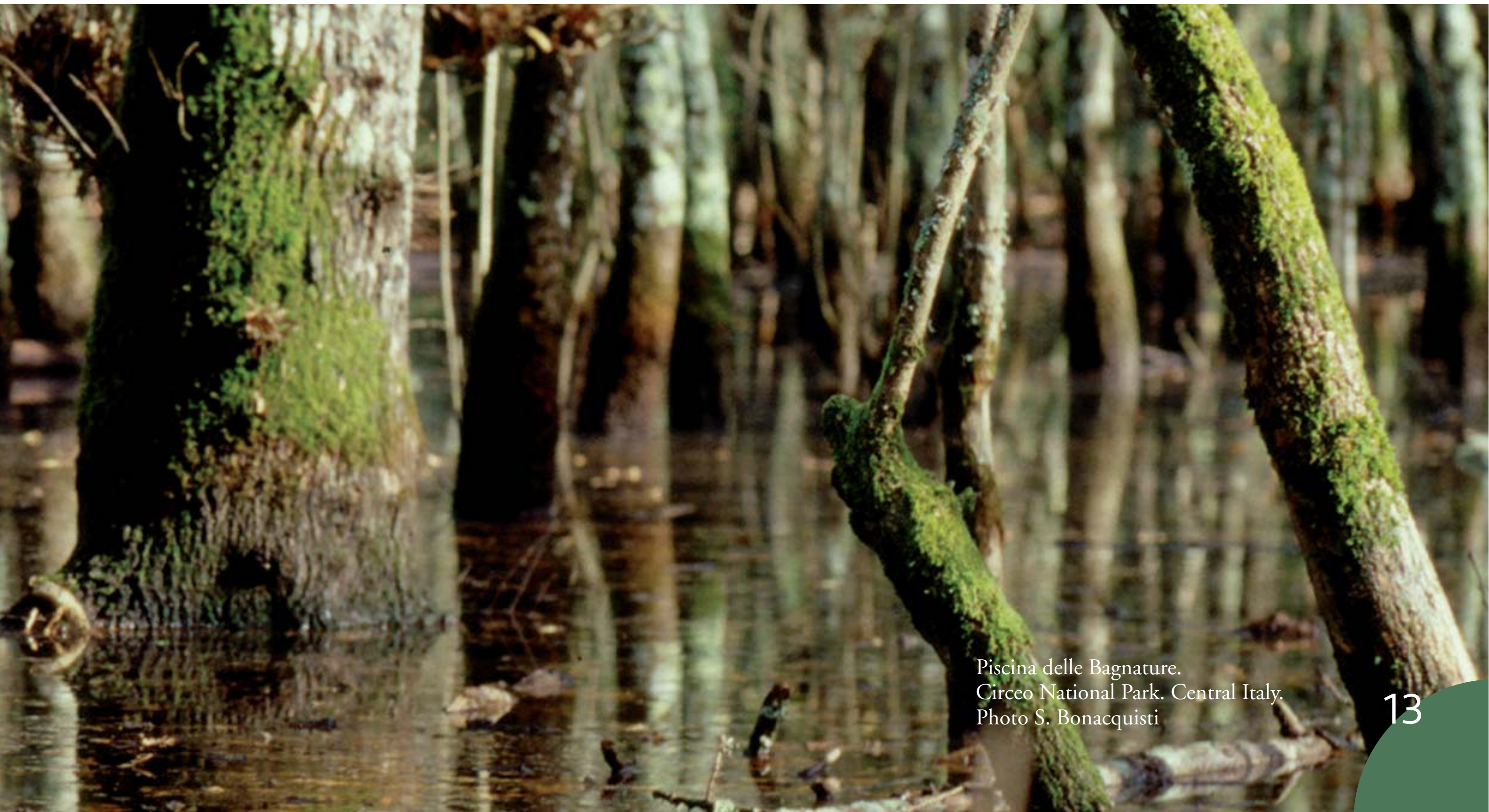
Old-growth forests are very rare in Europe, and even more so in the Mediterranean region (Gilg 2004). In Italy, the exploitation of natural resources dates back thousands of years, though it was particularly severe during World War II and immediately after. Stands with old-growth characteristics were unknown until a few years ago (Motta 2002), while recently detected stands have been the subject of thorough investigations by Italian researchers (Piovesan *et al*. 2005; Burrascano *et al*. 2008, 2009).

The Ministry of Environment, Land and Sea Protection funded a research program aimed at creating an Old-growth Forest Network in Italian National Parks. This project was coordinated by the "Biodiversity, Plant Sociology and Landscape Ecology" Interuniversity Research Center of the Sapienza University of Rome and involved all the Italian National Parks, several University Departments and the State Forestry Corps.

The ultimate goal of this research program is the creation of a Network of old-growth stands that represents, as closely as possible, the Italian forest types from an ecological and phytogeographic point of view.

This network represents a starting point for further investigations aimed at identifying sustainable management guidelines especially in terms of biological diversity.

Landscape of Alburni Mountains.
Cilento & Vallo di Diano National Park.
Southern Italy.
Photo M. Azzella



Piscina delle Bagnature.
Circeo National Park. Central Italy.
Photo S. Bonacquisti

Building up the Network

In order to collect data and to detect stands with old-growth features in 23 National Parks, a questionnaire was sent to National Parks Agencies and to coordinating units (CTA) of State Forestry Corps within each park.
A preliminary list of stands was then drawn up by combining the questionnaires and suggestions given by local experts. Sites were then selected from the list according to how representative they were, and surveys were conducted by local experts.

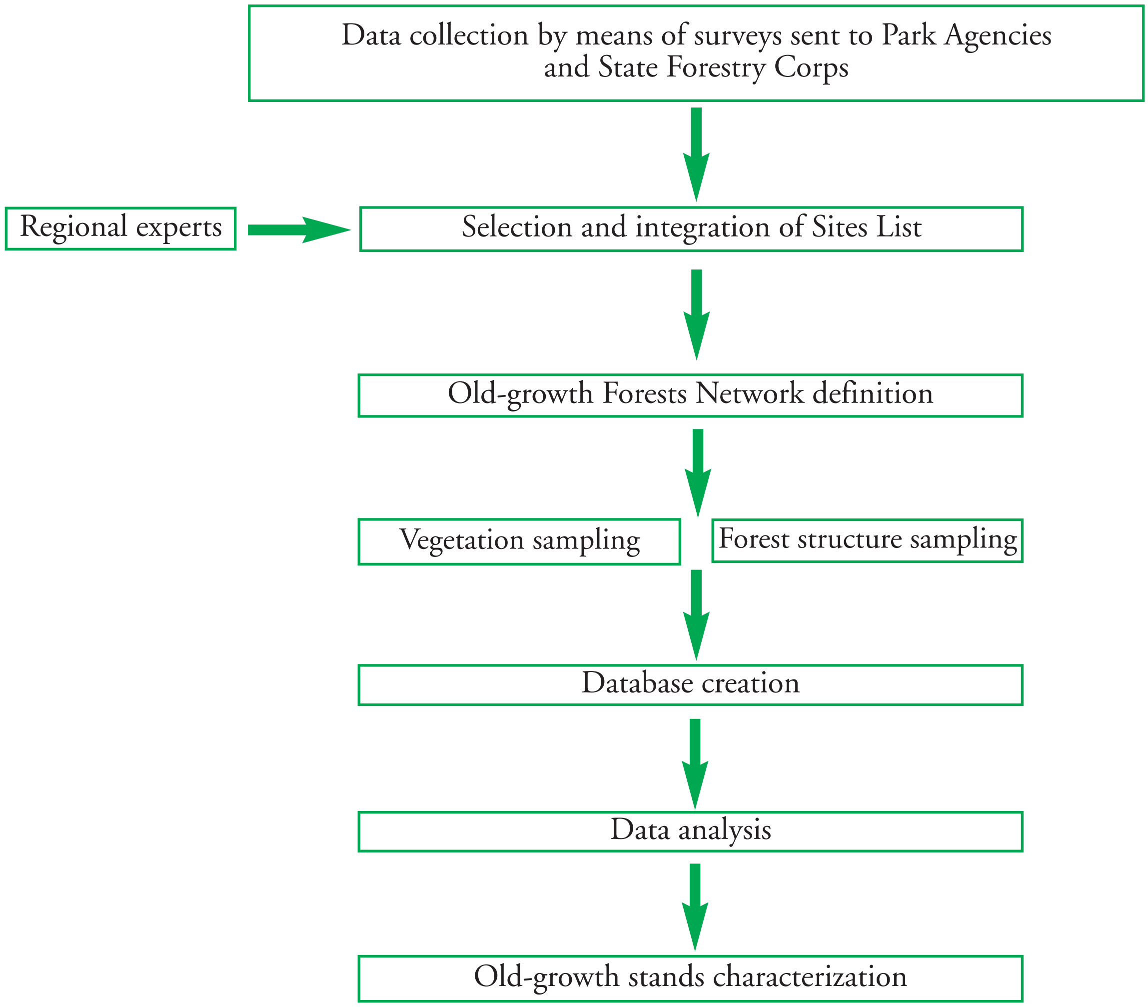
Potentilla micrantha.
Photo S. Bonacquisti

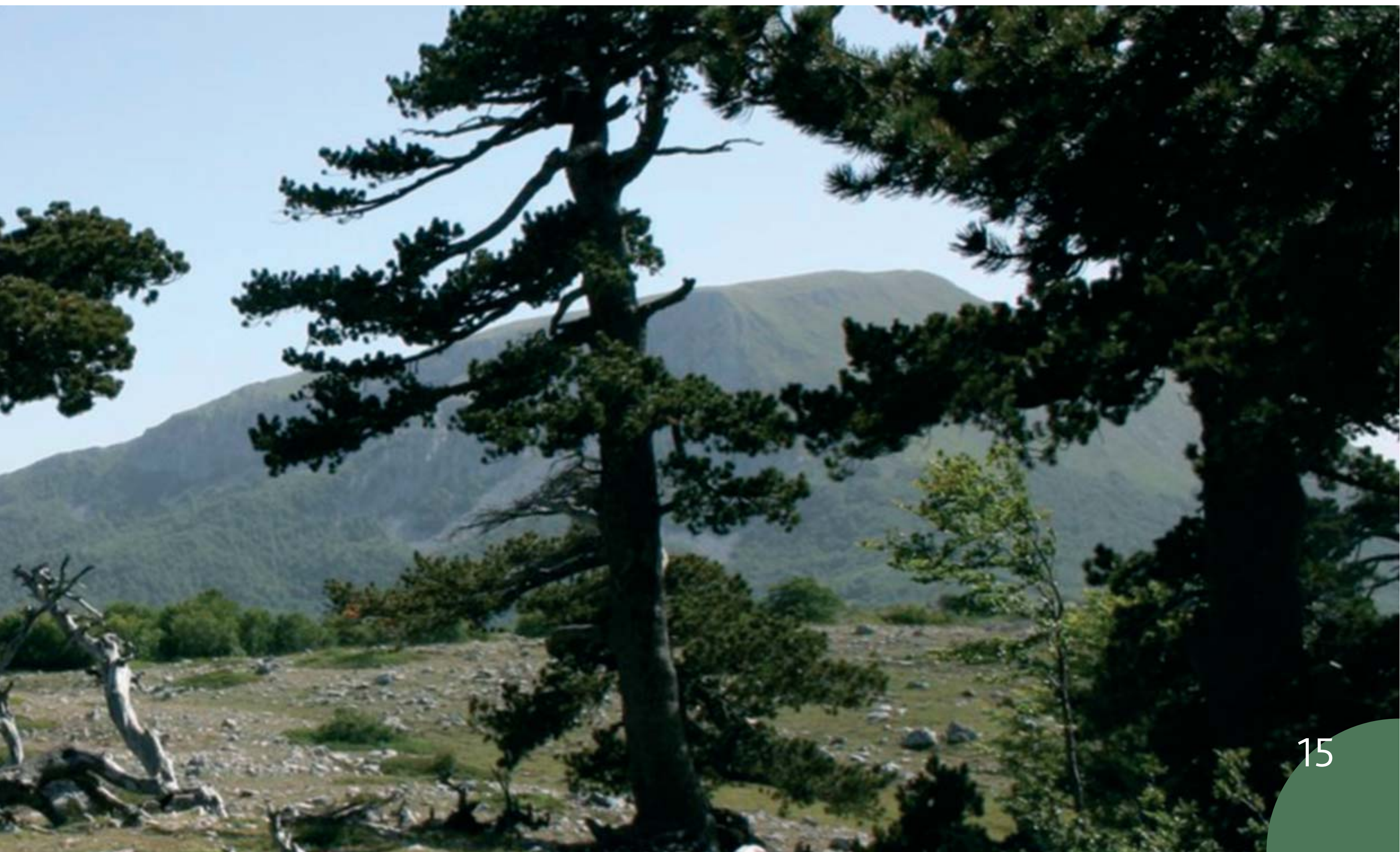
Uprooted individual of *Carpinus betulus*. Photo S. Bonacquisti

Vegetation and structural samplings were performed in each selected site to describe the stands and evaluate their membership to Vegetation Series by means of a phytosociological analysis. Structural sampling was performed following an *ad hoc* protocol. This protocol was designed to highlight the main old-growth features, such as the presence of large, old trees and deadwood, in order to determine the degree of old-growth of each stand.

In order to asses the degree of representativeness of the stands, a census of the Vegetation Series was conducted in each National Park. The map of forest types, derived from CLC map (IV level) and the Map of Vegetation Series of Italy (Blasi, in press) were intersected. This overlay allowed us to estimate the extension of each forest type within the Italian National Parks and, consequently, to select Old-growth Forest Network sites according to their degree of representativeness.

Scattered specimens of *Pinus leucodermis*.
Pollino National Park. Southern Italy.
Photo E. Carli


Data collection by means of surveys sent to Park Agencies and State Forestry Corps
Regional experts
Selection and integration of Sites List
Old-growth Forests Network definition
Vegetation sampling
Forest structure sampling
Database creation
Data analysis
Old-growth stands characterization



Old-growth level assignment

In order to assign a level of old-growth to each stand, three structural features were considered:

- diameter distribution of living trees
- amount of deadwood (volume)
- quality of deadwood (decomposition classes)

Diameter distribution and number of large trees attest to stand age and heterogeneity; the amount of deadwood, including the analysis of its various components, is internationally considered as an indicator of old-growth; lastly, the number of decomposition classes and the maximum decomposition class within each site were used to estimate the period of time in wich no disturbance events occurred (whether it be felling or woody debris collection).
As regards-living structure, from 0 to 4 points were assigned to each stand. The score depended on how closely the living structure fitted the diameter correspondence curves usually associated to old-growth stands, i.e. the reverse J-shape curve, which attests to the presence of numerous young trees and a decreasing number of trees with a larger DBH, and the rotated-sigmoid curve, which is the semilog graph of the tree number per DBH class (Lorimer & Frelich 1984).

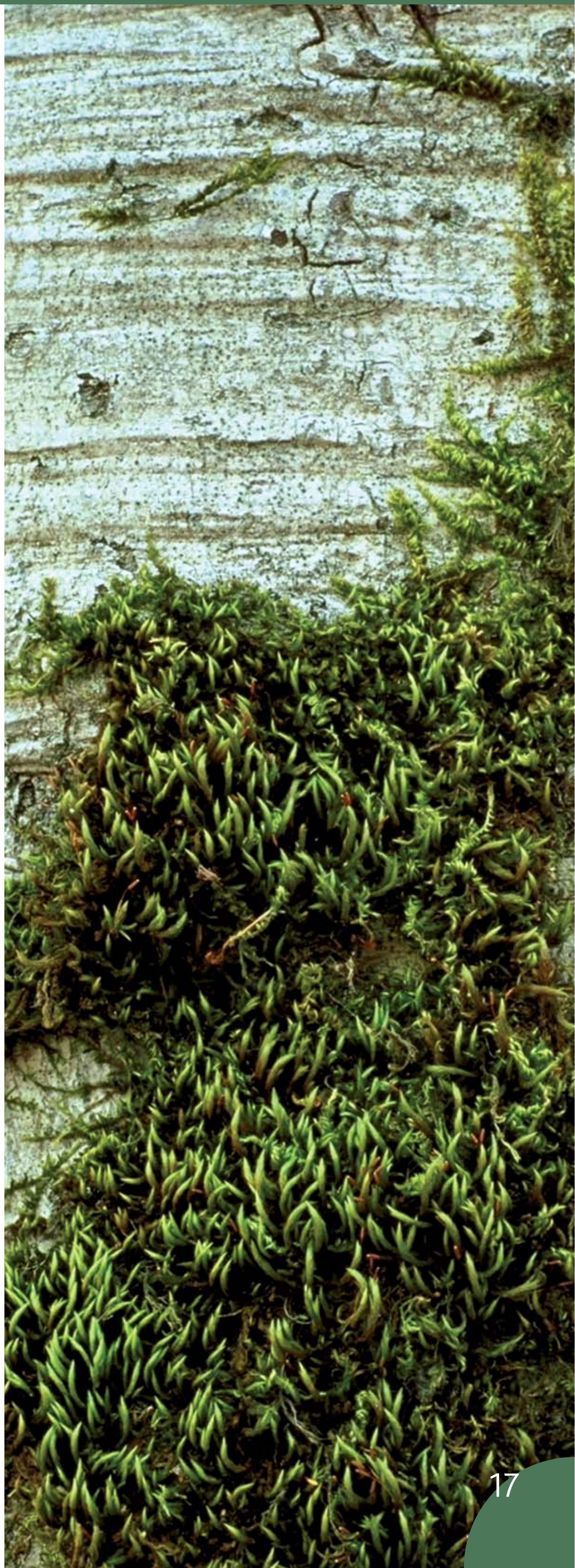
Campanula persicifolia.
Photo S. Burrascano

Lichens on beech bark.
Abruzzo, Lazio & Molise National Park. Central Italy.
Photo S. Burrascano

Another point was assigned on the basis of the number of large trees (DBH > 40 cm) per hectare. Every site with more than 70 large trees per hectare gained a point. This threshold was defined following Nilsson *et al*. (2002). A further four points were assigned for the amount and the quality of deadwood, two points being assigned for amount of deadwood per hectare and two points for the quality, the latter being determined on the basis of the number of decomposition classes and maximum class observed.
The stands scores thus ranged from a minimum of 0 to a maximum of 9 points. Each stand was then assigned to one of three old-growth levels: low, medium or high.

Old-Growth Level	# of sites
Low	26
Medium	37
High	5

A list of the vegetation series present, a map of the old-growth forests included in the Network and the structural and vegetation analysis of the selected sites were produced for each National Park.



Mosses on the bark of a beech (*Fagus sylvatica*) tree. Photo S. Bonacquisti

Data collected by means of questionnaires

We collected a total of 157 questionnaires filled out by Park Agencies, State Forestry Corps employees and local botanists from the Italian National Parks.

National Park	Sites detected
Gran Paradiso	22
Abruzzo, Lazio & Molise	20
Pollino	19
Stelvio	18
Sila	18
Dolomiti Bellunesi	11
Aspromonte	8
Gennargentu	8
Gran Sasso	8
Majella	7
Valgrande	4
Cilento	3
Gargano	3
Asinara	2
La Maddalena	2
Sibillini	2
Circeo	1
Vesuvio	1
Total	**157**

Sites detected within the parks on the basis of the questionnaire

Selected Old-growth Forests in Italian National Parks

As the number of sites detected on the basis of the questionnaire showed that interpretation of the definition provided varied depending on the park, field surveys were conducted to asses the accuracy of the information provided by the questionnaires.

A view of Monte Amaro.
Abruzzo, Lazio & Molise National Park.
Central Italy.
Photo S. Burrascano

Sites included in the Old-growth Forest Network

Sixty-eight forests were included in the National Network. Sites were ultimately selected on the basis of both their old-growth level and the Potential Natural Vegetation of the site in order to include as many forest types as possible in the network. The parks in which most sites were found are the largest, the most heterogeneous and oldest. As regards forest types, *Fagus sylvatica* woods largely prevail among the numerous forest types included in Old-Growth Forest Network. Nevertheless the number of forest types included in the network is relatively high (16).

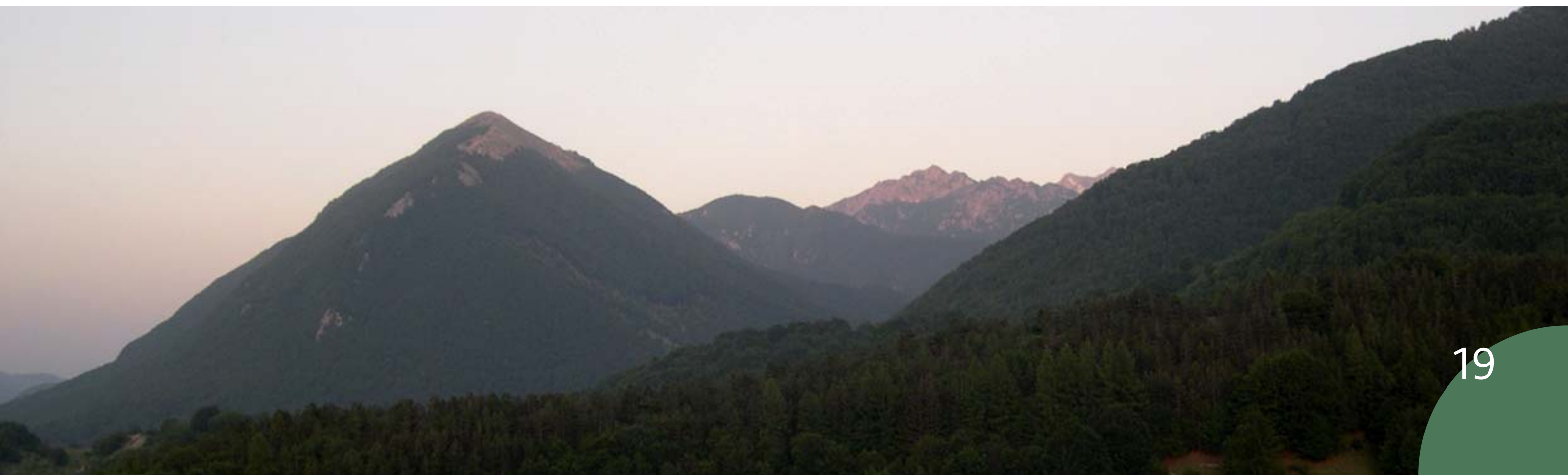
National Park	Sites selected
Cilento & Vallo di Diano National Park	8
Gargano National Park	7
Abruzzo, Lazio & Molise National Park	6
Pollino National Park	5
Aspromonte National Park	5
Stelvio National Park	5
Dolomiti Bellunesi National Park	5
Gran Paradiso National Park	5
Majella National Park	4
Gran Sasso & Monti della Laga National Park	4
Foreste Casentinesi, Monte Falterona & Campigna National Park	4
Sila National Park	3
Gennargentu & Golfo di Orosei National Park	2
Monti Sibillini National Park	2
Valgrande National Park	2
Circeo National Park	1
Total	**68**

Sites selected per National Park

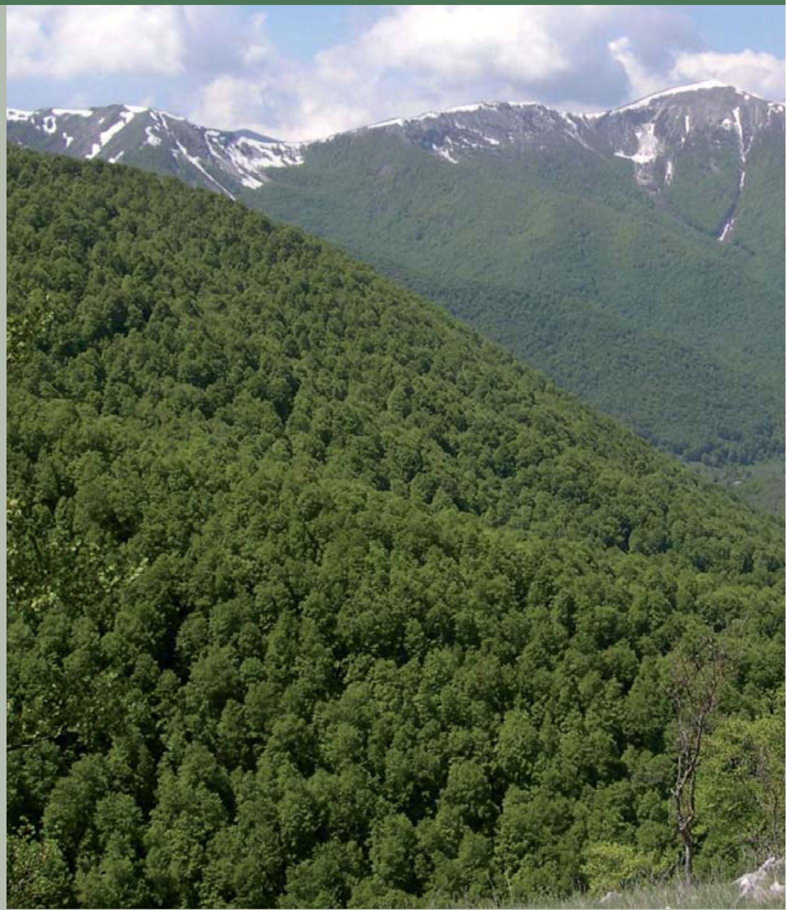
Standing dead tree,
Valle Cervara. Abruzzo, Lazio & Molise National Park. Central Italy.
Photo W.S. Keeton

Forest type	Number of sites
Fagus sylvatica woods	27
Fagus sylvatica and conifer mixed woods	13
Mesophilous mixed woods	4
Larix decidua and *Pinus cembra* woods	3
Larix decidua dominated woods	3
Quercus cerris dominated woods	7
Quercus ilex dominated woods	3
Picea abies dominated woods	3
Abies alba dominated woods	2
Pinus sylvestris woods	2
Carpinus betulus dominated woods	2
Pinus nigra subsp. *laricio* dominated woods	2
Quercus petraea dominated woods	1
Juniperus phoenicea e *Olea europaea* woods	1
Alnus cordata dominated woods	1
Alnus glutinosa dominated woods	1
Total	**75**

Sites selected according to vegetation type. The total number is higher than the n° of sites because some are made up of a mosaic of forest types



Valle Cervara – A Case Study



Among the selected stands, one of those displaying the most marked old-growth features is located in *Valle Cervara*, within the Abruzzo, Lazio and Molise National Park. It escaped logging for at least one century because of difficult access; moreover, it was never subjected to catastrophic disturbances in this period.
The old-growth stand extends over an area of approximatively 24 hectares, on a north facing slope between 1600 and 1850 m a.s.l. It is dominated by *Fagus sylvatica*, and can be referred to the *Cardamino kitaibelii–Fagetum sylvaticae* (*Aremonio-Fagion*) association, which includes the neutro-basiphilous beech woods located at the highest altitudes in the central and northern Apennines.

This forest was selected for further analysis because of its structure, which is highly diversified as it includes almost all phases of the forest life cycle (Piovesan *et al*. 2005). The various cohorts are due to the progressive death of dominant trees, some of which are older than 500 years (this finding disproves the previously held belief that the beech life cycle in Mediterranean region is shorter than 300 years), thereby creating a gap in the canopy that allows the regeneration of younger individuals.

Attributes such as stem density, large tree density, basal area, volume and biomass per hectare are comparable to those proposed by many authors for old-growth beech forests in Europe and for old-growth forests in general (Nilsson *et al*. 2002, Keddy & Drummond 1996; Peterken 1996). The diameter distribution of the Valle Cervara stand can be modelled by a rotated-sigmoid curve, considered the natural steady-state diameter distribution (Lorimer & Frelich 1984). Although this site does contain a large amount of decaying wood it is less than that generally found in old-growth forests elsewhere in Europe and North America.

In order to investigate the compositional features of the Valle Cervara forest, a comparison was made between this forest and a managed beech forest with similar environmental characteristics and the same potential natural vegetation (Blasi *et al*. 2000; Blasi & Michetti 2005).
This approach was adopted in order to:
1) investigating differences in plant species composition,
2) assessing if these differences give rise to a higher plant diversity,
3) relating forest structure to differences in plant species composition identifying the structural attributes more strongly related to the unmanaged forest vegetation.

These analyses were performed in an attempt to compensate for the total lack of such information in Italy and the general scarcity of data regarding old-growth forest composition in Southern Europe.

The results highlight significant differences between the two stands both from a structural and a compositional point of view. Indeed, the old-growth stand differs from the managed beech forest stand not only in the amount and quality of deadwood and in the diameter

Digitalis micrantha.
Photo S. Burrascano

Root system of a beech tree (*Fagus sylvatica*).
Valle Cervara. Abruzzo, Lazio & Molise National Park.Central Italy.
Photo W.S. Keeton

Valle Cervara. Abruzzo, Lazio & Molise
National Park. Central Italy.
Photo S. Burrascano

class distribution, but also in the degree of vascular plant diversity, which is greater in the old-growth stand. The structural variables adopted for the purposes of this survey (lying woody debris, standing deadwood, number of decay classes, number of large trees and of diameter classes) proved to be what determines old-growth stand vascular plant species composition to the greatest extent, and are therefore those that need to be preserved most in a conservation-oriented forest management (Burrascano *et al*. 2008). When the understorey species were analysed (Burrascano *et al*. 2009), besides displaying a higher species richness, the old-growth stand revealed significant differences in plant species composition, functional traits, Ellenberg's indices and taxonomic distances.

Indeed, the species that are typical of the old-growth forest included species that differed considerably in terms of functional traits: nemoral species with low dispersal ability, due to large seeds and to their dispersal mode, as well as species with traits that are more suited to open habitats, such as those characterized by a competitor strategy and small seeds that are prevalently dispersed by wind.
The occurrence of diverse microhabitats in the unmanaged forest further enhanced the differences between the two stands, even in terms of Ellenberg's species indices. Most of the unmanaged forest indicator species are characterized by high light indices and nutrient concentration. Such species can compete successfully because of the gaps and the accumulation decaying wood in the old-growth forest, which determine a variety of forest floor microclimatic conditions.

Lastly, differences between the two stands in terms of taxonomical structure are not due exclusively to higher species richness, but also to the fact that the phylogenetic relatedness of two taxa is often linked to ecological similarity.

These results suggest that forest management induced ecological differences strongly affect plant species composition; there is, therefore, the need to monitor forests more closely so as to be able to develop new approaches and practices in forest management aimed at the conservation of biodiversity.

Conclusions

The project opens a new season of forest research and conservation policies in Italy. Indeed, the results of this project represent an important starting point for research programmes and monitoring actions.
The sites displaying the highest level of old-growth could be monitored using an ecosystem approach including biodiversity investigations, particularly on taxa known to be related to old-growth forests (saproxylic organisms, lichens, bryophytes, etc.). These analyses would shed further light on the Italian forests with the highest degree of naturalness, thereby enhancing our knowledge of such ecosystems.

It may be possible to extend the comparison approach adopted for the Valle Cervara case study, combined with in depth biodiversity analysis, to other forest types in order to develop an accurate model of the natural dynamics in Italian forest types. Such a model would be extremely useful as a means of drawing up specific management guidelines aimed at biodiversity conservation in protected areas.

These actions, along with the involvement of political decision-makers, administrations, agencies, the academic world and stakeholders, would contribute to forest management policies aimed at enhancing the value of Italian forests. Indeed, the value of forests is no longer linked to timber production alone, but even to more important issues such as carbon sequestration, biodiversity conservation, as well as several other ecosystem services that are critical for people's quality of life.

Acer obtusatum in autumn.
Photo S. Bonacquisti

Dead downed beech. Macchiatonda.
Monti Sibillini National Park. Central Italy.
Photo S. Properzi

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