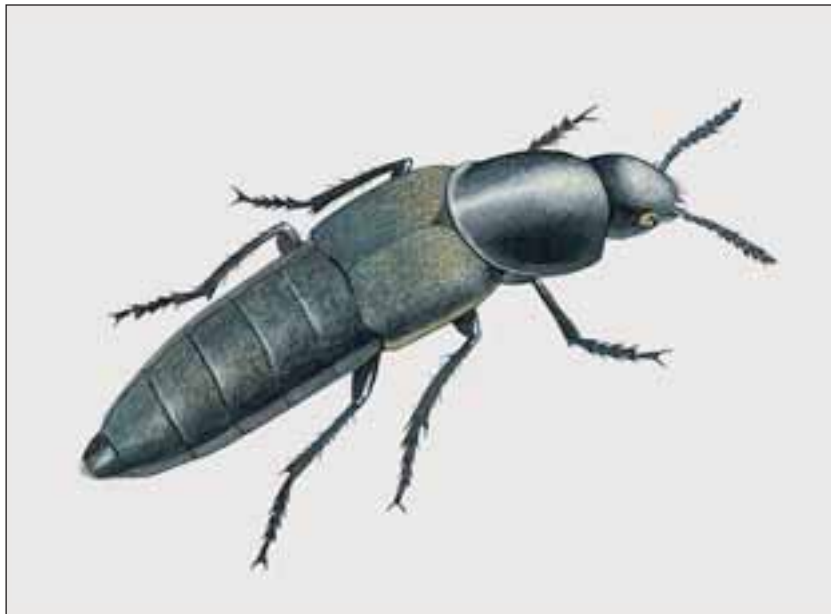


exclusively in tree-holes. Examples are culicid dipterans such as *Aedes geniculatus*, *Orthopodomyia pulchripalpis* and *Anopheles plumbeus*, ceratopogonids of the genus *Culicoides*, chironomids of the genus *Metriocnemus*, hoverflies like *Myiatropa florea*, and scirtid beetles like *Prionocyphon serricornis*: most of these species are exclusively found in Italy in plain woods.

Tree-holes have recently been "rediscovered" by Anglo-Saxon ecologists and are used as small model ecosystems, due to the simplicity of their food chains. They are also interesting because the larvae of particular species of mosquitoes, which may carry pathogens in tropical countries, are sometimes found here. Even in the same tree-hole, dipterans occupy highly specialized niches according to the changing degree of humidity: for instance, larvae of the hoverfly *Brachyopa* live on the walls of the hole, just above the level of the water in it, the water itself contains the "rat-tailed" larvae of *Myiatropa*, and drier cracks in the bark host *Fannia* larvae. The larvae of many genera of stratiomyids, such as *Beris* and *Pachygaster*, are also associated with these special rotting wood habitats.

Trees with holes in their trunks are essential for a large number of birds which



Velleius dilatatus

nest in them, like tawny owl, stock dove, and the rare lesser spotted woodpecker. Social insects like wasps and bees settle in them, adding to the environmental diversity, as there are many insect species which live exclusively in this way in trees, eating decomposing organic matter or preying on other animals. These insects are highly specialized and little



Hornet (*Vespa crabro*)

known, mainly because they are hard to identify. For instance, the staphylinid beetle *Velleius dilatatus* frequents the nests of hornets (*Vespa crabro*), so that the difficulty and danger of collecting it directly from its home environment may easily be imagined. Its presence has been ascertained in the Bosco della Fontana and in several parks in the Piedmont plain, using flight traps.

Mention must also be made of those animals, mainly insects, associated with woodland fungi. There is a further specialization between species linked with woody fungi (particularly polypores) and soft fungi, between eaters of fruiting bodies and spores and their predators. An example is the tiny but showy tinaeid moth *Euplocamus anthracinalis*, recently reported in the Bosco della Fontana. Fungi are in any case a particularly appetising source of food, and very many species eat them. As regards the animal community living on and in wood, it should be recalled that all the above species are associated with predatory insects and parasites, particularly beetles and parasitic hymenoptera.

Although the mass of leaves on a tree is far smaller than the mass of wood, leaves do represent a source of food of better quality and are thus more attractive, at least for insects. Among leaf-eating species, butterflies are probably the insects which attack plants most extensively. In the Bosco delle Sorti della Partecipanza, several crises in tree vegetation have been documented, as a result of pullulating numbers of moths, like processionary (*Thaumetopoea processionea*), gypsy (*Lymantria dispar*) and above all browntail (*Euproctis chrysorrhoea*) moths. Elsewhere, for instance in the Bosco della Fontana, similar phenomena have not occurred in recent times.



Caterpillar of gypsy moth (*Lymantria dispar*)

Another more refined and less invasive



Adult of green oak tortrix (*Tortrix viridana*)



Tree defoliated by *Tortrix viridana*

way of exploiting leaves is that used by miners, insects whose larvae dig, or mine, galleries in the thickness of the leaf. On oak, several tiny butterflies are well-known, particularly gracillariids and nepticulids, and a curculionid beetle (*Rhynchaenus quercus*). One dangerous leaf-roller is green oak tortrix (*Tortrix viridana*) which can cause terrible episodes of defoliation.

Even more complex is the production of galls by insects whose larvae, by means of a biochemical stimulus, produce excrescences of characteristic shape and size, inside which they develop. Oak-trees host galls of hymenopterans of the cynipid family.

The larvae of various curculionid beetles of the genus *Balaninus* live inside acorns. Acorns are a source food for several mammals and birds, such as jays. By transporting acorns into hiding-places sometimes relatively far away, jays help to spread seeds.

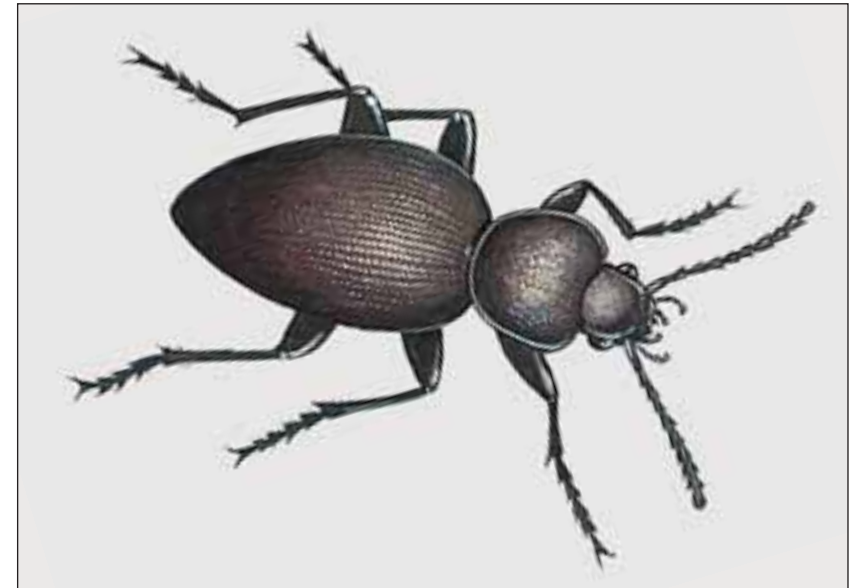
This brief description of the animal community linked to oak may generally be extended to other tree species. It should be recalled that, whereas animal species eating living organic matter, such as leaves and wood, may be monophagous, i.e., they only eat one plant species, those which live in rotting wood have less specificity and are mainly associated with any cavities it may have. In any case, pedunculate oak is the plain wood species which hosts the greatest number of animals. For example, in the Parco della Mandria, sixteen species of cerambycid beetles have been recorded, all associated with native species of the genus *Quercus*, whereas only three species have been found on red oak, introduced from North America. The lack of specific insects in red oak may at least partly explain its success in the woodland of northern Italy.

The animal communities living in shrubs generally have the same

characteristics as those preferring trees, although obviously saproxylic species are missing. However, their contribution to the overall diversity is still important, since there are many shrubby species in plain woods and many animals associated with them, as confirmed by samplings of butterflies in the Bosco della Fontana. Among the numerous species of this group, seven depending exclusively on the leaves of trees (oak, hornbeam, field maple, elder) have been obtained by breeding, twelve from shrubs (hazel, hawthorn, service tree, cornelian cherry, wild pear, viburnum), and three from introduced trees (locust, plane). Overall, 50% of the animal species collected live in grasses and shrubs and 25% in trees; the rest have various diets.

Populations in the grassy layer inside plain woods are relatively scarce. They become more abundant and varied in natural or artificial clearings where, mainly on flowers, many butterfly species may be seen, drinking nectar or mating, together with beetles, dipterans and hymenopterans. Their larvae often live at the expense of the trees in the woodland.

Next to the animal community in close connection with living plants are species associated with the soil, from ground litter to deep soil. The food resource composed of dead leaves, small branches and twigs is slowly demolished to the point of mineralization by micro-organisms (particularly



Laena viennensis, a tenebrionid beetle found in Veneto plain woods

bacteria and protists), fungi and animals. This community of demolishers differs from that scavenging on vegetation, since a greater variety of zoological groups is involved. In the aerial part of the wood, next to vertebrates, insects mainly prevail, with arachnids (particularly spiders) and molluscs. The soil is far more heterogeneous, with nematodes (cylindrical worms, often microscopic in size), gastropods (snails and slugs), annelids (earthworms and similar), arachnids (mites, spiders, harvestmen, scorpions and pseudoscorpions), isopod crustaceans (woodlice), chilopods (centipedes), diplopods (millipedes), pauropods, symphylans, wingless (primitive) insects, and a great number of others, with prevailing coleopterans and hymenopterans, mainly ants.

Organic matter is mainly demolished by nematodes, annelids, mites, isopods, diplopods and wingless insects; predators are represented mainly by arachnids, chilopods and insects (beetles and ants). The true soil, underneath the ground litter, is the most conservative of all terrestrial environments, since its micro-environmental conditions tend to remain constant in time. In the soils of Italian reliefs, both hilly and mountainous, there are many species of endemic invertebrates which have gradually adapted to life in this environment, by evolving characteristics adapted to life in this environment e.g., reduction of eyes and wings and depigmentation. In the Po-Veneto Plain, this does not happen, since the terrain is almost entirely composed of recent alluvial soil, generally not very suitable to the slow evolutionary phenomena which give rise to the differentiation of endemic species. However, studies on soil fauna still hold surprises. In the clay soils of the Bosco Panfilia near Ferrara, species of soil-living beetles have been found, lacking eyes and pigmentation (carabids of the genus *Anillus* and colydiids of the genus *Langelandia*). This finding, not unique to the Po Plain, may be explained by passive transport of insects by rivers (in this particular case, by the Reno, from the Appennines).

Together with its portion with "conservative" environmental features (that is, ground litter and soil), soil also contains temporary micro-environments subject to rapid evolution, composed of rotting materials such as dung (mainly that of mammals), the dead bodies of vertebrates and invertebrates, and rotting fungi. The number of species is very high and their turnover, in the cycle from colonization to complete humification of organic matter, is fast. Various beetles and dipterans are the most abundant demolishers, while staphylinid beetles are the most important predators.

The emergence of underground water or overflows from natural or artificial watercourses in the plain may lead to temporary or permanent flooding of portions of the plain woods. This phenomenon, which usually occurs in late



Libellula depressa

spring and autumn, creates pools hosting rich and diversified fauna.

Their aquatic fauna has been particularly studied in the relict woods of the low Friuli plain (e.g., Bosco Pradiziolo, Bosco Baredi, Selva Arvonchi). The animal communities here depend prevalently on the abundant food source composed of accumulating rotting leaves, since aquatic vegetation and algal flora are relatively scanty, in view of the small amount of light reaching the undergrowth. Here, at the base of the food chain, we find the detritivores - composed, for instance, of isopod crustaceans (*Asellus*, *Proasellus*) - and hydraenid, helophorid and hydrophilid beetles, families with very numerous species. There are also scrapers (e.g., gastropods of the genera *Lymnaea* and *Planorbis*), which eat the algal and fungal patinas on rotting leaves, and filter-feeders. The latter include mosquito larvae (culicids of the genera *Aedes*, *Culex* and *Culiseta*), which often pullulate in residual water and drying pools in late spring. This is why, during a summer walk in the plain woods, human walkers are plagued by biting insects. Together with these relatively large invertebrates, tiny pools of water also contain myriads of organisms varying in size from three-tenths of a millimetre to one millimetre, mainly belonging to three large groups of crustaceans: cladocers (like filter-feeders of the genus *Daphnia*), copepods (prevalently *Cyclops*, an invernial genus, together with *Eucyclops*, *Macrocyclops* and *Diacyclops*, omnivorous) and ostracods (the most common genera being the detritivores *Cypria* and *Pseudocandona*).

At a higher level of the food chain are the predators, which have occupied every available niche in woodland pools. Numerically, first come dytiscid



Bosco di Muzzana (Friuli): area flooded by spring waters

beetles - excellent swimmers, including the very large *Cybister* and *Dytiscus*, which may be more than 3 cm long. Next, and locally abundant, come dragonfly larvae (mainly *Aeshna* and *Libellula*), which live buried in mud and wait in ambush for other insect larvae and tadpoles, capturing them with a lethal extendible apparatus, the "mask". Pools and ditches host water-bugs of the genera *Gerris* and *Hydrometra*, which walk and skate on the water, exploiting its surface tension, and eat other small arthropods. Last come the planktonic predators, which live in suspension in the water, represented by the larvae of chaoborids (*Chaoborus* and *Mochlonyx*, the latter only recently reported in Italy, precisely in the woods of the Po-Veneto plain). Called "ghost larvae" because of their transparent bodies, they mainly eat minute crustaceans.

All the species associated with temporary bodies of water have developed survival mechanisms which allow them to overcome adverse periods of drought. One of these mechanisms is a phase of quiescence, with long-lasting eggs (in cladocers) and cysts (in copepods). Another is the capacity of these animals to bury themselves in the mud at the bottom of pools which, in plain woodland, remains damp even in the driest weather (molluscs, isopods). For the flyers, there is the possibility of abandoning dried-up pools to colonize permanent water nearby (most flying insects in the adult state).

One special contribution to biodiversity in woodland is supplied by *ecotones*: areas of transition between different ecosystems, like river-bank environments or shrubby areas between woodland and fields or cultivated land. Ecotones have their own characteristics, and many vegetal and animal species (e.g., nightingale) are regularly associated with them.

In fact, however, many of the relict woods of the Po Plain do not have true ecotones, since the transition belt is reduced and compressed by the surrounding cultivated land.

Study of vegetation and forest structure highlights the fact that the remains of woodland in the Po-Veneto plain are under or at the limit of what forestry experts call the *Minimum Dynamic Area* (MDA) - that is, the surface area over which the wood has resources enabling it to maintain itself and make necessary adjustments and repairs. The food networks in the Po Plain woods are completely incapable of autonomously supporting physically large species, particularly mammals, which require large quantities of food and ample space. When these species are introduced or maintained in these woods, they always have a considerable impact on the environment - as shown by the signs left by boar and deer in the Parco della Mandria. The threshold of extinction reached by boar in the Bosco della Fontana must be viewed as a positive natural event for this residual ecosystem.

Problems of conservation and management

FRANCO MASON

■ Isolation

Today, the situation of the Po Plain woods may be compared with that of islands emerging from a “sea” of single-crop cultivated land. If, for whatever reason, the population of a certain species disappears from one of these “islands”, extinction takes place. The size of a wood therefore represents the determinant factor for its own conservation and for that of the fauna which inhabits it. For instance, although isolated in the middle of single-crop fields, woods like the Bosco delle Sorti della Partecipanza (560 hectares) or Bosco della Fontana (230 ha) are sufficiently large to be less exposed to the risk of the local extinction of some species. Precisely because of their size, they can repair the damage caused by certain kinds of perturbations which, in plain woodland, are typically represented by wind.

A wood sufficiently large to regain its equilibrium readily and alone is an MDA (*Minimum Dynamic Area*), defined as the smallest area which, subjected to a regime of natural perturbation, can maintain its own internal recolonization, and is thus capable of minimizing any probability of extinction.

In actual fact, there is no single dimensional MDA threshold valid for all forest types. However, in a first approximation and regarding plain woods mainly composed of oak/hornbeam, it may be stated that 200 hectares can satisfy the requirements of an MDA; under 100 ha, the risk of local extinctions rises considerably. Thus, in this hypothesis, most of the Po Plain woods are at risk of extinction. The list of invertebrate species currently being compiled for the Bosco della Fontana (230 ha) confirms this assessment, since even the most demanding species, from the viewpoint of habitat, have survived until today. A surface area of 200 ha would thus also be sufficient to guarantee the dynamics and chronological seriation necessary to conserve pedunculate oak in the forest community. Only some portions of woods of this size, which have an adequate MDA, suffer wind damage, and so only rarely does wind influence their entire surface area. Instead, small woods, like the Olmé di Cessalto (24 ha) or tiny relicts like the Bosco di Carpenedo (2.5 ha) risk complete annihilation as a result of wind

Obvious state of isolation of a wood in Friuli plain





Bosco delle Sorti della Partecipanza di Trino Vercellese: "a raft floating on rice-paddies", an emblematic example of the state of isolation and insularity common to most woodland in the Po Plain

damage during storms, and cannot restore themselves naturally. Boundary situations, with minimum surface areas of 20 ha, are exemplified, for example, by the Bosco Grande in the province of Pavia (22 ha), where a violent storm in 1988 flattened most of the oldest trees and

completely changed the structure and overall dynamics of the wood.

In small woods, the effects of isolation are made worse by the so-called "margin effect", which extends for a distance of about 30 metres from the edge of the wood inwards. Thus, very small woods, like Tetti Girone (2.1 ha) and Carpenedo (2.5 ha) are more similar – at least from the microclimatic and thus ecological viewpoints – to "linear systems" (plantations or rows of trees) than large formations.

In all the oak/hornbeam woods of the Po Plain, even in the largest and best conserved, isolation thus imposes objective limitations to the management of fauna. None of these isolated woods is able to sustain large and medium-sized mammal populations without recourse to artificially and expensively controlled forms of forest management. This means that, even in the most extensive woods, large wild herbivores cannot survive. They damage vegetation and are

consequently eliminated: a typical example of this sad history is Stupinigi, where roebuck was exterminated in 1928 as a result of the considerable damage it caused to woodland vegetation. Similar problems now arise in the Parco della Mandria, due to the enormous increase in numbers of red and fallow deer which, in the last ten years, have exceeded tenfold the load compatible with environmental conditions. Today, their numbers have been reduced by culling from 1,300 to about 250, in accordance with the fauna re-equilibration plans of the park management authorities.

When ungulates are a familiar presence for the public, or represent an essential component, like the deer at Mandria, it would be suitable to consider keeping only sterilized specimens, or ones of only one sex, in order to control their numbers. This is what happens in the Bosco della Fontana, where only a few castrated or spayed specimens of boar now live. But boar are in fact extremely useful, since one of their main activities is to turn over the top layers of soil with their snouts, favouring the germination of acorns.

Lastly, it must be remembered that large mammals are subject to attack by ticks, disease-carrying parasites which live in tall, generally unmown grass, and which may attach themselves to humans, with all the negative implications which this may have for unwary visitors.

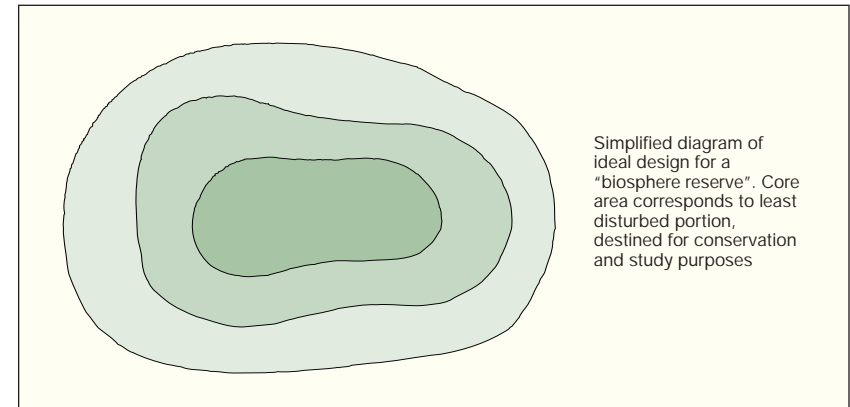
In plain woodland, it is definitely more realistic to flank the presence of “compatible” fauna with animals which are smaller and less obvious than deer and which do not raise any kind of management problem. Not only birds are involved here, but also insects, butterflies and beetles, orders particularly rich in species whose beauty can be appreciated also by the general public. Examples of this category are the large saproxylic (wood-eating) beetles associated with oak, like stag or long-horned beetles.

Under the conservative “umbrella” of birds, now fully part of naturalistic planning, invertebrates may finally benefit by the luxury of careful attention on the part of management, particularly as regards diversification of their habitats. But what practical and, above all, what realistically feasible solutions can reduce the effects of isolation?

Careful planning and in particular the creation of “biological corridors” is definitely one way of facing the problem rationally. However, already existing



Boar rooting about in undergrowth help to turn over top layers of soil and favour germination of acorns



infrastructures, growing urbanization or the lack of connectable forest habitats sometimes represent unsurmountable obstacles to such projects. Even if the problem of finding sufficient funds to purchase terrains were overcome, there remains that of planting new woods, either to be joined together or added to other natural, pre-existing units. This solution would be ideal, especially where the agrarian landscape is already suited to receive new mosaics of lines of trees, isolated specimens, or groups of large trees. Restoration of forest landscape must come to planners’ attention as one of the priority objectives of modern sustainable agriculture. The wood of Gerbasso (see drawing above) is an emblematic instance of reconstruction of a unit of plain woodland. It includes dead wood, which is generally neglected in such interventions.

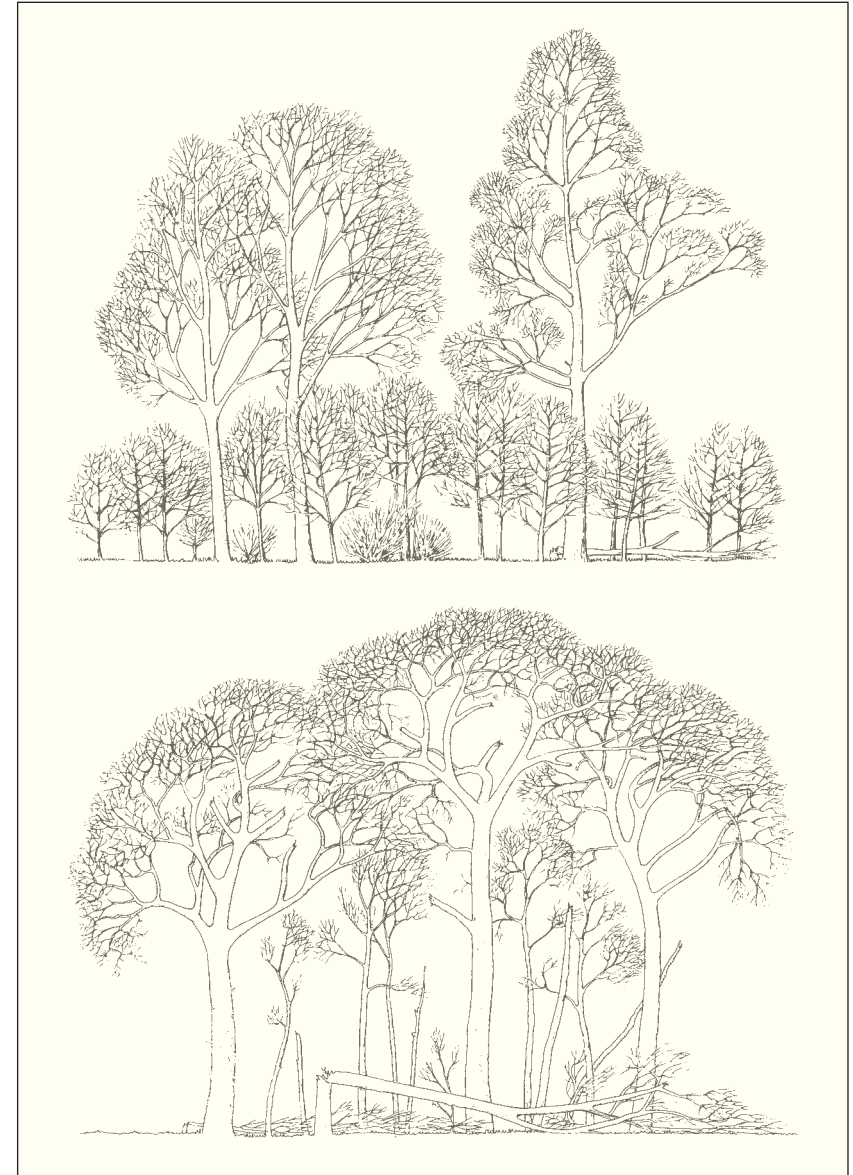
UNESCO proposes a “Biosphere Reserve”, the implementation of which would be particularly useful for the conservation of both small woods like Bosco Siro Negri, Olmé di Cessalto, Merlino and Tetti Girone, and medium-sized and large ones like Bosco della Fontana and Bosco delle Sorti della Partecipanza. On small surface areas, the creation of buffer zones would mainly attenuate the margin effect. On larger ones, it would diminish the anthropic impact affecting the natural, central part. This “core” would come to be identified as a sanctuary in which all man’s activities, except those connected with conservation and research, would be prohibited. Unfortunately, in real life, the natural and most sensitive part of Italian plain woodland is the only part available, and is thus increasingly sacrificed on the altar of tourism – a function which would certainly be better served by parks especially set up for the purpose. Proposals for reconverting into forest any highly profitable agricultural land surrounding plain woodland (which, even if offered for sale, is prohibitively expensive) - is a utopian dream, even more today than it was in the past.

■ Structural simplification

The structure of a forest is the expression of forestry techniques – that is, to use a forestry term, its type of management. Originally, all plain woods were composed of tall trees, variously stratified and regulated by complex dynamics. Today, in Europe, these are only found in a few forests considered natural, called *Urwald* by the Germans, *Prales* by the Czechs and Slovaks, and *Pra-gozd* by the Slovenes. These formations developed on several levels (for German forestry experts, *Stufen* = steps), filling the so-called “vertical biospace” with vegetal and animal life. At the current time, all the woods of the Po Plain, from Piedmont to Lombardy, Veneto and Friuli, have a “domesticated” structure - clearly the result of their centuries-old exploitation. Nearly all of them have been or are still cultivated, or “managed”, by coppicing with standards, a method based on the juxtaposition of cutting and high forest over the same area. That is, cutting exploits the capacity of the stumps of broad-leaved trees to produce new coppice-shoots. Once mature - generally after a period of 10-15 years, according to the dimensions of the assortment of timber available – the coppice-shoots are used to produce firewood or timber for poles and stakes. Above the coppiced level is high forest which, in coppicing with standards, is left uncut by multiples of coppicing time intervals. This is a system of intensive exploitation which has always been connected with a rural economy. Thus, over hundreds of years, coppicing with standards has produced a simplified forest structure.

Typically, there are two layers of arboreal vegetation which identify the profile of coppicing with standards (called *taillis sous futaie* by the French), and in this case the structure is biplane. Sometimes, the most exploited and degraded forms have only one layer, leading to the existence of a monoplane. But the history of the Po Plain woods has not always been associated exclusively with coppicing with standards. Rigorous control of high forest, certainly closer to natural conditions, was applied to the woods managed by the *Magistrato dell’Arsenale della Serenissima* (literally, the Arsenal Authorities of the Most Serene Republic of Venice), for which the conservation of tall-growing oak woods was absolutely essential in order to have a constant supply of high-quality timber for ship-building. Similar rigorous protection from 1700 onwards, with the decline of the Republic of Venice, resulted in the existence of only isolated vestiges of the original woodland in the low Veneto plain and Friuli. Instances, in the eastern Veneto plain, are the Bosco di Cessalto and, in Friuli, the large Bosco di Muzzana del Turgnano (province of Udine).

In his analysis of the forest situation in the low Friuli plain in the 1960s, the



Bosco della Fontana (Mantova). Above: biostatic phase in fragmentation, formed of hornbeam, under which an eco-unit of gean develops, in an advanced state of aggradation in typical lens-shaped form. Below: advanced biostatic eco-unit formed of aged coppiced wood – here, specimens of oak about 200 years old, with aged hornbeam shoots underneath. Decaying oak is essential for saproxylic invertebrates and for birds living and nesting in hollow trees



Boschi di Muzzana del Turgnano (Udine), May 2000. Classic example of coppicing with standards: tall forest (above) is formed of common oak; coppiced specimens are hornbeam. Stump of hornbeam (next page, left). Bundles and logs for use as firewood (next page, right) may be obtained from coppiced wood



botanist P. Paiero highlighted the transformation due to coppicing and the progressive simplification of forest structures. The 4,985 hectares with 80% of high forest existing in 1816 were reduced to only 786 ha (2% high forest and 98% coppiced) in 1962. To this was added the reduction of Bosco Baredi (Muzzana del Turgnano) and the almost complete destruction of Bosco Bando (near Muzzana and Carlino, Udine). In spite of this, the Boschi di Muzzana, overall, is still the largest wooded complex of the Friuli plain. Clearly, therefore, most of the plain woods have been or are still managed by coppicing, generally with standards, including the Bosco della Fontana in Lombardy, Stupinigi and Merlino in Piedmont, Olmé di Cessalto in Veneto, and Boschi di Muzzana in Friuli.

In a recent review on the Friuli woods, R. Del Favero notes that its oak/hornbeam association is structurally now highly varied, alternating monoplanes formed of originally agamic specimens and hornbeam exclusively, and biplanes where pedunculate oak is generated from seed. The two structures evidently correspond in the first case to simple coppicing and in the second to coppicing with standards. The latter is also the best suited to these two main species in the plain woods: hornbeam, which can tolerate shade for long periods, grows in the dominant plane, and pedunculate oak, which requires light in all phases of its development, grows in the higher plane. In the past, for instance in the Boschi di Muzzana, pedunculate oak was cut at intervals of about 60 years, whereas hornbeam was cut every 15 years. Every time cutting took place, the undergrowth received the light necessary for the regular development of pedunculate oak seedlings. In fact, in the past, renewal of pedunculate oak was probably facilitated by the release of a few "standards" (50-60 per hectare) from small-sized timber and foliage used as litter for livestock, with the overall results of providing "clean" undergrowth, well illuminated and thus receptive to germination and the initial phases of seedling life. If we returned to coppicing with standards today, the woodland would probably be treated in these traditional ways, with drastic cutting and frequent clearing.

100 When hornbeam and pedunculate oak are subjected to coppicing with standards, there is no possibility of compromise. As regards the efficiency of this technique - apart, obviously, from ecological aspects - there is no worse practice than prudent cutting, because diversified undergrowth is still allowed to grow. In such conditions, the woodland very rapidly disappears, killing even the most abundant seedlings of pedunculate oak after only three or four years, due to lack of light.

Some plain woods, not used for 50 years or so, are approaching structures similar to those of high forest, although the imprint of previous coppicing with standards is still clear. This is the typical situation of the Bosco della Fontana, which has hornbeam shoots about 50 years old (average diameter 30 cm, average height 23 m), topped by a dominating layer of pedunculate oak about 200 years old and 30 m tall. Quite well conserved and with specimens of pedunculate oak of respectable stature (25-30 m) are the forested areas in the hollows of terraces at Mandria and, locally, some more fertile parts of the Bosco di Stupinigi. Lastly, worthy of protection is the Bosco del Merlino, because its structure is quite well diversified, although changed by the presence of poplar plantations and quite small specimens of pedunculate oak (about 25 m).



Bosco del Merlino (Caramagna, Cuneo). Although small, this is one of the structurally best preserved oak/hornbeam woods

101 The "irregular" structures which are produced in the mid-term as a result of coppicing over the years are thus excellent premises for true passage to consolidated high forest. Sometimes, as at Stupinigi, the stand is lacking in its proper components and too many shrubs hinder development towards more mature forms. In addition, pedunculate oak suffers due to repeated defoliation by browntail moth, whereas hornbeam has completely disappeared and been replaced by red oak. In similar cases, even the floristic identity of the oak/hornbeam association has already been lost.

A unique case - and for this reason of great interest from the viewpoint of communal management of coppicing with standards in the plain - is that of the Bosco delle Sorti della Partecipanza. Still today, this wood, traditionally subjected to oak coppicing with standards, is managed according to an ancient custom, as in past centuries. Each year, a portion of the wood is chosen for coppicing and subdivided into a certain number of smaller portions, called "points", in turn subdivided into "quarters". Each point is assigned a number and, every year in November, the "participants" choose a number, at random. Thus, fate decides where the winner will have the right to coppice one or two quarters. This is why the wood is also called "*delle Sorti*" (= "dictated by fate"; in English, a "lucky dip" or even - these days! - a lottery).



Participants awaiting assignation of "quarters" in the Bosco delle Sorti della Partecipanza, in a photograph of the 1930s

The management authorities now aim at continuing the tradition of coppicing, ensuring the technical and scientific rigour necessary to preserve the wood from excessive exploitation.

Ecologically, coppicing produces open, sunny environments, i.e., positive as regards the conservation of certain fauna. Precisely because of the widespread and sudden abandon of coppicing, many butterfly populations are now in rapid decline. In particular, in Europe, blues are among the worst threatened by extinction due to the abandonment of coppicing, which previously had always kept at least part of the woodland open to light. The sketch on page 123 shows two of the possible operational solutions combining proper coppicing with protection of insects: optimal light conditions for fauna are ensured by the constant and regular presence of adjacent, open areas. In the case of the Bosco delle Sorti della Partecipanza, total, unexpected abandonment of coppicing, traditionally applied for centuries, would negatively affect invertebrate fauna.

From these simple examples, it is easy to appreciate the current deformities in forest structures and, clearly, for the plain woods of Friuli, the expert Del Favero is right when he states that “it is not easy to identify clearcut interest in oak/hornbeam woodland”. He adds: “... in some areas (for example, Boschi di Muzzana, Friuli), there is still the need to produce firewood for use by civilians, according to ancient tradition, whereas on other occasions tourism and leisure activities definitely take over. But in substance, a position of uncertainty prevails, often accompanied by little interest”.

■ The scarcity of timber

In forestry (the science which deals with productive planning of woodland), the term “growing stock” indicates the volume of timber (or the supply available) in a certain wood. This parameter is highly indicative, both for economic and productive calculations - timber represents the capital being exploited - and from the ecological viewpoint, since it is an indirect measure of the maturity and stability of a wood. Referring to a certain forest type, if the volume of timber is high, the wood is mature; vice versa, if it is low, the area has already been subjected to severe exploitation. In plain woodland, the “growing stock” per hectare varies considerably, and reveals the type of management applied: in coppicing with standards, e.g., Bosco delle Sorti della Partecipanza, the mean value is 100 m³/hectare. At Mandria, which reaches 220 m³/ha, and Bosco della Fontana, with 278 m³/ha (including branches up to 10 cm in diameter), the high values indicate quite mature woodland.

One of the most interesting aims at the present time, from the standpoints of production and natural history, is to bring plain woodland to volumes possibly exceeding 200-250 m³/ha, concentrating this mass especially on old specimens of pedunculate oak.

■ Deterioration of pedunculate oak

The core of the plain woodlands, pedunculate oak in Italian woods, when mature, is not particularly impressive: its foliage becomes scanty, dead branches increase in number, and leaves are small and chlorotic. Although these symptoms often indicate various “conventional” diseases caused by insects or fungi, they are all due to the weakening caused by repeated physiological stress: drought years, lowering of the watertable level, excessive amounts of stagnant waters, or the possible effects of pollutants. Recent studies have shown browning of the more external rings in tree-trunks, due to a whitish fungus identified as *Fusarium eumarti*, the hyphae of which penetrate the trachea, leaving toxic substances in them. In eastern Europe, this fungus is considered one of the prime causes of the deterioration of pedunculate oak.

For example, in the woods of Stupinigi, Trino and Aglié, pedunculate oak has undergone repeated defoliations by browntail moth since the mid-1950s; today, periodic pullulations of this moth have slackened off, to give way to



Stupinigi (Turin), March 2000. Simplified structure and woody growing stock (left), caused by excessive exploitation, produces stress, and exposes woodland to repeated attacks by defoliating insects (right: winter nests of *Euproctis chrysosorrhoea*)



One of the most frequent causes of decay of common oak, typically revealed as dry top branches, is water stagnating in soil, rotting roots

attack by geometrids, tendentially polyphagous beetles. The structural simplification typical of coppiced woodland clearly leaves pedunculate oak open to attack by defoliating insects. Symptomatically, at the end of the last century, when the Bosco della Fontana was intensively exploited, periodic defoliations were reported. The same wood, now ecologically more stable due to its structural maturity, no longer suffers from this type of problem, whereas the coppiced woods in the Po Plain still undergo regular infestations.

In the Bosco della Fontana, the outer smaller branches of pedunculate oak are killed by a buprestid beetle, *Coroebus florentinus*. Leaves turn yellow and chlorotic, probably due to acid deposits, a hypothesis supported by the fact that

the most significant species of epiphytic lichens are absent. In some areas, root asphyxiation is often caused by persisting stagnant water on the ground - fatal even for this water-loving species, which can only tolerate temporary surface water. This problem was already known to the administrative authorities of the Republic of Venice who, in 1704, required forest custodians to maintain "drainage ditches" around all areas of tall forest with marshy soils "in order to prevent the oak from rotting".

In the Bosco della Partecipanza, the network of drainage channels - still visible and in some cases still in working order - was hundreds of kilometres long and was used in the past to convey water from springs in the wood to the outside, for sale to the owners of nearby rice-paddies.

One of the most famous Italian forestry experts, A. Pavari, noted as long ago as 1955 (when damage due to acid rain was still unknown) that, in terrains with shallow watertables or ones which were frequently flooded, pedunculate oak begins to deteriorate at 100-120 years of age, the foliage gradually withering and many adventitious branches growing out of the trunk, so that the tree in all probability does not reach the age of 300 years.

Like all oaks, pedunculate oak is very long-lived. In Poland, for example, in the plain forest of Bialowieza, trunks reach diameters of 2.30 metres, and Germany has specimens one thousand years old.

In the Po Plain oak/hornbeam woodland of today, pedunculate oak does not exceed 150-200 years of age, simply because it is cut down before it reaches maturity. In other cases, as in the Bosco di Olmé di Cessalto, scanty



Bosco di Olmé di Cessalto (Treviso), May 2000. Common oak, having reached the biostatic phase, has serious problems in vegetating. Left: top foliage decays, and dense shoots branch out from lower part of trunk. Right: logs of common oak, stacked after widespread death of many specimens

watertable supplies are supplemented by increased surface water, but the death of pedunculate oak continues nevertheless, at very great speed, and even the most water-loving southern elm begins to show signs of distress. Clearly, although the practice of artificial flooding is definitely valid, in order to balance the general lowering of shallow watertables, it must be applied case by case and with great caution, precisely to prevent too much water from rotting the roots. Southern elm and black alder are similarly affected.

■ The problem of natural renewal of pedunculate oak

In the Po Plain woods, mature pedunculate oak suffers more or less everywhere, but the situation is not much better for seedlings, which are necessary to ensure the natural replacement of mature specimens. For example, at Stupinigi, renewal is well-known to be difficult, due to very strong competition by the dense grassy layer and the lack of reproducing adult specimens. In the Bosco della Partecipanza, seedlings are in competition with locust, which becomes an infesting species. Apart from these clearly recognizable anomalies, in other woods too, pedunculate oak seedlings develop poorly and saplings do not survive beyond their third year.

Apart from anomalies in terrain and competition from grassy species, the sole cause of deterioration is lack of light. In the Bosco della Fontana, surveys have ascertained that the optimal area for seedlings to develop is about 250-300 m² and that the best conditions for renewal are elliptical openings in the foliage running east-west. This is why, in the past, when pedunculate oak was heavily

exploited or coppiced with standards - both systems which produce large open clearings - the species had no difficulty in renewing itself. Symptomatically, pedunculate oak has always thrived in coppiced woodland with standards, when plenty of light can reach the soil, as occurs immediately after the felling of mature specimens of tall forest. But in old coppiced woods, no longer properly maintained, the wood is always "closed", which means that many seedlings die an early death.

Clearly, woods with transitional structures like old coppices with standards have not yet matured to their full identity: they are not sufficiently opened up to receive light, but neither have they been able to re-establish their natural dynamic cycles with the creation of natural and sufficiently large open clearings, allowing pedunculate oak to renew itself properly. This transitional situation should be carefully monitored and helped along by artificial intervention on a proper scale.

The main enemy of pedunculate oak renewal here is undoubtedly the lack of proper decision-making at the right time, combined with excessive prudence. On the contrary, "assisted development" towards tall forest should be adopted in good time. Alternatively, if socio-economic premises still exist locally to maintain coppicing with standards, cutting must be extremely drastic.

A case apart is that of many Piedmont woods in which opening up the tree cover would be counterproductive, as it would further favour the spread of



Bosco della Fontana in 1935. Coppicing with standards was carried out in its most classic form, trees being kept well spaced out, to allow renewal and development of common oak seedlings

locust which has replaced hornbeam more or less everywhere. In such cases, all the available reproducing specimens of pedunculate oak should be left standing, so that the wood can remain "closed" and locust regress on its own, due to lack of light.

■ Alien trees

Here, the term "alien" is not, of course, used in its science fiction sense, but includes all tree species extraneous to a certain forest formation. In the oak/hornbeam association, alien species include red oak from North America, very widespread in the Piedmont plain woods and in the Bosco della Fontana in Lombardy, but also Norway spruce and white pine, conifers inopportunistically introduced in the past. At least these species have the merit of being immediately identifiable and thus easy to eliminate.

One creeping menace is that of pedunculate oak genotypes coming from beyond the Alps or from elsewhere. True "Trojan horses", pedunculate oak acorns from all kinds of places have been propagated in nurseries, used in reforestation programs, and directly planted: documented examples include Austrian specimens introduced into the Bosco della Partecipanza, or Piedmont or Bergamasque specimens found in the Bosco della Fontana.

Research carried out by the Institute for Timber Trees and the Environment



Locust, one alien species which causes serious problems in most heavily exploited and open oak/hornbeam woods, remains confined to edges of wood if formation is kept closed, as at Bosco della Fontana

In 1987, the local authorities of Carmagnola (province of Turin), responding to appeals by naturalists and environmentalists from the local Museum of Natural History and the "Pro Natura" association, instituted the "*Bosco del Gerbasso*". The primary aim, clearly expressed both initially and later, was to recreate a plain oak/hornbeam wood, as complete as possible from the viewpoints of physiognomy and composition of vegetation and of the faunal communities of its various portions. The area chosen for this ambitious project, called Gerbasso, runs along the right bank of the Po, between the towns of Carmagnola and Carignano, both in the province of Turin. The land in question, of high agronomic quality and belonging to the town of Carmagnola, was only occupied at that time by infesting vegetation, as a result of the abandonment of, mainly, maize cultivation. Work began in November 1987 with the emplacement of the first tree species. In spring 2000, the true reforestation phase may be said to be almost complete, although plans to re-introduce target species will continue over the next few years. The Carmagnola Museum of Natural History played such an important role in promoting and implementing the project that in the early 1990s it was officially requested by the local planning authorities to direct all the phases of creating the wood, in order to provide proper technical and scientific support aiming at avoiding management errors and actions which were not in harmony with its ecological characteristics. Mistakes were made, of course, mainly in the initial and mid-phases of the project, like too few clearings, the planting of some

specimens of non-native species, and an excessive percentage of sycamore, but some of these errors have already been reversed and further improvements will be made in the future. The wood was reconstructed on the basis of historical records and personal knowledge of the tiny pieces of oak/hornbeam forest remaining in western Piedmont. First of all, for quality and extent, was the Bosco del Merlino, in the nearby territory of Caramagna Piemonte (province of Cuneo) and other very small woods like Tetti Girone (Vigone, Turin). These seriously threatened biotopes were absolutely essential for the direct reconstitution of some vegetational belts and communities of soil-living arthropods in the new wood. This phase was then followed by the transfer of grassy species, some tree species, and soil, humus and rotting wood from elsewhere to the re-created site. Considerable human resources and attention were devoted to implementing these phases, which also had as one of their aims the genetic conservation of indigenous Italian species. The oak/hornbeam part of the Bosco del Gerbasso, which covers a total surface area of 14.5 hectares, is bounded south and east by a long hedge composed of native shrubs, interrupted by many clearings of various shapes and sizes, which are kept mown. The northern side of the wood, on common land at the base of the terracing and subject to flooding by the Po, contains willow covering about 5 hectares, linking the oak/hornbeam woodland and the river bank. Here, pre-existing riverbank vegetation was reinforced with cuttings of common willow and other hygrophilous species, like common

alder, southern elm and white poplar. Until now, 37 plant species have been used in the Bosco del Gerbasso, of which 12 are trees, 8 shrubs, and 17 woodland grasses. In the next few years, work will be completed with the addition of some other species, like field elm, currently threatened by Dutch elm disease, bird-cherry, honeysuckle and rose, and a few other grasses, together with three orchids recorded in the Bosco del Merlino and belonging to the genera *Listera* and *Platanthera*. Apart from leaves, soil and tree-trunks in various stages of decay transported from nearby woodland, a good number of trunks, mainly coming from tree-lined avenues and public parks in the town, were laid down at various points in the Bosco del Gerbasso. In addition, bearing in mind maximum environmental diversification while respecting the original Po Plain woodland, several small ponds were dug

and made impermeable with clay. Various species of aquatic plants were then established in them, including water-lily, yellow iris, marsh trefoil, salvinia and bur-reed. Experimental research by the Museum, planned in collaboration with the University of Turin, records certain aspects of the evolution of the ecosystem, and has allowed birds and some other zoological groups to be studied, including terrestrial molluscs and wood-eating insects.



Bosco del Gerbasso (Turin). In artificial reconstruction of oak/hornbeam woodland, together with planting of trees and shrubs (above), dead tree-trunks were also introduced (below), to reconstitute fauna living in dead wood

110 and the Institute of Agrarian Genetics of the University of Turin has shown that most of the Piedmont woods have a substantially uniform genetic pattern. This uniformity could become a common practice and extended to all the Po Plain populations, but until ascertainments are completed it would be best, within the framework of naturalistic conservation, to maintain the genetic heritage of local populations intact, and to concentrate on proper management of single populations. All traces of this genetic pollution have been lost. In addition, extraneous specimens introduced decades ago into some plain woods are now mature and are probably already hybridizing with local populations. Pavari, indeed, observed that "the vast spread of pedunculate oak in such diverse climates explains why ecological or climatic race may be distinguished within the ambit of the species". In particular, he continued, a type or race (what we would perhaps call *ecotype*) of pedunculate oak typically grows leaves much later than ordinary oak. Called *chêne de juin* in French and *Späteiche* in German, it is reported in the southern part of its range from the Caucasus to Slavonia, to Germany and France. A singular case is that of the Parco di Racconigi oaks, for which a French provenance was originally hypothesized. Here, pedunculate oak specimens



Clearings allow light to penetrate, and play an important role in assisting fauna to survive

grow in diameter very fast, about one centimetre per year, and their leaves have biometric indexes which are different from those of other Po Plain populations. But historical records showed that they derive from "wild" specimens, growing spontaneously, recruited from the nearby natural woods along the Maira river, which were all cut down immediately after the Second World War. The rapid growth of the Racconigi specimens is therefore due to the exceptional fertility of the soil. In this site, which contains first-class soils, other broad-leaved species sometimes reach 50 metres in height, and pedunculate oak exceeds 35 metres. The myth of "rapidly growing species" has certainly contributed to the spread of alien species in the plain woods, partly due to the real need to reconstitute, in as short a time-span as possible, the many forests seriously impoverished during and after the Second World War. One of the species most frequently - and improperly - used to reconstitute plain woodland is red oak, now widespread in the Mandria, Stupinigi and Partecipanza woods, and eastwards as far as the Bosco della Fontana, where it is particularly aggressive. For those who are able to appreciate the landscape of plain woodland dominated by the heavy yet sinuous branches of pedunculate oak, the contrast of the bark of red oak, coldly grey and smooth,



Gaps ("*chablis*") represent very important microhabitats which must be conserved



Common oak along a road near Bosco del Merlino (Cuneo). Lines of trees along roads, mainly if composed of common oak, should be registered and rigorously protected

with its branches inserted at sharp angles in the trunks, is unpleasing to the eye. Unfortunately, the highly adaptable nature of this species - as regards both terrain (from mesoxerophilous to mesophilous) and availability of light (unlike pedunculate oak, red oak tolerates low light levels) - means that it grows so well in the plain environment that it poses a very serious threat to native populations.

Emblematic here are the reforestation operations carried out in the southern part of the Bosco della Fontana in the 1950s, both to repair damage caused by the hurricane of 1949, and to supply wood to the nearby city of Mantova, by means of large-scale felling of much timber. And yet, in less than 50 years, red oak has grown extensively, and average heights of 29 metres and diameters of 43 centimetres, respectively, have been measured. Red oak clearly finds here optimal pedological conditions - slightly less so at Stupinigi and Partecipanza where, although very widespread, it is less vigorous. In particular, at Stupinigi, unlike Bosco della Fontana, red oak shows only a limited capacity for renewal, mainly due to strong competition by the grassy layer. In northern Italy, red oak always prefers poorly illuminated environments. Open spaces of 100 m², totally insufficient for the renewal of pedunculate oak, suit red oak very well, and it spreads with devastating speed. Its extraneity to the oak/hornbeam association is also shown by the poverty of its entomological fauna: only three of the 27 species of buprestids normally found on native oaks live on red oak. Locust (*Robinia pseudoacacia*), an American species introduced into Italy by the Botanical Gardens of Padova in 1662, spreads because it is heliophilous (sun-loving), preferring open spaces in plain woodland, but it does not generally infiltrate woods where the trees grow very close together. An example is the Bosco della Fontana, which is dense and has thick undergrowth, where locust is confined to the perimeter. Vice versa, in heavily coppiced woodland, i.e., very open, like Partecipanza and Stupinigi, locust rapidly gains ground and becomes a forestry problem, which can only be solved by restoring the previously "closed" cover. In oak/hornbeam woodland in Lombardy, locust advances on a massive scale and predominates over large areas. However, it should be noted that its spread has been and still is encouraged by man, since locust wood makes excellent fuel.

Plane has been introduced everywhere, but is not a threat to oak/hornbeam, since it has neither the invasive capacity of red oak nor the agamic propagation of locust. At most, due to the contrast of its white bark, it is a further disturbing element in the oak/hornbeam landscape.

Euro-American poplar hybrids are unfortunately often planted, often in rows, in the ploughed areas of natural woods such as Stupinigi or Bosco del Merlino,

their artificial uniformity contrasting sharply with the complex landscape of the natural woodland. American poplar is not even suitable for introduction for productive purposes. Being highly phototropic (sensitive to the direction of the sun's rays), it grows contorted in the direction of light and is thus not of economic interest. The only species of poplar fitting the plain woodland is the white variety, which does not require any treatment and is therefore useful for conservation purposes. In fact, thanks to its very rapid growth and soft wood, it makes an excellent substrate for fast colonization by saproxylic organisms. In Mandria, white and Scotch pine have become naturalized by planting at the end of the 19th century, and now grow very vigorously on moorland and damp meadowland, sometimes reaching considerable diameters (about 80 cm). The Mandria management is planning to limit their expansion, but is not thinking of eliminating them in the short term, because they are used by several species of birds of prey. Black cherry, originally from North America and imported as food for game, is now a dominating species in the shrubby layer of the most degraded portions of the Cussago wood (Parco del Ticino, Milan) and also along the banks of the Ticino in Piedmont. It has also been reported recently in Mandria and Partecipanza, where plans for eliminating it involve girdling (artificial de-barking), dead specimens being left standing for saproxylic fauna, as for red oak in the Bosco della Fontana.

If we examine the distribution of exotics in the Po Plain, we really only find one area containing alien species: red oak generally grows in Piedmont as far as Lombardy, but is practically absent in the Veneto and Friuli oak/hornbeam woodland. Poplar currently covers large surface areas, emblematic cases occurring mainly in Piedmont and in the Bosco Panfilia in Emilia.

It so happens that the eastern woodlands of the Veneto and Friuli are practically impermeable to the entry of exotic species and to genetic pollution. This happy state of immunity is probably due to the centuries-old tradition of coppicing with standards, and its practitioners are fortunately not open to debatable innovations in forestry.

■ The disappearance of dead wood and old trees with rotting cavities

One side-effect of the centuries-long exploitation undergone by all the Po Plain woods is the disappearance of dead wood and senescent trees. Martin Speight, one of the most active supporters of conserving dead wood in Europe, lists 200 species typical of these habitats, especially beetles and dipterans. In Italy, as generally in all European forests, consideration and respect for dead wood habitats have reached a truly demoralizing level - to the



Microhabitats in old and dead trees. Left: gashes in trunk, allowing lymph to seep out. Right: fruiting bodies of wood fungi are tiny environments, now very rare yet absolutely essential for survival of many species of dipterans and other invertebrates

extent that the subject was covered by a specific although unheeded Recommendation (R(88) 10) made by the European Commission of Ministers. Conserving the dead wood in a forest is still viewed with diffidence by forestry managements, because it may lead to harmful infestations by fungi and insects. But dead and rotting wood *must* be safeguarded, both as a substrate for populations of rare organisms and to maintain the structure and fertility of the soil. It appears to be necessary to note here that the fauna inhabiting the dead wood of an ancient tree and that living in a young, vital tree are completely different! In the appalling cultural desert which exists on this topic, there is, however, something exceptional to report, and it closely concerns the plain woods. The guidebook to the Parco della Mandria contains a short but interesting note on dead wood and, indeed, in the same park, the oldest specimens of pedunculate oak have affixed to them a special notice stating that they are "*trees for biodiversity*". In the Bosco Siro Negri which, together with the Bosco della Fontana, is today one of the only remaining plain woods really containing dead wood, the ecological role played by dead tree-trunks for the benefit of greater spotted woodpecker and for spiders has been studied. Recent management plans for the Bosco della Partecipanza, and the Bosco della Fontana to an even greater extent, pay particular attention to the conservation of necrotic materials and old trees. On the other side of the Alps, in the Forêt de Romersberg (in the Lindre region, France), a constructive confrontation between naturalists and forestry experts gave rise to the preservation of "ageing islands" composed of oaks destined to remain for more than 360 years over 10% of the surface area of this forest, which is used



Urgent operations on relict habitats – Conservation and restoration of habitats for fauna living on dead wood and in old hollow trees

The LIFE Project, cofunded by the Italian Forestry Commission and the European Commission, began in October 1999, lasts for three years, and has as its aim the conservation and restoration of microhabitats in dead wood and old hollow trees, which have now entirely disappeared from the Bosco della Fontana as a result of felling and removal of all fallen timber. The management, since 1992 in the hands of the Italian Forestry Commission, has halted any further removal of dead material and protects still existing old trees, with the explicit aim of increasing the amount of dead wood. Accumulation of this type of wood was providentially favoured by the violent storm of June 1993 which, far from being considered harmful, caused a healthy increase in the volume of dead material for use by saproxylic fauna, raising it from zero to 26.3 m³/ha. However, dead wood is not uniformly distributed throughout the area. The most advanced stages of decay are missing and, even more importantly, so are the rarest and most severely threatened of the saproxylic fauna which habitually live in old hollow trees. Management plans anticipate that the overall volume of dead wood, either already lying on the ground or on still standing but senescent trees, will stabilize at more than 33-35 m³/ha. To restore the presence of dead wood as it normally occurs in a natural situation, it is even being created artificially, by uprooting, girdling, and precocious ageing of tree-trunks. A new technique in the European field is the use of explosives to produce large pieces of

trunk still standing (called *snags* in English, or *chandelles* in French). Target trees are red oak and plane, extremely invasive alien species introduced in the 1950s with the aim - perhaps praiseworthy for those times, but later revealed to be very harmful - of quickly filling the gaps in woodland caused by destruction during the Second World War. The planes, until now biologically sterile, will supply 1,450 extremely useful "habitat-trees", or 8 habitat-trees per hectare, a density which will become stable in twenty years' time. The qualitative and quantitative variations in the fauna of saproxylic insects are continually monitored using special traps. In particular, the efficiency of forestry operations as regards the presence of birds, e.g., woodpeckers, is constantly assessed, together with that of wood-eating invertebrates in hollow trunks. The artificial holes made in tree-trunks turned out to be about 40% occupied only three months after they had been drilled, clearly showing how rare and sought-after such habitats are.

The timings and costs of forestry operations have been quantified, and safety procedures for this type of work have been formulated. The resulting data will be indispensable if this idea is extended to other woodland areas, perhaps where trees are grown for timber. Various initiatives have been implemented involving both forestry management authorities and universities offering courses in environmental sciences, whose students will be the future managers of woodland. For school groups in particular, a hide for watching woodpeckers by closed-circuit television has been set up, and a special itinerary may be followed in the wood.



Ageing operations on species extraneous to oak/hornbeam association
Plane used as a habitat-tree.

Above: special slits cut in low part of trunk favour stagnation of water and colonization by invertebrate fauna.

Right: hole drilled in same trunk, at a height of about 3 m, to encourage appropriate birds to nest.

Below, left: specimen of red oak, girdled to provide standing dead wood for use by saproxylic fauna.

Below, right: window flight trap used to sample wood-eating insects.



to produce timber. A definite innovation for Italian forestry is the new Regulation issued by the autonomous province of Bolzano/South Tyrol, in force since September 27 2000 (DPGP 31.07.2000). It is special for its clearly defined provision under "General forestry principles" (Art. 13/j). This states: "standing or fallen necrotic masses, including hollow trees and tree-trunks, shall carefully be left *in situ* in the wood in proper quantities and distributions ...". A special project was started in 1999 in the Bosco della Fontana, cofunded by the European Union and the Italian Forestry Commission. This project (see preceding pages) aims at carrying out innovative artificial operations to conserve and restore dead wood habitats and to encourage their peculiar invertebrate fauna. In most woodland, however, dead trees are still systematically removed, mainly only for use as firewood.

There are definite and clearcut ecological reasons why old trees should be allowed to fall to the ground, by artificially uprooting them and not simply by cutting them down. Uprooting restores the natural remixing of soil layers. The roots also raise a mound of generally dry soil, and leave a pit underneath, which is very soon filled with debris of various kinds, and becomes damp as a consequence. A tree-trunk already lying on the ground, destined to decompose gradually, and slightly raised at one end by its remaining branches, favours the growth of seedlings of other forest trees, which benefit by being able to have sufficient air and space. The branches and foliage of the old tree cover a damper and cooler surface area, complementary to the more open, better illuminated, and thus drier gaps.

In Italian plain woods, for some decades now, dead wood has been accumulating not so much because of declared conservation or naturalistic interests, as for the lack of any economic interest. One occasion for restoring dead wood in plain woodland, missed in the 1970s, was certainly the large-scale death of elms due to Dutch elm disease, transmitted by bark beetles. However, it is only within the last few years that the question of conserving dead wood can be proposed without scandalizing forestry management authorities who, traditionally static and reactionary in their views, never raised the subject (and perhaps do not even now raise it), treating it as taboo.

Dead wood has various biological functions according to its size, position, and rate of decomposition. Rotting cavities in old trees are habitats of the rarest and most highly specialized fauna, e.g., hoverflies, because - unlike a dead trunk which, turning into humus, exhausts its function as a habitat in 10-20 years, according to the species which live in and on it - an old but still living tree continues to "produce" dead wood for far longer periods of time. Disappearing relatively fast, a dead trunk does not offer a stable, long-lasting



Dead trunk of common oak. Masses of dead materials are essential for conservation of biodiversity

habitat for saproxylic organisms. Still upright dead trees are also important - besides being useful for many species of birds which nest in them or take refuge in their holes (e.g., tits, woodpeckers, owls).

But Europe does still have forests containing dead wood, which forestry experts call Coarse Woody Debris (CWD). For example, in the Polish forest of Bialowieza, the volume of CWD reaches 75 m³/ha in the most natural areas. This figure is far higher than that of the Po Plain woods, even in those where conservation has been practised for some time.

Old hollow trees or snags act as habitat-trees and are absolutely essential for many species of arthropods and vertebrates. The number of habitat-

trees defines the quality of the site in terms of biodiversity: 5 habitat-trees per hectare indicates a forest of good quality, 3 is just moderate, and only one tree reveals poor quality, although the optimal number varies according to the type and structure of the area.

The first and obvious measure for proper management of dead material is not to remove it, but simply to leave it where it is. Many plain woods are often infested by alien species which may be precociously aged to produce hollow trees and nutritious substrates. Measures of this kind are especially suitable for protected areas, but may also be introduced into plantations of trees grown for timber, under ordinary management, where saproxylic fauna can be helped to survive simply by leaving old or deformed trees and respecting snags and dead trunks.

In M. Speight's definition, saproxylic organisms are "species of invertebrates that are dependent, during some part of their life-cycle, upon dead or dying wood of moribund or dead trees (standing or fallen), upon wood-inhabiting fungi, or upon the presence of other saproxylics." (Martin C.D. Speight, 1988, *Saproxylic invertebrates and their conservation*. Council of Europe, Strasbourg, p. 65). Saproxylic organisms are generally not very mobile, so that a constant supply of dead wood throughout their habitat is essential. A. Stubbs



Boschi di Muzzana del Turignano (Udine), May 2000. Old stumps must be rigorously protected, since they represent microhabitats necessary for larvae of *Criorhina*, a genus grouping many rare and showy species of hoverflies

lists some simple recommendations for management, in particular:

- a. recruit dead wood from a wide range of species, granting priority where possible to local indigenous species;
- b. maintain the maximum variety of qualitative situations in dead wood: wood rotting on still upright trees, dead trees or snags, ones lying on the ground or ones which have fallen slantways and are partially supported by others, especially those with large trunks. Their degree of humidity varies greatly according to their position, and thus the organisms which live on them vary according to their ecological requirements;
- c. keeping on a certain amount of small-sized CWD is a useful habit, although the largest trunks are ecologically the best; avoid cutting a

large dead trunk into several pieces;

- d. allow trees to age and thus create specific niches (cavities, gashes allowing lymph to seep out, etc.), since they are necessary for the most demanding and rarest species of wood-eating organisms;
- e. the tips of branches which fall off naturally and irregularly are preferable to sawn-off ones;
- f. respect dead trees which are sloping or leaning on other trees;
- g. ensure that trunks left to increase the mass of dead material artificially fall in shaded areas. Exposure to sunlight and climatic extremes must be avoided. Some sunlight is acceptable at the edges of the wood and along forest lanes, where dry trees exposed to the sun with beetle holes are occupied by the nests of solitary wasps;
- h. flowers blooming near dead trees supply nectar and pollen for the adult stages of many saproxylic insects, so ensure that they are regularly distributed by checking that the area has the necessary gaps;
- i. leave as they are trees with lymph seeping from their trunks, since they host increasingly rare insects such as hoverflies (genus *Ferdinandea*);
- j. keep decaying trees, although check that they do not represent an

unacceptable risk for the public, by cutting down if necessary specimens along roads or frequented spots;

- k. if fallen wood has to be moved from its original site, move it immediately and in any case before saproxylic organisms begin to colonize it, otherwise their populations will be wasted in vain.

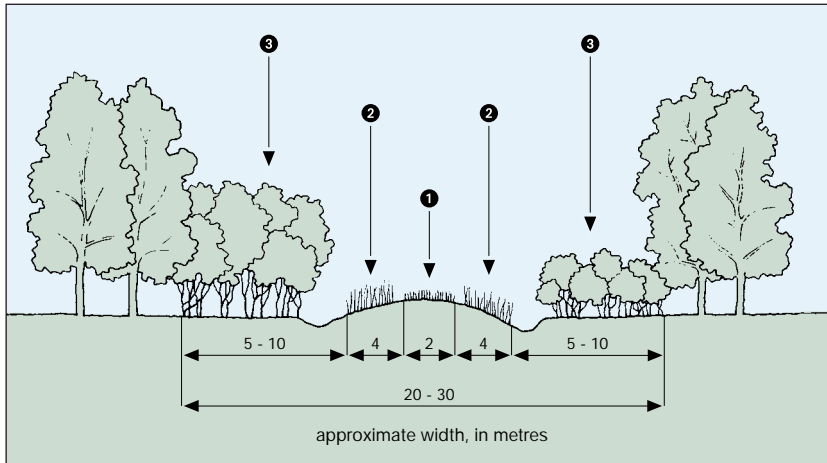
This section concludes with a quotation from a work by the great English novelist, Anthony Trollope. The following passage, taken from *The Warden*, published in 1855, is peculiarly appropriate here: "... though some fungi now disfigure the tree, though there be much dead wood, for how much good fruit have not we to be thankful? Who, without remorse, can batter down the dead branches of an old oak, now useless, but, ah! still so beautiful, or drag out the fragments of the ancient forest, without feeling that they sheltered the younger plants, to which they are now summoned to give way ...?" Apt words, indeed!

■ Management of vegetation along forest roads and paths

Plain woods of some size nearly always contain a network of roads or tracks, also called "rides", allowing access to those authorized to enter and use the



A ride in Bosco Baredi (Friuli): excessively shady, closed paths do not encourage fauna



"Sensitive" management of forest rides and tracks according to Warren and Fuller's "three-zone coppicing" system

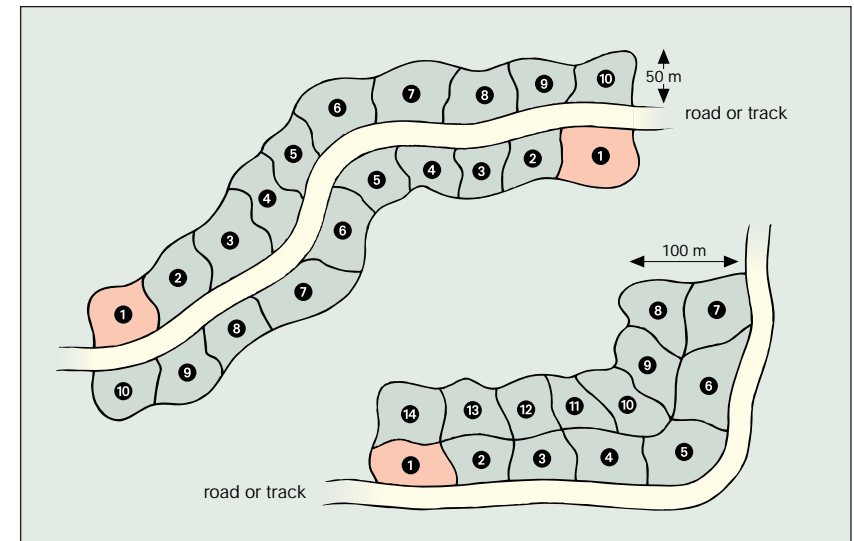
area. For example, in the Bosco della Fontana, paths radiate outwards from a series of seven "squares", subdividing the wood into forty visible portions, originally created to facilitate hunting. This star-shaped arrangement was created by the Austrians in 1758, but it is also frequently found in many forests in central and northern Europe. Tracks are commonly used to cart timber from the wood, as in the Bosco delle Sorti della Partecipanza or in most of the eastern Veneto plain woods. In all cases, if managed as "linear systems", these tracks break up the forest cover and have important faunistic implications.

The existence of a high number of animal and plant species in woodland is influenced by the presence of open spaces without trees. There are always more species and more specimens in areas where sunlight penetrates than there are in shadier ones. The edges of tracks, devoid of vegetation, are favourite places for reptiles, which warm themselves in the early morning sun. In the case of birds, chiff-chaffs and nightingales like wide tracks with shrubby borders; sparrowhawks hunt small birds along forest tracks, and green woodpeckers are attracted by clearings and woodland roads, where they find the ants they usually feed on. Both rides and clearings are also excellent habitats for small mammals, which are preyed upon by nocturnal raptors such as owl, little owl and tawny owl, and bats. For birds, the best conditions are shrubby margins at least 5 metres wide - even better if the shrubs are 8-10 years old. Gaps are also essential for the adult stages of many dipterans, which warm themselves on leaves and tree-trunks and feed on the pollen of flowers in sunny clearings,

where hoverflies, like tiny helicopters, and bombyliids, whose flight is similar to that of humming-birds, may frequently be seen.

M.S. Warren and R.J. Fuller supply several simple but effective models for increasing light in woodland environments, sacrificing the minimum number of trees and consequently also saving labour.

Proper management techniques of linear systems are based on two variables: the width and structure of the vegetation. The shadiness of a forest track is determined by its width, orientation with respect to the sun, and the height of the surrounding trees. In other words, the wider the road and the lower the surrounding trees, the sunnier the track will be. The moment when solar radiation should be measured is during the vegetative season, which in the northern hemisphere is between the spring equinox (March 21) and the autumn equinox (September 23). In summer months, tracks running east-west receive more sunlight than those running north-south. Many species of insects, especially butterflies, frequent only sunny areas with direct shade of less than 20%, although not all are so demanding: some species prefer partially or heavily shaded tracks, so that suitable variations in the light conditions of the wood must be planned. In general, to satisfy the light requirements of fauna, the width of any gap must be about 1.5 times the average height of the trees at its borders. This means that, in mature woodland with trees 20-30 metres high, the



Forest management with medium-term rotation of coppicing, useful for insects, above all butterflies. Clearings are constantly kept open on adjacent surface areas



Above: open rides allow growth of flower species necessary as food for adults of many insects. Below: closed, poorly lit rides do not encourage fauna

optimal width, measured from the base of mature trees on both sides, must be at least 30-45 metres. The structure of the vegetation may be diversified by subdividing the edge into several belts and applying different forestry procedures to each of them. The conservation of mature or senescent trees along linear systems and the accumulation of dead trunks at the shaded edges is an additional measure to be applied when management aims at conserving saproxylic fauna (as in the Bosco della Fontana). In this way, the lives of larval stages associated with dead wood, and adult stages which need nearby flowers to feed on, are both ensured.

Proper faunal conservation also involves deciding carefully when and how grassy portions are to be cut, although problems may arise in areas frequented by the public, owing to the presence of ticks, which prefer tall, unmown grass. "Sensitive" solutions to the question of conserving invertebrate fauna also include operations limited to small areas in rotation, which allows differentiated growth of grass and abundant summer flowers. Another type of ride management is the "three-zone system with coppicing" of Warren

and Fuller (see drawing on page 122), in which changing light and vegetation further enhance the potential of the ecotone.

Zone 1: the central strip of the track is mown once or twice a year, and is bordered on both sides by a belt of high grass. *Zone 2:* tall grass, small portions of which may be mown, for example, on a three-year rotational basis on opposite sides of the track, is in turn mown in the other years, so that every year only one-third or one-quarter of the border is cut. A simpler system is

alternate mowing of first one side of the track and then the other, every one or two years. Although this method favours many invertebrate species, it may harm insects which prefer high vegetation which has become established over longer periods of time. *Zone 3:* a belt of coppiced shrubs, cut on a rotational basis every 10-20 years.

In straight, wide tracks, wind may give rise to channelling (the so-called "canyon effect"), with high wind speeds and less shelter offered by vegetation, mainly affecting insects. In this case, the simplest solution is to create a series of gentle bends in the vegetation, which also have the positive effect of increasing the quantity of light. Sheltered portions may be made in an undulating pattern, leaving a few trees in good order, with irregularly shaped rather than uniform margins. Similar models may be created starting from the



Tiny patches of sunlight on water allow many species of dipterans (e.g., hoverflies) to sip. Simple barriers made of one or two logs allow water to flow well inside woodland

small clearings at crossroads, with intersecting gaps in the vegetation. For true benefit to fauna, these openings must cover at least 0.25 hectares, preferably 0.5-2 ha.

■ Water and drainage ditches in plain woods

Many plain woods are criss-crossed by a dense network of ditches, originally dug to convey water out of the wood and to prevent the roots of trees, particularly pedunculate oak, from rotting. The Bosco delle Sorti della Partecipanza has a network hundreds of kilometres long, through which some of the spring water was sold to the owners of adjacent rice-paddies. Today, these ditches should be used for the opposite purpose - to convey water back inside the wood. The flowers which are abundant along the edges of streams, especially in sunnier spots, supply pollen, which is indispensable to many groups of insects. Reptiles and amphibians are common in such places: the Italian agile frog, or Lataste's frog, a typical plain species, is food for the ringed snake and is occasionally preyed upon by black kite. The cool waters of streams in plain woods, lit by glancing rays of sunlight as it penetrates the foliage, are the favourite drinking-places of a large number of hoverflies.

Streams inside woods also act as constant and efficient natural water-purifying systems, reducing the concentrations of nitrogen and phosphorus, which are fixed by vegetation.

Specific research has shown that the flow of water in a wooded belt 30 metres wide is sufficient to remove most dissolved nitrates and phosphates.

The riverbank environment offers considerable opportunities as a “working area” for environmental training, particularly as regards itineraries which can be used for bird-watching or for teaching purposes. Carefully planned management of ditchwater is also essential for pedunculate oak, provided that the water does not stagnate and rot the roots which, as already noted, is one of the main causes of rapid decay in this species. In the Bosco della Fontana, ditchwater flow is regulated by simple barriers made on the spot using tree-trunks.

■ How oak-hornbeam woodland is perpetuated

If we consider *yin* and *yang*, concepts fundamental to ancient Chinese philosophy, we see how, when one of two forces reaches its peak, it already contains within itself the seed of its opposite force. The similarity between *yin-yang* and the natural cycle of a forest is clear. In his fundamental treatise on forestry, R.A.A. Oldeman analyses and classifies woodland cycles and dynamics. In his view, the “mosaic” of a wood reaches equilibrium when the eco-units of which it is composed have stabilized with respect to the local regime of changing events.

In very simple terms, for each eco-unit which terminates its existence, another is created, similar to that of the initial state. This mosaic may be likened to the image produced by a kaleidoscope - once a favourite toy for children in days gone by, and now probably replaced by images on TV or computer screens. But what happens when you rotate a kaleidoscope, what force causes the mosaic of a wood to change?

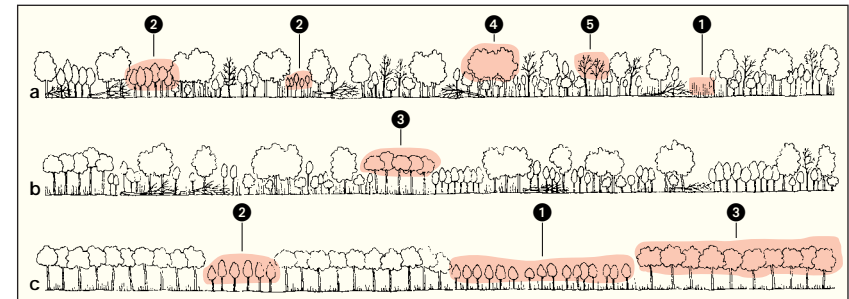
As we have seen, in plain woodland, changes are driven by wind, which produces shapes only really definable by two French words used in forestry:

- *chablis*: the uprooting of a tree; the uprooted tree itself; the heap of uprooted vegetation including the branches; and the resulting gap in the forest cover;
- *volis*: the breaking of a tree-trunk (caused, for instance, by a gust of wind); the highest part of a broken, fallen tree; and the mass of vegetation and branches (particularly snags, i.e., the broken-off part still standing).

In small eco-units, grasses and lianas grow in abundance: in France, one of these lianas was probably a variety of *Vitis vinifera* which today produces a special wine called *chablis* - whence the forestry term currently used.

The coloured glass fragments inside a kaleidoscope, or the eco-units which dynamically make up the mosaic of a wood, are classified into four phases.

The phase of *innovation* starts after mature trees are uprooted by wind. All



genetic information from their “seed banks” (vegetative parts, the seeds themselves, etc.) are mobilized, and the vegetation is immediately dominated by climbing grasses, roots, seedlings of forest tree species, and surviving trees.

The structure of this new eco-unit does not last long, since the only parts of it destined to play a role in the future are the seedlings of forest species.

The innovation phase is extremely rapid, although brambles may persist for a long time, preventing the development of seedlings for decades and thus forming eco-units of the pre-innovation phase.

The new eco-unit is followed by *aggradation*, which begins when portions of foliage start to grow densely together. Pedunculate oak in the Po Plain woods completes this phase in about 10-15 years.

Aggradation evolves into the *biostatic* or mature *phase* (in German, *Baumphase*, or tree phase), in which the eco-unit has its own organization and a lasting structure and, except for accidents, is very long-lived. The trees are no longer “future”, as before; they are now “present”.

Degradation (*Zerfallsphase* in German) occurs when the biostatic phase collapses, and corresponds to senescence. This phase opens up space to one or more young, new eco-units, completing the cycle.

Now, the “past” trees fall, multitudes of demolishing organisms flock to the dead wood, and epiphytes grow rapidly, thanks to the greater quantity of sunlight reaching the soil through the rotting crowns of the trees.

Eco-units, forest mosaics, and changing events.

The natural death of trees due to relatively modest external events, like small but violent storms, generates a mosaic of many small eco-units of all ages, and creates a natural situation (a) which is in fact very rare.

Situation (b) is closer to the reality of plain woods, where ordinary perturbations are added to large-scale events like very violent storms, giving rise to numerous eco-units of various size, structure, age and composition. A preponderance of high-energy events produces a series of a few, large, rapidly growing eco-units of various ages (c). This is the situation typical of extreme climates, or after forest fires or volcanic eruptions.

The diagram shows three types of wood mosaic: eco-unit 1, renewal; 2, aggradation; 3, initial biostatic phase; 4, biostatic phase; 5, decay



Areas where spring watercourses arise are common in the Po Plain

■ The importance of “open” and “closed” woodland

Forestry management generally tends to saturate all free space in woodland with trees. But fauna and the very dynamics of the forest itself require open spaces. The wind, the natural force for change in eco-units, produces a whole series of small gaps, the *chablis*, formed in plain woods of sets of three or four mature trees. This typical set of tiny eco-units is also called “small-gap dynamics”. The size of these gaps, distributed in a kaleidoscopic fashion, coincides with the light requirements of new pedunculate oak and stabilizes around a constant value when equilibrium is reached.

The hurricane which struck France on December 26, 27 and 28 1999 created *chablis* over large forested areas. It was described in dramatic terms by the media and presented as an ecological disaster, although in fact it was one of the long-term cyclic processes which are inherent in the natural dynamics of temperate forest. In “ordinary” dynamics, small gaps may thus trigger off exceptional events characterized by longer-term periodicity.

Examples of such exceptional events are also known in the Po Plain. One instance occurred on July 18 1949, when a hurricane flattened most of the southern portion of the Bosco della Fontana. In Minimum Dynamic Areas (MDAs), even the most catastrophic events always spare groups of trees or single specimens, from which new eco-units arise. The true damage is in fact caused by man, who may mistakenly replant the area with alien species which, perhaps for decades, prevent natural eco-units from re-establishing themselves; man also, equally mistakenly, removes dead wood. In the long term, apparently catastrophic events are in fact absolutely natural - although, as we have seen, they may totally obliterate small or very small isolated woods.

In these circumstances, the destructive power of wind is often completed by man, and the wood obliterated and replaced by cultivated fields - the centuries-old enemy of plain forests.

■ Open and closed areas in woodland: the percentage of gaps

Studying the silvigenetic phases of a natural forest, E.F. Torquebiau formulated a mathematical equation to calculate the percentage of *chablis* (gaps) with respect to closed, *non-chablis* areas. Applying this probabilistic method to plain woodland provides management with interesting and useful indications, since events due to natural causes (e.g., wind), which are probabilistic in nature, may be integrated with the succession of eco-units, which is

deterministic in type. If we have a set of time-series data for *chablis* and *non-chablis* areas, taken for instance from interpretation of aerial photographs, and insert them in a "transition matrix", we can calculate the approximate percentage of stable gaps. Extending these calculations (worked out, for example, for the Bosco della Fontana) to those plain woods which have reached equilibrium, the gaps should stabilize at around 30%. Distributed equally over gaps each covering 250-300 m², the light requirements of pedunculate oak seedlings are perfectly satisfied, and fauna is also favoured. In order to predict when the set percentage of *chablis* is reached, it is sometimes necessary to accelerate the natural growth of seedlings by producing them artificially. One economic method, also applicable to plain

Bosco della Fontana (Mantova) temporary artificial flooding (waterlogging) and consequent stagnation of water in woodland is a simple, economic method of diversifying habitats.
Hornbeam dies (below: dead but still upright trunks), whereas southern elm is favoured.

Above: temporary flooding encourages renewal of common oak and southern elm. This technique has been successfully applied in Bosco della Fontana since 1992



woods, is flooding. Water stagnating on the forest floor means that the trees are more vulnerable to uprooting, and species which cannot tolerate too much water for too long are eliminated. Controlled waterlogging, successfully tested in the Bosco della Fontana, thus becomes a cheap and easy method of re-equilibrating the tree cover and producing new gaps. For instance, if hornbeam happens to be in a stage of excessive expansion, periodic flooding of certain portions of the wood will kill it off in the course of a single summer, benefiting hygrophilous species like pedunculate oak, southern elm and black alder. But such operations must be carried out with great care, since pedunculate oak, although hydrophilous, cannot tolerate waterlogged ground for long. Both southern elm and black alder vegetate quickly even in well-watered soil, but neither can stand permanently waterlogged terrain.

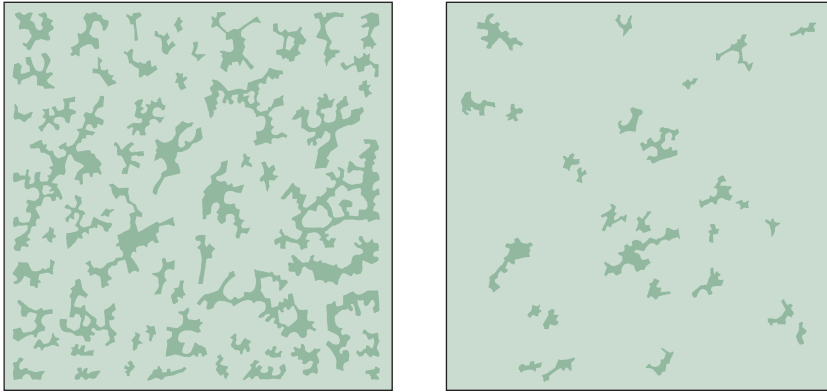
As regards grasses, water produces rapid changes: dense clumps of butcher's-broom are rapidly replaced by colonies of common reed, the seeds of which are conveyed by ditchwater.

The final aim of management in plain woods is the passage of a forest mosaic from a state of pre-equilibrium to one of "*eculibrium*" (a term coined by Oldeman, deriving from the first part of the word *eco-unit*). Having reached this state, for each *eco-unit* which evolves, from innovation to aggradation, biostatic phase and degradation, a second *eco-unit* enters another portion of the wood, in the "initial" innovation phase. The maintenance of this state of *eculibrium* thus presumes the occurrence of small-scale but violent storms. In plain woodland, there are at least one or more such events in the course of a decade, opening up gaps at random here and there and ensuring the continued existence of proper forest dynamics.

■ Structural play in oak/hornbeam *eco-units*

In coppiced woods left to age - for instance, in the Bosco della Fontana - an interesting and clearcut mechanism of competition arises. Specimens of hornbeam left to evolve, i.e., no longer coppiced, are so invasive that they compete with and supplant pedunculate oak for light. This struggle, the outcome of which is a foregone conclusion, is due to different growth strategies on the part of the two tree structures, or their "architecture", as it is sometimes called: pedunculate oak follows Troll's model, and hornbeam that of Rauh.

How do these structural models act? Rauh's model is based on the development of branches at right angles to the soil, so that, for every metre of lateral growth of a branch, pedunculate oak must produce a total of about 2



Size of gaps (dark green) in tree cover (pale green) caused by ordinary perturbations in a plain oak/hornbeam wood (Bosco della Fontana, Mantova). Left: opened-up area with large gaps, and (right) closed area in biostatic phase. In both cases, dynamics are based on "small eco-units" corresponding to surface covered by three or four mature trees

metres of axes, half of which is "wasted" in vertical growth. More economically, hornbeam branches only grow parallel to the soil, along plagiotropic axes, the apexes of which easily stretch out in all directions according to the stimulus of light.

This means that, in order to grow laterally by 1 metre, hornbeam only builds up 1 m of plagiotropic axes, and it is therefore far more efficient than pedunculate oak in terms of energy savings. In addition, hornbeam tolerates shade well, emitting long branches from the first part of its trunk and thus exploiting light filtering to lower levels. Instead, pedunculate oak grows very slowly and does not tolerate shade.

Precisely thanks to its adaptability, when hornbeam enters into direct competition with common oak, its branches insinuate themselves in the foliage of common oak and gain possession even of the smallest ray of sunlight. And as soon as it reaches and overtakes the foliage of common oak, hornbeam spreads its branches over it. Pedunculate oak then attempts to avoid the resulting shade and "escapes" by growing branches on the opposite side. In the meantime, its lower branches die, due to lack of light. If the expansion of hornbeam continues, the foliage of common oak becomes increasingly asymmetric, and the tree is weakened to the point of dying. This play of "architecture" is thus an exclusive property of eco-units with hornbeam and common oak, but not of the two species considered singly.

Oak/hornbeam associations deriving from the natural development of proper coppicing are all, more or less, subject to this type of negative evolution at the



Effects of wind: in perimetral areas (a) of oak/hornbeam woodland, concentration of dead wood may be high, locally 100 m³/ha. Drawing (a) shows gaps caused by hurricane of June 1993 in north-western part of Bosco della Fontana. In biostatic phases (b), there are fewer dead materials and they are smaller in size

expense of the former species, and their eco-units steadily decay and become fragmented - a long but unavoidable process. In the end, clearly, hornbeam prevails, first forming aggrading and then biostatic eco-units which, with their heavy shade, prevent the renewal of pedunculate oak.

Lastly, in oak/hornbeam associations, thanks to its tolerance of shade, hornbeam can germinate and grow abundantly even under a dense tree cover, and thus give rise to the so-called "early innovation".

Myriads of tiny, apparently weak, hornbeam seedlings are in fact ready to leave this latent phase, which may last for decades, as soon as a gap opens in the tree cover. This type of renewal, exclusive to and typical of tolerant species, generally develops irregularly, following an opportunistic pattern. In practice, hornbeam seeds continually rain down over the whole forest. Some germinate and develop in very small, temporary gaps, as long as there is sufficient light; they then stop growing when the gap closes. In the lower layers there is thus a constant, complex alternation of growth and latency which makes hornbeam the dominant species in the oak/hornbeam association.

The future of a forest mosaic, characterized by this imbalance in favour of hornbeam, may seem doomed. In this sense, the hypothetical configuration of the Bosco della Fontana in fifty years' time, if man does not intervene, is a tall, shady, sterile hornbeam forest, which would make it look very similar to a beech wood of the same age. One urgent corrective action on aged oak/hornbeam woodland is thus the creation of artificial gaps around mature specimens of common oak still able to produce seeds.

Such action should preferably be carried out in “fat” years, when common oak seed production is high. The optimal size of gaps sufficient to ensure development is, as already mentioned, around 250-300 m². Larger openings “continentalize” the microclimate, exposing new common oak to the risk of damage due to late frosts, whereas smaller ones rapidly close up, sometimes even before common oak seedlings have had time to reach dominant layers.

The average lateral growth of hornbeam is 8-10 cm/year, and the average vertical growth of common oak until aggradation is about 20 cm/year. Thus, at least approximately, we can calculate the size of gaps necessary for oak to reach the light.

Directed or targeted action in plain woods subjected to coppicing in the past is, clearly, absolutely necessary - precisely because, at the present time, none of these formations even approaches a state of equilibrium and none is able to self-regulate its alternating silvigenetic cycles.

Obviously, in the long term, natural management following ordinary forest processes as closely as possible is the best course to pursue.

In this sense, although they did not know it, the dynamics of plain woods had already been recognized centuries ago by the “inventors” of coppicing with standards - not by chance the common denominator of the Po Plain woods. The woodsmen of the past already knew, albeit empirically, that common oak requires light in order to grow, that it grows healthily to maturity in the dominant plane, and that hornbeam develops equally well in the shadow of the reassuring and robust foliage of common oak.

Proof of this ancient intuition is that, for better or for worse, common oak/hornbeam plain woods, even if intensely exploited in the past, have survived until today, precisely due to this understanding of the antagonism which exists between the two species.

This brief review of the structural and compositional “dysfunctions” and, above all, the isolation and fragmentation of plain woodland clearly highlights how difficult and lengthy it will be to return to the natural model of a balanced forest mosaic. But, although arduous, the task is not impossible, if management philosophy aims at taking into account not only productive factors but, more in general, also the naturalistic conservation of such areas.

The disaffection and cultural vacuum which surround the subject are alarming, and are further aggravated by lack of economic interest. All these facts mean that, these days, woods are subject to almost total neglect.

As regards present-day forestry practices, when the inhabitants of a town or village have the ancient right to exploit woodland but are no longer interested in doing so - as is now the case almost everywhere, due to changed social and

economic conditions - the first and obvious consequence is loss of technical forestry skills and traditions. Nowadays, the “culture” of coppicing, based as it was on a genuine passion for woodland life, may be said to have died a miserable death.

For centuries, coppicing was associated with the traditions and often impoverished economy of rural populations. Today, it is true to state that the need, or the desire, to cultivate woodland for what it is, has declined. But, rather than entrusting inexperienced or ignorant workers with the task of simply cutting down trees “on behalf” of those having the right to do so, it would certainly be more rational to enhance the conservational, educational and research aspects of the woodland itself.

It cannot be denied that Italian common oak/hornbeam woods are now rare and seriously threatened environments. To their rarity and fragility must be added the lack of economic interest, which means that management based on mere productive criteria is not high on the list of priorities.

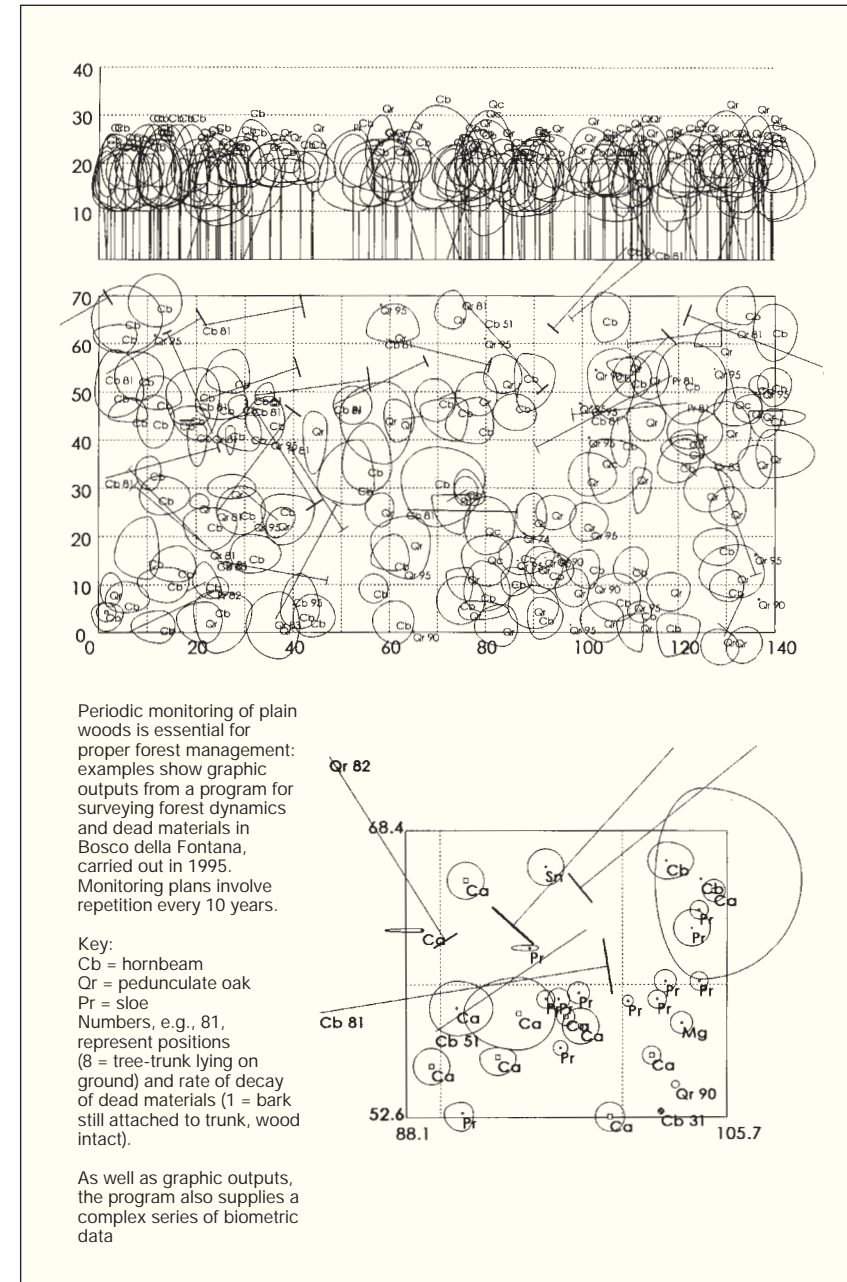


Transition between spring watercourse and wood: areas like these are important habitats for fauna

Changes in management philosophy do not necessarily have to be drastic. Coppicing could continue to be applied to portions of a plain wood, but *only* where socio-economic premises and consolidated local traditions exist. A highly equilibrated example of such a situation has been proposed for the Bosco delle Sorti della Partecipanza, part of which is maintained with coppicing with standards, part is left to develop freely, and the remaining portions are converted to high forest. Of course, the gentle steps in this return to a natural state must be taken gradually, but the aim must be one, and one alone: to bring the wood to maturity and to keep it that way. To apply the term used by North American forestry experts, the future of plain woods is a return to *old-growth forest*, i.e., woodland which is independent of its original, past management, has a high degree of heterogeneity, or *patchiness*, and sufficient biomass and necromass. Italian plain oak/hornbeam woods are very far from this natural state, but they cannot be abandoned during this transition phase. The best thing would be to imitate nature and accelerate its processes - at least until the stigmata of centuries-old anthropization have been cancelled and the equilibrium of the forest mosaic has been re-established. Lastly, the precarious state of the plain woods requires coordinated action and standardization of conservation practices in the various geographic and political areas of the Po Plain. An initial step would be an inventory, or even better, a standardized inter-regional register, constantly updated and if possible extended even to rows of trees in cultivated areas.

■ Long-term research: monitoring plain woodland

Research is essential for proper forestry management. The validity of any method for reaching a management objective must necessarily be based on objective data, and not - as is often the case - on uncertain anecdote. As woods are systems which take very long periods of time to react to external stimuli, only long-term research can effectively be applied to them. Any management project must therefore include plans for very careful monitoring. The degrees of commitment and in-depth study will be commensurate with the importance of the wood and may vary considerably: from simple photographs taken from the same point and perspective year after year, to more complex monitoring systems, e.g., graphic outputs. In cases of more sophisticated monitoring, follow-ups every 5-10 years can define the dynamics of a wood, according to its management and natural evolution. Periodic monitoring of fauna generally covers birds and insects such as carabid beetles or, more recently, hoverflies.



Plain woodland: suggestions for teaching

FRANCO MASON

The main principle to be instilled in teaching in natural environments is total respect for the preservation of all habitats and their fauna. Before planning any teaching activity, therefore, several fundamental variables must be taken into account, e.g., number of access points; how the wood is subdivided into zones, maps of its rides and paths; what infrastructures exist; and assessment of environmental risk for the public.

Although on one hand teaching in the Po Plain woods is facilitated by the fact that woodland is accessible to everyone, on the other it is extremely problematic. The main negative factor is the very climate of the Po Plain: foggy winters and hot humid summers limit school trips to a seasonal peak in March, April or May. Several difficulties spring to mind: organizational problems for accompanying teachers are transformed into true "forced marches"; the fauna is markedly and sometimes unacceptably disturbed, especially if visits coincide with the reproductive period of most birds and many other animals; and plain woods in Italy are generally very small. Some restrictions must be applied and priorities must be identified.

Logic and common sense show that the main significance of visits to such areas, for teaching purposes, is educational and scientific. So, when restricted access is indispensable, such purposes must first be imposed on the general public. However, measures such as these immediately come into conflict with the chronic lack of "alternative" public parks, gardens and green areas in general. It would appear better to set aside suitable, less vulnerable areas, where people who do not aim at purely naturalistic aspects can go walking or jogging. After all, they do not require a delicate, relict oak/hornbeam wood, perhaps when the black kite is nesting!

Planning "by priorities" like this presupposes maturity and sensitivity on the part of the public and, to an even greater extent, on that of local authorities, regarding the importance and rarity of these environments. In other words, visitors must be educated and informed in advance, so that a visit to a plain wood interests them as much as one to a historical monument or a museum. Local reality is unfortunately very different from this ideal state of affairs: it is



Illustration of woods of Basedo (S. Vito al Tagliamento, Friuli), in a map of 1728

140 not that ordinary citizens are to blame, but rather that the undeniable lack of proper information on natural history means that the value and uniqueness of plain woodland must be highlighted. Today, visiting a plain wood often only means taking a walk in a poorly defined and unknown “green area”. A survey conducted for the Bosco della Fontana reveals that only a tiny percentage of visitors really manifest some kind of true naturalistic interest.

In any case, identifying zones in woodland compatible with teaching activities is hedged about with obstacles, partly because, rationally, at least 100 hectares of space would be necessary. In addition, many plain woods are private property, or public but not protected, so that they simply represent “woods” for the general public. Even minimum infrastructures such as parking and picnic areas, tourist information centres, guided itineraries, and hides for bird-watching are often difficult to achieve in practical terms. The proper location of such structures can “deflect” the public towards less sensitive portions and is also a valid alternative to the creation of forbidden zones, which always have a negative impact on visitors.



Wood of Castions di Strada (Friuli)

Lack of properly trained personnel, often hired on a temporary basis, always reflects poorly on the overall quality of service, inevitably giving rise to trivial generalizations.

All these inconveniences can only be avoided by medium- and long-term training for permanent staff, following by qualified and constant follow-ups by those responsible for scientific management. In this sense, the best results are achieved when – as in the Bosco della Fontana – the personnel combine teaching with research, translating the scientific results into language comprehensible to all.

As regards teaching itineraries, aquatic birds, for instance, must be observed through binoculars at a minimum distance of 250 metres if they are not to be continually disturbed. This distance may be reduced if the path is “masked” for example, by hedges or “curtains” of shrubs or typical vegetation of the oak/hornbeam association. Elder is good for this purpose, due to its very rapid growth.

The organization of teaching includes other important and equally constantly



Woodland surrounded by areas of intensively cultivated land (Bosco Baredi, Friuli)



Ivy is often a problem for stability of the pedunculate oak

neglected infrastructures. These comprise signs and symbols, which must be reduced to the minimum, made of materials suiting the local landscape, contain concise information (not more than 150 words of text), and be located at strategic points. They must also be maintained and updated: illegible, out-of-date or poorly maintained information panels reveal neglect and lead the public to under-estimate the importance of the site.

Paths must be constructed of natural local materials and accessible to all, including children and the handicapped. The public must be persuaded to stick to the paths and to avoid damage to vegetation and soil: flanking itineraries with prickly hawthorn hedges, or positioning fallen trees on the ground create apparently natural obstacles. Of equal importance is the width of paths: the recommended width is 0.75-0.90 m, and 1.2-1.7 m if they are also intended to accommodate wheelchairs.

Hides must fit in with the landscape and the artefacts of the area. Picnic tables, benches, toilets, etc. are essential and must respond to legal safety requirements, in addition to being robust and practical.

As regards public hygiene and safety, particular attention must be devoted to ticks of the genus *Ixodes*, potential carriers of Lyme's disease, transmitted by a bacterium of the spirochaete group (*Borrelia*), which can have serious dermatological, neurological and rheumatological effects on man. On one hand, scaring people away is not advisable; on the other, the public must be properly informed about the danger, and the need to wear covering clothing and to use insect repellent on wrists and ankles.

Many blood-sucking insects fly in the oppressive summer heat of the plain woods: mosquitoes and horse-flies are attracted by dark clothing and by the carbon dioxide emitted during breathing. Along the watercourses where their larvae live, are simuliids, black flies which can cause irritating bites on arms and ankles. But these drawbacks can be overcome by protecting oneself properly, allowing enhancement of perceptions and true contact with the environment.

■ Suggestions for teaching

Today, plain woods - isolated remnants of once natural forests and important areas of biodiversity, scattered and increasingly fragmented - are threatened by modern intensive and industrialized agriculture. Students must be made as much as possible aware of the rarity and uniqueness of these relict environments. Two teaching schedules are proposed here, dealing with topics such as the conservation of biodiversity and the natural state of plain



Plain woodland near Carlino (Friuli)

oak/hornbeam woodland:

- Alien tree species in plain oak/hornbeam woodland;
- The habitats and microfauna of dead wood and old hollow trees.

Both schedules can be suited to various school levels, from the last years of junior school upwards.

■ “Alien” pollution of oak/hornbeam plain woodland

As we have seen, oak/hornbeam plain woods are ecosystems which have been profoundly altered in many respects. One of the easiest components to identify in this context is the introduction of tree species which are completely extraneous to Italian flora.

- Aims: to increase students’ knowledge of the territory and to enhance their capacity to perceive various types of environmental alterations and particular forms of “pollution”; to develop the capacity to compare and distinguish natural habitats from altered ones; to analyse critically the reasons and historical contingencies which caused changes in the original landscape; and to emphasize the importance of maintaining and restoring the natural aspects of these relict environments, so that they may be preserved for scientific purposes and for the benefit and knowledge of future generations.
- Level: as mentioned above, varying degrees of in-depth study, from junior school upwards. In senior school, work may be amplified to include specialized texts, e.g., an overview of the phenomenon of alien species in many plain woods; bibliographic research on the economic and historical reasons leading to the introduction of “alien” species; the development of concepts, modes and functions of statistical sampling in woodland.
- Necessary equipment: texts on the botanical characteristics of natural tree species in the oak/hornbeam association and alien species introduced; labels; plastic bags; secateurs; sheets of old newspaper for drying specimens; measuring-tape, for measuring the diameters of trees, starting with their circumference; cord marked off in metres, a ball of string, and wooden pickets; binoculars. Proper clothing for excursions: long trousers or jeans, long-sleeved shirt or sweater, light but stout shoes, insect repellent.

WORK PHASES: PRELIMINARY STUDY

1. Choose the best plain wood to visit; contact management authorities for general information, documentation and necessary entry permits, supply basic information on how teaching will be carried out.
2. Introduce the concept of “exotic” or “alien” species and indigenous or

native ones. Go further into problems associated with introducing exotic species as a threat to the natural state of oak/hornbeam woodland (e.g., invasiveness of red oak over pedunculate oak, changes in the landscape). Collect literature on botanical characteristics, area of origin and ecology of alien species (typically, red oak, American hybrid poplars, plane, black walnut, locust, tree of heaven), contrasting them with species natural to oak/hornbeam woodland (typically, pedunculate oak, hornbeam, southern ash, lesser ash, wild cherry, field maple).

3. Prepare an identification sheet for use on site, listing the main botanical features of both native and exotic species, and another sheet to count numbers of exotic species as opposed to indigenous ones, over a small sampling area. Give clear instructions on how to prepare a herbarium.

SAMPLING

4. Subdivide students into two or three groups. The sampling area will be a circle about 20 metres in diameter (314 m²), marked out with a measuring cord and string. Fix pickets to mark the area and carry out the following activities: identify species and count trees; measure trunk circumferences at chest height (say, 1.30 metres) from the ground, and convert them into diameters. Collect leaves, flowers and/or fruit to prepare the herbarium.

PROCESSING OF RESULTS

5. After counting all trees in the sampling area and measuring all their diameters, use the latter values to prepare a simple graph showing diameters (in centimetres) on the abscissa and number of trees in ordinate. Use this graph to interpret species development: a gaussian distribution highlights the presence of trees of the same age, a logarithmic curve shows trees of different ages, from younger to older, and thus tendentially in expansion.

CONCLUSION OF STUDY

6. On the basis of the data they have collected, students may extrapolate, for instance, the degree of “alien pollution” and, by simple graphic processing, hypothesize the future development of natural wood populations and alien ones. Comparisons of graphs with herbaria will highlight the botanical features of species found in the sampling area.

CONTINUATION OF STUDY

7. Extend samplings to other areas of the same wood or to another one, to make hypotheses and comparisons on the natural state and degree of



Dangerous branches on trees along paths and roads frequented by the public must be cut

alteration of these habitats. For older students, stimulate a debate on the significance of statistical sampling in a natural framework.

■ Habitats and microfauna of dead wood and old hollow trees

Plain oak/hornbeam woods are small and generally afflicted by problems due to their isolation and the resulting high, continual risk of the extinction of fauna.

As these areas, today, cannot support large mammals, it is perhaps easier to devote attention and available funds to the conservation of "small fauna", particularly invertebrates, members of ecosystems which are still today greatly neglected in conservation programs.

- Aims: enhancement of knowledge of invertebrate fauna associated with a particular habitat, called by forestry experts the "dead wood compartment". The saproxylic (=wood-eating) organisms which live in it are now dramatically declining throughout Europe, as a result of the destruction of their habitats due to the continual removal of the dead wood and old trees which are essential to their survival. Focus on recognition and identification at the level of orders. The final aim is that of educating the younger generations to perceive woodland as a natural system and, as such, necessarily complete in all its components – which include dead wood and old hollow trees. Students must understand that an excessively neat and orderly wood lacking in dead material is an unnatural and fragile system.

- Level: from late junior school upwards. For more senior classes, study may include examination of small samples of dead wood, from which adult insects may be taken, bred, and (for some taxa) identified.

- Necessary equipment: soft tweezers, insect pins, test-tubes, plastic containers, preserving fluid, stereoscopic microscope (if not available, magnifying glass with cross-hairs), plastic bags, brass nails 2-3 cm long (brass does not rust), gauze, small plastic boxes (about 50 cm³) in which to place dead wood samples and insects.

WORK PHASES: PRELIMINARY STUDY

1. Identify and describe the plain wood in question. Contact management authorities or owners for entry permits, etc. and information about the conservation of dead wood or the presence of old hollow trees.

2. In class, study the literature and discuss problems connected with the conservation of dead wood in Europe. Teach the morphological characteristics of the orders of saproxylic insects and other invertebrates,

150 covering the recognition and biology of "EC priority saproxylic species" living in plain woodland: e.g., stag beetle and long-horned beetle, and their importance in the various phases of the demolition of organic matter. Construct a proper cage or box for breeding insects. Prepare ID sheets of arthropod orders.

DATA COLLECTION

3. Identify a site with plenty of well-decomposed dead wood, e.g., a tree long fallen, and collect a few small pieces of its wood, observing maximum respect for the environment. If the bark of the dead trunk has been removed, re-attach it with small nails (good training!)
4. Put dead wood samples in the breeding box and, during spring, periodically sample the contents of the collection boxes containing fresh adult specimens of insects. Show students how to examine them under the stereomicroscope or magnifying glass.
5. Prepare a report describing the sampled environment, and the number and taxa obtained from breeding. Prepare a report on the presence of dead wood in the study habitat, taking into consideration the consequences of its presence/absence as regards the concepts of biodiversity and conservation.

CONTINUATION OF STUDY

6. Study may be continued, perhaps on an individual scale, by further field surveys, when possible, with the collaboration of staff from museums and institutions specializing in the study of invertebrates. This is an invaluable way of initiating students into the field of taxonomic study and specialization.

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Detail of map of 1756, showing woods of low Friuli plain

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Glossary

- > Biogeography: study and interpretation of the geographic distribution of living organisms, plants (phytogeography) and animals (zoogeography).
- > Coppicing: the forestry practice of subjecting trees or plants to periodic cutting over a certain area, applied to broad-leaved plants able to grow shoots rapidly from stumps.
- > Chablis: a gap in the forest cover, generally due to one or more trees falling and opening up space.
- > Chorology: geographic distribution of species or groups of species.
- > Deciduous: adjective referring to trees (or other plants) which, during the period of vegetative repose in their annual biological cycle, lose their leaves.
- > Habitat Directive: European Community Directive 92/43, regarding conservation of natural and semi-natural habitats and wild flora and fauna. Includes not only natural habitats but also animal and vegetal species, the conservation of which requires the designation of special preservation areas.
- > Eco-unit: portion of a vegetal community characterized by particularly homogeneous physiognomic, structural and ecological arrangements.
- > Saproxylic fauna: organisms which, during some part of their life-cycle, depend on the presence of dead or dying wood (standing or fallen), fungi inhabiting wood, or other species living in or on dead wood.
- > Phytogeography: see Biogeography.
- > High forest: woodland generated exclusively from seed.
- > Hygrophilous: adjective referring to organisms preferring damp environments.
- > Mesophilous: adjective referring to organisms which tend to avoid extreme climatic or environmental conditions.
- > Coppice-shoots: new stems budding from the stump of a tree, previously either felled by wind or cut during specific forestry operations (coppicing).
- > Seedlings: small plants originating from the heavy seeds of several tree species; the presence of seedlings may be associated with natural renewal of the wood or to forestry operations.
- > Thermophilous: adjective referring to warmth-loving organisms.
- > Zoogeography: see Biogeography.

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