

A plant population is the set of the individuals (organisms, phytoindividuals) of the same species that live in a given place at a given moment and interact with each other. A mapping of individuals coincides in part with that of populations, but it is still preferable to keep the two types (phytoindividuals and populations) distinct because they have different meanings and purposes, and because the methodologies used may be different.

Maps at this level, at fine (large) scale, are today a useful basis for conservation biology, since threatened species have greater probability of surviving due to the *rescue effect* involving migration between neighboring populations. On the other hand, maps at broader (smaller) scale become chorological, in that they may contain entire populations or, more generically, the absolute range of a species.

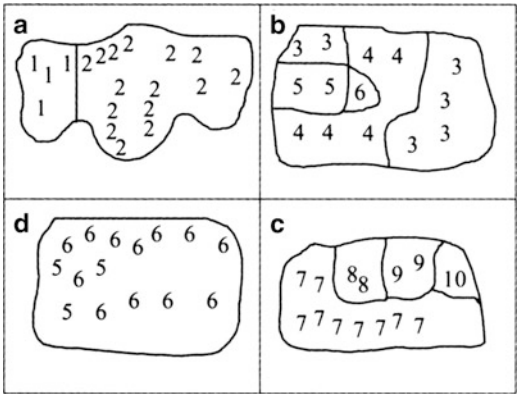
---

### Maps of Individual Plants

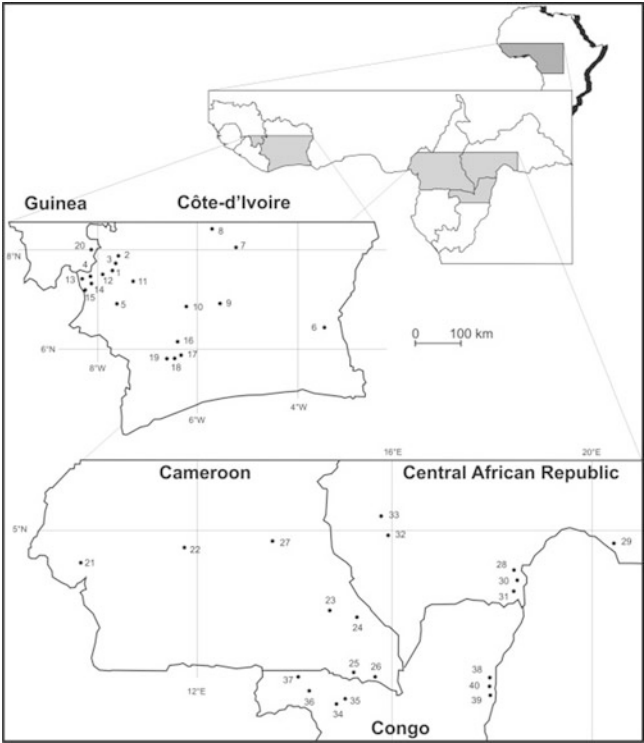
The purpose of maps of individual plants is to represent their distributions in localized areas. The mapping is done at a fine scale, recording also the composition in terms of organisms (units) of diverse types and functions (Falińska 1984). Beyond just the spatial representation of complex individuals, including genotypes identified by molecular methods (Figs. 2.1 and 2.2), this kind of the mapping permits monitoring all individuals in permanent areas, generally small but adequate, from  $1/4 \text{ m}^2$  to a few tens of  $\text{m}^2$  (Fig. 2.3). Naturally the mapping of herbaceous species is always more complex than that of woody species, as can be seen in Fig. 2.4, which shows a plot of  $50 \times 50 \text{ m}$  inside which all individuals of the herbaceous species present have been mapped.

Repeated mapping over time permits gathering information on the manner and rate of growth of the individuals, hence of the population that they compose (Fig. 2.5), and on the duration and disappearance of the individuals (Fig. 2.6), etc.

Use of sophisticated geopositioning systems (from theodolites to GPS) does not always result in the adequate required level of detail, as opposed to simpler and more immediate topographic positioning by means of corner coordinates, which

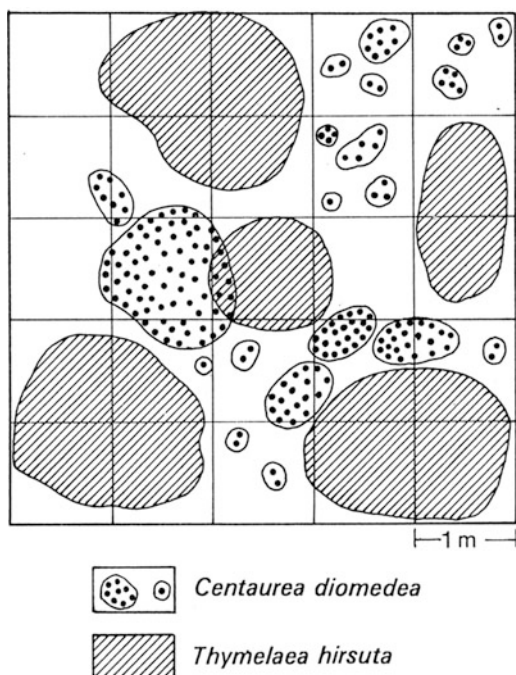


**Fig. 2.1** Distribution of four populations genotypes of *Festuca rubra* (a, b, c, d) identified by electrophoresis; the *numbers* shows different genotypes (From Falińska 1998)



**Fig. 2.2** Geographic and genetic origins of the wild *Coffea canephora* genotypes in West and Central Africa; the *numbers* corresponds to different genotypes names and origin (From Gomez et al. 2009)

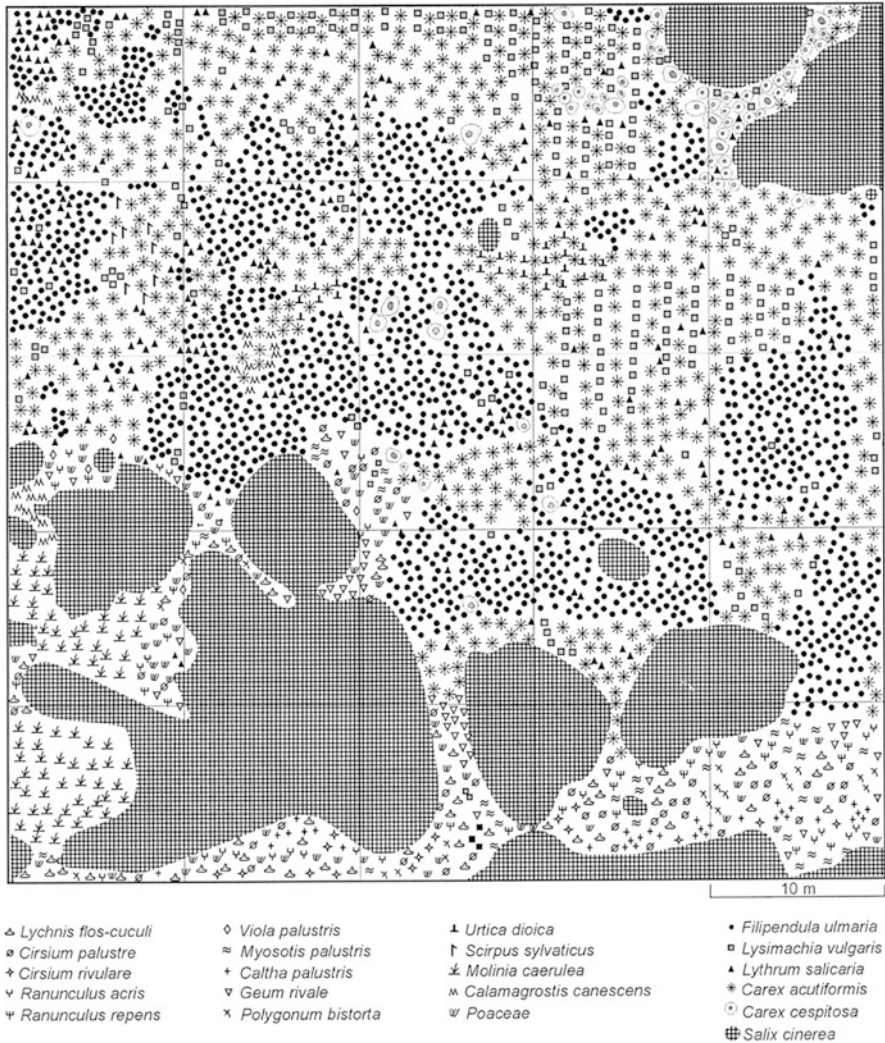
**Fig. 2.3** Spatial distribution of *Centaurea diomedea* individuals between those of *Thymelaea hirsuta*, Tremiti Islands, southern Italy (From Falińska 1999)



permit finding the mapped unit also at less phenologically optimum moments and with minimal impact. In these cases, the geographic coordinates of individuals are measured directly in the field, as for two populations of *Polylepis tarapacana* from the Nevado Sajama (Andes of Bolivia) in areas of about 4,000 m<sup>2</sup>, with the following distinct functional age classes: seedling, young individual, fertile adult, sterile adult and dead individual (Fig. 2.7).

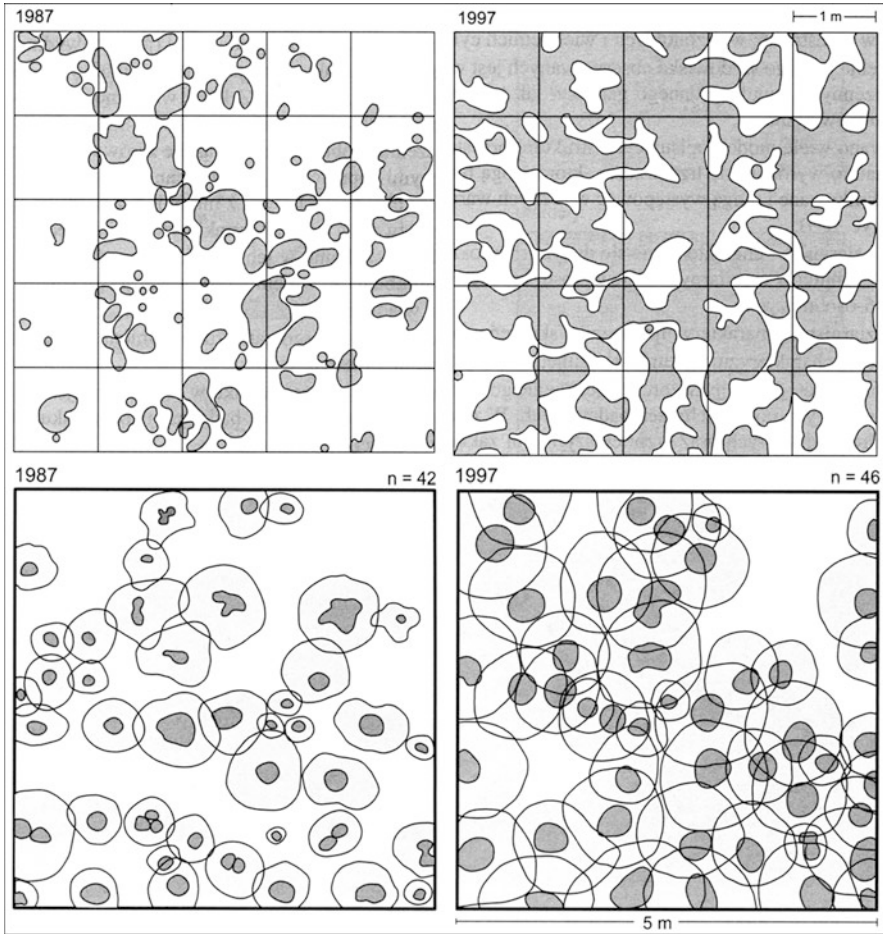
Naturally these considerations depend on the dimensions of the organisms: woody species require more space and benefit from more modern techniques for topographic positioning, such as photogrammetry (Fig. 2.8) or remote sensing (Fig. 2.9).

Generally, maps of the distribution of individual trees are made for rare species, as in the case of the Nebrodi fir (*Abies nebrodensis*), a species which exists in nature only as 30 individuals and as such has been mapped repeatedly, three times over the past 30 years (Fig. 2.10) (Morandini 1969; Morandini et al. 1994; Virgilio et al. 2000); and the case of the *bagolaro* (*Celtis tournefortii*), with a range limited to a few sites on the southwest slope of Mt. Etna (Fig. 2.11). Mapping of this type has also been done for the century-old individuals of larch pine (*Pinus laricio*), noted as the “giants of Sila” in the forest Bosco Fallistro (Avolio and Ciancio 1985), and for the *Quercus pubescens* trees of the zone Abbadia di Fiastra in the Marche (region) of Adriatic Italy, in which pollution damage suffered by the trees is indicated distinctly in four classes: no damage, plus light, moderate and severe damage (Fig. 2.12).



**Fig. 2.4** Spatial distribution of perennial herbaceous species in abandoned meadow in the Remski wetland, Narewka Valley, Białowieża (Poland) after 25 years, partially invaded by *Salix cinerea* (From Falińska 2003)

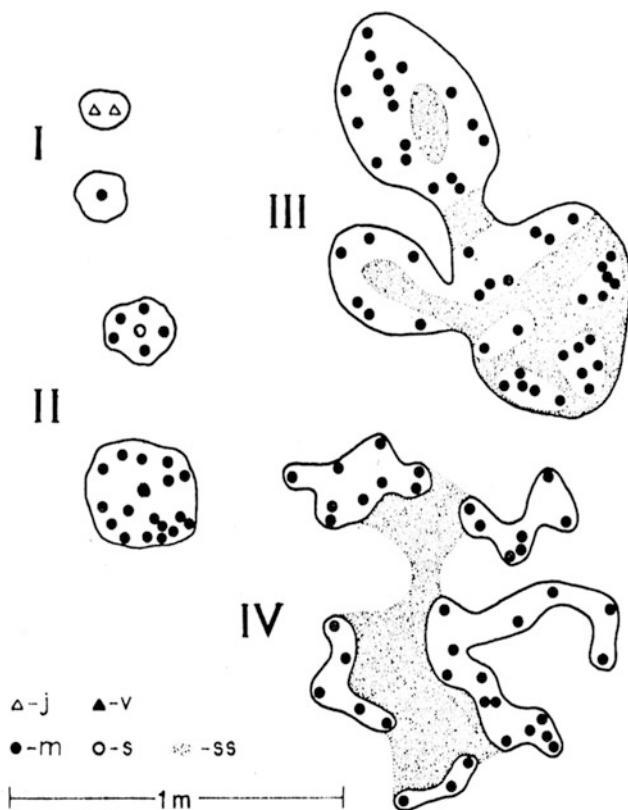
Trees are also mapped as a function of their ecology. Kondō and Sakai (2011) surveyed and mapped some tree species in relation to microtopography in a mountain area of central Japan. The species there occur mainly in particular geomorphological situations, such as *Salix cardiophylla* on debris cones; *Tsuga diversifolia*, *Abies mariesii* and *Abies veitchii* on mountain slopes and terraces; and *Alnus matsumurae* on valley and lower slopes (Fig. 2.13).



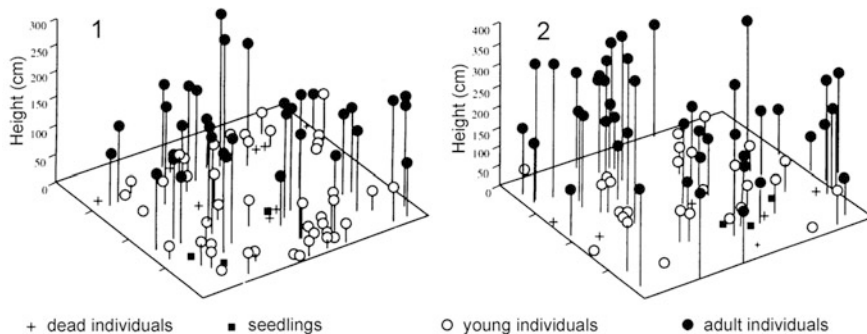
**Fig. 2.5** Spatial dynamic of a population of *Filipendula ulmaria* and another of *Carex caespitosa*, from 1987 to 1997 (From Falińska 2002)

Individual trees have also been mapped for the remains of two forests left standing under water when the two lakes in Trentino were created by a landslide around 1000BC. At the end of the Lago di Molveno lake, which was drained completely for construction of a hydroelectric impoundment, 142 individuals belonging to 7 species have been found and mapped, among them *Abies alba*, *Taxus baccata* and *Fagus sylvatica* (Marchesoni 1954). At the Lago di Tenno lake, 74 individuals belonging to 7 species were found and mapped, including especially *Fagus sylvatica* (Fig. 2.14). This mapping was done by a diver who marked the trunks found by means of cables tied to floats. Using a theodolite along the shoreline, it was possible to map the positions of the individual floats, each of which corresponded to a tree trunk on the

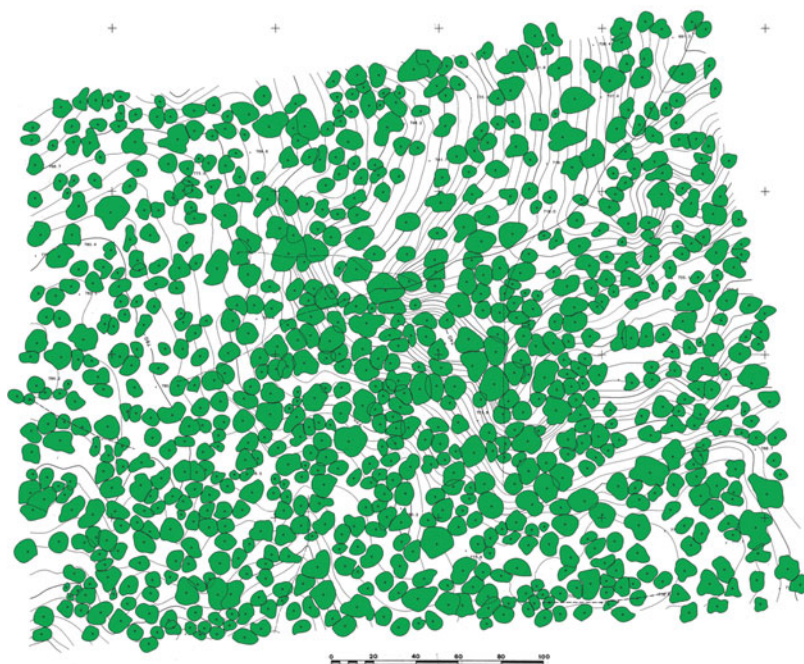




**Fig. 2.6** Development and shape variation of *Filipendula ulmaria* polycormon. Development phases: I – beginning, II – juvenile; III – mature; IV – senescent (over 10 years); j – young, v – virginal (physiologically ready for reproduction; but still without differentiated reproductive organs), m – fertile; s – old, ss – dead parts of the underground organs (From Falińska 1984)



**Fig. 2.7** Spatial distribution of two populations of *Polylepis tarapacana*, Nevado Sajama, Bolivia, number 1 at 4,720 m and number 2 at 4,370 m; dimensions and age were surveyed for each individual (From Liberman Cruz et al. 1997)



**Fig. 2.8** Distribution of *Fagus sylvatica* trees in the canopy of forest in the Riserva Pavari, Foresta Umbra, Mt. Gargano, Apulia region of Adriatic; southern Italy; the distribution was obtained by photorestitution

lake bottom. With such research it is possible to understand the composition of the forest at the time the lakes were formed.

## Maps of Populations

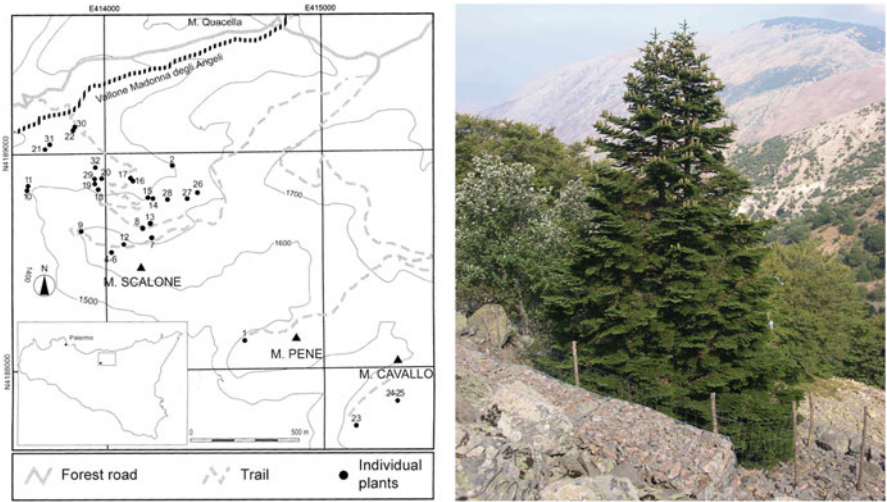
Cartographic representation of one population may involve:

- One species in a phytocoenosis (coenopopulation or coenotic population, i.e. all individuals of the same species in a phytocoenosis), at the location of a given ecosystem; in this case it is possible to show the dynamic and spatial relations of subpopulations and ecotonal or synusial populations (Fig. 2.15); or
- One species in a territory (administrative, geomorphological, landscape, etc.) in which different coenotic populations are distinguishable; in this case it is possible to show the functional relations within the metapopulations, i.e. a set of populations connected by a flow of individuals but separated by environmental heterogeneity and various dynamic processes (including phenology).

Mapping the dynamics of these populations permits expression of the relations among ecological and dynamic processes in populations, interpretable as spatial process patterns that can occur simultaneously or sequentially in a single “dynamic

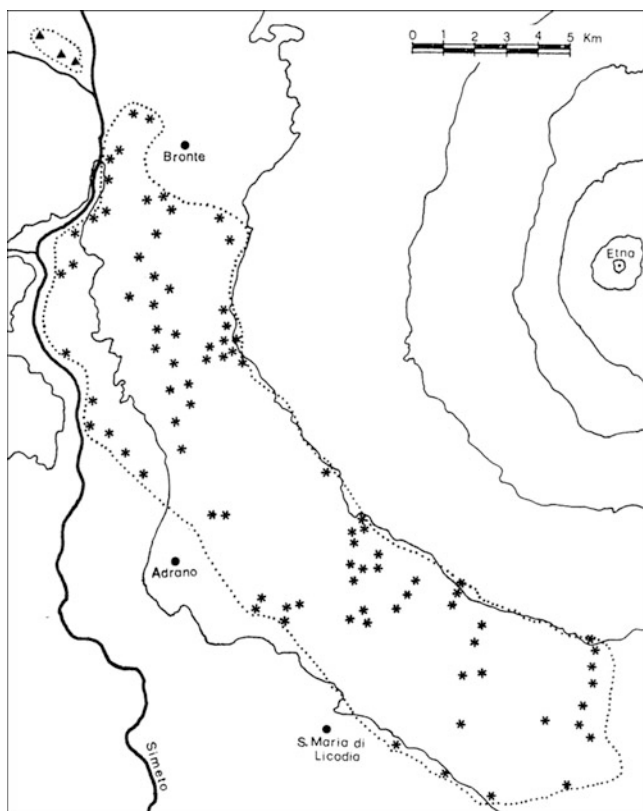


**Fig. 2.9** IKONOS image Carterra PAN – MS (1 and 4 m resolution) from 22 June, 2000, on the Kassandra peninsula, Chalkidiki, Greece. The image show the number of *Pinus halepensis* trees and the density of tree biomass, as represented by crosses of different sizes (Software developed by Advanced Computer Systems A.C.S. S.p.A., Rome)



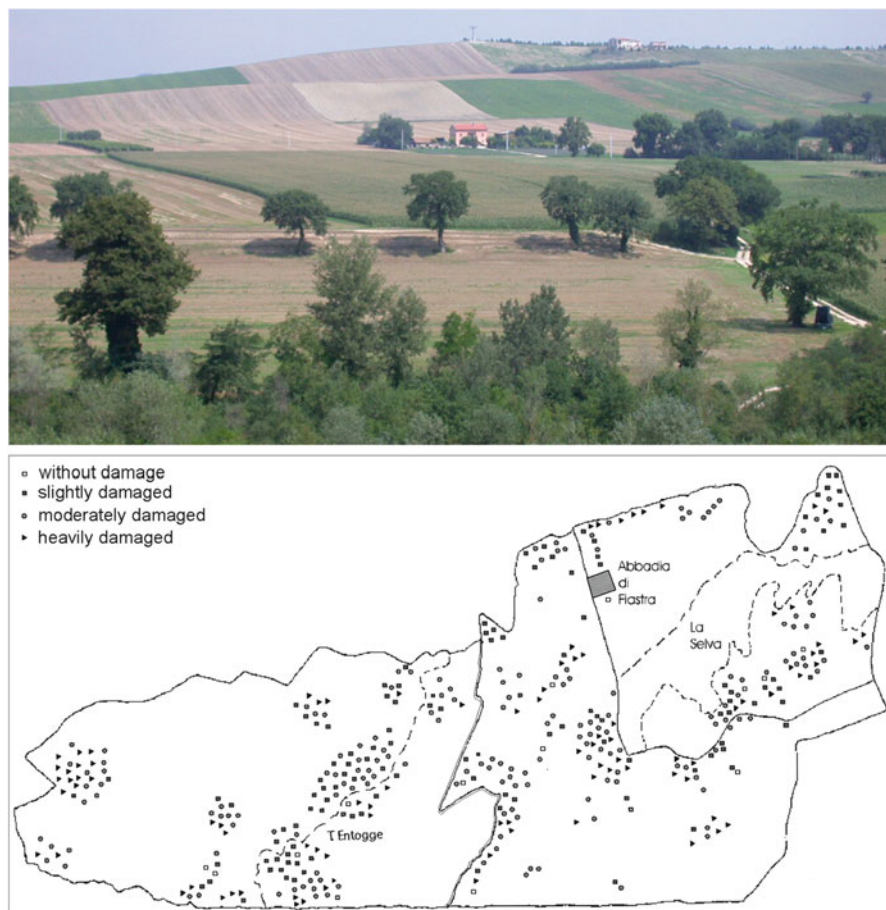
**Fig. 2.10** On the left, the distribution of individual *Abies nebrodensis*; trees, numbered from 1 to 32, Mt. Scalone, Sicily; on the right, the tree no. 27 (From Virgilio et al. 2000; photo Rosario Schicchi)





**Fig. 2.11** Distribution of *Celtis tournefortii* on Mt. Etna, Sicily (From Poli et al. 1974)

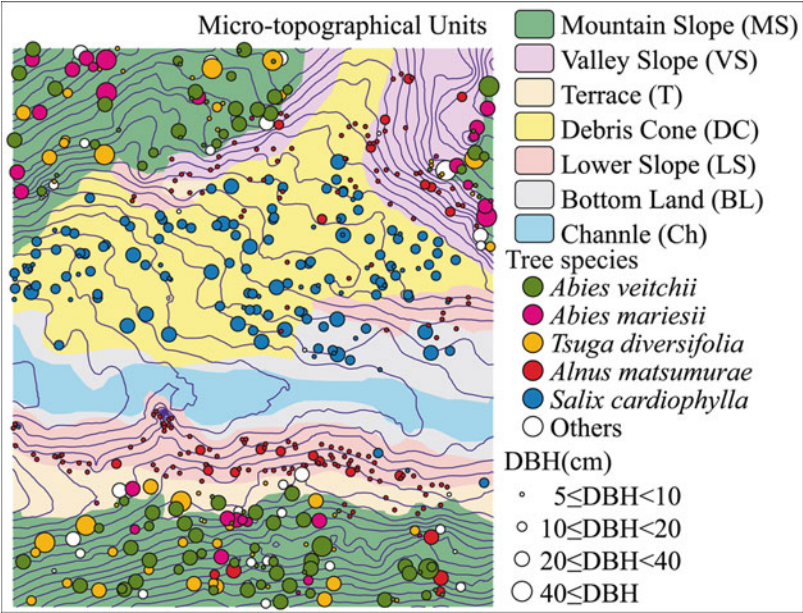
landscape”. The expansion of a species on a territory can be described as a complex balance among distinct populations in various dynamic states (pioneers, expanding, regressing, etc.) (Canullo 1991b, 1993a, b), as can be seen in the case of *Anemone nemorosa* at Białowieża (Fig. 2.16) and of *Cytisus sessilifolius* at Torricchio (Fig. 2.17). The variations in the populations can be observed and mapped also in relation to the various successional stages of the communities in which they occur, for example during the secondary succession of a marsh and progressive formation of a shrubby stand of *Salix cinerea* (Fig. 2.18) or of *Alnus glutinosa* (Fig. 2.19), or of *Cyclamen hederifolium* in the beechwood of Mt. Gargano (Fig. 2.20). In the wetland area of Reski (Białowieża forest), Falińska (2003) followed variations in populations in the association *Cirsietum rivularis* from 1980 to 1995, producing four maps, one every 5 years. The wetland was invaded progressively by shrub species, in particular *Salix cinerea*, which replaced the pre-existing populations of herbaceous species completely over the course of the 15 years (Fig. 2.18).



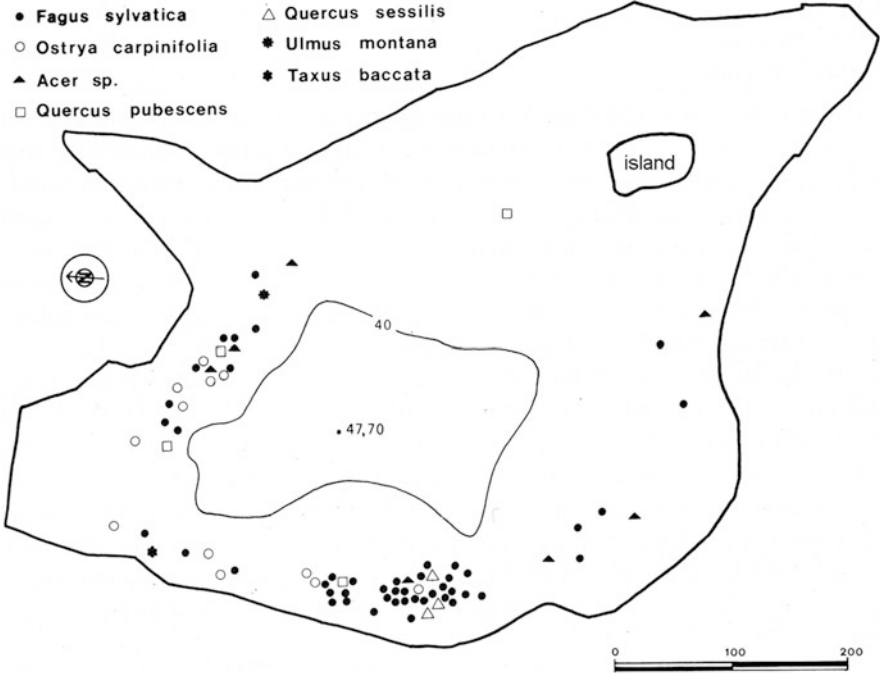
**Fig. 2.12** Distribution of field oaks (*Quercus pubescens*) from the hills of Abbadia di Fiastra, Marche Region, Adriatic central Italy, with degrees of pollution damage (From Campetella et al. 2002)

In particular cases it is possible to map *biogroups*, i.e. aggregations of several species of trees and bushes of various ages, of which one is older, is found at the center of the aggregation and grows taller than the others, assuming a promoting role (Canullo and Falińska 2003). In the Torricchio nature reserve (near Camerino, see list of frequently cited locations), *Juniperus communis* and other woody species frequently grow according to this model of development (Fig. 2.21).

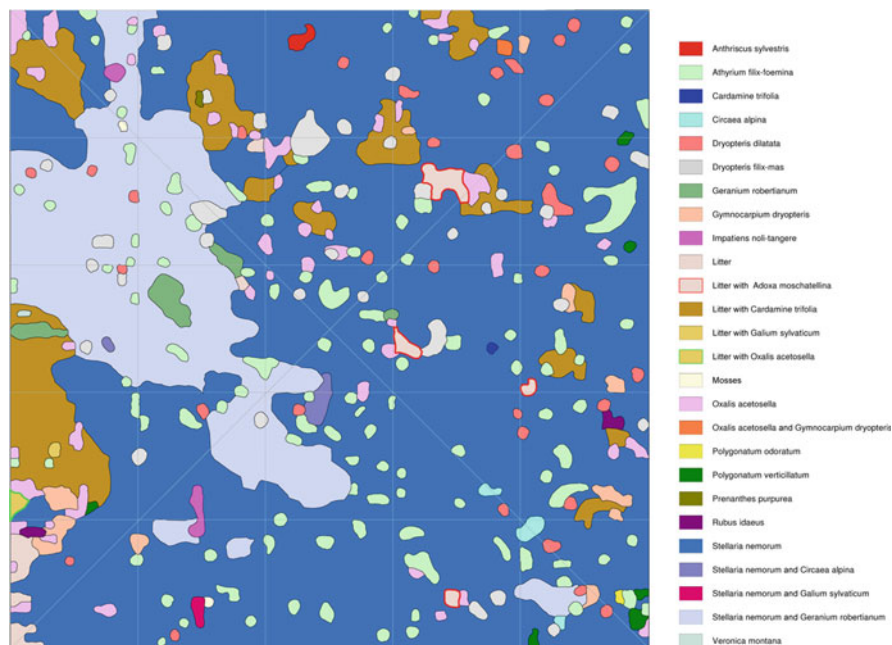
Accurate boundary mapping of individual populations can be done by standard survey equipment, such as a Laser Electronic Theodolite, Electronic Distance Measurer or a Global Positioning System. The different accuracies of these



**Fig. 2.13** Micro-topographical units and tree distribution in central Japan (From Kondō and Sakai 2011)



**Fig. 2.14** Distribution of tree trunks rooted on the bottom of the Lago di Tenno (lake), Trentino-Alto Adige Region, northern Italy (From Biondi et al. 1981)



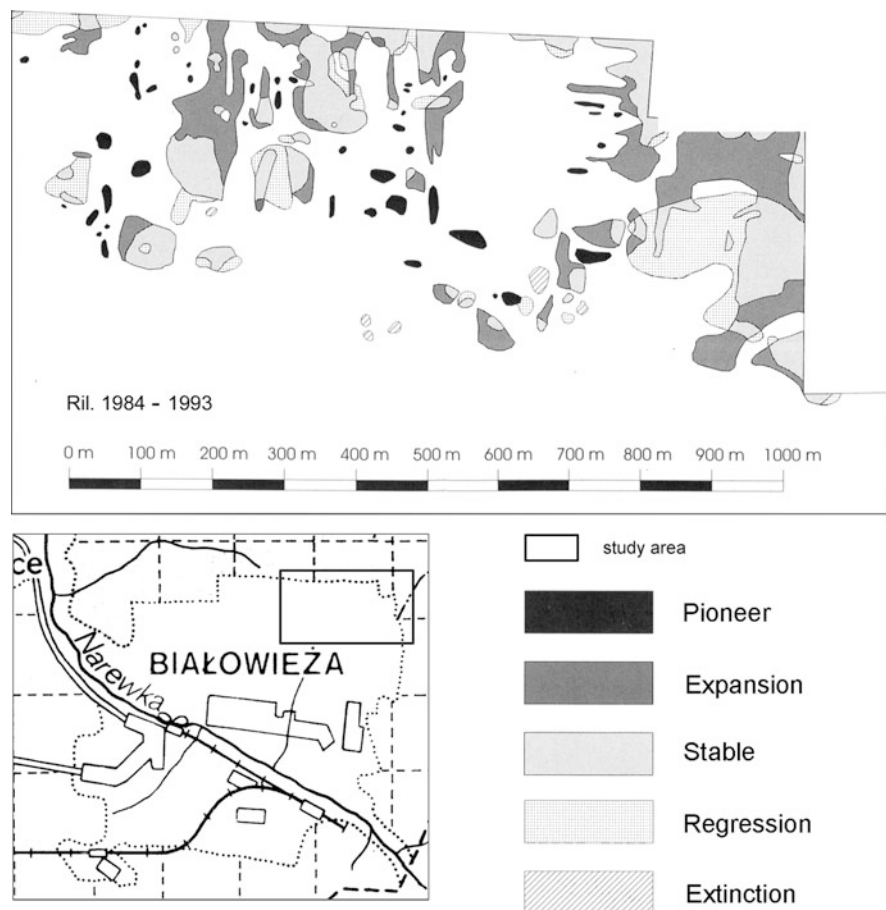
**Fig. 2.15** Dominant plant species (populations) in the understory of a beech forest belonging to the *Galio odorati-Fagetum*. Vallone Vallor, Piano del Consiglio, Veneto Region, northern Italy. The map was produced during summer 2005, based on a visual record 1:100, in a 50 × 50 m permanent monitoring plot of the ICP forests, CONECOFOR national network. The dominant species units refer to the understory up to 2 m high, with 50 cm accuracy. *Stellaria nemorum* dominates the ground layer (more than 85 %), sometimes in co-dominance with other species. Other species are represented by a number of small patches (*Athyrium filix-femina* and *Oxalis acetosella*, represented respectively by 113 and 50 units), often single individuals, polichormones or clones (e.g. *Cardamine trifolia* or *Polygonatum odoratum*). Scattered populations occur on litter-covered areas (Field surveys by Leonardo Ghirelli and Maria Cristina Villani; elaboration by Monica Foglia and Roberto Canullo)

instruments define the scale at which they can be used profitably, depending on the local population dimension, grain and extent (Elzinga et al. 1998).

## Maps of Vegetation Structure

The horizontal structure of vegetation is the (horizontal) spatial distribution pattern of plant populations, synusia or phytocoenoses; the vertical structure is the way in which vegetation is organized into strata (Ivan 1979). Horizontal structure involves the distributions, in a certain area, of the components of the phytocoenoses, i.e. the individuals of the various species. This is done separately for the herbaceous, shrub and tree strata (layers). The methodology is similar to that used for populations

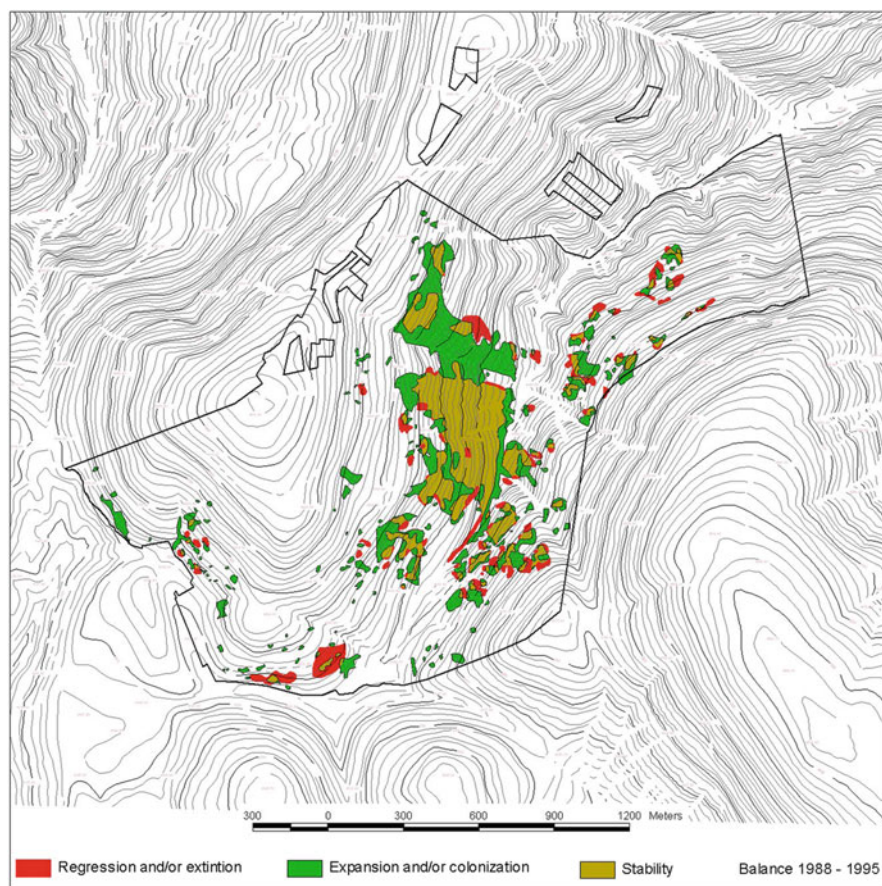




**Fig. 2.16** Map of populations of *Anemone nemorosa* in different dynamic states in *Tilio-Carpinetum* forest, from 1984 to 1993, in a clearing in the Białowieża primeval forest, Poland (From Canullo and Tavolini 1999)

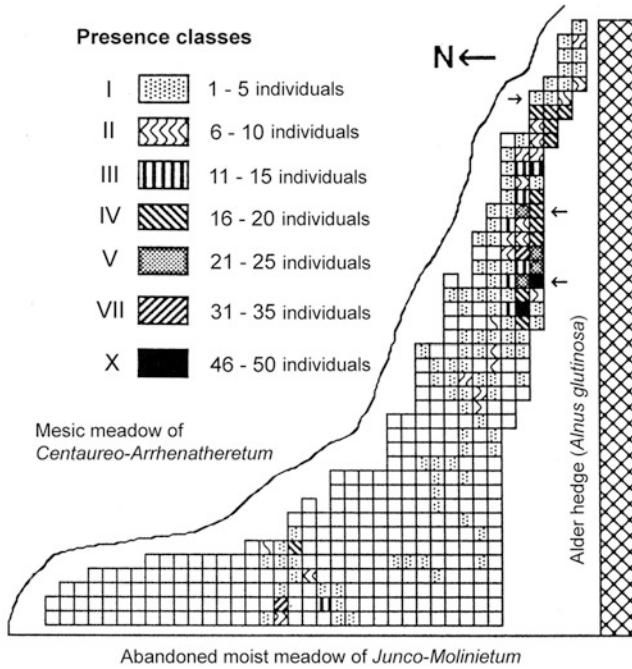
(Fig. 2.22). Vertical structure, on the other hand, considers the height of individual plants as they appear in distinct strata (Fig. 2.22). The demographic structure of vegetation (Canullo and Falińska 2003) considers also the age of the individuals, as was done for two populations of *Polylepis tarapacana* from the Andes of Bolivia (Fig. 2.7).

Maps of vegetation structure can be analytical or synthetic. Analytical maps are for individuals, as already said; synthetic maps are for homogeneous vegetation units with the same type of structure, as can be observed in the map of the vegetation structure of the Fiastra forest (Fig. 2.23).

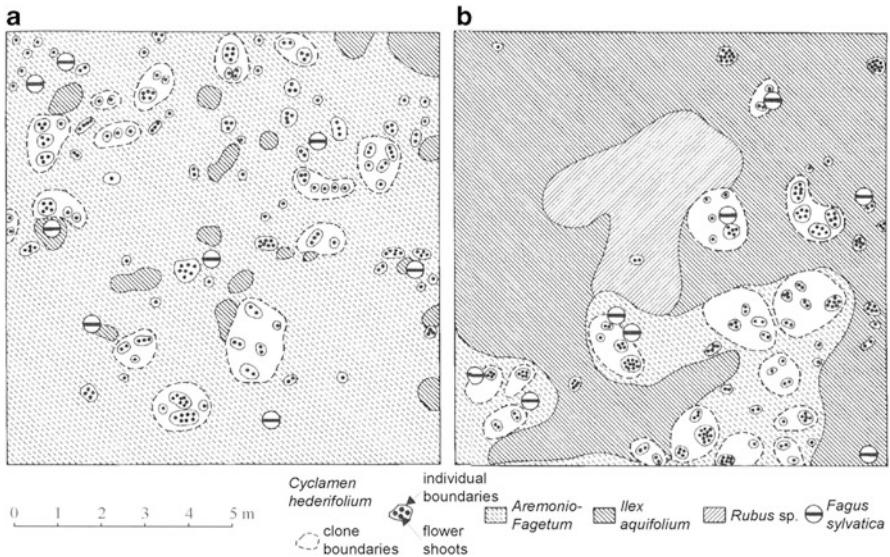


**Fig. 2.17** Variations in the populations of *Cytisus sessilifolius* (1988–1995) in Torricchio Natural Reserve, Marche Region, Adriatic central Italy (From Canullo and Campetella 2010)



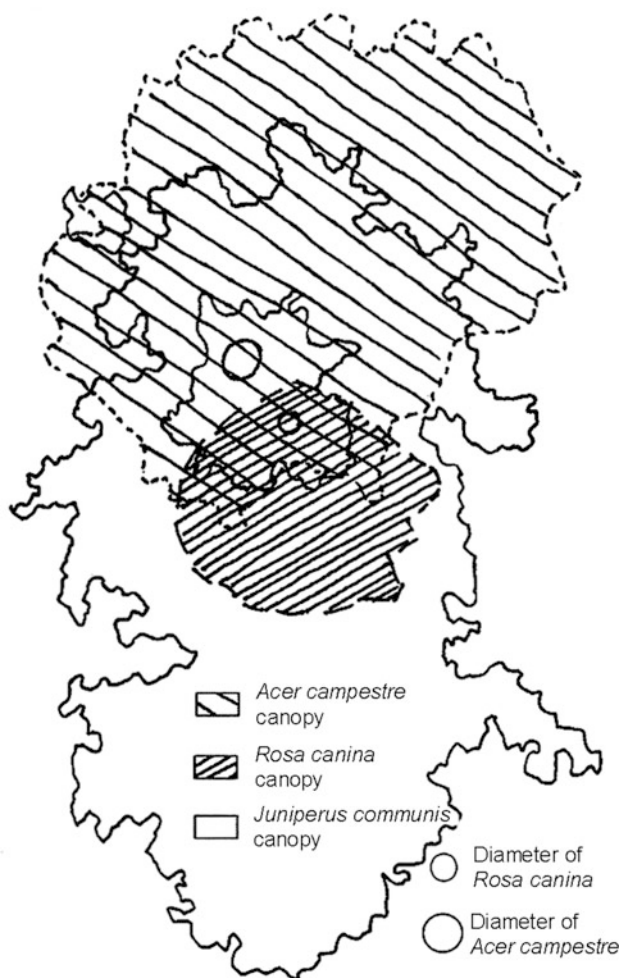


**Fig. 2.19** Occurrence of individuals of *Alnus glutinosa* in abandoned meadow of the association *Junco-Molinietum*, Piné, Trentino-Alto Adige Region, northern Italy; the occurrence is evaluated and mapped in  $0.5 \times 0.5$  m areas (From Gafta and Canullo 1992)

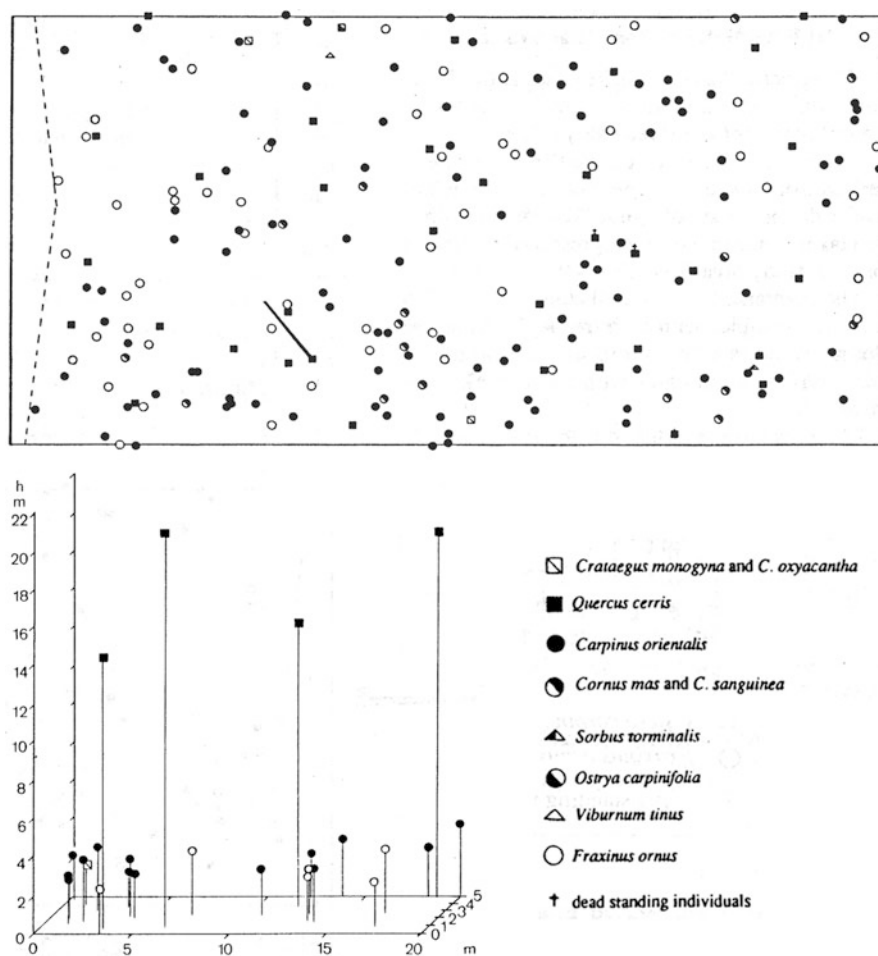


**Fig. 2.20** Changes in the spatial structure of *Cyclamen hederifolium* population in some dynamical stages of *Aremonio-Fagetum* forest, Mt. Gargano, Apulia Region, Adriatic southern Italy; (a) forest in fluctuation stage; (b) forest in degeneration stage because of invasion of *Ilex aquifolium* (From Falińska 1993)

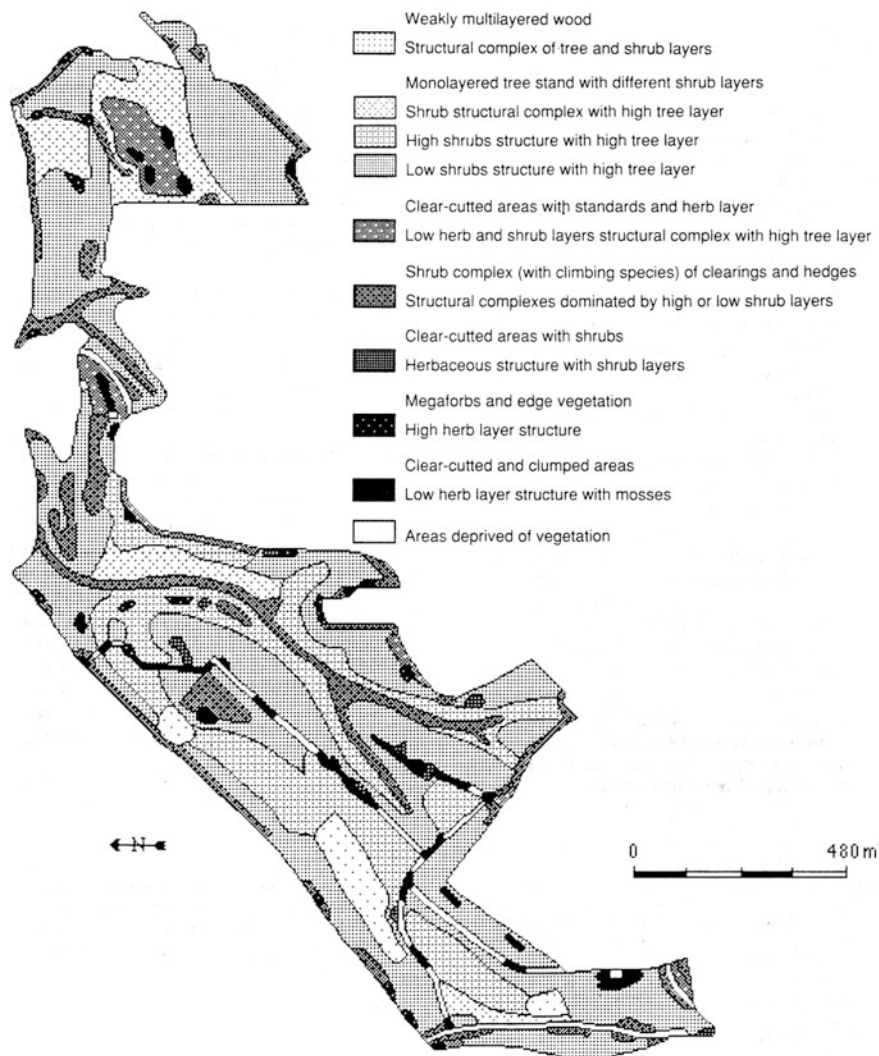




**Fig. 2.21** Canopy projection and trunk positions of species in the biogroup formed by *Juniperus communis*, *Acer campestre* and *Rosa canina* in the Torricchio Natural Reserve, Marche Region, Adriatic central Italy (Field survey of Simone Galassi, Camerino)



**Fig. 2.22** Above: horizontal species distribution of individuals or stumps in tree study plots in mixed deciduous coppice; below: the vertical structure of the tree study plots, as simplified by a representative transect of the tree and shrub layers (From Canullo 1991b)



**Fig. 2.23** Vegetation structure of the Fiastra Abbey forest, a relict oak-mixed coppice wood in the submediterranean hilly belt of the Marche Region, Adriatic central Italy (From Canullo 1991a)



<http://www.springer.com/978-3-642-30234-3>

Plant and Vegetation Mapping

Pedrotti, F.

2013, XIII, 294 p., Hardcover

ISBN: 978-3-642-30234-3