BOJA (1989) *Ley 2/89, de 18 de julio, por la que sea prueba el inventario de Espacios Naturales Protegidos de Andalucía y se establecen medidas adicionales para su protección.* BOJA, Sevilla.
CSIC (1963) *Estudio agrobiológico de la provincia de Cádiz.* CSIC, Sevilla.
Didon, J., Durand-Delga, M. and Kornprobst, J. (1973) Homologies geologiques entre les deux rives du détroit de Gibraltar. *Bulletin Societé Geologique Francaise* 15, 77–105.
González, A., Torres, E., Montero, G. and Vázquez, S. (1996) Resultados de cien años de aplicación de la selvicultura y la ordenación en los montes alcornocales de Cortes de la Frontera (Málaga), 1890–1990. *Montes* 43, 12–22.
Gutiérrez, A., Nebot, M. and Díez, M.V. (1996) Introducción al estudio polínico de sedimentos del Parque Natural de 'Los Alcornocales'. *Almoraima* 15, 87–92.
Huntington, E. (1915) *Civilisation and climate.* Yale University Press.
JA (1995) *Plan de Medio Ambiente de Andalucía.* Junta de Andalucía, Sevilla.
López Ontiveros, A., Valle Buenestado, B. and García Verdugo, F.R. (1991) *Caza y paisaje geográfico en las tierras béticas según el Libro de la Montería.* Junta de Andalucía, Córdoba.
Marañón, T. (1988) Agro–sylvo–pastoral systems in the Iberian Peninsula: *Dehesas* and *Montados. Rangelands* 10, 255–258.
McNeill, J.R. (1992) *The mountains of the Mediterranean World. An environmental history.* Cambridge University Press, New York.
Ojeda, J.F. (1989) El bosque andaluz y su gestión a través de la Historia. In: García, G.C. (ed.) *Geografía de Andalucía.* Tartessos, Sevilla, pp. 315–355.
Ojeda, F., Arroyo, J. and Marañón, T. (1994) Biodiversity components and conservation of Mediterranean heathlands in Southern Spain. *Biological Conservation* 72, 61–72.
Ojeda, F., Marañón, T. and Arroyo, J. (1996) Patterns of ecological, chorological and taxonomic diversity at both sides of the Strait of Gibraltar. *Journal of Vegetation Science* 7, 63–72.
Paola, G. and Ciciliot, F. (1998) Examples of woodland management related to timber supply for shipbuilding in the 18th century in western Liguria (NW Italy). In: Watkins, C. (ed.) *European woods and forests: studies in cultural history.* CAB International, Wallingford, pp. 157–163.
Sánchez, F.J. (1994) La gestión del Parque Natural de Los Alcornocales (Cádiz-Málaga): influencia en la población rural. In: *Simposio mediterráneo sobre regeneración del monte alcornocal.* IPROCOR, Mérida, pp. 23–26.
Thirgood, J.V. (1981) *Man and the Mediterranean Forest.* Academic Press, London.
Torres, C. (1974) *El antiguo reino nazarí de Granada (1232–1340).* Anel, Granada.

11

Landscape Evolution on a Central Tuscan Estate between the Eighteenth and Twentieth Centuries

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The last two centuries of landscape evolution on a farm in central Tuscany were investigated. The authors report information concerning the history of the forest vegetation of the area from the Middle Ages. A large-scale study defines the distribution of land use types from 1823 and analyses the direction of landscape changes. A small-scale study investigates the factors influencing secondary successions. The evolution of farming activities and population changes had influenced the territory of the farm in the following ways: (i) growth of the forest and shrubland cover, due to colonization of old fields and pastures, and reduced landscape diversity; (ii) increased floristic diversity, due to secondary successions in chestnut stands, pinewoods, oakwoods and old fields; (iii) growth of structural diversity inside single landscape patches; (iv) increased fire risk because of dense understorey; and (v) loss of cultural heritage, in the form of local practices and traditions and loss of the skill to use small-scale resources.

Introduction

The object of this study is to define the evolution of the landscape in a part of the territory of the Gargonza estate between 1823 and 1995. The changes were closely related to social and economic factors which had a strong influence on the structure and dynamics of forest and agrarian landscapes. Large-scale and small-scale changes were studied in order to define the general variations in land use and secondary succession. Another purpose of this study is to suggest guidelines for the management of an area now mostly devoted to recreation and tourism, an interesting application of historical investigation to the management of the forest resources.

The Environment

The estate of Gargonza is named after the castle to which it belongs, placed on the hills of western Valdichiana Valley, near the town of Monte San Savino (Arezzo Province). It covers an area of approximately 700 ha, going from the plain to 600 m above sea level. The main geological formation of the territory is Macigno sandstone, with fluvial deposits and marsh in the valley.

The soils (sandy loam, pH 6.5, profile type A–C) belong to acid-brown soils of the old classification and to different classes of Inceptisols under modern soil taxonomy. The climate is sub-Mediterranean: mean annual temperature is 12.5°C, annual temperature variation 19°C, annual rainfall 925 mm, with a minimum during the summer when there may be two months of drought. Most of the area is included in the phytoclimatic hot under zone of *Castanetum,* according to the Pavari classification. The vegetation belt is the 'lower sub-Mediterranean' (Mediterranean series of *Quercus pubescens*) according to Ozenda.

Sources and Methods

We carried out a detailed analysis of approximately one-third of the farm (267 ha), situated on the upper side of the hills. This area had a small amount of cultivated land, but many pastures and much woodland in the past. The sources considered were a 'cabreo' of the second half of eighteenth century, the accounting books of the estate, the cadastre of Tuscany made in 1823, two maps of the estate made by the land agent around 1920–1930 and in 1958, and some aerial photo surveys made in 1954 and 1985. Other information was collected with the help of oral history and the analyses of material evidence. The actual situation on the ground was studied through field survey.

The large-scale investigation concerned five different land use types: cultivated land; pasture and wood-pasture; shrubland; woodland; and urban (the castle). The woodland was further divided into: pinewood; coppice; mixed woods (pine/oak); and chestnut orchards.

For statistical analyses we used: Hill's diversity number (Ludwig and Reynolds, 1988) related to effective number of land use types contributing to landscape diversity ($N1 = e^H$, where H is the diversity index of Shannon, calculated on the proportion of land use types); and the dominance index (DI) of Shannon and Weaver (1962) calculated on the proportions of different land uses (O'Neill *et al.,* 1988).

We also carried out small-scale investigations, using sample plots 30–80 m long and 10 m wide, divided into squares of 25 m^2. For each individual tree in the plots, species, height, age and cover were determined. The spatial distribution of woody species was studied through: Clapham dispersion index (variance/average ratio); and tests of association among woody species based on 2 × 2 contingency table (presence–absence) and χ^2 test, the null hypothesis being that species distributions are independent.

From Roman Age to the Birth of the Estate

Valdichiana was considered the granary of the Etruscan country in the first century AD; Plinius the Young describes it as a pleasant place, with a nice climate, quite populated, with flourishing agricultural activity and many forests. The fall of the Roman Empire and the barbarian invasions caused deep changes. In much of the valley was a swamp. People lived in villages surrounded by walls on the top of the hills, and used to cultivate vines, wheat and olive trees, along the hill slopes (Guidoni and Marino, 1972). The swamp extended for all the length of the valley, almost 40 km, and much of its width (25 km). Roads ran high on the hills with bridges to cross the swamp, each town had a port since the valley included a big lake linked with the Tevere River and Rome to the south, and the Arno River and Florence to the north.

The first information on the castle of Gargonza goes back to the thirteenth century, as it seems that Dante Alighieri stopped there one night on his way to Rome (Repetti, 1855). Between the thirteenth and fifteenth centuries the valley was divided between the rule of Florence, supporting the Pope, and the rule of Siena, supporting the Emperor. The situation was very unstable and several times hired armies conquered the towns of the valley, as they passed frequently from one lord to another. The forest, mostly oaks and chestnuts, was present in many areas, and also some timber trade was carried out in the eastern hills. At the end of the fifteenth century the Republic of Florence decided to start to dry the swamp, entrusting Leonardo da Vinci with the project. In 1503 he drew a detailed map of the valley, now collected in the Royal Library at Windsor, showing an archipelago of hills emerging from the swamp, which at that time had probably reached its greatest extent. However, only a small amount of the swamp was drained at that time. Halfway through the sixteenth century Florence gave Gargonza to the family of Della Stufa; in this period we have the first reliable information on its forests. The statute of Monte San Savino, the town nearby, reports the prohibition of cutting oak and chestnut trees, especially the big ones, in this area.[1] It is probable that the growth of population in this century had already had some effects on the woodland. A description of the seventeenth century divides the territory of the valley into cultivated area, pastures and swamp vegetation, but no forest is mentioned (Guidoni and Marino, 1972). In this period, works to dry the swamp were increasing and they would last until the final drainage of the valley in the nineteenth century. New arable land was created and farmhouses built in the plains.

In 1727, after the coming of the Corsi family, Gargonza was turned into an estate, divided into many smallholdings, each one with its farmhouse. In the second half of the eighteenth century the owner decided to make a topographic survey, all the fields were measured and the maps, together with the pictures of the farmhouses, collected in a cabreo. The drawings show very clearly the way the land was cultivated: the hills around each farmhouse

[1] Bilbioteca Comunale di Monte San Savino, Statuti di Gargonza, anno 1509.

were terraced, and each terrace was held up by a dry wall. Olives and vines were cultivated together, and maple, *Acer campestre*, used to train vines. Large areas were devoted to pastures and wood-pastures, while woodland covered most of the rest of the territory (Agnoletti, 1989).[2]

The Organization of the Estate between the End of the Eighteenth and the Beginning of the Nineteenth Century

Unfortunately not all the maps of the cabreo were preserved, but the organization of the estate can be understood from the accounting books made at the end of the eighteenth century and still present in the castle. Gargonza had 23 holdings: eight of them were placed on the higher side of the hills, between 450 and 600 m, six between 300 and 400 m, nine on the lower side of the hills and the plains. Cultivation was carried out with a 3 year rotation, wheat and rye were growing on one-third of the land, minor cereals were sown in the second third, while the rest was fallow land. Wheat was the most important crop, besides wine and olive oil; other crops were corn, barley, oats, vetch, lupins, great millet and millet. In the plains, flax and hemp were cultivated by the farmers, and the woven linen sold to merchants. However, the most important income of the farm came from livestock breeding, representing 52% of the total income; 450 sheep, 183 pigs, 25 mules and 85 cows were kept on the estate and were free to graze in the woodland. Between the eighteenth and nineteenth centuries important changes occurred. The owners decided to extend the cultivated areas, terracing more hill slopes and carrying out works for the management of watersheds, since the reduction of woodland increased erosion. In 25 years, the growth in wheat production was very high, almost 40%, but vine production also increased by 30% (Agnoletti, 1989). This caused the reduction in woodland cover, a common feature of Tuscany in this period. In fact the Grand Duke Pietro Leopoldo allowed wood cutting with no restrictions, and deforestation occurred all around the country.

The cadastre made by the Duke of Tuscany in 1823 is the first reliable document on the estate. The landscape described is quite complex showing many land uses. Cultivated land was divided into arable land, arable fields with olives, with vines, with poplars; pastures were also of different types: pastures, pastures with oaks, with olive trees, with mulberry trees. The forest had different features: high forests, chestnut orchards (for nut production), coppice, trees along the hedges, bushes. Cultivation played a different role according to the geographical position of the holdings. On the higher slopes of the hills, chestnuts and pastures were the most important element. The harvest of wheat was not sufficient to feed the farm families, so the harvest of chestnuts was very important to feed the peasants; in fact the castle had a drying room for chestnuts, as well as an olive mill. In the holding called 'Casali', at 530 m above sea level, cultivated land (2 ha) was surrounded by a stone wall, to protect it against grazing, while the rest of the land was chestnut orchard (14 ha), with

2 State Archive of Florence, Guicciardini Corsi Salviati, Cabreo di Gargonza.

Fig. 11.1. Extension of cultivated fields, pasture, woodland and shrubland in Gargonza, from 1823 to 1984. Urban area was not considered because it remained unchanged.

some pasture inside. The lower slopes had a small amount of pastures and more cultivated areas, while the plains were entirely cultivated.

Landscape Changes between 1823 and 1984

Between 1823 and 1920 both cultivated land and woodland increased (Fig. 11.1). Over part of this time, 1814–1864, the population almost doubled, from 488 to 858 people.[3] The distribution of population in Gargonza followed two patterns: one was related to the life of the group living inside the castle, the second was more linked to farming, with many families distributed in the territory according to the location of the farmhouses. In 1931 most of the population lived in the farmhouses (80%), the total number of families was 133, with an average of 5.6 people in each family.

Pasture to woodland

Woodland and cultivated land spread on to pastures and shrublands. From 1823 to 1920–1930, pasture and wood-pasture disappeared to be replaced by cultivated land, mixed oak/chestnut forest, pine woods and chestnut coppice. Sheep were no longer kept; pigs and cows were reduced in number as well, and were kept in stall. Most of the woodland existing in 1920–1930 was coppice. More people meant more need for fuelwood and charcoal (much lighter to transport) and thus coppice was managed on the short rotation best suited for charcoal. Coppice was also used for farming activities (poles and tools) and to feed livestock. The rise in population is a general feature of the period and the nearby town of Monte San Savino showed a more than 50% increase. This meant more buildings and one of the most important economic activities, around 1870, was the production of bricks. In the area there were ten kilns, one of them in Gargonza, which needed enormous amounts of

3 Sources for the analyses of population changes are found in the Archive of Monte San Savino (Arezzo): Censimento del 1814, Filza 1862; Note dei parroci e tassa familiare del 1836, Filza 3241; Registro della popolazione a norma del decreto 31/12/1864, volume quinto; VII° Censimento generale della popolazione del Regno d'Italia, 21/4/1931.

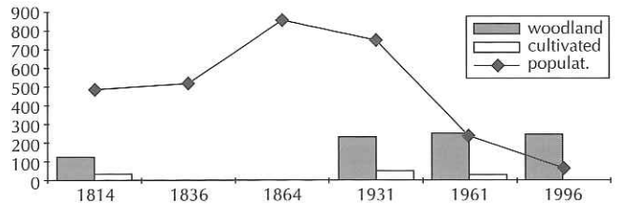

Fig. 11.2. Population, woodlands and cultivated land between 1814 and 1996 in Gargonza (y axis shows ha and number of people).

fuelwood collected from coppice. Some chestnut coppice was still utilized in 1885 using mules for logging since the coppice was far from main roads.

After the Second World War, there was a dramatic fall in the number of people living in Gargonza: peasants left the countryside and went to work in the cities (Fig. 11.2). This is the age of the so-called 'Italian Miracle' and the rise of Italian industry. Together with the strong reduction in population, there was a dramatic fall in fuelwood and charcoal production since people changed to fuels derived from petroleum for heating and cooking. Today fuelwood production is increasing again, but farmers seem to cut only those coppices close to the roads; more remote coppices are now ready to be turned into high forest stands.

Cultivated land

Between 1823 and 1920, cultivated land increased (+6%), but later there was a decrease of almost 11%. The decades after the First World War saw the greatest extension of cultivated areas, but also the start of the reduction of population. At Gargonza the arable land was mostly concentrated in the plains. In 1958 most of the cultivated land, in the area of our study, was turned into a plantation of *Pinus pinaster*, while in the remaining land we found natural pine forest and coppice. Only the farms of the lower hills were still cultivated, olive trees and vineyards were still present on the medium hills, while the upper hills are completely abandoned.

In 1984 there was still some cultivated land, but most of it had been afforested with pine stands or affected by early stages of secondary successions (Fig. 11.3). The pine (*Pinus pinaster* and some *Pinus nigra*) was planted for economic purposes but, since no thinning was done, the timber quality of these stands is poor. The packing industry did use these trees regularly until 1986, especially where pine trees were growing in mixed oak forest which produce better quality timber.

Shrublands

Shrublands played an important ecological and economic role. They are the result of degradation of the woodland or fire (the last big fire destroyed

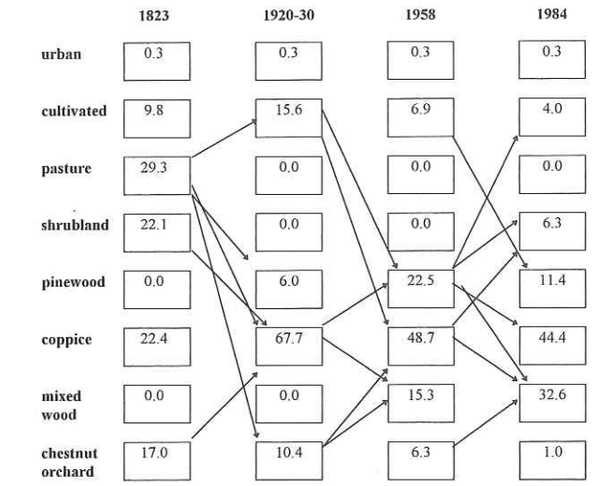

Fig. 11.3. Land use changes from 1823 to 1984, expressed as total surface percentages (267 ha). The arrows indicate the direction of changes.

272 ha of shrublands and forests in 1972). They covered 22% of the land in 1823, but seemed to disappear in 1920–1930 and 1958. However by 1984, 6% of the land was again covered with shrubs. The cadastre of 1823 did not use the word shrubs but 'scope' (brooms): this term did not mean degraded forest, but areas where *Erica scoparia* and *Erica arborea* were cultivated. The interest in these species was due to the production of brooms, then quite common in the area, and still being made today. Shrublands changed quite often over time, as it was easy to shift from coppice to shrubs and vice versa. According to some oral sources, in the sixties, woods were sometimes burnt to allow the growth of heather since its economic value was higher than fuelwood. In this period, cultivation of heather became perhaps more convenient than coppice, since many small businesses were producing brooms. Even in 1985 some lumbermen preferred to cut shrublands than to cut coppice.

Chestnut orchards

Until the end of the nineteenth century, stands of chestnut were very important for the population. In 1920 they decreased by 3%, by 1958 there was only one-third of the previous chestnut forest area, while by 1984 they had almost disappeared. The reduction in farmers' families in the upper slope of the hills had two effects: the first was that chestnut flour was not necessary anymore. Improved agricultural techniques and the extension of cultivation in the plains were giving more crops to feed the population. Secondly, the abandonment of the land meant that no one was left to care for this kind of forest. So the chestnut high forest degraded, due in part to diseases like *Cryphonectria parasitica*. Chestnut trees were cut and coppice and pine

Table 11.1. Dominance index D1 and diversity number N1, applied to land use type analysis.

	1823	1920–1930	1958	1984
D1	0.34	1.10	1.27	1.18
N1	3.54	1.66	1.41	1.52
D1*	0.48	0.93	1.12	1.20
N1*	2.48	1.57	1.31	1.21
D1†	0.50	0.82	0.73	0.78
N1†	4.83	3.52	3.85	3.67

* This analysis considers woods and shrubs together, urban, cultivated and pasture.
† Analysis considers cultivated land, pasture, shrubs and all wood categories separately.

replaced the old high forest; in 1984, there were 87% fewer chestnut stands compared to the beginning of the nineteenth century. Perhaps the most important species since the sixteenth century had nearly disappeared.

The detailed changes in area for each land use type are given in Fig. 11.3. In Table 11.1 the values for the landscape index are reported. The dominance index (D1) was lowest in 1823, when the highest landscape diversity was found (3.54 land use types). In 1920–1930 the dominance index increased, as woodland reached its greatest extent with the maximum value being reached in 1958. By 1984, shrubland had increased, mainly through colonization of fields by woody species, and maximum landscape uniformity was reached. Considering each woodland class, the highest dominance value was reached in 1920–1930 because of coppice extension.

Secondary Succession in Old Fields and Woodland: Small-Scale Analyses

Abandoned fields

In old fields, once cultivated with vines and olive trees, the invasion by tree species (*Acer campestre* and *Quercus pubescens*), shrubs (*Prunus spinosa, Cornus mas, Cytisus scoparius, Rubus* spp., *Rosa* spp.) and herbs, mainly *Graminaceae* and *Leguminosae*, is observed. Field maple (50%), olive tree (25%) and pubescent oak (25%) show an aggregated distribution (Id = 9.26**), with thick strips next to the lower edge of dry terrace walls. Cover is around 40%, with a multilayer structure showing an average height of the dominant layer of 6 m. Maple and oak are significantly associated ($\chi^2 = 4.38$, $P<0.05$). Regeneration near the base of dry walls is favoured by the spread of seeds by birds, and also by ecological factors such as moderate shading, reduced competition from herbs and protection against harvesting and browsing (Salbitano, 1987; Gandolfo, 1994).

On old olive cultivations invaded by shrubs, the resulting structure is characterized by a dense layer, 2 m high, of *Prunus spinosa* (70%) and *Crataegus monogyna* (5%), with scattered *Quercus pubescens* (12%) and *Olea europea* (13%), 6–8 m high. Cover is around 80–100%, and age analyses showed that most species invaded the fields within 20 years after the abandonment of cultivation. *Prunus spinosa* and *Crataegus monogyna*, both having a strong colonizing capacity, tend to be uniformly distributed (Id = 0.30). *Q. pubescens* and shrubs are not significantly associated in space. The thorny shrubs probably favoured the coming of oaks protecting them against browsing, in the first stages of colonization. During the colonization of the old fields, the first stages of succession are quite fast, but they can be slowed down in early stages dominated by shrubs (Puerto and Rico, 1988).

Chestnut orchards

Chestnut stands are present on the east–northeast slopes between 400 and 500 m above sea level. These woods have developed a structure showing two layers: the dominant one consists of old chestnut trees (80 trees ha^{-1}, average height 15 m, G = 4.16 m^2), mainly scarred by chestnut blight. The lower layer is made up of shoots sprouting from old trees, seedlings of *Castanea sativa* (maximum height 6–8 m), *Fraxinus ornus, Ostrya carpinifolia, Acer campestre, Quercus pubescens* and *Corylus avellana. Pinus pinaster* colonizes these stands in the openings. In the undergrowth, *Cytisus scoparius* is abundant, with *Brachypodium rupestre* and *Festuca ovina* common in the field layer. Chestnut stands are thus changing into a mixed hardwood forest.

Coppice-woods

Overgrown oak coppices prevail on the south and southwest slopes, between 450 and 650 m. Most of them are coppice with standards (*Quercus pubescens* and *Quercus cerris*), mixed with *Pinus pinaster* and *Pinus nigra*. There is selection amongst the shoots and some of them eventually overtop the others: thus the coppice is evolving into a mixed high stand of vegetative origin. In the regeneration layer (40–160 cm), under canopy cover, in addition to deciduous oaks, there are also *Quercus ilex, Sorbus torminalis* and *Robinia pseudoacacia*, while *Pinus pinaster* regenerates only in the openings. The most common shrubs in the undergrowth are *Cytisus scoparius, Juniperus communis, Erica scoparia* and *Rubus* spp.

Pinewoods

The *Pinus pinaster* stands were never thinned, thus the trees are quite drawn up, with crooked stems. The stands are dense (800 trees ha^{-1}), with a single layer structure (dominant height between 14 and 20 m, G = 12–25m^2). Mechanical stability is very low with many wind breakages, especially in the even-topped trees, and this is compounded by diseases such as *Dioryctria* sp. *Pinus nigra* stands are also very dense (750 trees ha^{-1}, dominant height 17 m, G = 20–22 m^2) but the stem shapes are better. Regeneration of pine occurs in the openings, formed by wind damage, where some extraction of timber has been carried out. Under less dense canopy cover, *Quercus pubescens*,

Fraxinus ornus, *Robinia pseudoacacia*, *Acer campestre* and *Castanea sativa* regenerate. On the other hand, under dense canopy cover, *Quercus ilex* prevails. This secondary succession of broadleaves in artificial conifer stands, is a common ecological process in Tuscany (Bernetti, 1987).

Conclusions

The abandonment of farming activities and population changes have had several effects on the territory of Gargonza.

- There has been growth of forest cover (woodland and shrublands) due to the colonization of old fields and pastures. Woodland is playing the role of a connective element among the patches of the ancient landscape mosaic. With its spread, landscape diversity has been reduced.
- There is increased biodiversity, due to secondary successions, in chestnut stands, pinewoods, oakwoods and old fields. Succession seems to go in the direction of mixed broadleaved woods.
- Structural diversity within individual landscape patches has increased, since colonization occurring in old fields is quite irregular. Also the structure of the old coppice, pinewoods and old chestnut stands is evolving towards a more complex pattern.
- Fire risks are increased because both in woodland and in old fields there is now a dense understorey.
- There has been a loss of cultural heritage, in the form of local practices and traditions, and loss of the skill to use small-scale resources. This is quite evident in the abandonment of many farmhouses and decay of the material evidence of human presence such as dry walls, dams, tracks and old roads. The cultural landscape survives in some land uses such as heather cultivation and small areas with chestnut, both as coppice and high forest.

The actual economy of the area is no longer devoted to agriculture but mostly to tourism and recreation, as the forest of Gargonza represents an important environmental resource for the nearby towns. The conservation of some evidence of the old chestnut high forest and coppice, as well as gradual landscape restoration, could be considered. Secondary succession occurring in artificial pinewoods could be accelerated by thinning, favouring the invasion of broadleaves. In abandoned terraces invaded with flammable bushes, the risk of fire would suggest some management oriented to the replacement of shrubland by plantations of local broadleaved species for timber production such as sessile oak, or reviving olive tree cultivation. It is also important to preserve some of the material evidence of the ancient organization of the territory.

References

Agnoletti, M. (1989) La fattoria di Gargonza fra '700 e '800. Elementi per una storia del bosco in Valdichiana. *L'Italia Forestale e Montana* XLIV, 67.

Bernetti, G. (1987) *I boschi della Toscana.* Edagricole, Bologna.

Gandolfo, G. (1994) *Indagine storico-biologica sull'insediamento della vegetazione forestale in consequenza della cessata coltivazione delle pendici terrazzate nel Ponente ligure (Valle Arroscia, Imperia).* Tesi di laurea, Università degli studi di Firenze.

Guidoni, E. and Marino, A. (1972) *Territorio e città della Valdichiana.* Roma.

Ludwig, J.A. and Reynolds, J.F. (1988) *Statistical ecology.* John Wiley and Sons, New York.

O'Neill, R.V., Krummel, J.R., Gardiner, R.H., Sigihara, G., Jackson, B., De Angelis, D.L., Milne, B.T., Turner, M.G., Zygmunt, B., Christensen, S.W., Dale, V.H. and Graham, R.L. (1988) Indices of landscape patterns. *Landscape Ecology* 1, 153–162.

Puerto, A. and Rico, M. (1988) Influence of tree canopy (*Quercus rotundiflora* and *Quercus pyrenaica*) in old fields succession in marginal areas of central-western Spain. *Acta Oecologica, Oecologia Plantarum* 9, 337–338.

Repetti, E. (1855) *Dizionario geografico, storico della Toscana.* Cinelli, Milano.

Salbitano, F. (1987) Vegetazione forestale ed insediamento del bosco in campi abbandonati in un settore delle Prealpi Giulie (Taipana-Udine). *Gortania, Atti del Museo Friulano di Storia Naturale* 9, 83–143.

Shannon, C.E. and Weaver, W. (1962) *The mathematical theory of communication.* University of Illinois Press, Urbana, Illinois, 125 pp.