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Evaluation of beech genetic resources for sustainable forestry
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Structure and management of beech (*Fagus sylvatica* L.) forests in Italy

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Beech forests characterise the landscape of many mountain areas in Italy, from the Alps to the southern regions. This paper analyses the relationship between stand structure and the management history of beech in Italy. The aim is to outline possible strategies for the sustainable management of these forest formations. The present structure of beech forests in Italy is the result of many interacting factors. According to the National Forest Inventory, more than half the total area covered by beech has a long history of coppicing. High forests cover 34% of the total beech area and 13% have complex structures which have not been classified in regular types. Coppices are very widespread mainly because of the past, but also present importance of firewood and charcoal for mountain populations. A particular type of beech coppice, the selection coppice (or uneven aged coppice), was traditional in Tuscany and in some alpine areas. Starting from the fifties, following the widespread use of other low cost energy sources and the depopulation of mountain areas, many beech coppices have been progressively abandoned. Forest policies have been increasingly directed to favouring beech coppice conversion to high forests, which are considered more productive and ecologically more functional. Beech high forests have a very interesting management history which is a very good example of the separation between classical forest management, *i.e.*, forest management systems defined by "scientific forestry", described in text books and usually prescribed in forest regulation plans, and real life forest management, *i.e.*, how forests have been, and mostly still are, actually managed. The analysis of the management history of beech high forests in Italy shows that management systems which favour simplified stand structure and composition according to rigid, predetermined models have been rarely applied. However, the traditional silviculture of beech stands in Southern Italy, based on the opening of very small gaps organized in time and space according to the different situations and to the reactions of the stand, can provide an example for a sustainable approach.

Keywords: Sustainable forest management, Coppice, Gaps, Traditional silviculture, Continuous cover forestry

Introduction

Beech forests (*Fagus sylvatica* L.) characterise the landscape of many mountain areas in Italy, from the Alps down to the southern regions of Campania, Basilicata, Calabria and Sicily in the Mediterranean area (Fig. 1). According to the National Forest Inventory (INFC 2005), the total area covered by beech in Italy is 1 042 129 hectares, which corresponds to 9.4% of the country's total forest area. This area includes 1 035 103 ha of beech forests and 7 023 ha of "other wooded land" (according to the FRA2000 definition - Tab. 1).

Over the centuries wood from beech forests, mainly for firewood and charcoal as well as timber for building and furniture, has been a fundamental resource for people living in mountain areas. Thus intensive use has significantly the modified distribution, composition and structure of beech stands all over the country.

Economic and social changes in the last decades have brought about changes in the forestry sector in Italy, which, in turn, have impacted forests and forest management. Beech forests have not been immune to these changes and in some ways represent an interesting case study on the changing perspectives of forest management in the face of changing environmental and socio economic conditions.

This paper analyses the relationship between stand structure and the management history of beech forests in Italy. The aim is to outline possible strategies for the sustainable management of these forest formations.

Distribution of beech forests in Italy

Beech forests are present in all the regions except for Sardinia (Tab. 1). In the Alps, beech generally forms pure stands above 1000 m altitude in areas with relatively low rainfall, while it grows at around 600-700 m in more humid areas.

On the Apennine mountains beech usually grows above 900-1000 m. Beech forests are more widespread on the northern slopes and where rain and fog maintain moist air conditions. On the sunnier and warmer southern slopes, the lower vegetation limit for beech tends to move higher (Hofmann 1991, Pignatti 1998). On the northern slope of the Mount Etna in Sicily beech reaches an altitude of 2000 m (Hofmann 1960, Del Favero 2008).

Today, permanent pastures usually characterise the higher areas of the Apennine

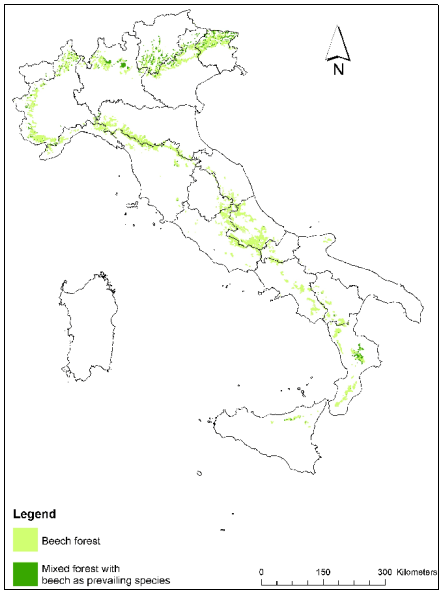

Fig. 1 - Distribution of beech forests in Italy. Data from CORINE Land Cover 2000 4th Level.

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Tab. 1 - Beech distribution in Italy. Data from INFC 2005.

Region	Beech forests		Other wooded land	
	area (ha)	SE (%)	area (ha)	SE (%)
Piedmont	115501	5.6	404	100
Valle d'Aosta	1156	57.3	0	-
Lombardy	65681	7.9	441	100
Alto Adige	3781	31.4	0	-
Trentino	62247	7.1	360	100
Veneto	67196	7.0	374	100
Friuli V.G.	88812	5.7	1115	57.5
Liguria	37004	9.4	733	70.2
Emilia Romagna	100863	5.6	368	100
Tuscany	72260	6.9	361	100
Umbria	15115	15.3	0	-
Marche	17837	14.1	0	-
Lazio	71710	6.8	0	-
Abruzzo	122402	4.8	1731	44.4
Molise	14836	15.5	390	99.8
Campania	55197	7.8	0	-
Apulia	4661	28.6	0	-
Basilicata	26448	11.5	373	99.9
Calabria	77237	6.6	373	99.9
Sicily	15162	15.6	0	-
Sardinia	0	-	0	-
Italy	1035103	1.8	7023	22.9

mountain range, which were once covered by beech forests (Carpaneto et al. 2006). Big, isolated beech trees once used for shading livestock, can still be seen in these pastures, and in some cases beech stands grow up to the mountain ridge, usually along valleys and over saddles (Fig. 2).

In the central Apennines sporadic beech or beech stands can also be found at lower altitudes (< 700-800 m) in chestnut or mesophilous mixed oak forests; these are considered relict sites and proof of a much wider diffusion of beech in the area (Montelucci 1956, Anzalone 1961, Anzalone 1980, Scoppola & Caporali 1997, Scoppola 1999).

In the southern regions, in areas with high air moisture conditions, beech can descend to an altitude of 400-500 m, where it comes into contact with evergreen oak (*Quercus ilex* L.). In some valleys on the Aspromonte mountain range at the southernmost tip of Calabria, there is an inversion of the vegetation planes, with beech occurring at lower elevations compared to evergreen oak. In the Gargano peninsula (Puglia) beech grows at an altitude of 200-300 m a.s.l. (Hofmann 1961, Fenaroli 1966, Pignatti 1998).

Beech forests also host other mountain hardwoods, such as helm, linden, cherry, sycamore and Norway maple (Pignatti 1998). Silver fir (*Abies alba* Mill.) is found in beech forests along the Apennine mountains and, especially, in the Alps. Eight habitat types characterized by beech according to the Habitats Directive (92/43/EEC) have been identified in Natura 2000 sites in Italy (Tab. 2).

Composition and structure of beech forests in Italy

The composition and structure of beech forests in Italy are the result of many interacting factors. One of the most significant has surely been the type of cultivation and management which has characterised the history of each stand. According to the National Forest Inventory (INFC 2005), more than 53% of beech stands have a long history of coppicing. High forests cover 34% of the total beech area and 13% have complex structures which have not been classified in regular types. Property ownership has strongly influenced management history. Approximately 39% of beech forests grow on private properties; the remaining 61% is divided between State forests, regional forests and forests owned by provinces or townships (Tab. 3).

In many areas the presence of beech has been favoured by the type of cultivation. This is the case of beech forests where there had been spruce or silver fir and other hardwoods, and which have been transformed into pure beech stands by repeated coppicing. This phenomenon occurred mainly in private and collective properties in the Alps and in the Central and Northern Apennine range (Hofmann 1991).

In many valleys in the north eastern Alps, beech coppicing started in the Middle Ages and became very intensive during the eighteenth century, when demographic pressure increased rapidly (Crivellari 1955). During this long phase of intensive exploitation spruce, which was naturally present in the area, practically disappeared because clear felling and the subsequent rapid growth of beech sprouts created unfavourable ecological conditions for the regeneration and growth of spruce. Furthermore, spruce was repeatedly suppressed by local populations because of their greater need for firewood and charcoal (Andreatta 2008).

In the northern Apennines exploitation of beech forests became very intensive in the second half of the eighteenth century when beech forests where extensively clear cut leaving only some seed trees (generally 30 per hectare - Gabbrielli 1991a, Rovelli 2000). Stands were thus transformed into coppices, which were repeatedly utilized until the second half of the twentieth century. This intensive exploitation caused the disappearance of silver fir from vast areas in the northern and central Apennines (Senni 1955, Gori Montanelli 1939, Marchesoni 1959).

In many areas of southern Italy extensive felling in beech forests started in 1826, when the Kingdom of Two Sicilies passed the so-called Bourbon Law, which dictated that all public owned forests be managed according to "regular felling", i.e. clear cut leaving 58 seed trees per hectare (Hofmann 1956, Bianucci 1982). The law decreed that the forest should be divided into a number of sections equal to the rotation length for the main species (this law also applied to oak forests) and a section could be cut each year; in the cut section grazing was absolutely prohibited (*difesa* - Gabbrielli 2004). This type of treatment caused the degradation of many beech forests on the warmer, southern slopes and where soil conditions where more difficult; in addition, notwithstanding the law, repeated grazing and fire contributed to the

Tab. 2 - Natura 2000 habitat types with *Fagus sylvatica* L. in Italy.

9110	*Luzulo-Fagetum* beech forests
9130	*Asperulo-Fagetum* beech forests
9140	Medio-European subalpine beech woods with *Acer* and *Rumex arifolius*
9150	Medio-European limestone beech forests of the *Cephalanthero-Fagion*
9180	* *Tilio-Acerion* forests of slopes, screes and ravines
9210	* Apennine beech forests with *Taxus* and *Ilex*
9220	* Apennine beech forests with *Abies alba* and beech forests with *Abies nebrodensis*
9510	* Southern Apennine *Abies alba* forests

Fig. 2 - Permanent pastures have usually replaced the original beech forests in the higher areas of the Apennine mountain range, but sometimes beech stands still grow up to the mountain ridge, usually along valleys and over saddles (Pollino National Park, photo Nocentini).

definitive transformation of many beech forests into degraded pastures (Hofmann 1956, Susmel 1957). On the northern slopes and where there were better moisture conditions, beech regenerated massively both from seed and from stumps, often excluding other species. According to Susmel (1957) this is the main reason why the natural mixed beech and silver fir forest was reduced to small relict areas along the southern Apennine mountain range. Iovino & Menguzzato (1993), analysing the presence and distribution of silver fir in Basilicata, reach the same conclusion, i.e. that the marked reduction of fir stands in this region was

Tab. 3 - Beech forests in Italy. Area divided by type of property. Data from INFC 2005. (*): of total beech area in Italy; (**): of total public properties.

Region	Private properties		Public properties								Total
	Total		State or Region		Province or Township		Other public properties		Total public properties		
	(ha)	%*	(ha)	%**	(ha)	%**	(ha)	%**	(ha)	%*	
Piedmont	56563	49	2828	5	55301	94	808.0	1	58937	51	115501
Valle d'Aosta	385	33	0	0	771	100	0.0	0	771	67	1156
Lombardy	33942	52	882	3	28653	90	2204.0	7	31738	48	65681
Alto Adige	2647	70	0	0	1134	100	0.0	0	1134	30	3781
Trentino	19952	32	721	2	34367	81	7207.3	17	42295	68	62247
Veneto	39591	59	8556	31	18675	68	373.5	1	27605	41	67196
Friuli V.G.	32701	37	11520	21	41991	75	2601.2	5	56111	63	88812
Liguria	26013	70	2198	20	8427	77	366.4	3	10991	30	37004
Emilia Romagna	74381	74	10298	39	16183	61	0.0	0	26481	26	100863
Tuscany	41910	58	23485	77	2529	8	4335.8	14	30350	42	72260
Umbria	7373	49	369	5	1106	14	6267.1	81	7742	51	15115
Marche	11520	65	1486	24	4831	76	0.0	0	6317	35	17837
Lazio	7369	10	0	0	58446	91	5895.3	9	64341	90	71710
Abruzzo	9773	8	7629	7	100656	89	4343.6	4	112629	92	122402
Molise	390	3	781	5	13665	95	0.0	0	14445	97	14836
Campania	1803	3	368	1	52289	98	736.5	1	53394	97	55196
Apulia	0	0	3496	75	777	17	388.4	8	4661	100	4661
Basilicata	5195	20	373	2	19762	93	1118.6	5	21253	80	26448
Calabria	26865	35	14925	30	32462	64	2984.9	6	50372	65	77237
Sicily	4928	33	2274	22	7202	70	758.2	7	10234	67	15162
Sardinia	0	0	0	0	0	0	0.0	0	0	0	0
Italy	403300	39	92189	15	499224	79	40388.8	6	631802	61	1035102

Fig. 3 - Beech selection coppice in the Foreste Casentinesi, Monte Falterona and Campigna National Park (photo Nocentini).

caused by extensive fellings in the past century which practically excluded fir regeneration and favoured massive beech regeneration.

From the middle of the nineteenth and throughout the first half of the twentieth century a contrasting phenomenon occurred in several forests in northern Italy, where many beech stands were gradually transformed into artificial conifer stands, mainly spruce in the Alps (Poldemengo 1950, Morandini 1959).

In the Apennines silver fir had often been preserved in small areas around monasteries, such as Vallombrosa and Camaldoli (Senni 1955). In the Tuscan Apennines, from the end of the eighteenth century silver fir planting started in various forests, often with seeds imported from Germany (Gabbrielli 1991a). The trend increased during the nineteenth century, following ideas coming from Germany and the activity of Karl Siemon, a Bohemian forester who was in charge of the Grand Duke Leopold II's forests in Casentino (Arezzo) from 1838 to 1876 (Gabbrielli 1978). Forest regulation plans were regularly drafted with the aim of creating highly productive even-aged silver fir stands. With the transfer of several forests from both Religious Orders and private properties to the Italian State, this trend continued and was further implemented by forest regulation plans drawn up by professors of the Forestry School which was established in Vallombrosa in 1869.

For example, around 1800 the Camaldoli Forest in Casentino comprised pastures, chestnut groves, Turkey oak stands and beech stands in decreasing order; at that time silver fir probably covered less than 160 hectares (Gabbrielli 1991b). In 1872, when this forest was declared State property, the pure silver fir stands had increased to 365 hectares, and by 1916 they extended over more than 603 hectares (Ferrari 1916, in Gabbrielli 1991a).

The first forest regulation plan for the Vallombrosa State Forest (Florence) was drawn up by Giacomelli in 1876. At that time silver fir stands covered approximately 200 hectares around the Abbey. By 1960 this area extended over more than 680 hectares: thus in less than a century pure, even-aged fir stands had replaced natural beech and other hardwood stands in most of the Forest (Ciancio & Nocentini 2006).

Since the end of the nineteenth century yet another phenomenon has contributed to changing the forest landscapes originally characterized by beech. From that period, and more intensively between 1920 and 1950, many degraded mountain pastures were reforested with conifers - usually Austrian pine (*Pinus nigra* Ar.) to halt soil erosion in the beech vegetation area.

Management of beech forests in Italy

Currently, the management situation of beech forests in Italy is very diversified. Beech forests have been abandoned in many areas. In general beech forests can be classified in the following management types: coppices, stands in transition from coppice to high forest, high forests.

Beech coppices

Beech stands originated from coppicing are found all over Italy, but the regions where coppices are more widespread are Piemonte, Lombardia and Veneto in the alpine area, Emilia Romagna, Toscana and Marche in the Apennines, whereas in Southern Italy only Sicily has more beech coppices than high forests (Tab. 4). Usually coppicing has been more common on private (almost 50% of beech coppices are on privately owned lands - Hofmann 1991) and on municipally-owned properties.

Beech coppices were generally clear felled leaving 60-80 standards per hectare. The rotation age traditionally varied between 16 and 24 years. Yields varied between 2-3 and 5-6 m^3 ha^{-1} (Hofmann 1963, IPLA 1976). In the Northern Apennines, right after coppicing, it was customary to cultivate cereals and potatoes in the spaces between coppice stools; brushwood was usually burned to fertilize the soil. This intensive exploitation greatly reduced the density and fertility of many beech coppices (Sanesi 1962, Ferrari et al. 1979).

Starting from around 1960, following the development and widespread use of other low cost energy sources and the depopulation of mountain areas, many beech coppices have been progressively abandoned (Ciancio et al. 2006a). In 1985, according to the first Italian Forest Inventory (MAF/ISAFA 1988), < 6.3% of beech coppices in Italy were less than 5 years old, while over 45% were 30 years or older. In 2005 only 0.1% of the total beech coppice area was in the regeneration phase, 4.8% in the "young phase", 55.4 in the "adult phase" and over 39% in the "old phase" (IFNC 2005). These data indicate that at the beginning of the eighties coppicing had stopped in most beech coppices and the trend is increasing (Tab. 5). The 1985 National Forest Inventory

Tab. 4 - Management types for beech forests in Italy. Data from INFC 2005.

Region	Coppice		Coppice stands in conversion to high forest		High forests		Not classified		Total
	(ha)	%	(ha)	%	(ha)	%	(ha)	%	(ha)
Piedmont	72020	62.5	2424	2.1	29898	25.8	11158	9.7	115500
Valle d'Aosta	0	0.0	0	0.0	771	66.7	385	33.3	1156
Lombardy	43199	65.8	882	1.3	13224	20.1	8376	12.8	65681
Alto Adige	1512	40.0	0	0.0	1890	50.0	378	10.0	3780
Trentino	27027	43.4	7568	12.2	17069	27.4	10582	17.0	62246
Veneto	39965	64.2	3735	4.9	16773	22.0	6723	10.0	67196
Friuli V.G.	10033	11.3	11891	13.4	34931	39.3	31958	36.0	88813
Liguria	24913	67.3	733	2.0	10625	28.7	733	2.0	37004
Emilia Romagna	78059	77.6	11034	10.9	5517	5.4	6252	6.2	100862
Tuscany	37215	55.1	11201	14.4	11201	14.4	12644	17.5	72261
Umbria	10322	68.3	369	2.4	2949	19.5	1475	9.8	15115
Marche	11520	65.3	0	0.0	2230	12.2	4087	22.9	17837
Lazio	33161	46.2	4053	5.7	28233	39.4	6264	8.7	71711
Abruzzo	50703	41.8	18822	15.3	41293	33.5	11584	9.5	122402
Molise	3904	26.3	0	0.0	9760	65.8	1171	7.9	14835
Campania	4380	7.9	2210	4.0	41609	75.4	6997	12.7	55196
Apulia	388	8.3	0	0.0	4273	91.7	0	0.0	4661
Basilicata	2983	11.3	373	1.4	18271	69.1	4822	18.2	26449
Calabria	14925	19.3	2985	3.9	57088	73.9	2239	2.9	77237
Sicily	10993	72.5	0	0.0	2274	15.0	1895	12.5	15162
Sardinia	0	0.0	0	0.0	0	0.0	0	0.0	0
Italy	477225	46.1	78280	7.6	349879	33.8	129723	12.5	1035107

(MAF/ISAFA 1988) estimated a mean standing volume of 151.5 m^3 ha^{-1} for beech coppices. Volume data from the 2005 National Forest Inventory broken down by stand composition and management type are not yet available. It is probable that this average volume has increased due to increasing average age.

A particular type of beech coppice is the selection coppice (or uneven aged coppice), where shoots of different ages (usually three age classes) grow on each stool. This type of coppice was traditional in Tuscany and in some areas of Piemonte, Lombardia, Veneto and Friuli (Mannozzi-Torini 1949, Giannini & Piussi 1976, IPLA 1981, Camia et al. 2002, Menicacci 2002 - Fig. 3).

With the coppice selection system, the biggest shoots are cut every 6-8 years and a light thinning of the smaller shoots is also done. According to Giannini & Piussi (1976) selection coppices in Tuscany usually had circa 1300 stools per hectare; each stool had 1-2 (rarely 3) dominant shoots with heights of 9-10 m, 4-5 intermediate shoots (approx. 7 m high) and 10-15 shoots with heights of 2.5-3.0. With the selection coppice a continuous cover is maintained and good yields have been reported: Mannozzi-Torini (1949) estimated annual yields of 7-7.5 m^3ha^{-1} near Lake Como, and 9.5-10 m^3ha^{-1} in the Tuscan Apennines. These good yields are explained by the fact that repeated, frequent thinning stimulates growth of the remaining shoots and favours new sprouting from the stool. The success of this system depends on the ability and experience of the woodsmen (Ciancio & Nocentini 2004).

Selection coppices have been mostly abandoned except for very limited areas. Camia et al. (2002) describe the history and present management system of a selection coppice (180 ha) in Piemonte which is still regularly utilized. The coppice is owned by the township. Rules for the use of the coppice by residents were set out at the middle of the nineteenth century and have remained practically unchanged. Selection cutting is allowed on each compartment every 9 years, all shoots with dbh>12 cm can be cut and the smaller shoots are thinned, at least 200 to 300 quintal ha^{-1} (approx. 20-30 m^3 ha^{-1}) must be left after cutting depending on site fertility. The current annual volume increment is estimated at 2.9 m^3 ha^{-1} $year^{-1}$.

Today there is a renewed scientific and operational interest in this management system because it can produce relatively high quantities of firewood in mountain areas where modern and efficient wood burning stoves are gradually gaining importance while guaranteeing continuous cover and adequate soil protection (Ciancio & Nocentini 2004, Coppini & Hermanin 2007).

Coppice conversion to high forest

Forest policies have been increasingly directed to favouring the conversion of beech coppices to high forests which are considered both more productive and ecologically more functional (Bagnaresi & Giannini 1999).

In general, conversion to high forest has been carried out by progressively reducing stand density with repeated thinning of the shoots (Ciancio & Nocentini 2004). The aim is to favour growth of the best shoots and at the same time reduce resprouting (Giannini & Piussi 1976; Bagnaresi & Giannini 1999). Conversion to high forest is completed with seedling establishment following regeneration felling. On the whole, it is quite a long process which, in mountain areas, can last up to 150 years, depending on site fertility (Ciancio & Nocentini 2004).

Numerous experimental trials on beech coppice conversion to high forest have been conducted in several areas (Bianchi 1976, Amorini & Gambi 1977, Cappelli 1981, Andriollo et al. 1987, Tagliaferro 1987, Amorini et al. 1988, Bianchi & Hermanin 1988, Amorini & Fabbio 1991, Avolio & Ciancio 1991, Fratello et al. 1993, Cantiani & Cantiani 1994, Cesaro & Colpi 2002, Ciancio et al. 2006b, Ciancio et al. 2007). In general, results show that in coppices which have passed the normal rotation age, thinning increases stand stability, reduces shoot mortality, maintains a "regular" stand structure, increases growth both of individual shoots and total stand volume. Recently, conversion to high forest of beech coppices

Tab. 5 - Beech coppices: area distribution by development phase for even aged coppices; uneven aged coppice distribution - data from INFC 2005. (*): % of total even aged coppices; (**): % of total coppice.

Region	Coppice with and without standards, compound coppice										Uneven aged coppice		Total coppices
	Young phase		Adult phase		Old phase		Regeneration phase		Total				
	Surface (ha)	%*	Surface (ha)	%*	Surface (ha)	%*	Surface (ha)	%*	Surface (ha)	%	Surface (ha)	%**	Surface (ha)
Piedmont	4848	6.8	45355	63.3	21413	29.9	0	0.0	71616.2	100.0	404	0.6	72020
Valle d'Aosta	0	0.0	0	0.0	0	0.0	0	0.0	0.0	100.0	0	0.0	0
Lombardy	882	2.0	27330	63.3	14988	34.7	0	0.0	43199.3	100.0	0	0.0	43199
Alto Adige	0	0.0	378	25.0	1134	75.0	0	0.0	1512.4	100.0	0	0.0	1512
Trentino	360	1.3	15496	57.3	11171	41.3	0	0.0	27027.4	100.0	0	0.0	27027
Veneto	747	2.4	16808	54.2	13446	43.4	0	0.0	31000.9	100.0	8964	22.4	39965
Friuli V.G.	0	0.0	2601	25.9	7432	74.1	0	0.0	10033.2	100.0	0	0.0	10033
Liguria	733	2.9	19051	76.5	5129	20.6	0	0.0	24913.3	100.0	0	0.0	24913
Emilia Romagna	2575	3.3	44490	57.5	30259	39.1	0	0.0	77323.8	100.0	736	0.9	78059
Tuscany	0	0.0	13730	43.7	17704	56.3	0	0.0	31434.4	100.0	5781	15.5	37215
Umbria	0	0.0	2212	21.4	7742	75.0	369	3.6	10322.3	100.0	0	0.0	10322
Marche	0	0.0	7804	70.0	3344	30.0	0	0.0	11148.1	100.0	372	3.2	11520
Lazio	2579	7.8	13633	41.1	16949	51.1	0	0.0	33160.9	100.0	0	0.0	33161
Abruzzo	3982	8.0	20994	42.0	25003	50.0	0	0.0	49979.3	100.0	724	1.4	50703
Molise	390	10.0	2733	70.0	781	20.0	0	0.0	3904.1	100.0	0	0.0	3904
Campania	1066	24.3	2210	50.4	1105	25.2	0	0.0	4380.4	100.0	0	0.0	4380
Apulia	0	0.0	388	100.0	0	0.0	0	0.0	388.4	100.0	0	0.0	388
Basilicata	373	12.5	1864	62.5	746	25.0	0	0.0	2982.9	100.0	0	0.0	2983
Calabria	1119	7.5	10074	67.5	3731	25.0	0	0.0	14925.0	100.0	0	0.0	14925
Sicily	2274	20.7	7960	72.4	758	6.9	0	0.0	10992.5	100.0	0	0.0	10993
Sardinia	0	0.0	0	0.0	0	0.0	0	0.0	0.0	0.0	0	0.0	0
Italy	21928	4.8	255111	55.4	182836	39.7	369	0.1	460244.8	100.0	16980	3.6	477225

has also been examined in relation to the carbon cycle and the Kyoto Protocol (Pilli et al. 2008).

In many public properties in the eastern Alps and in the Northern Apennines, beech stands are currently in the transition stage from coppice to high forest. Due to irregular application of conversion interventions (such as not removing standards, excessive or too light thinning of shoots, etc.) in practice these stands show very diversified structures which are not easily classified in regular structural models (Cucchi 1976, Bianchi 1981). Usually, forest management plans for the older transition stands prescribe regeneration felling carried out according to the uniform shelterwood system, but the regeneration stage has rarely been reached in practice.

In private properties and in many small community forests, conversion to high forest has not been so widespread and there are vast areas where beech coppices have long been abandoned. Following the renewed interest in firewood as an energy source, the high standing volume which has accumulated in decades of abandonment and the availability of relatively low cost labour due to illegal exploitation of immigrant workers, there is increasing pressure for a return to coppicing, especially in the more accessible areas. This situation presents various risks which must be seriously taken into account. Widespread cutting of beech coppices which have not been utilized for several decades will quickly consume a natural capital which has built up during the years. This does not include only wood but also organic substances in the soil, a fundamental element for the functionality of these forests. Some Regions are setting stricter age and cutting area limits to stop the return to beech coppices.

Tab. 6 - Number of trees in different size and age groups according to the "cultivation type" for uneven aged beech forests in Southern Apennines. From Susmel 1957, modified.

Approx. tree age (years)	DBH (cm)	n. trees per group	
		group size 277 m^2	group size 416 m^2
0-20	-	-	-
20-40	5-10	-	-
40-60	10-20	33	50
60-80	25-30	13	20
80-100	35-40	8	11
100-120	45-55	5	7
120-140	55-70	2	3

Beech high forests

Almost 50% of all beech high forests in Italy are in the southern regions of Abruzzo, Molise, Puglia, Campania, Basilicata and Calabria (Tab. 4).

In the Southern Apennines beech high forests have a very interesting management situation which is a good example of the separation between classical forest management, developed with "scientific forestry" (Lowood 1990, Johann 2007) and based on regulation plans which aimed at ensuring

Tab. 7 - Tree distribution in age class groups for small group selection beech stands in Calabria. From Ciancio et al. 2008, modified.

Age of trees (years)	DBH (cm)	n. trees per group	Hm (m)
<10	6-9	16	<10
10-20	12-15	11	13-14
20-30	18-24	10	16-18
30-40	27-36	9	18-21
40-50	38-45	3	21-22
> 50	>45	2	>22

Tab. 8 - Stand parameters for small group selection beech forests in Calabria and uneven aged structural model for beech forests in Southern Apennines. (*): data from Ciancio et al. (2008), (**): data from Susmel (1957).

Stand Parameters	Number trees ha^{-1}	Average DBH (cm)	Basal area (m^2 ha^{-1})	Volume (m^3 ha^{-1})
Small group selection system in Calabria (*)	461-467	27.3-31.4	27.40-35.65	368-403
Selection forest model for beech forests in southern Apennines (**)	370	34.7	35.00	289

sustained yield, and real life forest management, i.e. how forests have been, and mostly still are, managed in reality.

From the beginning of the twentieth century, Di Tella and then Patrone, founders of the Italian Forestry School, following the example of the German Forestry School, considered the uniform shelterwood system as the most rational form of management for beech stands. The belief that this was the only system that could be applied in good site conditions has endured for a long time (Hofmann 1956, Hofmann 1991, Mayer 1977, Cantiani 1983, Bernetti 1995).

There are several reasons for this: first of all beech was believed to have a natural tendency towards even-aged structures; second, even-aged structures were always considered better for the production of high quality timber, whereas selection cutting has always had a bad reputation because it is suspected of degenerating into the commercial selection of the best trees (Bernetti 1995). Last, but not least, since the uniform shelterwood system is based on area regulation methods for determining prescribed yield, in theory the normal forest, i.e. the well regulated forest, is easier to attain. Thus the management model developed by the Forestry School of Florence prescribed rotation ages between 90 and 100 years, uniform shelterwood system and a regeneration period of 20 to 30 years (Patrone 1957).

As I have already mentioned, many beech high forests of Southern Italy are the result of extensive fellings carried out according to the 1826 Law. This type of felling was conducted well into the twentieth century, when it became customary to utilize beech stands with a very intensive cut leaving few seed trees (circa 50 per hectare).

Resulting stands today show different structures, ranging from even-aged pure beech stands with sparse old big trees, to stands with a light cover of big trees from the old cycle and with a lower plane formed by beech regeneration, originating both from seed or stool, to multi-stratified stands where felling of some of the big old seed trees has opened up space for new regeneration (Iovino & Menguzzato 2004, Ciancio et al. 2008). It is interesting to note that, according to the National Forest Inventory, beech forests have a relatively higher number of "monumental" trees as compared to other forest formations in Italy (INFC 2005).

In the face of this extremely varied situation, forest management plans for beech high forests on public properties in the southern Apennines have systematically prescribed the shelterwood system, but this management type - with all its phases - has only been applied rarely (Bianucci 1982, Masci et al. 1999, Ciancio et al. 2008, Marone et al. 2009 in press). Generally a very heavy cut is applied at rotation age utilizing 50% or more of standing volume, instead of 30% as prescribed by the shelterwood system for beech. Removal cuttings are usually indefinitely postponed because they are not considered financially profitable (Ciancio et al. 2008).

Instead, the traditional treatment for beech stands on private, and, rarely, on some public properties, was and still is a selection cut applied without precise written rules, but according to the needs of the owner and to the particular situation of each stand.

Susmel (1957) reported on various areas between Campania and Basilicata where beech stands, from at least 1850, had been managed successfully with a "selection cut" and where wood production quality was very good. Fellings were carried out approximately every 14 years in the same stand. This type of management created an "irregular" small group structure. Putting together data from "irregular" beech forests in Corleto Monforte (Campania) with data from private forests in Muro Lucano, Susmel elaborated a theoretical "cultivation type" for uneven aged beech forests in the Southern Apennines (Tab. 6). The cultivation type refers to a stand structure with a balanced tree distribution in diameter classes according to the De Liocourt function (De Liocourt 1898). Compared to the traditional management system, the proposed "cultivation type" was based on a selection cut repeated every 10 years and the creation of groups varying between 277 and 417 m^2. According to Susmel, the final aim of this management model was to favour the transformation of pure beech stands into mixed fir-beech stands with balanced uneven aged structures. Susmel (1959) later prescribed this model in a management plan which had the aim of "creating order" in the beech forests in Corleto Monforte. But this model has not been applied in practice (Marone et al. 2009).

More recently, studies conducted in various privately owned beech forests in Calabria (Iovino & Menguzzato 2004, Ciancio et al. 2008) have described a similar form of treatment and the resulting stand structures. The traditional system consists of a selection cut which eliminates the biggest trees and which is repeated at short intervals (8-10 years). This type of felling creates small gaps - 40 to 100 m^2 in size- where beech regeneration quickly sets in (Ciancio et al. 2008). Stands are formed by very small groups of trees that can be classified according to age as is shown in Tab. 7. Reductions in the number of trees in the groups with increasing age is due only to mortality from competition since traditionally no thinnings are carried out; this produces well shaped, regular boles. Data collected 5 years after a selection cut carried out by the owner according to the traditional system showed that vigorous regeneration had set in in the very small gaps (40-50 m^2) created by cutting individual big trees, and an average of 25 young beech trees with DBH< 3 cm and height < 2 m were present in each gap (Ciancio et al. 2008).

Comparison between the Susmel theoretical cultivation type and the Calabrian beech stands shows a lower number of trees, relatively higher average diameter and lower standing volume (Tab. 8).

Conclusion

Beech forests in Italy are a very important and characterizing element of many mountain areas, especially in the Mediterranean regions. Their management history is the result of complex interrelations between social and economic phenomena which have characterized at least the last two centuries. A less evident but indeed fundamental role has also been played by changing cultural and scientific reference systems.

Surely the trend of coppice abandonment will continue in the remotest and more difficult zones. In areas where coppicing is again financially convenient, felling must be accurately controlled. Conversion to high forest should continue, but here too stand structure diversification should be favoured. At the landscape scale, appropriate planning of beech coppice conversion to high forest can provide for a pattern of patches with different ages and structures with significant value in terms of biodiversity conservation (Nocentini 2005).

In the future beech will increasingly spread into neighbouring artificial conifer stands where site conditions are favourable. Here it is necessary to help natural processes and management should sustain evolution towards more complex and efficient forest systems.

The analysis of the management history of

beech high forests in the Apennines shows that management systems which favour simplified stand structure and composition according to rigid, predetermined models, have rarely if ever been applied because they do not take into account both the real structure of beech stands and local traditions.

For beech high forests, the management approach which has been described for private properties in Southern Italy, based on the opening of very small gaps organized in time and space according to the actual structure of the stand, can instead provide an interesting example for sustainable use of these forest formations. Although no specific study has as yet been carried out to evaluate the economic return of this type of management, the fact that it has been applied with constancy and often for well over a century in private properties would indicate that economic sustainability is self-implied. Examples of similar silvicultural treatment, based on selection cut and very small group stand structures, have been described for other forest types in Southern Italy, such as *Pinus nigra* var. *laricio* (Ciancio et al. 2006b) and *Pinus halepensis* Mill. (Ciancio et al. 2008).

This type of forest management, carried out outside regular management plans, but according to un-written rules passed on by owners and woodsmen, is based on an adaptive approach that maintains a continuous forest cover. Therefore it can offer an important contribution to the definition of a sustainable way for managing beech forests.

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